MITIGATING ZOONOTIC THREATS THROUGH ONE HEALTH: INTEGRATING HUMAN, ANIMAL, AND ENVIRONMENTAL HEALTH

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ABSTRACT

Zoonotic diseases pose a significant global health challenge, especially in underdeveloped nations where health care systems are already overburdened. Approximately 1,400 infectious diseases affecting humans, an estimated 60% are of animal origin. Moreover, 75% of emerging infectious diseases worldwide are zoonotic in nature. Addressing this growing threat requires a comprehensive and interdisciplinary approach. The "One Health" concept provides an effective framework for the prevention and control of zoonoses by fostering collaboration among professionals across human, animal, and environmental health sectors. This includes physicians, veterinarians, wildlife experts, public health officials, environmental scientists, nurses, dentists, osteopaths, physicists, biomedical engineers, plant pathologists, biochemists, and other related disciplines. Through integrated efforts, the One Health approach enhances surveillance, strengthens response mechanisms, and supports sustainable public health outcomes.

HUMAN–ANIMAL INTERACTION: AN ANCIENT BOND WITH MODERN CHALLENGES

The interaction between humans and animals is not a recent phenomenon. It dates back to the Vedic era and even earlier. This deep-rooted connection has been an essential part of human survival, culture, agriculture, and spirituality. From domestication to mutual dependence for food, labour, and companionship, animals have been integrated into almost every aspect of human life. It would not be an exaggeration to say that humans and animals may not survive without one another.

However, as this relationship evolved over time, so did its complexity. With the advancement of civilization and changes in lifestyle, agriculture, and animal husbandry, the frequency and nature of human–animal interactions have increased significantly. While this has brought numerous benefits, it has also given rise to new challenges most notably, the emergence and transmission of diseases between animals and humans.

Throughout history, and particularly in recent times, we have seen how zoonotic diseases those that can be transmitted from animals to humans and vice versa—have become a major public health concern. Evolution has not only strengthened our interdependence with animals but has also facilitated the bidirectional flow of pathogens, making both species vulnerable.

This reality emphasizes the need for awareness, responsibility, and a coordinated response guided by the One Health approach to manage the shared health risks emerging from our close and continuous bond with animals. But before we move further, it is important to first ask: What is zoonosis?

INTRODUCTION: UNDERSTANDING ZOONOTIC THREATS

Zoonoses are infectious diseases that are naturally transmitted from wild or free-living animals to humans by direct contact, inhalation, ingestion, or inoculation of infectious material. That approximately 75% of new emerging human infectious diseases are defined as zoonotic, meaning that they may be naturally transmitted from vertebrate animals to humans. Researchers including Louis Pasteur and Robert Koch and physicians such as William Osler and Rudolph Virchow demonstrated the collaborative links between animal and human health. By definition, zoonoses harm domestic animals and may threaten wildlife.

Zoonoses is a great public health concern and a direct human health hazard that may even lead to death. Across the globe, the 13 most common zoonoses were most impactful on poor livestock workers in low and middle-income countries and have caused an estimated 2.4 billion cases of illness and 2.7 million deaths in humans per year in addition to their negative effect on human health. Most of these diseases affect animal health and decrease livestock production. The zoonotic diseases include viral (rabies, yellow fever, influenza, Kyasanur forest disease, etc.), bacterial (anthrax, brucellosis, plague, leptospirosis, salmonellosis, etc.), rickettsial (tick typhus, scrub typhus, murine typhus, etc.), protozoal (toxoplasmosis, leishmaniasis, trypanosomiasis, etc.), helminths (hydatid disease, taeniasis, schistosomiasis, leishmaniasis, etc.), fungal (histoplasmosis, cryptococcus, etc.), and ectoparasites (scabies, myasis, etc).

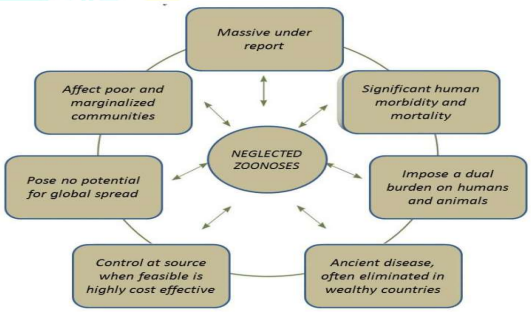
WHY ZOONOTIC DISEASES A GLOBAL CONCERN TODAY?

Around 6 in 10 human infections are zoonotic. The best known zoonoses, before the 20th century were glanders, rabies, anthrax, plague, tuberculosis, influenza, yellow fever, and certain zoonotic parasitic diseases. Sixty percent of three hundred infectious agents reported between 1940 and 2004 were listed as zoonoses, and the majority. Meanwhile, the global rise in zoonotic diseases in 1990–2000 was 22% and in 2000–2010was 21%. In most developing countries, the zoonotic diseases surveillance between human medicine and veterinary medicine is not known in the One Health context. In addition, many countries lack the capacity for diagnosis and the health system. Zoonotic diseases also incur financial costs, including those caused by losses to humans, animals, and the environment**.** Many zoonotic diseases are endemic in the developing world, which negatively impacts the health conditions and livelihoods of poor people. When we talk about the types of zoonotic diseases, there are many. However, in recent times, the focus has shifted toward *emerging* and *re-emerging* zoonoses, which are becoming a major concern. But what exactly are emerging and re-emerging zoonotic diseases? Emerging zoonosis is a zoonosis that is newly recognized, newly evolved, or has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range. At least 250 zoonoses were listed as emerging and re-emerging zoonotic diseases during the last 70 years. Among 175 reported emerging diseases, 132 diseases are considered to be emerging zoonotic diseases.

Examples of major emerging zoonoses include avian influenza, bovine spongiform encephalopathy (BSE), feline cowpox, rotavirus infection, norovirus infection, Ebola, hantavirus infection, West Nile fever, canine leptospirosis, MRSA infection, cat scratch disease, severe fever with thrombocytopenia syndrome (SFTS), Middle East respiratory syndrome (MERS), severe acute respiratory syndrome (SARS), and the most recent coronavirus disease 2019, (COVID-19). On the other hand, rabies, brucellosis, Japanese encephalitis, tuberculosis (*M. bovis*) and *Schistosoma japonica* infection are considered to be re-emerging zoonoses in many parts of the world.

NEGLECTED ZOONOSES

Neglected zoonoses is a relatively new and important term that has gained attention in recent years. Neglected zoonoses are often under-reported due to their endemic nature and receive less attention and funding compared to emerging diseases. As a result, they are termed "neglected." Many developed countries have successfully controlled or eliminated these diseases.



BASIC FEATURES OF NEGLECTED ZOONOTIC DISEASES

Mainly, tropical countries are more vulnerable for neglected diseases, which is why these diseases have been sometimes known as neglected tropical diseases. Since the neglected zoonotic diseases have lower priority in the health systems in many countries, they have silently triggered significant morbidity among rural people. Now question arises in terms of India?

ZOONOTIC DISEASE BURDEN IN INDIA

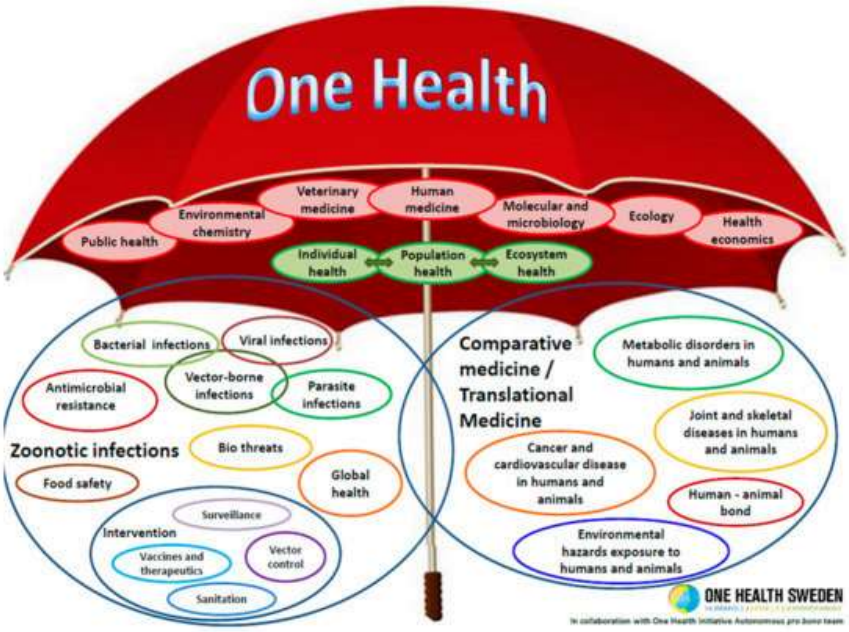
Zoonotic diseases are on the rise globally, including in India. Out of the 1,407 known human

pathogens, 816 (approximately 58%) are zoonotic, meaning they can be naturally transmitted between animals and humans. These pathogens comprise 538 bacteria and rickettsia, 317 fungi, 208 viruses, 287 helminths, and 57 protozoa. Notably, 177 pathogens (13% of the total) are categorized as emerging or re-emerging, with 130 of them (75%) identified as zoonotic in nature. In the Indian context, a study by the International Livestock Research Institute reported that 13 major zoonotic diseases are responsible for approximately 2.4 billion human illness cases and 2.2 million deaths annually.

In India, the major public health zoonotic diseases are rabies, brucellosis, toxoplasmosis, cysticercosis, echinococcosis, Japanese Encephalitis (JE), plague, leptospirosis, Scrub typhus, Nipah, trypanosomiasis, Kyasanur forest disease (KFD), and Crimean-Congo haemorrhagic fever. In this context, the One Health approach emerges as one of the most effective solutions. But before we explore how it can help, let's take a step back and ask what exactly is the One Health approach, and why is it so important today?

THE ONE HEALTH APPROACH, WHY IS IT SO IMPORTANT?

With increasing the number of novel emerging zoonotic diseases, that are mostly originating from animals, in the 20th and 21st centuries, there are major challenges to face those infectious diseases. One health is a concept that was officially adopted by international organizations and scholarly bodies in 1984. It is the notion of combining human, animal, and environmental components to address global health challenges that have an ecological interconnectedness. The One Health concept is not recent and can be traced back 200 years or more. One health is defined by the One Health Commission as the collaborative effort of multiple disciplines to obtain optimal health for people, animals, and our environment. One Health concept is the cooperation between various sectors including animal, human, and environmental health. Several zoonotic agents need a One Health strategy for their successful surveillance, detection, and control. One Health" (OH) approach to mitigation of zoonoses has been presented as a framework which includes the creation of one health surveillance and response programs for future emerging diseases.



The One Health Umbrella, developed by One Health Sweden and the One Health Initiative Autonomous pro bono team.
(Mackenzie, J. S., & Jeggo, M, 2019)

WHY IMPORTANT TO UNITE UNDER ONE HEALTH NOW?

One Health ex-tends the scope of comparative medicine to animal and environmental surveillance for early diagnosis and

a better knowing of threats to mitigate risk and impacts. Building an integrated surveillance system to include human, animal and environment can elucidate pathogen transmission mechanisms providing more comprehensive approaches to prevent the pathogen spread at the source. Plague, Nipah virus outbreaks, Ebola hemorrhagic fever, Zikavirus, and Corona virus (COVID-19). The recent COVID-19 outbreak in China is the sixth global health emergency in the past decade which killed around 3500 people and more than100,000 people affected so far. The highest zoonotic diseases burden with wide spread diseases burden are in Ethiopia, Nigeria, Tanzania, and India. It is noteworthy that the global economy was severely impacted by the SARS outbreak, which impacted multiple sectors including the tourism sector. The economic impact of SARS in Singapore, China, Hong Kong, and Taiwan was severe. Likewise, India faced economic losses due to the restriction of tourism that resulted from the plague outbreak in 1994. Plague which has killed 12 million Indians keeps resurfacing regularly in different parts of India. About 1.8 million receive anti-rabies vaccine, and 20,000 die of rabies every year. Brucellosis is another economically-important zoonoses. Brucellosis in cattle resulted in annual economic losses in Kenya, Argentina, and Nigeria. Brucellosis alone has contributed to loss of 30-million man days and economic loss of Rs. 24 crores a year. It is estimated that millions of people will face extreme poverty due to the stalled growth resulting from these pandemics. Recent pandemics have highlighted the need for surveillance systems for zoonotic events, and the need for better communication across the human-animal-ecosystems continuum. Because human, animal, and ecosystem health are intimately related, surveillance should be organized in an integrated way. The WHO claims to engage in cross-sectorial activities to address health threats at the human-animal ecosystem interface effectively.

The One Health approach plays a crucial role in the prevention and control of zoonotic diseases by promoting coordinated action across human, animal, and environmental health sectors. Key recommendations under this approach include: (1) establishing a dedicated "Zoonotic Disease Unit" to strengthen collaboration between human and animal health agencies; (2) formulating a national strategy to guide the operations of the Zoonotic Disease Unit; (3) fostering leadership and engagement among multi-sectoral researchers and stakeholders to prioritize zoonotic disease research; (4) implementing veterinary public health policies in collaboration with international partners; and (5) conducting regular reviews (every 2–5 years) of zoonotic diseases to address emerging and re-emerging threats through sustained surveillance, epidemiological interventions, and laboratory diagnostics. In brief, the one health concept plays a significant role to address emerging and re-emerging zoonoses; to control the effect of zoonotic diseases among humans, animals, and environmental components; and to make the world free from threats of zoonotic diseases. In recent years, a new term has emerged in the scientific and medical communities one medicine concept.

A NEW DIMENSION-WHAT IS THE ONE MEDICINE CONCEPT?

The concept of One Health is not new and can be traced back for at least two hundred years, firstly as One Medicine, but then as One World, One Health and eventually One Health. There is no single, internationally agreed upon definition of One Health, although several have been suggested.

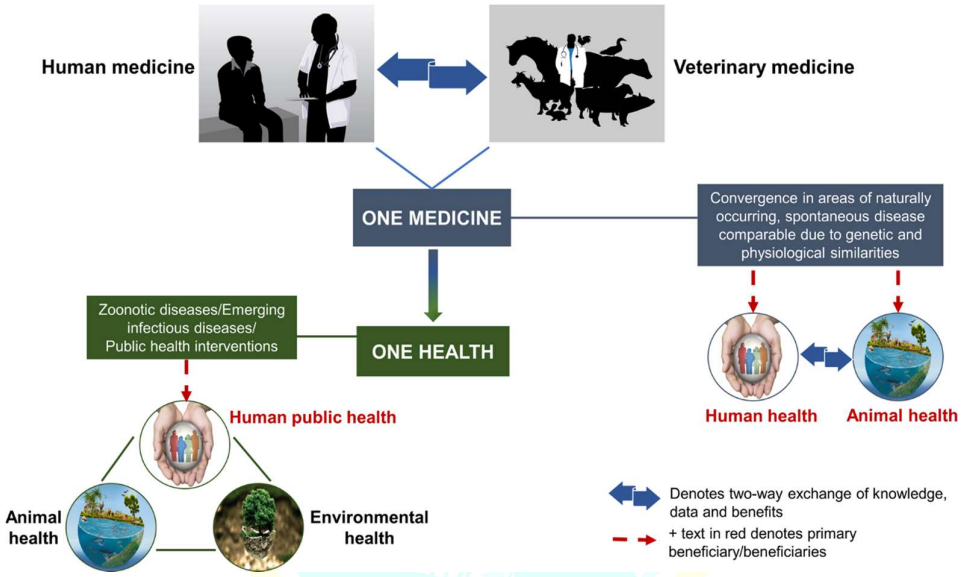
One Medicine has been thought to be self-explanatory, or synonymous to 'One Health', the two terms are distinct from each other. Currently, there is no universal standard definition for either One Health or One Medicine. One Medicine concept as being to promote collaboration between the medical and veterinary disciplines to benefit both human and animal health via parallel studies of naturally occurring spontaneous disease, comparable to each other due to genetic and physiological similarities.

One Medicine is the concept that human and veterinary medicine are interlinked and interdependent upon each other. By routinely collaborating with each other, this would afford equitable progress for both animal and human health.

CONTROLLING ZOONOTIC DISEASES: A MULTISECTORAL APPROACH

Surveillance plays a vital role in the prevention and control of zoonotic diseases. Concerted and multidisciplinary approaches are required for the control of emerging and re-emerging zoonoses. It enables the early detection of infections in both humans and animals, identification of reservoirs, vectors, and mapping of endemic regions and disease hotspots. Effective surveillance systems inform the development and

implementation of targeted control strategies, helping to manage outbreaks, reduce transmission, and ultimately minimize the morbidity and mortality associated with zoonoses in both human and animal populations. such as SARS and Highly Pathogenic Avian Influenza (HPAI) can rapidly spread across international borders, there is a critical need for coordinated surveillance efforts at local, regional, national, and global levels. To ensure comprehensive disease monitoring, surveillance must extend to all potential sources of zoonotic infections, including exotic species, pets and companion animals, wildlife, aquatic animals, and rodents. Such an integrated approach strengthens early warning systems and supports timely, effective responses to both emerging and re-emerging zoonotic threats.



Effective control and prevention of zoonotic diseases require not only a collaborative, interdisciplinary approach but also significant financial investment something that remains a major challenge for developing countries. To bridge this gap, it is imperative that developed nations and international donor organizations extend their support. Agencies such as the World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organization for Animal Health (OIE), U.S. Agency for International Development (USAID), U.S. Department of Agriculture (USDA), European Union (EU), Department for International Development (DFID), Biotechnology and Biological Sciences Research Council (BBSRC), and the Danish International Development Agency (DANIDA) can play a pivotal role in providing the necessary funding and technical assistance. Strengthening global partnerships and ensuring equitable resource allocation are essential to safeguarding both human and animal health worldwide through the One Health approach.

CONCLUSION

Zoonotic diseases are a shared threat, but with shared action, we can stop them. The One Health approach unites humans, animals, and the environment for a safer, healthier future. Many of the health challenges faced by both humans and animals have no single answer and require a blended approach if we are to ensure that the benefits are shared equitably and progress made in parallel in both animal and human health. Together, we can break the chain of infection before it begins.

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