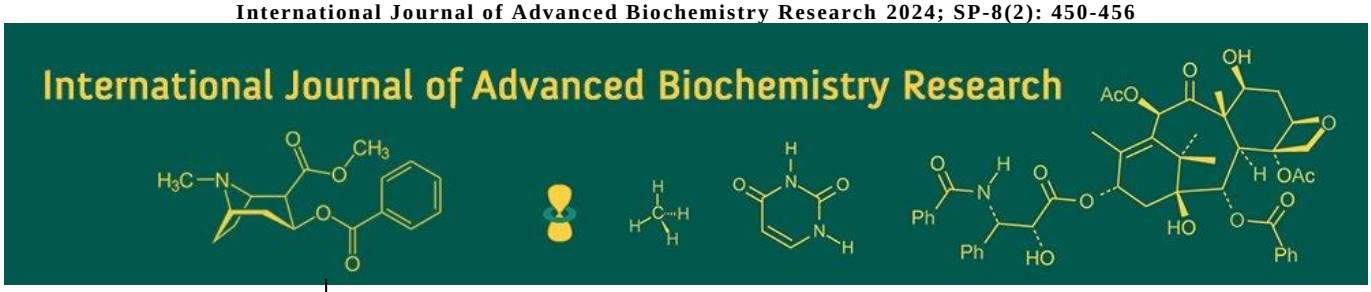

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(2): 450-456
www.biochemjournal.com
Received: 17-12-2023
Accepted: 23-01-2024

Bashetti PN
Department of Veterinary Pathology, IVRI, Izatnagar, Uttar Pradesh, India

Rohit Kurhe
Department of Animal Reproduction and Veterinary Gynecology, IVRI, Izatnagar, Uttar Pradesh, India

Rajeshwar Khandare
Department of Veterinary Biotechnology, IVRI, Izatnagar, Uttar Pradesh, India

Ashvini Bansod
Animal Nutrition, IVRI, Izatnagar, Uttar Pradesh, India

Mukesh Namapalle
Department of Poultry Science, CARI, Izatnagar, Uttar Pradesh, India

Amit Kshirsagar
Department of Veterinary Surgery, NVC, Nagpur, Maharashtra, India

Chaitrali Avhad
Department of Veterinary Surgery, COVAS, Parbhani, Maharashtra, India

Corresponding Author:
Rohit Kurhe
Department of Animal Reproduction and Veterinary Gynecology, IVRI, Izatnagar, Uttar Pradesh, India

One health perspective for infectious diseases of animals

Bashetti PN, Rohit Kurhe, Rajeshwar Khandare, Ashvini Bansod, Mukesh Namapalle, Amit Kshirsagar and Chaitrali Avhad

DOI: https://doi.org/10.33545/26174693.2024.v8.i2Sf.636

Abstract
Infectious diseases pose significant threats to human, animal, and environmental health, highlighting the critical need for a holistic perspective in addressing these complex challenges. This review explores the One Health framework, emphasizing the interconnectedness of human, animal, and environmental health in the context of infectious diseases. By examining zoonotic diseases, antimicrobial resistance, and emerging pathogens through a One Health lens, we elucidate the intricate interplay between humans, animals, and ecosystems in disease transmission dynamics. Through an extensive literature review, we analyze the multifaceted factors contributing to the emergence and spread of infectious diseases, including ecological disruptions, human behavior, and microbial evolution. We also evaluate the effectiveness of One Health interventions in disease prevention, surveillance, and control, highlighting successful case studies and identifying areas for improvement. Furthermore, we discuss the importance of interdisciplinary collaboration and policy integration to foster a unified approach to infectious disease management. Embracing the One Health paradigm offers promising opportunities to mitigate the impact of infectious diseases on global health security while promoting sustainable coexistence among humans, animals, and the environment.

Keywords: One Health, infectious diseases, zoonoses, antimicrobial resistance, interdisciplinary collaboration

Introduction
Once a noble prize winner Joshua Lederberg after the epidemic of HIV said that, "As one species, we share a common vulnerability to these scourges. No matter how selfish our motives, we can no longer be indifferent to the suffering of others. The microbe that felled one child in a distant continent yesterday can reach yours today and seed a global pandemic tomorrow" (Lederbeg 1988) [21]. This is the current situation due the pandemic COVID-19 and what we are facing now is not only affecting global health but also the global economy.
A healthy individual does not exist in isolation; we are all a part of the larger community. We are connected with the different types of animals and the environment in which we live. Twenty first century is the era of modernization and globalization. No doubt we have achieved a lot of things today and made our lives so much easy and sophisticated. But along with these positive effects we are harming our companion animals and environment so badly that it inversely reacting and causing serious damage to the life on the earth. Currently the population of the world is 7.9 billion and it is estimated that till 2024 it will be increased to 9 billion. To full fill all needs and demands of such huge population we are just draining all the natural resources like massive land use, exploiting the forest, cutting of trees etc. Due to these activities so many global issues like climate change, species extinction and global warming, pollution, and habitat and soil degradation have been emerging. Along with this the wild life trading and trading market has increased and this directly affects the human and animal health resulting due the spill over event from wild to domestic species. As a result of this since last 2 decades we have been facing too many outbreaks like Ebola virus disease, avian influenza, peste des petits ruminants, African swine fever, SARS, MERS and COVID-19. However the most challenging and emergent threat to the both human and animal health is antimicrobial resistance (Kim *et al.* 2020) [45]. This shows that the health system of human, animal and environment is connected in a manner that it is independent on one another.

What is One Health?

One Health is broader concept and it can be defined according to the One Health Commission, 2001 as the collaborative effort of multiple health science professions, together with their related disciplines and institutions - working locally, nationally, and globally - to attain optimal health for people, domestic animals, wildlife, plants, and our environment. As we discussed earlier the health of all these aspects are interdependent on each other so disturbance of one component can cause damage to other. Human and animals live in close proximity and they are connected with each other through their environment. So the diseases of humans and animals include almost 60% of zoonotic potential whereas 80% can originate due to environmental hazards. This explains the importance of One Health concept.

Origin of One Health

At the Rockefeller University Wildlife Conservation Society organized the symposium of all the health experts around the world on 29th September 2004 after the outbreaks of Ebola, Avian Influenza, and Severe Respiratory distress syndrome (SARS) to discuss the current potential risks of diseases in human, animal and environmental health domain. And this event was named as “One World, One health”. Manhattan principles which are very helpful in preventing epidemic disease were formulated. These principles are.

1. Acknowledge the interconnectedness of human, domestic animal, and wildlife health in disease management.
2. Understand the health implications of land and water use decisions.
3. Integrate wildlife health science into global disease prevention and control efforts.
4. Recognize the potential of human health programs to support conservation initiatives.
5. Develop comprehensive strategies to address emerging and resurging diseases.
6. Integrate biodiversity conservation and human needs into infectious disease solutions.
7. Regulate and reduce the international wildlife trade to minimize disease transmission risks.
8. Limit mass culling of wildlife to situations of urgent health threats with scientific consensus.
9. Increase investment in global health infrastructure to combat disease threats.
10. Foster collaborative partnerships across sectors for global health and biodiversity conservation.
11. Support wildlife health surveillance networks for early disease detection and response.
12. Promote education and awareness to emphasize the link between health and ecosystem integrity.

In 2007, the American Medical Association (AMA) joined forces with the American Veterinary Medical Association (AVMA) to endorse the One Health Resolution, advocating for collaboration between human and veterinary medicine. Subsequently, in 2008, a coalition of organizations including the Food and Agricultural Organization (FAO), the World Organization for Animal Health (OIE), and the World Health Organization (WHO), in conjunction with UNICEF, UNISC, and the World Bank, formulated a strategic framework aimed at mitigating the risks of infectious diseases emerging at the interfaces of human, animal, and environmental domains. In the year 2000, the United States Agency for International Development (USAID) initiated the Emerging Pandemic Threats Program, and the One Health office was established at the Centre for Disease Control and Prevention (CDC) to address these concerns. By 2010, the concept of One Health gained further traction with the development and promotion of the tripartite approach, emphasizing the interconnectedness of human, animal, and environmental health. The inaugural One Health conference took place in Africa in 2011, followed by four successive conferences held in different countries from 2013 to 2019.

Notably, in response to the COVID-19 pandemic, a conference was convened on October 25, 2019. During this event, the "Berlin Principles on One Health" were introduced, representing a refinement of the earlier Manhattan Principles. These are the 10 Berlin principles.

1. Recognize the vital link between human health, wildlife, domestic animals, plants, and the natural world. Preserve biodiversity to sustain life and well-being.
2. Establish strong institutions integrating human, animal, and environmental health insights for effective policies.
3. Address the urgent challenges of the climate crisis, threatening human, animal, and environmental health.
4. Understand that land use and environmental decisions directly affect human, animal, and ecosystem health. Take proactive measures to mitigate impacts.
5. Develop comprehensive strategies for detecting, preventing, and controlling diseases, considering species, ecosystems, and societal dynamics.
6. Incorporate biodiversity conservation into disease mitigation efforts, balancing human health with ecosystem preservation.
7. Increase investment in global health infrastructure for humans, animals, and ecosystems, acknowledging emerging disease threats.
8. Strengthen cross-sectoral health surveillance and information-sharing for better coordination among stakeholders.
9. Foster collaborative relationships among governments, NGOs, Indigenous Peoples, and communities to address global health challenges.
10. Invest in education on planetary health, promoting understanding across all age groups and advocating policy changes prioritizing ecosystem integrity and human health.

One health: An old concept

The concept of One Health is not novel but has ancient origins, with its earliest mention tracing back to the writings of the Greek physician Hippocrates, who recognized the interconnectedness between the environment and human health. In the 1800s, a pioneer in veterinary pathology emphasized the unity of animal and human medicine, coining the term "zoonosis" to describe diseases transmissible between animals and humans (Kahn *et al.* 2007) [17]. Figures like Sir William Osler and Louis Pasteur made significant contributions to both human and animal health through their research and vaccine developments. Similarly, in the 19th century, Robert Koch's studies on infectious diseases spanned both humans and animals, highlighting their shared vulnerabilities. Key discoveries

were made by figures like Daniel E. Salmon and Theobald Smith, who jointly identified the immunizing properties of heat-treated pathogens in animals and humans. Additionally, John McFadyean's research challenged prevailing beliefs about bovine tuberculosis transmission, demonstrating its impact on human health through milk consumption. In the 20th century, individuals such as Karl F. Meyer and Calvin W. Schwabe continued to bridge the gap between human and animal health, studying diseases like typhoid fever, malaria, and brucellosis. Schwabe, in particular, advocated for a unified approach to zoonotic diseases, coining the term "One Medicine," later known as "One Health." James H. Steele, a prominent figure in veterinary public health, played a significant role in promoting the One Health concept throughout his career, emphasizing its importance in addressing global health challenges. His efforts have been instrumental in advocating for a unified approach to human, animal, and environmental health (Atlas 2012) [2].

One Health Umbrella

One Health is a holistic approach endorsed by organizations like the US Centre for Disease Control and Prevention and the One Health Commission. It emphasizes collaboration across sectors and disciplines at local, regional, national, and global levels to enhance health outcomes by acknowledging the interconnectedness of humans, animals, plants, and the environment. Another perspective, as proposed by the One Health Global Network, highlights the interdependence of human, animal, and ecosystem health. This approach calls for coordinated, multidisciplinary efforts to address risks emerging at the interface of these entities. A simpler rendition from the One Health Institute at the University of California, Davis, describes One Health as a strategy for safeguarding the well-being of people, animals, and the environment through collaborative problem-solving, locally and globally. Furthermore, a comprehensive understanding of One Health, as advocated by One Health Sweden and the One Health Initiative Autonomous pro bono team, encompasses key areas such as emerging and re-emerging zoonoses, antimicrobial resistance (AMR), and food safety. These facets underscore the importance of addressing health challenges that transcend species boundaries and geographical borders (Mackenzieand Jeggo 2019) [22].

Importance of Zoonosis in Public Domain

The significance of zoonotic diseases in the public domain is substantial. As per the World Health Organization (WHO), out of approximately 1415 pathogens known to infect humans, around 868 are of zoonotic origin, highlighting that roughly 61% of human pathogens have the potential to transfer from animals. Among these zoonotic pathogens, about 75% are categorized as emerging infections, encompassing well-known diseases like HIV, Ebola, SARS, and MERS. Annually, five new diseases emerge, with three originating from animals. Additionally, an alarming 80% of agents with potential for bioterrorism have zoonotic implications. This underscores the significant impact of zoonoses on both human and animal health. (Statistics Division, United Nations, 2003; World Health Organization, 2009).

Emerging and Re-emerging zoonosis: Emerging infections refer to new infections resulting from changes in existing pathogens, spread to new geographic areas or populations, or the diagnosis of infections caused by previously unrecognized agents. Conversely, re-emerging infections are those that resurface after being eradicated or controlled (Dhama *et al.*, 2013a) [10]. Zoonotic diseases are those naturally transmitted from animals or birds to humans. The rapid evolution of RNA viruses, facilitated by mechanisms such as point mutation, deletion, recombination, and reassortment, contributes significantly to the emergence and spread of diseases across species barriers. Additionally, antimicrobial resistance among zoonotic bacteria limits the effectiveness of antibiotic treatments in animals, further exacerbating the issue. Factors such as the introduction of invasive or migratory species and accidental release of foreign species into new environments can also contribute to the emergence of diseases. Recent infectious disease outbreaks, such as Severe Acute Respiratory Syndrome (SARS), avian influenza (H1N1), and swine-origin influenza virus (SOIVH1N1), have underscored the global health community's vulnerabilities in preparedness and response to diseases arising from the human-animal interface (Dhama *et al.* 2013b) [11]. Furthermore, handling poultry meat can pose risks for various infections including Avian Influenza (AI), tuberculosis, salmonellosis, campylobacteriosis, colibacillosis and diseases like listeriosis, Newcastle disease (ND), eastern equine encephalitis (EEE), West Nile virus, cryptosporidiosis, erysipelas, clostridial infections, arizonosis, cryptococcosis, histoplasmosis, and allergic alveolitis also contribute to human infections (Tiwari and Dhama, 2012) [12].

Wildlife and emerging/re-emerging zoonotic diseases

Approximately 75% of infections are categorized as emerging, many of which originate from wildlife. Consequently, wildlife can serve as a potential yet unknown reservoir for diseases that pose zoonotic threats. These diseases include vector-borne viral illnesses such as Hendra and Nipah viruses, Menangle virus, West Nile virus, and Monkeypox (Taylor *et al.*, 2001) [34]. This situation not only endangers biodiversity but also jeopardizes human and animal health. Several factors contribute to the occurrence of zoonoses from wildlife reservoirs. One significant factor is the increased encroachment of human populations into wildlife habitats, driven by population growth. This intrusion can lead to the emergence of various infections, such as Kyasanur Forest disease (KFD) (Varma, 2001) [36]. Furthermore, changes in agricultural practices, such as the domestication of wild animal species, can result in the re-emergence of zoonoses. For instance, the domestication of deer populations has been associated with the re-emergence of bovine tuberculosis (Wilson, 2002) [39]. Specific instances highlight the consequences of human activities on disease emergence. For example, the removal of forests and the expansion of non-industrial pig farming, coupled with the cultivation of fruiting trees, led to the Nipah virus outbreak in Malaysia during 1998-1999 (Daszak *et al.*, 2004) [9]. Additionally, the spread of rabies can occur due to the movement of wild animals into domestic environments. Moreover, activities involving close contact with wildlife, such as petting zoos and the trade of exotic birds have been implicated in several zoonotic outbreaks. These outbreaks have involved pathogens like Escherichia coli O157:H7,

Salmonella, and rickettsial pathogens such as Coxiella burnetii (Bender and Shulman, 2004) [6].

Impact of Transboundary diseases on One Health

Trans-boundary diseases are highly contagious illnesses that spread rapidly across national borders, affecting both humans and animals (Yadav *et al.* 2020) [44]. They pose serious socio-economic and public health risks, with South Asian countries identified as significant hotspots for their emergence. Given the interconnectedness of human, animal, and environmental health, it's crucial to adopt a One Health approach to address these diseases at national, regional, and global levels difficult (National Research Council, 2005; Dhama *et al.*, 2012) [25, 12]. However, managing their spread is challenging due to diverse contributing factors. Therefore, comprehensive research is essential to understand these diseases' dynamics across different host species and environments (Karesh *et al.*, 2005) [18].

Bioterrorism

The One Health concept is crucial in addressing various threats, including bioterrorism, where 80% of bioterrorist agents have zoonotic potential. Bioterrorism involves the deliberate use of biological organisms or toxins against humans, animals, or crops, leading to harm to their normal health (Block 2001) [47]. These agents can be spread through air, water, and food. To combat this threat, the Defense Department of the USA has established the Global Emerging Infections Surveillance and Response System and other programs for worldwide biosurveillance. Therefore, the "One World, One Health" approach plays a vital role in combating bioterrorism globally.

The CDC categorizes bioterrorism agents into three categories based on their ease of spread and severity of illness or death they cause:

Category A: These agents pose the highest risk to public health and national security and include organisms or toxins such as Anthrax (*Bacillus anthracis*), Plague (*Yersinia pestis*), Tularemia (*Francisella tularensis*), and Viral Hemorrhagic Fever Viruses (Ebola, Marburg, Lassa, Machupo). They are easily spread from person to person, resulting in high death rates and significant public health impact, requiring special preparedness.

Category B: These agents are of moderate priority as they are moderately easy to spread, resulting in moderate illness rates and low death rates, necessitating enhanced disease monitoring.

Category C: Emerging pathogens with the potential for mass spread in the future are included in this category. They are easier to acquire, produce, and disseminate, posing potential for high morbidity and mortality rates and significant health impact.

Antimicrobial Resistance: One health

Antimicrobial resistance poses a significant global health challenge (WHO 2014), making it increasingly difficult to treat various infections. The overuse of antimicrobials in multiple sectors - human, animal, and agriculture - has led to widespread resistance. Microorganisms under selection pressure enhance their fitness by acquiring and expressing resistance genes, which are then shared with other bacteria, contributing to the spread of resistance. Approximately 29% of emerging zoonotic diseases are caused by pathogens resistant to antimicrobials, including tuberculosis, campylobacteriosis, salmonellosis, *E. coli*, and Staphylococcus aureus infections.

In veterinary medicine, there are differences in antimicrobial use between companion animals and food-producing animals. Companion animals receive individualized treatment for clinical infections, while food animals often receive antimicrobials through feed or water, even when not all animals are infected (O'Neill 2016) [26]. This mass administration, termed "metaphylaxis," contributes to antimicrobial resistance by promoting the selection and spread of resistant bacteria (McEwen and Collignon 2018) [23]. Antimicrobial growth promoters, administered to entire groups of animals over prolonged periods, also contribute to resistance (Sykes 2013) [33]. To improve both human and animal health, excessive antimicrobial use must be curbed.

One Health Approaches used to control and prevent the Zoonotic Diseases.

Utilizing One Health approaches is vital in controlling and preventing zoonotic diseases. Early detection of zoonotic pathogens is key, facilitated by improved laboratory capacity and surveillance at the interface between animals and humans. The launch of the Global Health Security Agenda in 2014 aimed to assist countries in fulfilling their responsibilities under the World Health Organization International Health Regulations (2005), emphasizing the rapid detection, response, and control of infectious disease threats. Three approaches can be tailored to resource availability and the nature of the disease, ensuring effective implementation of preventive measures.

1. Umbrella Approach. (Ethiopia)

The Rabies Prevention and Control Program in Ethiopia, launched in 2015, is a collaborative effort between the Ethiopian Public Health Institute (Pieracci EG *et al.* 2016) [28], Ministry of Livestock and Fisheries, Addis Ababa Urban Agriculture Bureau, and the US Centre for Disease Control and Prevention (CDC). Targeting priority zoonotic diseases, particularly canine rabies, the program operates under an umbrella approach in selected zones across three regions and Addis Ababa, potentially impacting around 10.6 million individuals. Key components include surveillance, mass canine vaccination, modern human rabies vaccines, and educational initiatives. Despite resource constraints, prioritizing funding for vaccines and surveillance is crucial. The program's success is attributed to government engagement, technical consultation, and significant financial investment, with international partners playing a vital role in providing resources and support for implementation (Hampson K *et al.* 2015) [15].

2. Stepwise Approach

The Monkeypox Detection and Prevention Program in the Tshuapa Province of DRC focus on addressing endemic human disease through a comprehensive approach. Initiated by establishing a robust public health laboratory-based surveillance system, the program gradually introduced additional activities, including research and applied public health interventions for both veterinary and human aspects (Reynolds *et al.* 2016) [46]. Questions persist regarding the monkeypox virus, such as the range and nature of human-to-

human transmission, the zoonotic reservoir of the virus, and the ecological determinants of disease incidence. To address these concerns, the CDC partnered with the Kinshasa School of Public Health and the DRC Ministry of Health in 2010 to strengthen laboratory-based surveillance in the Tshuapa Province. The program provided necessary specimen collection kits, data collection tools, and training sessions for local animal and human health workers, emphasizing a One Health approach (Bass *et al.* 2013) [4]. By enhancing and reinforcing the surveillance system, the program has established a foundation for additional research activities. Partnerships with the University of Kinshasa have been instrumental in designing studies, conducting fieldwork, and training young scientists in the DRC. Epidemiological research and response activities have focused on assessing human-to-human transmission and zoonotic risk factors, with partnerships extending to educational entities for community-based disease prevention efforts. These collaborative efforts, among various intersectoral partners, have significantly bolstered the capacity to detect and respond to monkeypox disease in the region.

3. Pathogen Discovery

Upon detection of an emerging zoonotic pathogen, scientists engage in epidemiological, ecological, and pathological studies, drawing from knowledge of related organisms. Research and surveillance commence concurrently, with in-country partners learning techniques for sample collection, processing, and diagnostics. In Georgia, a joint program involving government agencies implemented a One Health approach following the discovery of the Akhmeta virus in 2013 (Vora *et al.* 2015) [37]. Collaborating with the CDC, the National Centre for Disease Control and Public Health (NCDC), and the National Food Agency, efforts focused on studying the virus's epidemiology and characteristics while enhancing laboratory capacity for detection in humans and animals. The initiative also included ecological research to explore the virus's distribution and dynamics in potential small mammal reservoirs.

One Health approach to cost-effective rabies control in India

Rabies is a significant zoonotic disease in India, causing over 20,000 deaths annually, accounting for one-third of global fatalities. Implementing a One Health approach is crucial for controlling this endemic disease. While provisions for One Health in rabies control have been limited nationwide, Tamil Nadu stands out as the first state to adopt such an approach. Pioneering a "One Health" committee, Tamil Nadu focuses on post-exposure vaccination for humans following dog bites, along with canine vaccination and sterilization efforts. This comprehensive strategy has proven to be cost-effective, particularly emphasizing vaccination of stray dogs. Vaccinating approximately 7% of stray dogs resulted in a 70% reduction in human rabies deaths within five years, and with 13% coverage, human rabies decreased by nearly 90% (Fitzpatrick *et al.*, 2016) [13].

One-Health approach: A best possible way to control Rabies in Bhutan

In Bhutan, despite being a small country with a population of approximately 800,000, significant efforts have been made towards rabies elimination through the adoption of a One Health approach. While the disease remains endemic in Southern Bhutan near the Indian border, the government's commitment to a comprehensive "One Health" strategy has been instrumental. From 2006 to 2016, only 17 deaths were reported from rabies. Key strategies contributing to Bhutan's success include providing free rabies vaccines and immunoglobulins, extensive surveillance for rabies and bite exposures; ongoing mass dog vaccination programs integrated into dog population management efforts, and targeted research initiatives (Lavan *et al.*, 2017) [19].

One health in Avian Influenza

The emergence of new influenza viruses like A/H5N1 and A/H7N7 from birds has underscored the importance of the One Health Concept, particularly evident during the 2009 H1N1 pandemic. Terms like 'bird flu' and 'swine flu' have become commonplace, highlighting the need to understand the interplay between human and animal health. Influenza viruses, naturally present in migratory water birds, can spill over into human and animal populations, leading to pandemics. These viruses, belonging to the Orthomyxoviridae family, possess important antigenic features such as haemagglutinin (H) and neuraminidase (N), crucial for attachment to target cells and virion maturation (Pfeiffer *et al.* 2013) [27].

To address this threat, One Health actions are essential, including enhanced surveillance of clinical human and veterinary diseases, combined clinical and laboratory surveillance, and coordination of local, regional, national, and international surveillance programs. Rapid dissemination of surveillance data, understanding transmission patterns, and comprehending disease pathogenesis in animals and humans are also key components of One Health strategies (Munyua *et al.*, 2019) [24].

One Health Status in India

In India, while the One Health concept may not be widely known, several initiatives have been undertaken by various organizations to implement a One Health approach in addressing diseases at the Human-Animal-Environment interface. Notably, in 2007, the National Standing Committee on Zoonoses was established to control the emergence of zoonotic diseases. Additionally, the Food Safety and Standards Act regulate food safety issues, including foodborne zoonoses.

The Indian government has also launched control programs targeting zoonotic and highly communicable diseases such as rabies, brucellosis, and foot-and-mouth disease. The Centre of Zoonosis at the National Centre for Disease Control has published a manual for handling zoonotic diseases, and there are ongoing pilot initiatives for the development of a protocol for a Database of Zoonotic Disease Research in India. Furthermore, an OH hub has been established in India to facilitate intersectoral activities involving both human and animal health sectors (Aggarwal and Ramachandran, 2020) [1].

Role of Veterinarian

As discussed previously, the One Health approach plays a vital role in bridging the gap between human, animal, and environmental health systems, highlighting the importance of preventing and controlling diseases at the animal level.

Veterinarians are integral to this process, leveraging their expertise in comparative and population medicine to lead initiatives in One Health. Sherman (2010) [31] emphasizes that veterinarians, with their formal training and understanding of the interconnectedness between different species, are well-equipped to champion the One Health concept. They play a pivotal role in disease surveillance, implementing prevention and control strategies at every stage of meat production - from farm to plate - to ensure the health and welfare of animals. Furthermore, veterinarians are instrumental in administering treatments such as antibiotics and vaccines to animals, thereby not only safeguarding animal health but also indirectly mitigating risks to human health, as in the case of rabies prevention. Their multifaceted contributions underscore the critical role veterinarians play in promoting the health of both animals and humans within the framework of One Health.

Challenges

Despite years of discussion, several challenges hinder the effective implementation of One Health preparedness strategies. Successful One Health networks rely on coordinated, interdisciplinary partnerships that transcend sectoral interests, yet limited uptake persists due to professional segregation, data separation, and bureaucratic obstacles. While One Health aims to integrate diverse disciplines for better anticipation and response to health issues, funding shortages, policy gaps, and inadequate training (Barrett *et al.* 2011) [3] impede its implementation (Lebov *et al.* 2017) [20]. Key barriers include the absence of well-defined surveillance systems (Willingham *et al.* 2016) [38], insufficient collaboration among sectors (Schurer *et al.* 2016) [30] and a lack of evaluation metrics (Baum *et al.* 2017) [5]. To overcome these challenges, close collaboration at all levels, robust health surveillance, prioritization of zoonotic diseases, early detection, and comprehensive disease surveillance are essential. By addressing these issues, One Health can effectively prevent and control infectious diseases across animal and human populations.

Future Directions in One Health

Moving forward, the future of One Health hinges on several key thrust areas. Firstly, there is a pressing need to raise public awareness about the interconnectedness of human, animal, and environmental health, fostering support for collaborative endeavours across disciplines. Additionally, embracing One Health as a platform for interdisciplinary research collaboration can drive innovative solutions to complex health challenges. Strengthening disease reporting and surveillance systems is crucial for early detection and response to health threats spanning the human-animal-environment interface. Investment in improved laboratory facilities will enable rapid and accurate diagnosis of zoonotic diseases, facilitating effective disease control measures. Furthermore, engaging policymakers to prioritize One Health approaches and align regulations with prevention and control guidelines is paramount. By focusing on these initiatives, the One Health community can forge ahead in safeguarding public health, protecting animal welfare, and preserving environmental integrity for generations to come.

References

1. Aggarwal D, Ramachandran A. One health approach to address zoonotic diseases. Indian Journal of Community Medicine: Official Publication of Indian Association of Preventive & Social Medicine. 2020;45(Suppl 1):S6.
2. Atlas RM. One Health: its origins and future. In: One Health: the human-animal-environment interfaces in emerging infectious diseases; c2012. p. 1-13.
3. Barrett MA, Bouley TA, Stoertz AH, Stoertz RW. Integrating a One Health approach in education to address global health and sustainability challenges. Frontiers in Ecology and the Environment. 2011;9(4):239-245.
4. Bass J, Tack DM, McCollum AM, Kabamba J, Pakuta E, Malekani J, *et al.* Enhancing health care worker ability to detect and care for patients with monkeypox in the Democratic Republic of the Congo. International health. 2013;5(4):237-243.
5. Baum SE, Machalaba C, Daszak P, Salerno RH, Karesh WB. Evaluating one health: Are we demonstrating effectiveness?. One Health. 2017;3:5-10.
6. Bender JB, Shulman SA. Animals in Public Contact subcommittee of the National Association of State Public Health Veterinarians. Reports of zoonotic disease outbreaks associated with animal exhibits and availability of recommendations for preventing zoonotic disease transmission from animals to people in such settings. Journal of the American Veterinary Medical Association. 2004;224(7):1105-1109.
7. Saravanabavan V, Abeesh P. Environmental health status of fishermen in Mahe district. Int. J Geogr Geol. Environ. 2020;2(2):95-102.
8. Centers for Disease Control and Prevention. Multistate outbreak of monkeypox-Illinois, Indiana, Kansas, Missouri, Ohio, and Wisconsin. Morb. Mortal. Wkly. Rep. 2003;52:642-646.
9. Daszak P, Tabor GM, Kilpatrick AM, Epstein JO, Plowright R. Conservation medicine and a new agenda for emerging diseases. Annals of the New York Academy of Sciences. 2004;1026(1):1-11.
10. Dhama K, Chakraborty S, Kapoor S, Tiwari R, Kumar A, Deb R, *et al.* One world, one health-veterinary perspectives. Adv Anim Vet Sci. 2013;1(1):5-13.
11. Dhama K, Chakraborty S, Wani MY, Verma AK, Deb R, Tiwari R, *et al.* Novel and emerging therapies safeguarding health of humans and their companion animals: a review. Pakistan journal of biological sciences: PJBS. 2013;16(3):101-111.
12. Dhama K, Verma AK, Rajagunalan S, Deb R, Karthik K, Kapoor S, *et al.* Swine flu is back again: A review. Pakistan journal of biological sciences: PJBS. 2012;15(21):1001-1009.
13. Fitzpatrick MC, Shah HA, Pandey A, Bilinski AM, Kakkar M, Clark AD, *et al.* One Health approach to cost-effective rabies control in India. Proceedings of the National Academy of Sciences. 2016;113(51):14574-14581.
14. Foreign Agriculture Service. Trade Data. U.S. Department of Agriculture; c2003.
15. Hampson K, Coudeville L, Lembo T, Sambo M, Kieffer A, Attlan M, *et al.* Estimating the global burden of endemic canine rabies. PLoS Negl Trop Dis. 2015;9(4):e0003709.

16. John TJ, Dandona L, Sharma VP, Kakkar M. Continuing challenge of infectious diseases in India. The Lancet. 2011;377(9761):252-269.
17. Kahn LH, Kaplan B, Steele JH. Confronting zoonoses through closer collaboration between medicine and veterinary medicine (as 'one medicine'). Veterinaria Italiana. 2007;43(1):5-19.
18. Karesh WB, Cook RA, Bennett EL, Newcomb J. Wildlife trade and global disease emergence. Emerging infectious diseases. 2005;11(7):1000.
19. Lavan RP, King AIM, Sutton DJ, Tunceli K. Rationale and support for a One Health program for canine vaccination as the most cost-effective means of controlling zoonotic rabies in endemic settings. Vaccine. 2017;35(13):1668-1674.
20. Lebov J, Grieger K, Womack D, Zaccaro D, Whitehead N, Kowalcyk B, *et al.* A framework for One Health research. One Health. 2017;3:44-50.
21. Lederberg J. Medical science, infectious disease, and the unity of humankind. JAMA. 1988;260(5):684-685.
22. Mackenzie JS, Jeggo M. The One Health approach - Why is it so important?
23. McEwen SA, Collignon PJ. Antimicrobial resistance: A one health perspective. Antimicrobial resistance in bacteria from livestock and companion animals. 2018:521-547.
24. Munyua PM, Njenga MK, Osoro EM, Onyango CO, Bitek AO, Mwatondo A, *et al.* Successes and challenges of the One Health approach in Kenya over the last decade. BMC public health. 2019;19(3):465.
25. National Research Council. Animal health at the crossroads: preventing, detecting, and diagnosing animal diseases. National Academies Press; c2005.
26. O'Neill J. Tackling drug-resistant infections globally: final report and recommendations; c2016.
27. Pfeiffer DU, Otte MJ, Roland-Holst D, Zilberman D. A one health perspective on HPAI H5N1 in the Greater Mekong sub-region. Comparative Immunology, Microbiology and Infectious Diseases. 2013;36(3):309-319.
28. Pieracci EG, Hall AJ, Gharpure R, Haile A, Walelign E, Deressa A, *et al.* Prioritizing zoonotic diseases in Ethiopia using a one health approach. One Health. 2016;2:131-135.
29. Reynolds MG, Carroll DS, Karem KL. Factors affecting the likelihood of monkeypox's emergence and spread in the post-smallpox era. Current Opinion in Virology. 2012;2(3):335-343.
30. Schurer JM, Mosites E, Li C, Meschke S, Rabinowitz P. Community-based surveillance of zoonotic parasites in a 'One Health'world: A systematic review. One Health. 2016;2:166-174.
31. Sherman DM. A global veterinary medical perspective on the concept of One Health: Focus on livestock. ILAR journal. 2010;51(3):281-287.
32. Statistics Division, United Nations. Online Statistical Database; c2003.
33. Sykes JE, Giguère S, Prescott JF, Dowling PM. Antimicrobial drug use in dogs and cats. Antimicrobial Therapy in Veterinary Medicine; c2013. p. 5.
34. Taylor LH, Latham SM, Woolhouse ME. Risk factors for human disease emergence. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. 2001;356(1411):983-989.
35. Tiwari R, Dhama K. Avian/bird flu: an update. Poult Fortune. 2012;14:36-42.
36. Varma MGR. Kyasanur Forest disease. In: Service MW, editor. The encyclopedia of arthropod-transmitted infections. New York: CABI Publishing; c2001. p. 254-60.
37. Vora NM, Li Y, Geleishvili M, Emerson GL, Khmaladze E, Maghlakelidze G, *et al.* Human infection with a zoonotic *orthopoxvirus* in the country of Georgia. New England Journal of Medicine. 2015;372(13):1223-1230.
38. Willingham AL, Cruz-Martinez L, Scorpio DG, Gallagher CA. Global solutions to regional challenges: bridging the one health divide in the Caribbean. One Health. 2016;2:8-10.
39. Wilson PR. Advances in health and welfare of farmed deer in New Zealand. New Zealand veterinary journal. 2002;50(sup3):105-109.
40. Wolfe ND, Daszak P, Kilpatrick AM, Burke DS. Bushmeat hunting, deforestation, and prediction of zoonotic disease. Emerging infectious diseases. 2005;11(12):1822.
41. World Health Organization. Data and statistics: Causes of death. Geneva: World Health Organization. Available: http://www.who.int/research/en/.
42. World Health Organization. Antimicrobial resistance global report on surveillance: 2014 summary (No. WHO/HSE/PED/AIP/2014.2). World Health Organization; c2014.
43. World Health Organization. International Health Regulations; c2005). 3rd ed. [cited 2017 Oct 19]. http://apps.who.int/iris/ bitstream/10665/246107/1/9789241580496-eng.pdf.
44. Yadav MP, Singh RK, Malik YS. Emerging and transboundary animal viral diseases: Perspectives and preparedness. In: Emerging and Transboundary Animal Viruses. Springer, Singapore; c2020. p. 1-25.
45. Kim D, Lee JY, Yang JS, Kim JW, Kim VN, Chang H, *et al*. The architecture of SARS-CoV-2 transcriptome. Cell. 2020 May 14;181(4):914-21.
46. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, et al. Global disparities of hypertension prevalence and control: A systematic analysis of population-based studies from 90 countries. Circulation. 2016 Aug 9;134(6):441-450.
47. Block SM. The Growing Threat of Biological Weapons: The terrorist threat is very real, and it's about to get worse. Scientists should concern themselves before it's too late. American Scientist. 2001;89(1):28-37.