The Shadow of Zoonosis: Unraveling the Mystery of Zoonotic Infections

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Abstract

Zoonotic illnesses, or infections that are spread from animals to people, are a serious hazard that is examined in this chapter. This chapter offers a thorough summary of the intricate world of zoonoses, examining their causes, motivators and far-reaching effects. We look at the complex network of causes that lead to zoonotic spillovers, such as habitat fragmentation and loss, the frequently uncontrolled wildlife trade, and the exacerbated consequences of climate change. The chapter looks at a number of transmission modes, including foodborne, vector-borne, and direct contact. We emphasize how zoonoses, such as pandemics like COVID-19, have a terrible human cost and produce significant economic disruptions that affect commerce, livelihoods, and world economies In order to successfully prevent and control these new hazards, the chapter highlights the urgent need for a multi-sectoral "One Health" strategy that includes greater intersectoral coordination, early warning systems, and surveillance. In order to protect people and animals, this chapter acts as a plea for Change, imploring scientists, national governments and global institutions to give zoonotic disease mitigation and control top priority.

Keywords: Zoonosis, Spillover, One health, Wildlife trade, Habitat loss, Climate change

Cite this Article as: Chishti AA, Abbas S, Zaman MA, Hussain T, Jafar Z, Iqbal S, Mubeen F and Khaliq A, 2025. The shadow of zoonosis: Unraveling the mystery of zoonotic infections. In: Abbas RZ, Akhtar T and Jamil M (eds), Pathways of Infection: Zoonoses and Environmental Disease Transmission. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 242-249. https://doi.org/10.47278/book.HH/2025.197

A Publication of Unique Scientific Publishers

Chapter No: 25-034

Received: 07-Jan-2025
Revised: 17-Apr-2025
Accepted: 18-May-2025

Introduction

The Shadow of Zoonosis: A Wake-Up Call

The Greek words "zoon," that means animal, and "noses," which indicates sickness, is a root of the phrase "zoonoses." Zoonosis is defined by the World Health Organization (WHO) as any illness or sepsis that may spread on natural basis from chordate animals to people or from humans to animals. Estimated to be 61% of human pathogens are zoonotic. Zoonoses are a serious society health issue and a direct risk to human biological condition that can potentially be fatal. Furthermore the detrimental effects on human health, the 13 most prevalent zoonoses worldwide have been especially detrimental to low- and middle-income nations' impoverished livestock workers, resulting in an evaluated nearly 2.5 billion instances of disease and 2.7 million annual mortality rate of humans (Rahman et al., 2020). WHO estimates that 600 million instances of food-borne illnesses, including about 350 million from pathogenic bacteria, were reported in 2010 (Chlebicz & Slizewska, 2018). Recent very virulent viruses that posed a threat of pandemic and high mortality have brought attention to the importance of zoonoses to human health. These events include the West African Ebola outbreak from 2013 to 2016, the 2009 "Swine Flu" H1/N1 influenza pandemic, and the 2005 H5/N1 avian influenza outbreak (Cross et al., 2021). Many different types of pathogens can cause zoonotic illnesses.

Zoonoses are categorized according to their causation: viral zoonoses (like AIDS, Ebola, rabies, and avian influenza), bacterial zoonoses (like anthrax, salmonellosis, Lyme disease, plague, brucellosis,and tuberculosis) fungal zoonoses (like ringworm), mycoplasma zoonoses (like *Mycoplasma pneumoniae* infection), chlamydial zoonoses (like psittacosis), protozoal zoonoses and illnesses brought on by pathogenic agents without acellular structure (like mad cow disease and transmissible spongiform encephalopathies) as shown in Table 1. Zoonoses affect both human and animal health in a variety of ways. Zoonoses' impact is difficult to measure; however, it may be evaluated using metrics like economic loss, morbidity, mortality, incidence, and prevalence of the illness. Zoonoses have a major impact on human well-being and livelihood. The impacted people face obstacles that impair their capacity to sustain their families and, consequently, their efficiency at work. These conditions are commonly observed in developing Asian and African nations. There are situations where those who are impacted could remain socially isolated, making them more vulnerable to mental health problems. One worldwide health concern that may have an adverse effect on the administration of bacterial zoonoses is antibiotic resistance. Patients with illnesses brought on by germs that are resistant to treatment require specialized care, costly medications, and are typically a strain on the medical industry, particularly in poor nations (Rahman et al., 2020). We must take into account the following actions for future consideration: implementing the "one-health" approach to improve structured collaboration between the veterinary, medical, agricultural, and ecological domains, establishing a feasible national zoonotic elimination follow-up task force; improving surveillance and fast data exchange on animal-to-human disease threats (including flu) for prompt risk analysis and response, expanding the capacity for quick and efficient assessment of zoonoses and

emerging zoonotic outbreaks with a focus on interorganizational collaborations, using modern tools and new regimens and introducing medications quickly, paying particular attention to private institutions (Awaidy & Al Hashami, 2020).

Table 1: Some Zoonotic Diseases (Viral, Bacteria & Protozoal)

Zoonotic Diseases		References
Bacterial Zoonoses		
1 Brucellosis	Brucella bacteria	
2 Cat Scratch Disease	*Bartonella henselae*	
3 Leptospirosis	Leptospira bacteria	
4 Lyme Disease	*Borrelia burgdorferi*	
5 Plague	*Yersinia pestis*	
6 Salmonellosis	Salmonella bacteria	Rahman et al., 2020
7 Tuberculosis	*Mycobacterium tuberculosis*	
Viral Zoonoses		
1 Avian Influenza	Influenza A virus	
2 Covid-19	SARS-CoV-2	
3 Dengue	Dengue virus	
4 Ebola	Ebola virus	
5 Rabies	Rabies virus	
Protozoal Zoonoses		Rahman et al., 2020
1 Giardiasis	*Giardia intestinalis*	
2 Malaria	Plasmodium spp.	
3 Trematodosis	Tremtode spp.	Rahman et al., 2020
4 Eimeriosis	*Eimeria spp.*	Sarfaraz et al., 2025

1. Fueling the Fire: The Roots of Zoonotic Spillovers

1.1. Habitat Loss: Shattering the Balance of Nature

Deforestation is the deliberate or organic removal of forests on a large scale, which frequently has a negative impact on the ecosystem and the quality of the land. Due to human involvement, 47% of the Earth's expansive forests that has been around for over 8 thousand years has gone extinct. 35,000 square kilometers (km^2), or more than 25% of the earth's surface, are still covered by forest despite the aforementioned regrettable event. Of these, 55% are found in underdeveloped countries, primarily in tropical regions (Bodo et al., 2021). Pakistan's forest cover, which makes up less than 5% of the country's total geographical area, is reportedly fast decreasing, particularly in the country's mountainous regions. According to estimates, the pace of deforestation is 1.5%, which is quite concerning (Faiza et al., 2017). People in cities tend to consume larger quantities of raw or processed forest products, especially when they have more money to spend on other things (Bodo, 2019c). In the across much of the developing world, urban forests are being lost to make way for infrastructure such as the Implementation of projects involving bridges, parks, schools and market places, highways, and industries. In light of this, several experts have noted that environmental improvements are not usually the result of urbanization. Environmentally speaking, one of the causes of deforestation is urbanization (Bodo, 2019a; Bodo, 2019b). Wildlife is at risk from environmental contamination linked to extractive industries, which is thought to be a possible degrading factor for habitat. Fluid releases have an especially negative impact on wildlife (Scanes, 2018). Wildlife is the source of three-quarters of newly developing infectious illnesses, and nearly two-thirds of these are zoonotic (Cunningham et al., 2017). Land conversion and habitat fragmentation are two examples of human changes to the environment that increase the chances of contact with animals and, consequently, the spread of illness (Johnson et al., 2020). The danger of zoonotic disease transmission is increased by all of these consequences of animal habitat loss and fragmentation, which also increase contacts between wildlife and people (Faust et al., 2018; Wilkinson et al., 2018; Borremans et al., 2019; Zohdy et al., 2019; Gibb et al., 2020; Johnson et al., 2020; White & Razgour, 2020). According to Lo Iacono et al. (2016), the worldwide SARS epidemic, the swine influenza the global epidemic, and the Ebola epidemic, the most likely source of the COVID-19 pandemic, were all likely caused by a single spillover event.

1.2. The Wildlife Trade: A Risky Business

Illegal wildlife trafficking occurs daily all around world. Emerging infectious disease (EID) consequences are made possible by the illicit wildlife trade (IWT). Anthropogenic factors, such as the movement of wildlife through legal and illicit commerce, can be linked to emerging infectious disease (EID) occurrences (Rush et al., 2021). Wild animals, birds, and reptiles are caught, sold, transported via trade centers, and delivered to final customers on a daily basis. There are several possible points of engagement during the trade process, such as with handlers, buyers, intermediary marketers, and hunters. More than one billion interactions between wildlife and people or domestic animals from commerce occur annually, according to researchers (Borsky et al., 2020). The kinds of illicit trade activities varied spatially, and hotspots of activity involving particular taxa were not all the same. With a total of fifty bird species, thirty six mammal species, twenty eight reptiles, nine amphibians, and one fish, Brazil, China, and the United States of America got the numerous species susceptible to zoonotic infections. There have been outbreaks of opisthorchiasis, a liver fluke infection that a family The monkey pox virus was brought to the United States by a variety of exotic rodents from Africa, through naturally occurring simian retrovirus illnesses in African poachers from the bush meat exports, and illegally purchased raw fish from an extremely prevalent location that exposed prairie dogs (*Cynomys spp.*) in the pet trade, an outbreak of

chlamydiosis affected 7/15 Belgian officials were shown parakeets that were being trafficked (Alfano et al., 2020) and an incidence of *Salmonella* was documented from fourteen states in the United States of America, affecting twenty six people living in areas where little pet turtles were illegally bought from temporary roadside sellers (CDC, 2019).

1.3. Climate Change: A Perfect Storm for Disease Emergence

The health of humans and animals may be impacted by the complex effects of climate change. For instance, the environment for infections and zoonotic disease vectors is changed by changing in climate. Over the past several years, there has been a rise in zoonoses, which are spread via mosquitoes and other associated vectors. Particularly in less developed nations, the warming of the planet has made it easier for some vectors to proliferate (Bartlow et al., 2019). Once found in hotter tropic regions, zoonotic viruses have been observed all over the planet, distributing to subtropical climes and high-altitude regions. Rising climate change induce temperature changes and the occurrence of diseases in formerly disease-free areas. Additionally, the Zika and dengue viruses, which are currently worldwide dangers, are examples of how climate change is worsening people's general health and facilitating the spread of zoonotic infections (Fouque & Reeder, 2019; Córdoba-Aguilar et al., 2021). Additionally, the quantity of freshwater accessible has decreased due to an increase in flooding and drought in less developed areas, resulting in people drinking water tainted with zoonotic waterborne illnesses such schistosomiasis (Cisse, 2019; De Leo et al., 2020). The roots of zoonotic spillovers is shown in figure 1.

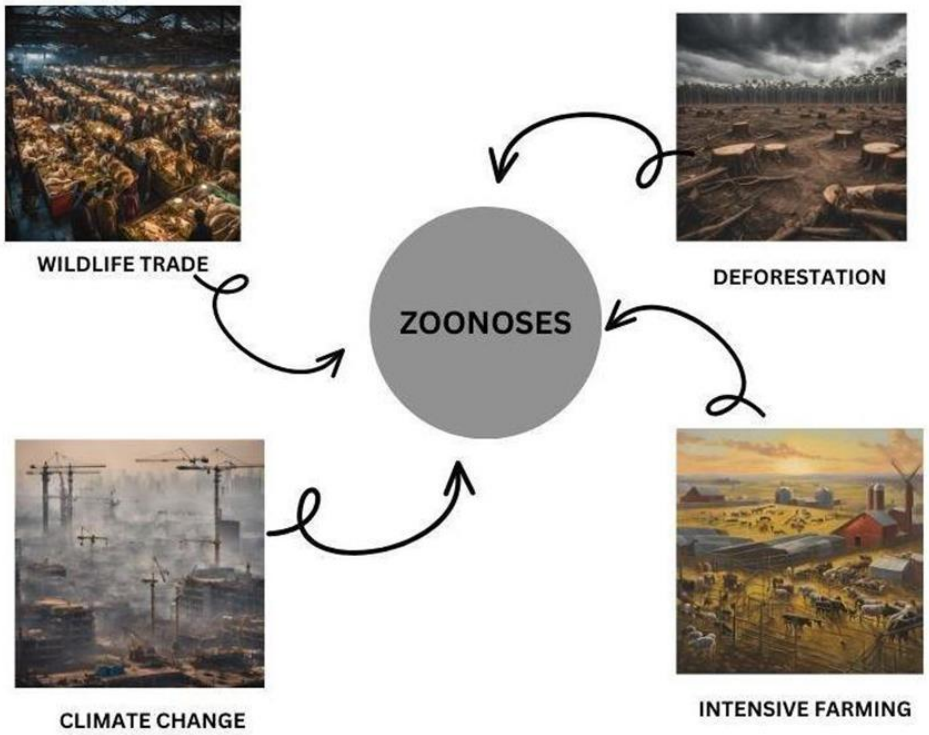

Fig. 1: The Roots of Zoonotic Spillovers

2. Transmission Trails: How Zoonotic Diseases Spread

2.1. Direct Contact: The Unseen Handshake

Direct zoonotic diseases are illnesses which are transmitted from animals to humans directly via media such as air (Mortimer, 2019). The virus that causes avian influenza infects humans via droplets or fomites are a well-known example of a direct zoonotic infection. Similar to rabies, one of the deadliest zoonotic illnesses, vulnerable people may be directly infected by sick animals through bites. It is brought on by a rabies virus that is a member of the Rhabdoviridae family. Through saliva, the virus gets within a person's body directly when a human is bitten by a mad animal (bat, dog, monkey, skunk, raccoon, or fox). Likewise, infections may spread to humans through vectors. Avian influenza, a viral illness that infects people by droplets or fomites, is a classic example of direct zoonoses. As in the case of rabies, one of the most deadly zoonotic illnesses, infected animals can potentially directly transmit infections to vulnerable humans through bites. It is brought on by a rabies virus that is a member of the Rhabdoviridae family. Through saliva, the virus enters the human body directly when a human is bitten by a rabid animal (dog, bat, monkey, skunk, raccoon, or fox). In a similar vein, infections may spread to humans through vectors. Although arthropods, such as ticks and mosquitoes are frequently thought of as the sole vectors, any animal that has the capacity to spread diseases to humans might be regarded as a vector (Huang et al., 2019). Cat scratch illness is one of the major zoonoses linked to pets. *Bartonella henselae* is the disease's causative agent. A frequent infectious condition that is typically benign is cat-scratch disease. The illness is horizontally transmitted from cat to cat. Additionally, cat licking of an individual's open wounds or bites and scrapes that result in wounds are the most common ways that the disease is spread in humans. The sickness might take anything from three to fourteen days to incubate. At the site of infection, a number of lesions, including redness and swelling with elevated, circular regions, as well as pus formation, may manifest. Additionally, the lymph nodes in the neck region or close to the bite or scratched location are typically enlarged (Rahman et al., 2020).

2.2. Vector-Borne Threats: Silent Carriers in Action

Worldwide, vector-borne zoonotic diseases (VBZDs) pose a serious threat to both animal welfare and public health. VBZDs have alarmingly increased in recent years, mostly due to novel or re-emerging bacteria, parasites, and arboviruses (Duzlu et al., 2020). Yellow fever, plague, typhus, malaria, rabies, dengue, and Rocky Mountain spotted fever are among the zoonotic illnesses spread by vectors. It is now known that plague is caused by the zoonotic bacillus *Yersinia pestis*, which is frequently present in rat and other small mammals, possibly the worst illness in history. Usually spreads from animal to human by the bite of an infected fetus, but it can also spread through direct contact with contaminated human or animal tissues or through inhaling respiratory droplets (Shaw, 2024). It is now recognized that an RNA arbovirus belonging to the favivirus genus causes yellow fever, an acute hemorrhagic illness that is spread to people by mosquito bites (WHO, 2019). The only mosquitoes that bite humans or other primates are females, and their blood meal supplies vital nutrients, particularly iron, for the formation of eggs (Shaw, 2024). One of the most destructive diseases in the modern world is still malaria. Due to its long-standing connection with filthy stagnant water and the popular assumption at that point that noxious air (miasmas) was the root of disease, it was given the Roman moniker malaria, which means "bad air." Plasmodium, the protozoa parasite that causes malaria, is spread to humans via the bite of a female Anopheles mosquito carrying the infection (Nosten et al., 2022).

2.3. From Farm to Fork: The Dangers of Foodborne Zoonoses

Food-borne zoonotic illnesses are a group of zoonotic diseases that are transferred by eating tainted food items that come from animals and include various disease-causing organisms. People get food poisoning after consuming tainted food. The most common cause of campylobacteriosis is eating tainted beef, pig, or fowl. It was shown that eating poultry was responsible for over 30% of all infection cases, including 50–80% of isolated strains of *Campylobacter spp.* that came from chickens, 20–30% of cases that came from bovine pathogens, and a small number of pathogenic strains that came from other sources (Hald et al., 2016; Josefsen et al., 2016). All nontyphoid *Salmonella* serotypes (except from *S. typhi* and *S. Paratyphi* A, B, and C) that have been identified from people and animals, including cattle, are responsible for salmonellosis (Kurtz et al., 2017). Water or food contaminated with fecal microbiota might allow pathogens to enter the body. Accordingly, the environment plays a significant role as a vector in the spread of Salmonella species (Kurtz et al., 2017; Andino & Hanning, 2015). Stomach discomfort and diarrhea are common signs of infection with nontyphoid Salmonella spp., although additional symptoms might include cramps, nausea, fever, chills, articular or muscle pain, and appetite loss (Jarvis et al., 2016; Antillon et al., 2017; Hung et al., 2017).

2.4. Waterborne Woes: Contaminated Sources and Hidden Hazards

The most essential element for life's nourishment is water. Water became contaminated as a result of expanding industry, uncontrolled exploitation, and population growth. In both people and animals, water may be a significant source of several infectious and noninfectious illnesses. Water-borne illnesses that are contracted by contaminating the water supply systems with human or animal urine and feces. A large majority of these illnesses are spread via contact with water. Over the past two decades, it has been acknowledged that a large number of illnesses are brought on by newly or re-emerging pathogens, of which 75% are zoonotic. The most prevalent illness in the world is diarrhea with over 4 billion cases reported annually. Both gastrointestinal disorders like diarrhea and other illnesses like hepatitis and leptospirosis are brought on by waterborne microorganisms. Waterborne Nematode Infections: Dracunculus is a significant waterborne nematode illness. It is contracted by ingesting water that contains certain copepods that serve as *Nematoda* vectors. Certain blood fluke members of the *Schistosomatidae* family are another type of aquatic metazoan infections. Usually, they infect anyone whose skin comes into touch with water (Praveen et al., 2016). Spreading of zoonoses is explained in Fig. 2.

3. The Human Cost: A Global Impact

3.1. Pandemics: A Global Health Emergency

Zoonoses provide a direct and potentially lethal threat to human health, making them a significant public health concern. In addition to their detrimental effects on human health, the 13 most prevalent zoonoses worldwide have been especially detrimental to low- and middle-income nations' impoverished livestock workers, resulting in an evaluated nearly 2.5 billion instances of disease and 2.7 million annual mortality rate of humans. The majority of these illnesses has an impact on animal health and reduces productivity of cattle (Rahman et al., 2020). According to estimates, there might be up to 48 million food poisoning cases in the US annually, with up to 2 million cases of salmonellosis and campylobacteriosis alone. Every year, more than 200,000 instances of bacterial zoonoses are reported in the EU, with the actual number likely far higher. The European Centre for Disease Prevention and Control (ECDC) and the European Food Safety Authority (EFSA) reported in 2017 that Salmonella and Campylobacter bacteria were the most frequent causes of food-borne zoonotic illnesses. Approximately 3.1 and 5 million cases of food poisoning occur each year in Canada. The incidence is 5.4 million in Australia (Chlebicz & Slizewska, 2018). With 510,000 new cases of tuberculosis are recorded annually, Pakistan is ranked fifth among nations with a high TB burden (Shah et al., 2017) with 510,000 new TB cases emerging annually (Yasmeen et al., 2022). Dog bites result in 50,000 fatalities and 5 million recorded cases each year (World Health Organization [WHO], 2018). The National Rabies Control Program of Pakistan (NRCP) reports that 54.7% of dogs have bitten people were not rabies-vaccinated, and that many rural regions of Pakistan remain at high risk of contracting the disease (Noureen, 2018). Numerous dengue outbreaks have been documented in various parts of Pakistan; the 2005 epidemic in Karachi, in example, claimed 52 lives and resulted in over 6000 cases. More than 21,000 dengue illnesses and 350 fatalities occurred in Lahore in 2011, and 44,415 individuals were afflicted and 66 died in 2019 (Junaidi, 2019).

3.2. Economic Disruptions: The Hidden Costs of Disease Outbreaks

Zoonotic illnesses endanger human livelihoods, endanger the health and production of animals, and infect and kill consumers. It has been estimated that over the past ten years, zoonotic illnesses have caused over $20 billion in direct costs and over $200 billion in indirect losses

globally (Mekonnen et al., 2021). Due to the expenses of control, treatment, and death, the parasites result in decreased productivity and monetary losses. The average reduction in the production of milk and organ condemnation resulting from overall cow parasite infections was found to be 12.95% and 1.16 L animal−1 day−1, respectively. Additionally, the average calculated pecuniary and percentage losses were 17.94% and US$ 50.67 animal−1 year−1, respectively. The economically significant parasitic illnesses listed below are brought on by certain helminth and protozoan species (Rashid et al., 2019). Infection with the buffalopox virus (BPXV) is now spreading throughout Punjab, Pakistan. It is stated that BPXV owes around $6,455.00 USD in financial losses per year (Usmani et al., 2022).

Fig. 2: Factors Involving in Spreading Zoonoses

4. Charting a Safer Course: Strategies for Prevention and Control

4.1. The One Health Approach: A Multidisciplinary Response

In order to effectively address global health issues, international organizations and investigators have developed a notion known as the "One Health Concept" or "One Health Approach" helps stop and manage zoonotic and other infectious illnesses. This concept promotes cooperation between wildlife biologists, veterinarians, doctors, agricultural workers, ecological researchers, biomedical engineers, epidemiologists, and microbiologists to protect human, animal, and environmental health (Rahman et al., 2020). The prevention and management of zoonoses are closely related to one's health. One health approach to prevent and control zoonotic diseases suggests the following:

i. Creating a "Zoonotic Disease Unit" to improve Humans and animal health organizations.
ii. Establishing a nationwide "Zoonotic Disease Unit" approach.
iii. Enlisting governance from involving multiple sectors researchers and pertinent personnel to prioritize zoonotic disease research.
iv. Adopting veterinary public health regulations in cooperation with foreign partners.
v. Reviewing zoonotic diseases on frequently (2 to 5 years) to combat the new and existing illnesses through laboratory diagnosis, epidemiological implementations, and routine surveillance (Pieracci et al., 2016).

4.2. Early Warning Systems: Detecting Threats Before They Emerge

Continuous, targeted, and interdisciplinary methods are needed to manage newly developing and re-emerging zoonotic diseases. Appropriate strategies to lessen the impact of zoonotic infections include surveillance, laboratory testing, preparation planning, and epidemic response (Kheirallah et al., 2021). Surveillance is crucial for preventing and managing zoonotic diseases. It may be used to identify reservoirs, vectors, endemic areas, including "hotspots," early infection, and affected humans and animals. Both human and animal aspects must be taken into consideration during zoonoses control initiatives. A sufficient amount of safe food must be made accessible to customers in order to control food-borne zoonoses. Risk assessment and food product risk management are two general strategies that might be used to accomplish this for the manufacture of wholesome food. Additional ways to combat zoonoses include laws and regulations related to quarantine and isolation, the establishment of strong and effective mechanisms for reporting outbreaks (notice), farm safety, mass vaccination, testing, being slaughtered, or culling, public awareness, and health education (Rahman et al., 2020).

5. Emerging Threats and Future Challenges: A Call to Action

We must concentrate on the several pandemics that are now developing and linked to zoonoses. Numerous bacterial and fungal infections, some of which are resistant to antibiotics, affect people with COVID-19 and are linked to far poorer outcomes and fatalities. A number of reasons, including the prevalence of tainted antibiotics in some underdeveloped nations, have been linked to this (Ukuhor, 2021). Global investments in wildlife virology is expected to rise in response to the COVID-19 pandemic's urgency, and new monitoring programs will find hundreds of new viruses that might one day endanger human health (Carlson et al., 2021). The ecology and type of the illness determine the obstacles to a successful zoonotics management campaign. Limited effective multisectoral coordination amongst the key stakeholders is the fundamental obstacle to the successful implementation of zoonotic disease management policies, strategies, and plans. Among the crucial measures that we must implement are the following:

(i) Implementing the "one-health" approach to improve coordination and collaboration between the veterinary, human, food, and environmental sectors

(ii) Implementing effective systematic monitoring and securing an effective national zoonotic eradication follow-up task force

(iii) Enhancing surveillance and evidence sharing of emerging zoonoses, such as influenza, at the animal–human interface for quick risk assessment and response (Awaidy & Al Hashami. 2020).

Conclusion

Zoonoses pose a serious and complex risk to the health of both humans and animals, with far-reaching social and economic repercussions. As recent pandemics have shown, the incidence and scope of zoonotic epidemics have alarmingly increased, underscoring the urgent need for a strong, international, and coordinated response. This calls for a fully integrated "One Health" strategy that acknowledges the connections between environmental, animal, and human health. It is critical to fortify surveillance systems in order to facilitate early identification and prompt action. This includes stronger data sharing networks, better diagnostic tools, and increased capability for pathogen discovery. Crucially, lowering spillover hazards requires the promotion of sustainable wildlife management techniques. This entails controlling the trafficking in wildlife, safeguarding important ecosystems, and encouraging peaceful cohabitation of people and animals. Address underlying causes such as destruction of habitat, deforestation, and climate change to prevent zoonotic spillovers. Research and development in diagnosis, treatments, and vaccines must continue. Investments in One Health facilities multidisciplinary cooperation and public awareness can help ensure a secure future.

References

Alfano, F., Fusco, G., Mari, V., Occhiogrosso, L., Miletti, G., Brunetti, R. & Decaro, N. (2020). Circulation of pantropic canine coronavirus in autochthonous and imported dogs, Italy. *Transboundary and Emerging Diseases*, *67*(5), 1991-1999.

Andino, A., & Hanning, I. (2015). *Salmonella enterica*: survival, colonization, and virulence differences among serovars. *The Scientific World Journal*, *2015*(1), 1-16.

Antillon, M., Warren, J. L., Crawford, F. W., Weinberger, D. M., Kürüm, E., Pak, G. D. & Pitzer, V. E. (2017). The burden of typhoid fever in low- and middle-income countries: a meta-regression approach. *PLoS Neglected Tropical Diseases*, *11*(2), 1-21.

Awaidy, S. A., & Al Hashami, H. (2020). Zoonotic diseases in Oman: successes, challenges, and future directions. *Vector-Borne and Zoonotic Diseases*, *20*(1), 1-9.

Bartlow, A. W., Manore, C., Xu, C., Kaufeld, K. A., Del Valle, S., Ziemann, A. & Fair, J. M. (2019). Forecasting zoonotic infectious disease response to climate change: mosquito vectors and a changing environment. *Veterinary Sciences*, *6*(2), 1-20.

Bodo, T. (2019a). Garden city or garbage city: the case of Port Harcourt metropolis, Rivers State, Nigeria. *Asian Journal of Advanced Research and Reports*, *3*(3), 1-11.

Bodo, T. (2019b). Deep issues behind the crisis in the Niger Delta Region: The case of oil exploration in Ogoniland, Rivers State, Nigeria. *Asian Journal of Geographical Research*, *2*(1), 1-12.

Bodo, T. (2019c). Rapid Urbanisation Problems and Coping Strategies of Port Harcourt Metropolis, Rivers State, Nigeria. *Annals of Geographical Studies*, *2*(3), 32-45.

Bodo, T., Gimah, B. G., & Seomoni, K. J. (2021). Deforestation and habitat loss: Human causes, consequences and possible solutions. *Journal of Geographical Research*, *4*(2), 22-30.

Borremans, B., Faust, C., Manlove, K. R., Sokolow, S. H., & Lloyd-Smith, J. O. (2019). Cross-species pathogen spillover across ecosystem boundaries: mechanisms and theory. *Philosophical Transactions of the Royal Society B*, *374*(1782), 1-9.

Borsky, S., Hennighausen, H., Leiter, A., & Williges, K. (2020). CITES and the zoonotic disease content in international wildlife trade. *Environmental and Resource Economics*, *76*, 1001-1017.

Carlson, C. J., Farrell, M. J., Grange, Z., Han, B. A., Mollentze, N., Phelan, A. L., & Webala, P. W. (2021). The future of zoonotic risk prediction. *Philosophical Transactions of the Royal Society B*, *376*(1837), 1-12.

Chlebicz, A., & Slizewska, K. (2018). Campylobacteriosis, salmonellosis, yersiniosis, and listeriosis as zoonotic foodborne diseases: a review. *International Journal of Environmental Research and Public Health*, *15*(5), 1-28.

Cisse, G. (2019). Food-borne and water-borne diseases under climate change in low-and middle-income countries: Further efforts needed for reducing environmental health exposure risks. *Acta Tropica*, *194*, 181-188. https://www.sciencedirect.com/science/article/pii/S0001706X18309525

Córdoba-Aguilar, A., Ibarra-Cerdeña, C. N., Castro-Arellano, I., & Suzan, G. (2021). Tackling zoonoses in a crowded world: Lessons to be learned from the COVID-19 pandemic. *Acta Tropica*, *214*, 1-4. https://doi.org/10.1016/j.actatropica.2020.105780

Cross, A. R., Baldwin, V. M., Roy, S., Essex-Lopresti, A. E., Prior, J. L., & Harmer, N. J. (2019). Zoonoses under our noses. *Microbes and*

Infection, *21*(1), 10-19.
Cunningham, A. A., Daszak, P., & Wood, J. L. (2017). One Health, emerging infectious diseases and wildlife: two decades of progress?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1725), 1-8.
De Leo, G. A., Stensgaard, A. S., Sokolow, S. H., N'Goran, E. K., Chamberlin, A. J., Yang, G. J., & Utzinger, J. (2020). Schistosomiasis and climate change. *Britis Medical Journal*, *371*, 1-8. https://doi.org/10.1136/bmj.m4324
Duzlu, O., Inci, A., Yıldırım, A., Doganay, M., Ozbel, Y., & Aksoy, S. (2020). Vector-borne zoonotic diseases in Turkey: rising threats on public health. *Türkiye Parazitolojii Dergisi*, *44*(3), 168-175.
Faiza, N., Weiguo, J., Aijun, Y., & Wenxing, S. (2017). Giant deforestation leads to drastic eco-environmental devastating effects since 2000; A case study of Pakistan. *JAPS: Journal of Animal & Plant Sciences*, *27*(4), 1366-1376.
Faust, C. L., McCallum, H. I., Bloomfield, L. S., Gottdenker, N. L., Gillespie, T. R., Torney, C. J. & Plowright, R. K. (2018). Pathogen spillover during land conversion. *Ecology Letters*, *21*(4), 471-483.
Fouque, F., & Reeder, J. C. (2019). Impact of past and on-going changes on climate and weather on vector-borne diseases transmission: a look at the evidence. *Infectious Diseases of Poverty*, *8*(03), 1-9.
Gibb, R., Redding, D. W., Chin, K. Q., Donnelly, C. A., Blackburn, T. M., Newbold, T., & Jones, K. E. (2020). Zoonotic host diversity increases in human-dominated ecosystems. *Nature*, *584*(7821), 398-402.
Hald, B., Skov, M. N., Nielsen, E. M., Rahbek, C., Madsen, J. J., Wainø, M., & Madsen, M. (2015). *Campylobacter jejuni* and *Campylobacter coli* in wild birds on Danish livestock farms. *Acta Veterinaria Scandinavica*, *58*(11), 1-10.
Huang, Y. J. S., Higgs, S., & Vanlandingham, D. L. (2019). Arbovirus-mosquito vector-host interactions and the impact on transmission and disease pathogenesis of arboviruses. *Frontiers in Microbiology*, *10*(22), 1-14.
Hung, Y. T., Lay, C. J., Wang, C. L., & Koo, M. (2017). Characteristics of nontyphoidal Salmonella gastroenteritis in Taiwanese children: A 9-year period retrospective medical record review. *Journal of Infection and Public Health*, *10*(5), 518-521.
Jarvis, N. A., O'Bryan, C. A., Dawoud, T. M., Park, S. H., Kwon, Y. M., Crandall, P. G., & Ricke, S. C. (2016). An overview of Salmonella thermal destruction during food processing and preparation. *Food Control*, *68*, 280-290. https://doi.org/10.1016/j.foodcont.2016.04.006
Johnson, C. K., Hitchens, P. L., Pandit, P. S., Rushmore, J., Evans, T. S., Young, C. C., & Doyle, M. M. (2020). Global shifts in mammalian population trends reveal key predictors of virus spillover risk. *Proceedings of the Royal Society B*, *287*(1924), 1-10.
Josefsen, M. H., Bhunia, A. K., Engvall, E. O., Fachmann, M. S., & Hoorfar, J. (2015). Monitoring Campylobacter in the poultry production chain—from culture to genes and beyond. *Journal of Microbiological Methods*, *112*, 118-125. https://doi.org/10.1016/j.mimet.2015.03.007
Junaidi, I. (2019). Dengue outbreak sets new record in Pakistan. *The DAWN, November*, *6*. https://www.dawn.com/news/1515168/dengue-outbreak-sets-new-record-in-pakistan
Kheirallah, K. A., Al-Mistarehi, A. H., Alsawalha, L., Hijazeen, Z., Mahrous, H., Sheikali, S. & Samhouri, D. (2021). Prioritizing zoonotic diseases utilizing the One Health approach: Jordan's experience. *One Health*, *13*, 1-10. https://doi.org/10.1016/j.onehlt.2021.100262
Kurtz, J. R., Goggins, J. A., & McLachlan, J. B. (2017). Salmonella infection: Interplay between the bacteria and host immune system. *Immunology Letters*, *190*, 42-50. https://doi.org/10.1016/j.imlet.2017.07.006
Lo Iacono, G., Cunningham, A. A., Fichet-Calvet, E., Garry, R. F., Grant, D. S., Leach, M. & Wood, J. L. (2016). A unified framework for the infection dynamics of zoonotic spillover and spread. *PLoS Neglected Tropical Diseases*, *10*(9), 1-24.
Mekonnen, S. A., Gezehagn, A., Berju, A., Haile, B., Dejene, H., Nigatu, S. & Jemberu, W. T. (2021). Health and economic burden of foodborne zoonotic diseases in Amhara region, Ethiopia. *PLoS One*, *16*(12), 1-15.
Mortimer, P. P. (2018). Influenza: the centennial of a zoonosis. *Reviews in Medical Virology*, *29*(1), 1-10.
Nosten, F., Richard-Lenoble, D., & Danis, M. (2022). A brief history of malaria. *La Presse Médicale*, *51*(3), 1-5.
Noureen, R. (2018). Knowledge, attitude and practice regarding rabies in rural area of Lahore. *International Journal of Scientific & Engineering Research*, *9*(7). 868-873.
Outbreak of Salmonella Infections Linked to Pet Turtles, October 2019, Salmonella, CDC. Available online: https://www.cdc.gov/salmonella/oranienburg-10-19/index.html (accessed on 10 May 2021).
Pieracci, E. G., Hall, A. J., Gharpure, R., Haile, A., Walelign, E., Deressa, A. & Belay, E. (2016). Prioritizing zoonotic diseases in Ethiopia using a one health approach. *One Health*, *2*, 131-135. https://doi.org/10.1016/j.onehlt.2016.09.001
Praveen, P. K., Ganguly, S., Wakchaure, R., Para, P. A., Mahajan, T., Qadri, K. & Dalai, N. (2016). Water-borne diseases and its effect on domestic animals and human health: A Review. *International Journal of Emerging Technology and Advanced Engineering*, *6*(1), 242-245.
Rahman, M. T., Sobur, M. A., Islam, M. S., Ievy, S., Hossain, M. J., El Zowalaty, M. E. & Ashour, H. M. (2020). Zoonotic diseases: etiology, impact, and control. *Microorganisms*, *8*(9), 1-34.
Rashid, M., Rashid, M. I., Akbar, H., Ahmad, L., Hassan, M. A., Ashraf, K. & Gharbi, M. (2019). A systematic review on modelling approaches for economic losses studies caused by parasites and their associated diseases in cattle. *Parasitology*, *146*(2), 129-141.
Rush, E. R., Dale, E., & Aguirre, A. A. (2021). Illegal wildlife trade and emerging infectious diseases: pervasive impacts to species, ecosystems and human health. *Animals*, *11*(6), 1-20.
Sarfaraz, M. Z., Abbas, S., Zaman, M. A., Parveen, A., Kousar, S., & Zulqarnain, M. (2025). A Step Forward to Revolutionize the Eimeriosis Controlling Strategies in Cattle by Using Traditional Medication. *Experimental Parasitology*, *271*, 108926-108939. https://doi.org/10.1016/j.exppara.2025.108926
Scanes, C. G. (2018a). Animals and human disease: zoonosis, vectors, food-borne diseases, and allergies. In *Animals and human society* (pp. 331-354). Academic Press.
Scanes, C. G. (2018b). Human activity and habitat loss: destruction, fragmentation, and degradation. In *Animals and human society* (pp. 451-482). Academic Press.

Shah, T., Hayat, A., Jadoon, A., Ahmad, S., & Khan, S. B. (2017). Molecular detection of multi drug resistant tuberculosis (mdr-tb) in mdr-tb patients'attendant in north western pakistan: Tuberculosis. *Pakistan Armed Forces Medical Journal*, *67*(6), 982-987.

Shaw, J. A. (2024). Vector-Borne/Zoonotic Diseases. In *Historical Diseases from a Modern Perspective: The American Experience* (pp. 65-100). Cham: Springer Nature Switzerland.

Ukuhor, H. O. (2021). The interrelationships between antimicrobial resistance, COVID-19, past, and future pandemics. *Journal of Infection and Public Health*, *14*(1), 53-60.

Usmani, M. W., Rizvi, F., Khatoon, A., & Mahmood, M. S. (2022). Seroprevalence, associated risk factors and clinico-pathological studies of buffalopox disease in various regions of Punjab province, Pakistan. *Polish Journal of Veterinary Sciences*, *25*(1), 137-147.

White, R. J., & Razgour, O. (2020). Emerging zoonotic diseases originating in mammals: a systematic review of effects of anthropogenic land-use change. *Mammal Review*, *50*(4), 336-352.

WHO. Yellow fever. World Health Organization; 2019. https://www.who.int

Wilkinson, D. A., Marshall, J. C., French, N. P., & Hayman, D. T. (2018). Habitat fragmentation, biodiversity loss and the risk of novel infectious disease emergence. *Journal of the Royal Society Interface*, *15*(149), 1-10.

World Health Organization. (2018). *WHO expert consultation on rabies: third report* (Vol. 1012). World Health Organization. https://www.who.int/publications/i/item/WHO-TRS-1012.

Yasmeen, N., Jabbar, A., Shah, T., Fang, L. X., Aslam, B., Naseeb, I. & Liu, Y. (2022). One health paradigm to confront zoonotic health threats: A Pakistan Prospective. *Frontiers in Microbiology*, *12*, 1-11. https://doi.org/10.3389/fmicb.2021.719334

Zhang, T., Wu, Q., & Zhang, Z. (2020). Probable pangolin origin of SARS-CoV-2 associated with the COVID-19 outbreak. *Current Biology*, *30*(7), 1346-1351.

Zohdy, S., Schwartz, T. S., & Oaks, J. R. (2019). The coevolution effect as a driver of spillover. *Trends in Parasitology*, *35*(6), 399-408.