Review

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# Understanding of Wildlife-Human-Livestock Interface for Prevention and Control of Emerging and Re-Emerging Infectious Diseases

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Posted Date: 13 August 2025

doi: 10.20944/preprints202508.0863.v1

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Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 13 August 2025 doi:10.20944/preprints202508.0863.v1



*Review*

# Understanding of Wildlife-Human-Livestock Interface for Prevention and Control of Emerging and Re-Emerging Infectious Diseases

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**Abstract**

Emerging and re-emerging infectious diseases (EIDs and REIDs) continue to pose a major threat to global human and animal health. The close interactions among wildlife, livestock, and humans-especially in areas where natural habitats are disturbed create ideal conditions for diseases to spill over from animals to people. Changes in land use, deforestation, climate change, urban expansion, and global travel have all contributed to the rise of new infections or the return of old ones. Examples such as Nipah virus in Malaysia, Ebola in West Africa, and COVID-19 highlight how human-wildlife contact can quickly lead to large-scale outbreaks. Many pathogens now cross species more easily due to ecological pressure and increasing movement of people and goods. In India, outbreaks of diseases like Lumpy Skin Disease, avian influenza, and Nipah virus have affected both public health and the livestock sector, causing significant economic losses. The One Health approach-linking human, animal, and environmental health-is now essential for controlling disease risk. Strategies like improved surveillance, better diagnostics, vaccine development, responsible use of antibiotics, and restoration of ecological buffer zones are key. This review emphasizes the need for coordinated action across disciplines to reduce future outbreaks and improve preparedness for zoonotic and environmentally driven infectious diseases.

**Keywords:** emerging infectious diseases; re-emerging infectious diseases; wildlife-livestock; public health

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## 1. Introduction

Human, livestock (cattle, buffalo, goat, and sheep) and wildlife at wildlife-livestock-human interface (WLHI) may play an important role in epidemiology of transmission of emerging and re-emerging infectious disease (EIDs and REIDs). This substantial difference in extinction risk between these orders of mammals suggests that their close relationship predisposes them to disease transmission. WLHI are areas where the ranges and resource use of human, wild, and livestock species overlap. The increased rate at which natural habitats are being turned into agricultural land and grazing pastures intensifies competition between wildlife and livestock for natural resources, and the projected exponential growth in their interactions may lead to the emergence of more infectious diseases and this infectious disease may zoonotic disease economically important disease. This interface is important for emerging and re-emerging of infectious disease because they harbor many pathogens, and wildlife can serve as reservoirs and transmit the pathogen to livestock and vice

 doi:10.20944/preprints202508.0863.v1



versa. Through indirect contacts between wildlife and livestock that share resources like food and water, exposure to an environment polluted by pathogens (aerosols or excretion from infected animals, feces, saliva, or any natural discharge from an infected animal) can result in disease. Infectious disease has been recorded in human and animals (domesticated and wild), and they are caused by a variety of pathogens, including viruses, bacteria, parasites, fungus, and others, with many pathogens capable of infecting several species and zoonotic in nature. With high morbidity, mortality, and healthcare expenditures, infectious illnesses constitute a serious threat to global health security. In the past few decades, many infectious diseases have emerged and reemerged because of dynamic host-pathogen interactions *viz* Peste des petits ruminants virus (PPRv) in ruminants, Crimean-Congo Hemorrhagic Fever (CCHF) in red deer, African swine fever virus (ASFV) and Foot-and-mouth disease virus (FMDV) in wild boar, West Nile virus (WNV) in wild birds etc. These interactions are influenced by anthropogenic selection, niche adaptation, and climate change. Traditional diseases that were "on their way out" (such as malaria and tuberculosis) are resurging and may become more common in the near future, while at least a dozen "new" diseases have been identified, including acquired immunodeficiency syndrome (AIDS), Legionnaires' disease, hantavirus pulmonary syndrome, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), monkey pox, and others. While infectious diseases continue to be the most prevalent cause of mortality worldwide, they pose a threat to both humans and animals. Understanding of the epidemiology of EIDs and REIDs at WLHI helps in developing practical operative preventive, control, and eradication of any shared infectious pathogens where wildlife host acts as carrier or natural reservoir [1]. Therefore, regular and thorough surveillance (active and passive), early detection is required to monitor spillover at WLHI and prevent disease transmission between humans, animals, and wildlife in either direction. Current review will provide an in-depth look at emerging and re-emerging infectious diseases at WLH interface with respect to zoonotic and economic importance disease.

## 2. Emerging Infectious Diseases (EIDs):

EIDs are newly identified and previously unknown infectious agents that cause public health problems locally or globally, but it also includes diseases that have occurred throughout history but have only recently been recognized as distinct diseases caused by an infectious agent *viz.* Ebola, Zika, West Nile virus, hantavirus pulmonary syndrome (HPS), Lassa fever etc. [2,3].

### *2.1. Emerging Infectious Diseases (EIDs): A Chronological and Multispecies Perspective:*

Emerging infectious diseases (EIDs) are infections that have newly appeared in a population or have existed but are rapidly increasing in incidence or geographic range. They may arise due to newly identified infectious agents, changes in host-pathogen interactions, zoonotic spillovers, ecological disturbances, or global travel and trade. EIDs pose a significant threat to global public health, impacting both human and animal populations and stressing healthcare systems and biosecurity frameworks. This review chronologically outlines notable EIDs, elaborates on their clinical manifestations in humans and animals, details their modes of transmission, and discusses how they were identified.

**Table 1.** Chronological Emergence of Key Infectious Diseases in Humans.

| Year | Disease | Pathogen | Host(s) | First Reported Location | Transmission | References |
|---|---|---|---|---|---|---|
| 1976 | Ebola Virus Disease | Ebolavirus | Bats (reservoir), non-human primates, humans | Yambuku, Zaire (now DRC) | Direct contact with blood or body fluids | [4] |
| 1981 | HIV/AIDS | HIV-1, HIV-2 | Humans; zoonotic origin | USA (recognized), | Sexual, blood, vertical | [5] |

doi:10.20944/preprints202508.0863.v1



| | | | | | | |
|---|---|---|---|---|---|---|
| | | | from non-human primates | Central Africa (origin) | | |
| 1993 | Hantavirus Pulmonary Syndrome (HPS) | Sin Nombre virus | Deer mouse (Peromyscus maniculatus), humans | Four Corners region, USA | Inhalation of aerosolized rodent excreta | [6] |
| 1997 | Avian Influenza (H5N1) | Influenza A H5N1 | Birds (primary), humans | Hong Kong | Contact with infected poultry | [7] |
| 2002 | SARS | SARS-CoV | Bats, civets, humans | Guangdong, China | Respiratory droplets | [8] |
| 2009 | H1N1 Pandemic (Swine Flu) | Influenza A H1N1pdm09 | Pigs, humans | Mexico, USA | Respiratory secretions | [9] |
| 2012 | MERS | MERS-CoV | Bats, camels, humans | Saudi Arabia | Respiratory droplets, zoonotic | [10] |
| 2014 | Ebola Virus (Resurgence) | Zaire ebolavirus | Bats, humans | Guinea, Liberia, Sierra Leone | Direct contact, nosocomial | [11] |
| 2015 | Zika Virus Outbreak | Zika virus | Humans, mosquitoes (Aedes spp.) | Brazil | Mosquito-borne, sexual, vertical | [12] |
| 2019 | COVID-19 | SARS-CoV-2 | Bats, humans (possible pangolin link) | Wuhan, China | Respiratory droplets, aerosols | [13] |

## 3. Re-Emerging Infectious Diseases (REIDs):

REIDs are diseases that have been known for some time, had dropped to such low levels that they were no longer considered public health problems, and are now showing upward trends in incidence or prevalence worldwide, or have appeared in areas where they were previously unknown. Many infectious disease specialists classify re-emerging diseases as a subcategory of emerging diseases. For example, tuberculosis has resurfaced as a result of bacterial evolution. The pathogen has developed resistance to tuberculosis antibiotics (either through mutation or genetic exchange), and long-term antibiotic use (both within an individual and across the population) has selected for the pathogen's proliferation. Malaria has also developed drug resistance, and the vector mosquito has developed pesticide resistance. The re-emergence of diseases such as diphtheria and whooping cough (pertussis) is linked to insufficient population vaccination. When the proportion of immune individuals in a population falls below a certain threshold, the pathogen is introduced into the population, causing an outbreak of the disease.

**Table 2.** Example of few emerging/reemerging infectious disease for public importance.

| Types of infectious disease | Etiology | Emerging/re-emerging |
|---|---|---|
| Lyme disease | Borrelia spp. | Emerging |
| Cholera | *Vibrio cholerae* | Re-emerging |
| Plague | *Yersinia pestis* | Re-emerging |
| Vancomycin resistant *Staphylococcus aureus* infections | *Staphylococcus aureus* | Re-emerging |
| Pathogenic Escherichia coli infections (food poisoning) | Pathogenic E. coli strains (O157:H7 & O104:H4) | Emerging |
| Multidrug-resistant tuberculosis infections | Mycobacterium tuberculosis | Re-emerging |
| *Cryptococcus gattii* infections | *Cryptococcus gattii* | Emerging |
| Cyclosporiasis infections | Cyclospora cayetanensis | Emerging |
| Drug-resistant malaria | *Plasmodium* spp. | Re-emerging |
| Variant Creutzfeldt–Jakob disease | Prion | Emerging |
| West Nile fever | West Nile virus | Re-emerging |
| Hantavirus pulmonary syndrome | Hantavirus | Emerging |
| Dengue fever | Dengue virus | Re-emerging |
| Japanese encephalitis | Japanese encephalitis virus | Re-emerging |
| Ebola hemorrhagic fever | Ebola virus | Re-emerging |

| | | |
|---|---|---|
| Hendra virus infection | Hendra virus | Emerging |
| Nipah virus infection | Nipah virus | Emerging |
| Highly pathogenic avian influenza | H5N1, H7N9 influenza virus | Emerging |
| Severe acute respiratory syndrome | SARS-CoV-1 | Emerging |
| 2009 Pandemic influenza | Swine-origin H1N1 influenza | Emerging |
| COVID-19 | SARS-CoV-2 | Emerging |

## 4. Zoonotic Emerging and Re-Remerging Infectious Diseases:

Disease which are transmitted between human and animals or vice-e-versa is referred as zoonotic disease or zoonosis and wildlife play an important role [14]. In one health, zoonotic disease provides strong bonds between human, animal, and environment health. Therefore, zoonotic EIDs (Ebola, West Nile Fever, Hantavirus infection etc.) and REIDs (Rabies, Dengue, Malaria, Japanese Encephalitis, Brucellosis etc.) may acts as an indicator for ecological and environmental changes, biodiversity loss, intensive deforestation, illegal wildlife transport/ trade etc. [15]. As per the available data, out of 60.3 percent of new zoonotic diseases, 71.8 percent were originated from wildlife [16,17]. Important zoonotic disease associated with wildlife species depicted in table 3.

**Table 3.** List of zoonotic disease encountered with wildlife species.

| Disease | Etiological agent | Reservoir | Route of transmission | Occurrence | References |
|---|---|---|---|---|---|
| SARS-CoV-2 | SARS coronavirus | Bats | Aerosol | Worldwide | [18] |
| MERS | MERS coronavirus | Camel | Aerosol | Worldwide | [18] |
| Dengue | Dengue virus | Monkey | Vector (Aedes aegypti) | Africa, Southeast Asia, America, Caribbean, Pacific | [19] |
| Highly Pathogenic Avian Influenza (H5N1) | Influenza viruses | Birds | Direct contact with feces, saliva, or mucosa of infected bird | China, Hong Kong Europe, Africa, China, Russia, Kazakhstan | [20] |
| Ebola Hemorrhagic Fever | Ebola virus | Bats/Apes and Monkey | Multiple organ systems of the body are affected+ extensive internal breeding | Democratic Republic of Congo, Sudan, Uganda, Gabon | [18] |
| Hantavirus p Pulmonary Syndrome | Hanta virus | Rodents | Contact with rodent's feces | America, Asia, Europe | [18] |
| Nipah Virus Diseases | Paramyxovirus | Pigs, Bats | Direct contact or consuming contaminated food products | Malaysia, Singapore, India, Bangladesh | [18] |
| Rabies | Lyssa viruses | Raccoons, Skunks, Bat, Foxes | Direct contact (skin, mucous, tissues)/bite of rabid animal | All Continents Except Antarctica | [21] |
| Rift Vally Fever | Rift Valley Fever Virus | Cattle, Buffalo, Sheep Goat, Camel | Direct contact or bite of infected mosquitos | African Madagascar, Saudi Arabia, Yemen | [22] |
| Septicaemic Plague | *Yersinia pestis* | Rodents | Flea Bites or via skin lesion | Hong Kong, Africa, Asia, South America | [23] |
| Pneumonic Plague | *Yersinia pestis* | Rodents, Rabbits, and large animals | Aerosol | Manchuria, Congo, Madagascar, Peru | [23] |
| Bubonic Plague | *Yersinia pestis* | Rodents | Flea bites | Europe Africa, Asia, South America | [23] |

| | | | | | |
|---|---|---|---|---|---|
| Anthrax | Bacillus anthracis | Cattle, Sheep, Goats, Horses and Swine. | Inhaling /ingesting food contaminated with spores | Asia, Europe, Africa, Australia. | [24] |

## 5. Important EIDs and REIDs in India:

Emerging and reemerging diseases like *Vibrio cholerae* O139, diphtheria in 1980, plague in 1994, Nipah virus infection in 2001, chikungunya and dengue virus infection, avian influenza (H1N1), CCHF in 2011, acute encephalitis syndrome, SARS-CoV-2, Lumpy disease in cattle in 2019, monkeypox virus infection, and others have all occurred in India in the past few years.

India has experienced multiple waves of emerging and reemerging infectious diseases, affecting both human and animal populations. Diseases such as *Vibrio cholerae* O139 (1992) [25], diphtheria (resurging in the 1980s) [26,27], the 1994 Surat plague [28,29], and more recently Nipah virus infections [30], avian influenza, SARS-CoV-2, and Lumpy Skin Disease (LSD) in cattle have challenged public health systems and veterinary services alike [31].

COVID-19, emerging in 2020, caused over 500,000 deaths in India and crippled the economy [32]. Similarly, LSD, an emerging transboundary viral disease affecting cattle, spread across 15 states by 2023, causing large-scale livestock mortality and disrupting milk production [33]. Diseases like monkeypox [34] and CCHF [35] are now part of India's infectious disease surveillance framework due to repeated importations and local spillovers.

Many of these diseases originate in wildlife reservoirs (e.g., bats, rodents, birds) and spill into human and animal populations due to ecological disturbance, including deforestation, agricultural encroachment, and livestock grazing in wildlife-dense areas. Buffer zones, the ecological space between forest and human settlements, are vital in controlling this interface [36]. Unfortunately, the degradation or absence of such buffer zones—especially in states like Kerala, Maharashtra, and Gujarat has heightened the frequency of zoonotic spillovers.

India’s One Health strategy aims to create integrated surveillance and response systems at the human-animal-environment interface. Emphasis is now placed on reinstating buffer zones, monitoring wildlife morbidity, and vaccinating livestock to minimize outbreaks, especially in areas near biodiversity hotspots.

**Table 4.** Chronological Emergence of Key Infectious Diseases in India (Human and Animal).

| **Disease/ Pathogen** | **First Known Outbreak** | **Affected Species** | **Transmission Route** | **Vaccine/ Therapeutics Available** | **Economic Impact** | **Source/ Reference** |
|---|---|---|---|---|---|---|
| *Vibrio cholerae* O139 | 1992 | Humans | Contaminated water | Yes (OCVs) | Seasonal burden in East India | [37] |
| Diphtheria resurgence | 1980s | Humans | Respiratory droplets | Yes (DPT) | Rural child mortality | [38] |
| Plague | 1994 (Surat) | Humans | Rodents, fleas | No | Trade panic, emergency measures | [39] |
| Nipah Virus | 2001, 2018, 2023 | Humans, bats | Bats, Humans | No | Local trade, tourism affected | [40] |
| Dengue & Chikungunya | Recurrent | Humans | Aedes mosquito | No | Outbreak cycles in metros | [41] |
| Avian Influenza (H5N1, H1N1) | 2006–ongoing | Poultry, Humans | Contact with infected birds | Yes (Flu vaccine) | Poultry trade loss | [31] |
| CCHF | 2011 onward | Humans, livestock | Ticks, blood contact | No | Occupational risk | [42] |
| Acute Encephalitis Syndrome | Seasonal outbreaks | Humans (children) | Viruses, toxins | No | Pediatric deaths in Bihar, Assam | [43] |

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|---|---|---|---|---|---|---|
| SARS-CoV-2 (COVID-19) | 2020–2022 | Humans | Respiratory transmission | Yes (Covaxin, Covishield) | National GDP loss, >500K deaths | [44] |
| Lumpy Skin Disease (LSD) | 2022–ongoing | Cattle | Insects, contact | Yes (Goatpox-based) | Dairy sector losses (INR crores) | [33] |

## 6. Public Health and Socioeconomic Considerations of Emerging Diseases:

Emerging and re-emerging infectious diseases in India continue to place considerable strain on both healthcare systems and socio-economic structures. These diseases not only disrupt medical services but also have far-reaching impacts on rural economies, food systems, and ecological health. Recognizing this complexity is vital for designing effective One Health strategies that address the full range of health determinants [45].

### *6.1. Populations Affected:*

The most affected groups are often vulnerable and underserved rural communities near forests, urban slum dwellers, and smallholder livestock keepers. These populations typically lack access to clean water, health services, and education, making them especially susceptible to outbreaks. For instance, vector-borne diseases like Acute Encephalitis Syndrome (AES) disproportionately impact children in low-sanitation regions such as Bihar and Assam [43,46].

### *6.2. Economic Losses:*

India incurs billions in economic losses due to both human pandemics and livestock diseases. LSD, for example, led to an estimated ₹20,000 crore loss due to cattle mortality and milk production decline [47]. Similarly, the COVID-19 pandemic resulted in GDP contraction, job losses, and increased healthcare costs [48]. In agrarian economies, the loss of even a single productive animal can have severe microeconomic consequences for smallholder families.

### *6.3. Buffer Zones:*

Buffer zones ecological transition areas between forests and human settlements are vital in reducing disease spillover. However, widespread degradation due to deforestation, mining, and unregulated land use has increased contact between humans, livestock, and wildlife. The 2018 Nipah virus outbreak in Kerala is a case in point, occurring in areas where fruit orchards were located near human dwellings and bat roosting sites, highlighting the role of shrinking wildlife habitats in disease emergence [49]. The restoration of these zones is central to One Health preparedness and disease prevention.

## 7. Factors Contributing to Emergence and Reemergence of Infectious Diseases:

EIDs and REIDs are not random events but rather the direct consequences of intricate interactions between pathogens, hosts, and their shared environment. One of the most profound drivers of EIDs and REIDs emergence is ecological change, encompassing phenomena such as deforestation, climate change, and habitat alteration. These environmental transformations directly impact vector distribution, host populations, and the frequency of human-wildlife interactions, thereby creating novel opportunities for pathogen spillover and amplification [50–52]. The constant need for the development of cost-effective diagnosis, prevention, and therapeutic strategies, as well as the maintenance of real-time epidemiological surveillance, pose significant challenges to the public health and agricultural systems. A comprehensive understanding of these underlying drivers is critical for anticipating future threats and developing robust preventative measures at WLHI which would help in making disease control strategies.

 doi:10.20944/preprints202508.0863.v1



*7.1. Agent:*

Pathogenic infectious agent evolution (microbial adaptation and change), mutations, drug resistance development, pesticide resistance of vectors, and so on.

7.1.1. Antimicrobial Drug Resistance (AMDR):

Antimicrobial drug resistance (AMDR) is a critical global health threat driven by inappropriate prescribing, patient non-adherence, counterfeit pharmaceuticals, and extensive use of antimicrobials in human, livestock and agriculture [53]. Resistant pathogens often emerge in livestock or wildlife and spill over to humans through direct contact, food, or contaminated environments, especially in buffer zones between human settlements and natural habitats [54]. A notable case is the discovery of the *mcr-1* gene in China (2015), conferring colistin resistance across pigs, food, and humans [55], with global dissemination underscoring the urgency of integrated surveillance. The One Health approach emphasizes the interconnectedness of human, animal, and environmental health in combating AMDR [56].

7.1.2. Introduction of New Disease Agents:

If any new pathogen introduce that becomes established in indigenous wildlife *viz.* West Nile virus infection in eastern North American birds, plague in wild rodents in Western North America.

7.1.3. Genetic Changes in Pathogens:

Genetic changes in the pathogens/ hosts may play an important role in EIDs and REIDs [17].

7.1.4. Advanced Diagnostics Tools and Techniques:

Improved modern diagnostics tools and techniques may disclose the new pathogens or discovery of existing pathogens [57].

7.1.5. Bioterrorism:

Bioterrorism means using harmful germs like anthrax, smallpox, or salmonella to attack people, as seen in the 2001 anthrax attacks in the U.S. [58] and the 1984 salmonella poisoning in Oregon [59]. Other diseases like glanders (used in World War I), plague (used by Japan in China during the 1930s–40s), tularemia (tested during World War II and the Cold War), and melioidosis (studied as a potential weapon) can also be used this way [60–62]. Many of these come from animals and spread to humans, showing the “One Health” link [56]. When wild animals move closer to humans due to deforestation, diseases can spill over from forests into towns [16].

*7.2. Host:*

Human demographic change (moving to new areas)- contact with animals and natural environment; human behaviour (sexual & drug use, sharing needles, drug abuse, body piercing); human susceptibility to infection (Immunosuppression)- stress and lifestyle changes; nutritional changes- increased use of pesticides; globalization of travel and trade; agricultural practices such as pig farming (Nipah virus), goose farms (West Nile virus- Israel); breakdown of public health measures such as breakdown in vector control etc.

7.2.1. Wildlife, Livestock, Human and Zoonotic Diseases:

Buffer zones—ecological transition areas between wildlife habitats and human settlements—play a pivotal role in the EIDs and REIDs of zoonotic diseases by facilitating interactions among wild animals, domestic species, and rural populations. Many wildlife acts as carrier or reservoirs for zoonotic pathogens and responsible for spillover and contamination of WLHI [63]. These zones become hotspots for spillover events, especially when intensified by deforestation, agricultural

 doi:10.20944/preprints202508.0863.v1



expansion, or climate-driven animal migration and responsible for disease transmission from one species to another [64]. Once a pathogen crosses into rural communities, it can rapidly reach urban populations through livestock trade, human mobility, and weak surveillance systems. A well-documented example is the Nipah virus outbreak in Malaysia (1998–1999), where fruit bats displaced by habitat loss infected pigs, which then transmitted the virus to farmers, eventually leading to cases in urban hospitals [65]. Similarly, the 2014–2016 Ebola outbreak began in the forested region of Guinea and spread to major cities such as Monrovia and Freetown due to high population movement [66]. More recently, COVID-19 (2019-nCoV) is believed to have originated in wildlife, possibly bats, and spread from live animal markets in Wuhan to the global population via dense urban connectivity [67]. These cases highlight the need for integrated One Health surveillance across buffer zones and rural interfaces to prevent future pandemics.

### *7.3. Others Driving Factors:*

#### 7.3.1. Deforestation:

For instance, the destruction of natural habitats through deforestation brings human populations into closer proximity with wildlife reservoirs, increasing the likelihood of zoonotic transmission or spillover of other infectious disease having economic importance. This mechanism is clearly observed in the escalating incidence of disease like Lyme disease, where fragmented forest landscapes lead to higher densities of deer and ticks, enhancing the exposure of human populations to Borrelia burgdorferi [51,68,69].

#### 7.3.2. Climate Change:

The impacts of climate change, particularly rising temperatures and altered precipitation patterns, expand the geographical ranges of arthropod vectors like mosquitoes. This expansion facilitates the spread of vector-borne diseases such as malaria and dengue fever into previously unaffected regions, while also potentially shortening the extrinsic incubation period of the pathogen within the vector, accelerating transmission cycles [70,71]. Furthermore, shifts in weather patterns can dramatically influence rodent populations, subsequently elevating human exposure to hantaviruses and precipitating outbreaks of Hantavirus Pulmonary Syndrome (HPS) [72,73].

#### 7.3.3. Agricultural Practices:

Agricultural intensification, particularly the rise of concentrated animal feeding operations (CAFOs) and the continued use of live animal markets (often referred to as wet markets), creates ideal conditions for the EIDs and REIDs of zoonotic pathogens. These environments often house large numbers of genetically similar animals in close confinement, facilitating rapid pathogen transmission and genetic reassortment [74–76]. In this environment, livestock manoeuvres can aid as mixing vessels for disease agents, while agriculture farming can attract disease-carrying wildlife to areas of human activity [77]. Furthermore, outbreaks of Nipah virus in Southeast Asia have been directly linked to the expansion of intensive pig farming into areas adjacent to fruit bat habitats, thereby bridging the transmission pathway from bats to pigs and subsequently to humans [78,79].

#### 7.3.4. Human and Wildlife Coexistence and Conflict:

Wildlife is a part of biodiversity and play an important role in maintaining healthy environment [15] but human-wildlife conflicts may arise and resulting in crop damage, increased chance of livestock as well as human predation, high probability of disease transmission, illegal wildlife trade, emergence and re-emergence of zoonotic disease, public health issues etc. [80–82]. The wildlife trade especially illegal trade of exotic animals and consumption pathways represent another significant avenue for human exposure to exotic pathogens [83]. The capture, transport, and consumption of wild animals for food, traditional medicine, or the pet trade directly increase the points of contact between humans and a diverse array of wildlife pathogens that would otherwise remain geographically or ecologically isolated [84,85]. All these activities manipulate wildlife and provide WLH interface enabling a nascent pathogen spillover [86]. Frequently spillover of Ebola Virus Disease from wild animals (natural reservoirs like bats and non-human primates) into human populations through contact with infected bushmeat or direct interaction [51,87]. The initial SARS outbreak in 2003 was strongly associated with civet cats sold in live animal markets, implicated as an intermediate host in the virus's transmission to humans, highlighting the direct link between wildlife commerce and disease emergence [88,89]. Similarly, sporadic outbreaks of Monkeypox, though typically less severe, are often traced back to direct contact with infected wild animals, with the global spread occasionally exacerbated by the international trade in exotic pets [90,91]. Another best example of spillover of pathogen to human was human immune-deficiency virus (HIV) and it was originated from non-human primates and it could be due to contacts with hunted primates [5,92].

7.3.5. Changes in Land Use:

If use of land is changed then it brings human, livestock and other wildlife in very close contact and this may lead to transmission of unknown disease [93].

7.3.6. Prey and Predator Dynamics:

Biodiversity plays important role in emergence of disease. High biodiversity is responsible for distribution of effect of pathogens in large number of hosts while biodiversity loss can converse the pathogens distribution in lesser species and this can lead to increasing transmission rates to humans. Furthermore, predator-prey dynamics may be altered and ultimately lead to population change of predators and prey.

7.3.7. Wildlife Farming:

Mammals like deer. Rodents, civets and other fur animals are legally bred for income and protein source worldwide [94–96] but as per the published literature farming system are poor which leads to poor health condition of these captive wildlife [96,97]. Due to poor health condition, immunity of these animals becomes very poor and predispose to emergence of many infectious disease like avian influenza in ostrich farms in South Africa [98], rabies outbreak in Kudu (*Tragelaphus strepsiceros)* population in Namibia [99], SARS-CoV-2 in mink (*Neovison vison)* farm in the Netherland [100].

Beyond localized ecological shifts, globalization, characterized by an unprecedented increase in international travel and trade, serves as a powerful accelerator for pathogen dissemination. In a highly interconnected world, a novel pathogen can rapidly traverse continents, transforming a localized outbreak into a global pandemic within days or weeks [101]. For example, the severe acute respiratory syndrome (SARS) epidemic in 2003 and SARC-CoV-2 provided an early and stark illustration of this phenomenon, with the virus swiftly spreading from its origins in Asia to numerous countries via international air travel [102–104]. Similarly, the rapid expansion of Zika virus across the Americas in the mid-2010s was largely attributable to increased human movement and the subsequent introduction of the virus into regions with competent Aedes aegypti mosquito populations [105,106].

## 8. Prevention and Control of EIDs and REIDs: A One Health-Based Strategy

Preventing EIDs and REIDs requires a wide, coordinated effort. The One Health approach, which joins human, animal, and environmental health efforts, plays a key role in controlling these diseases, especially those that pass between animals and people [17]. Share health warnings early at all levels—local to global—to guide public action [45]. Improve teamwork between countries by sharing outbreak reports, tools, trained manpower, and healthcare training programs [16]. Offer rapid testing and treatment in rural areas where most diseases spill over from animals to humans

[65]. Use antibiotics wisely to avoid creating resistant bacteria [44,55]. Continue research on vaccines, fast diagnostics, and new treatments for high-risk diseases like Ebola and COVID-19 [67]. Build global health systems with strong political and financial support to respond faster to future outbreaks.

### *8.1. Surveillance and Response*

Quick detection of strange or unexpected disease patterns helps stop outbreaks early. Real-time data sharing between local and global health teams can limit spread before it becomes serious [45,67]. Monitoring areas where people and animals live closely—such as buffer zones or forests being cut down—is important, as these are common places where diseases jump between animals and humans [16,107].

### *8.2. Applied Research*

Scientists and public health teams must work together to study disease patterns and improve ways to diagnose and treat infections. Special focus should be on diseases that come from food or animals, such as E. coli and Campylobacter, which often spread through meat, milk, or water [108]. Research should also track how antibiotic-resistant infections are rising, such as the spread of mcr-1, a gene that makes bacteria resistant to last-line antibiotics like colistin [55].

### *8.3. Infrastructure and Training*

Countries must improve hospitals, labs, and data systems to help detect and manage outbreaks faster. Healthcare workers, vets, and environmental scientists should be trained together under One Health so they can respond better to shared health threats [56].

## 9. Reducing the Risk of Future Outbreaks

Emerging infections come from complex reasons including changes in the environment, farming, animal health, and human behavior. To manage these risks, we need strategies that connect all areas of health. Strengthen global health systems and improve quick response abilities. Watch for new diseases in animals and people before they spread widely. Develop and deliver vaccines for diseases like Lassa fever, Ebola, and new coronaviruses. Support research on new antibiotics and other medicines, especially for drug-resistant bugs. Avoid overuse of antibiotics in people, animals, and farming to slow resistance. Control disease carriers like mosquitoes and keep wildlife and domestic animals healthy. Teach the public how to prevent infections and handle food safely, especially in rural and high-risk zones.

## 10. Conclusion

In conclusion, the emergence and re-emergence of infectious diseases at wildlife-livestock-human interface is a multifaceted problem driven by a complex interplay of ecological disruption, global connectivity, intensive agricultural practices, direct human-wildlife interfaces through trade and consumption, and the insidious rise of antimicrobial resistance. Addressing these interwoven drivers requires integrated, interdisciplinary approaches that prioritize ecological health, sustainable development, and robust public health infrastructure to mitigate the risk of future pandemics. Even in the twenty-first century, infectious diseases are the most common public and animal health problems. A variety of factors influence the occurrence of EIDs and REIDs, including human behaviour, microbial adaptation, ecology, globalization, and public health infrastructure. These infectious diseases continue to impose enormous and unpredictable burdens on global health and the economy. One Health is an important approach to improving the effectiveness of public health response and interventions, as well as the recruitment and application of multiple areas of expertise to fight EIDs and REIDs. Thus, understanding emerging and re-emerging infectious diseases in terms of disease surveillance and preparation for potential epidemics and pandemics is critical for mitigating the impact of future outbreaks.

**Conflict of interest statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest

**Credit Author Statement:** KK, RR, VL, Conceptualization, writing – original draft, writing – review & editing, VG-Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

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