EMERGING INFECTIOUS DISEASES (EIDS) IN ANIMALS

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Zoonotic diseases in animals also referred to as Emerging Infectious Diseases (EIDs) are proving to be a major threat to health, wildlife, and agriculture. They result in increased morbidity and mortality thus affecting the production of animal products and constitute public health threats because of the zoonotic potential of the diseases in terms of their recent emergence or expansion in area of occurrence. This chapter covers various aspects of EIDs in animals to include the emergence of these diseases, the rates at which new diseases are being discovered, and other related issues. Several studies have however indicated that EIDs are dynamic and complex diseases which will be highlighted in this chapter by evaluating their origins, transmission mechanisms, and the factors that lead to the emergence of the diseases. The increasing occurrence of EIDs is illustrated in the study about wildlife, domestic animals, and changes in the environment to give a view of the zoonotic potential of the diseases as one Health framework. Also, the chapter overviews surveillance approaches, diagnostics, and the need to perform early identification and response to EIDs' effects. Thus, a complex approach should be used to minimize the risks connected with EIDs. Thus, further epidemiological research, and collaboration with practitioners such as veterinarians, and specialists in ecology and other branches of science are crucial for investigating disease processes and finding effective prevention measures. The chapter also focuses on One Health activities that are essential in understanding the interconnection of human, animal, and environmental health.

1. Introduction

Emerging infectious diseases, often known as EIDs, are contagious illnesses that have been identified for the first time in a community or that have been present in the past but are seeing a significant increase in the number of cases or geographic ranges they affect. In other words, these could be novel infections arising from modifications or adaptations in current organisms or established infections that extend to different geographical regions or populations. On the other hand, previously unrecognized infections are emerging in areas undergoing ecological changes, or recurring infections are due to the development of antimicrobial resistance in known agents or failures in public health interventions. The results of the Ninth International Conference on Emerging Infections show that emerging infections account for a minimum of fifteen percent of all human disorders (McArthur, 2019). There is a significant cause for worry over the synergistic communication that occurs between newly developing illnesses and other infectious and non-infectious ailments. An animal receptacle is responsible for the incubation of the organism, which then involves random transmission into human populations. Many newly developing illnesses are zoonotic or synoptic disorders.

Similarly, EID may be transmitted via the air, by vectors, or through food. On the other hand, for an EID to be created, the infectious agent must first be introduced into a population that is susceptible to the illness, and the infectious agent must also be capable of transmitting the disease from one person to another (McArthur, 2019). Infectious illnesses, in contrast to other human diseases, have the capacity to be unexpected and have the potential to cause epidemics affecting the whole world. Additionally, there is the possibility of developing immunity against reinfection despite the fact that they are contagious. Vaccines have the potential to eradicate many diseases, and they may be used to prevent their spread. The conduct of humans and the natural world are interdependent on one another (Fauci & Morens, 2012). The difficulty of EID is related to the influence that they have on people, including pandemics and epidemics, as well as the risks to human health and the stability of the world government (Fauci & Morens, 2012; Morens & Fauci, 2013). It is well known that the emergence of new pathogens is inevitable. However, despite the progress that has been made in the creation of preventative measures, diagnostics, treatments, and vaccinations, the addition of worldwide travel and growing global interdependence has increased the number of challenges that arise when attempting to diagnose and control these illnesses. As emerging illnesses in the current day, the majority of people may relate to the human immunodeficiency virus (HIV) and AIDS, severe respiratory syndrome, and pandemics, such as the H1N1 influenza that occurred in 2009 (Zambon, 2014). Not to mention the profound effect that these illnesses had on the quality of life of those who were affected and their families, the social and economic impact of these diseases was remarkable. It is essential to have a solid understanding of the many types of infectious illnesses. There are three distinct groups of organisms those that are just beginning to emerge, those that have already established themselves and may sometimes reappear, and those that have become endemic in a stable manner (Morens & Fauci, 2013).

Zoonotic illnesses are diseases that are transferred from animals to people by direct contact or through food, drink, or the environment. Zoonotic diseases are responsible for 61% of the infectious organisms that harm humans. The capacity of zoonotic illnesses to spread among people may be broken down into five phases, beginning with the pathogens that are exclusively transmitted between animals and progressing all the way up to the infections that are transmitted to humans (Wolfe et al., 2007). The National Center for Emerging and Zoonotic Infectious Diseases (NCEZID) functions with the purpose of safeguarding individuals from both local and international health hazards. Their coverage encompasses foodborne and waterborne infections, nosocomial infections, antibiotic-resistant infections, lethal diseases like Ebola and anthrax, illnesses affecting immigrants, migrants, refugees, and travellers, zoonotic diseases, and vector-borne diseases transmitted by mosquitoes, ticks, and fleas (Control & Prevention, 2022). The interaction between people, animals, and the environment is a breeding ground for illnesses that have the potential to affect public health as well as the social and economic well-being of the whole world population. Take into consideration the elements that were mentioned before. When people live close to animals and when humans come into touch with animals in new geographical locations, the risk of contracting zoonoses is increased. Some examples are Lyme disease, which is spread by tick bites, and salmonella, which is transferred through contact with hens. The recent occurrences of Salmonella outbreaks in shell eggs, chicken products, raw turkey products, and pet guinea pigs are memorable events (Byrne & Hays, 2021).

Vectors are insects and ticks that feed on blood and are capable of spreading infections from one host to another. These particular illnesses are among the leading causes of death and disease on a worldwide scale. Ticks and mosquitoes are responsible for the transmission of the most frequent illnesses in the United States. These infections include Lyme disease, Rocky Mountain spotted fever, West Nile virus, dengue fever, and Zika virus. In both the United States and across the world, these illnesses are becoming an increasingly severe threat to public health. Both municipal and state health agencies are responsible for monitoring data; nevertheless, there has been a noticeable improvement on a national scale in terms of surveillance, diagnostics, reporting, and vector management, in addition to the introduction of new vaccinations (Rosenberg, 2018).

Due to the existence of the particular vector, EID infections that are transmitted by mosquitoes have the potential to spread locally in the United States. In a similar vein, international travel and immigration have the potential to introduce these illnesses to the United States, where they might potentially be transmitted. The Zika virus, yellow fever, chikungunya virus, and dengue virus are the four viruses that are transmitted by mosquitoes and are considered to be of concern (Table 2) (Rosenberg, 2018).

Table 1: Biological Agents that could present a threat to National Security

Category A	**Category B**	**Category C**
Variola major (smallpox)	*Coxiella burnetti* (Q fever)	Nipah virus
Bacillus anthracis (anthrax)	*Brucella* species (brucellosis)	Hantaviruses
Yersinia pestis (plague)	*Burkholderia mallei* (glanders)	Tick-borne hemorrhagic fever viruses
Clostridium botulinum toxin (botulism)	Alphaviruses	Tick-borne encephalitis viruses
Francisella tularensis (tularaemia)	Venezuelan encephalomyelitis	Yellow fever
Filoviruses	Eastern and Western equine encephalomyelitis	Multidrug-resistant tuberculosis
Ebola hemorrhagic fever	Ricin toxin from *Ricinus communis* (castor beans)	
Marburg hemorrhagic fever	Epsilon toxin of *Clostridium perfringens*	
Arenaviruses	*Staphylococcus enterotoxin* B	
Lassa (Lassa fever)	A subset of list B agents includes pathogens that are food- or waterborne. These pathogens include but are not limited to	
Junin (Argentine hemorrhagic fever) and related viruses	*Salmonella* species	
	Shigella dysenteriae	
	Escherichia coli O157:H7	
	Vibrio cholerae	

2. FACTORS CONTRIBUTING TO EMERGENCE OF OUTBREAKS

From 1940 to 2004, a total of 335 occurrences of Emerging Infectious Diseases (EID) were documented. Approximately 63% of the cases were derived from natural habitats of wild animals, whereas roughly 20% of the cases were transmitted from animal hosts to human hosts by disease-carrying organisms like ticks and mosquitoes (Jones et al., 2008). In the year 2008 and beyond, the discovery of the thrombocytopenia virus and the Middle East respiratory syndrome coronavirus, as well as the unanticipated outbreaks of the Zika virus, yellow fever, and Ebola, caused severe fever. This EID highlights the significance of demographic transitions, global travel and business, and the potential impact of climate change as driving forces (Van Doorn, 2014). The following are

examples of biological, social, and environmental factors, all of which are directly connected 1) The modification and adaptability of microorganisms (for example, the genetic drift and shift in influenza A), 2) The susceptibility to infection, 3) The high population density of the human people. The following factors contribute to the spread of infectious diseases Poverty and social inequalities (such as TB); the impact of agricultural development on the environment; the globalization of the food market and manufacturing; environmental pollution; climate change; population expansion, spread in health care institutions, an aging population, international travel, changing and growing vector habitats (higher temperatures may enable mosquitoes and the diseases they carry to spread to new locations), and international travel. Drug resistance is a factor that leads to the reoccurring of microorganisms such as bacteria, viruses, and other microorganisms that evolve throughout time. Influenza, A virus that causes illness and alters its genetic code, is a good illustration of how these factors impact the development of new diseases at the present moment (van Doorn, 2017). Pandemics can arise when these alterations are significant because they provide a challenge to the human immune system. When people live in close proximity to agricultural animals, such as chickens, ducks, and pigs, who are natural hosts of the virus, the likelihood of those humans being infected with the virus and experiencing genetic alterations is enhanced. The avian H5N1 influenza, often known as bird flu, may only be acquired via direct contact with birds that are infected with the illness. Even though this virus is very lethal, it is not capable of spreading from one person to another. This contrasts with the H1N1 influenza virus, which was transmitted from pigs to people. Because of human activities, particularly air travel, this virus was able to spread worldwide in 2009 (McArthur, 2019). HIV serves as an additional illustration of an infectious illness that may be traced back to human actions. It is a widely held belief that the first human infection with HIV occurred in remote parts of Africa and that it was transmitted to humans via intimate contact with chimpanzees, maybe through the act of hunting bushmeat. The medium of air travel was responsible for the spread of the disease from rural areas to international locations. Human actions, such as the use of intravenous drugs, sexual transmission, and the transfer of blood products, happened before the identification of the new illness, which resulted in the fast spread of the disease (McArthur, 2019). Taking into consideration the variations in the environment, take into consideration the tropical sickness known as chikungunya, which was explained before. The mosquito that is responsible for transmitting this virus was initially only found in tropical locations within the vicinity of the Indian Ocean. After an epidemic of this illness occurred in 2007, more than two hundred people living in a town in Italy were affected by it. The subsequent events have resulted in epidemics occurring on every continent. As individuals who offer medical treatment within the context of healthcare systems, it is essential to continue the conversation about the shifting demographics of the population. An increasing number of risk factors for infection and consequent hospitalization are associated with advancing age, which further increases the patient's susceptibility to infection. In this article, the author addresses the newly discovered fungus species Candida auris, which is responsible for outbreaks in healthcare institutions and is linked to high death rates in patients who have underlying comorbidities (KRISTEN, 2018; Petersen et al., 2018).

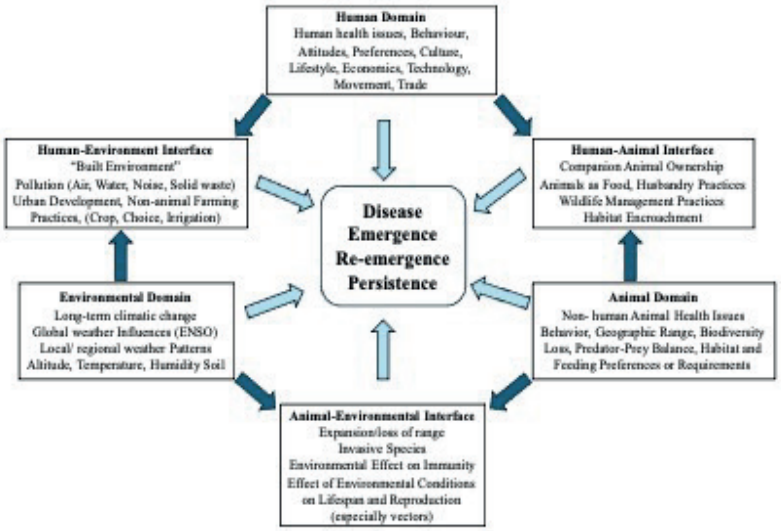


Figure 1: The emergence of infectious diseases: Animal, Human, and Environmental dimensions

The emergence of zoonotic illnesses in human populations and cattle populations may be impacted by a variety of factors, which can be classified into three categories biological, ecological, and socio-economic factors. In one health viewpoint, the interplay of human, animal, and environmental elements in the transmission and development of infectious zoonotic illnesses has been described in Figure 2. This interaction relates to the spread of contagious diseases. On the other hand, these elements are further categorized, and the following is a discussion of the crucial factors that may contribute considerably to the establishment of zoonotic infectious diseases (Usmani et al., 2023).

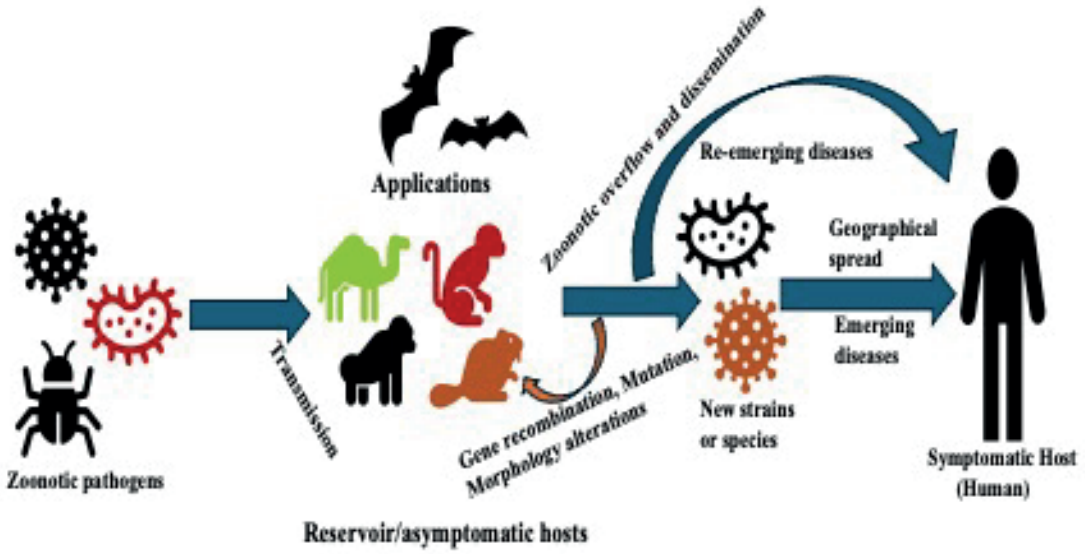


Figure 2: Emergence of infectious disease in animals and transmission to humans

2.1. ECOLOGICAL CHANGES

Habitats have been altered as a result of human-induced changes to ecosystems, such as deforestation, agricultural expansion, and urbanization (Fong & Fong, 2017). These changes have also seen an upsurge in the interaction between human population, livestock and wildlife. Because of such interaction, a concave for spreading zoonotic diseases was created, and consequently, dynamics of diseases and corresponding changes in fragmentation and distribution, as well as the behaviour of humans, livestock, and animals, were created. These changes increased their interactions, as concluded by García-Pena et al. (2016), and escalated the chances of transferring infections across

different species from one region to another (García-Peña et al., 2016).

2.2. CLIMATE CHANGE

Climate altering across the world affects vector-borne diseases, that is, those diseases that are transmitted by insects and other carriers and mechanical vectors, including mosquitoes, ticks, and flies, and their biological carriers. Barry et al. (2018) also highlighted this point by explaining that it also led to shifts in the spatial organization of populations of humans, animals, and cattle that heightened the odds that pathogens would be passed between the species (McMahon et al., 2018). It is noteworthy that the frame of climate change influences the distribution and behaviour of zoonotic pathogens and their hosts, including animals and insects like ticks and mosquitoes, transformed and changed as well. The authors Alvi et al. also agree that the hosts and vectors of these pathogens enlarged and shifted to the warmer and more humid temperate areas, which in turn exposed them to novel people and animal communities (Alvi et al., 2020). Due to such a rise in the temperature, contrary conditions that are optimum for the reproduction and sustenance of vectors that spread diseases are enhanced. For instance, elevated temperatures facilitate diseases spread by mosquitoes, such as malaria, dengue fever, and the Zika virus (ZIKV); alterations in atmospheric temperature affect zoonotic pathogens' transmission patterns (Imran et al., 2023). The fact is that epidemics may develop more violently regarding the severity of illness in conditions of high temperature, short incubation time, and high transmission coefficient. This may lead to the spread of diseases at a larger scale and, sometimes, severe cases in terms of the illness. Some of the aspects that are affected by climate change include the host and pathogen's physiological and behavioural characteristics. It remains possible that this will alter the dynamics of the interaction between the host and the pathogen and, subsequently, the patterns of occurrence, morbidity and severity of the diseases (Petersen et al., 2016).

2.3. GENETIC DIVERSITY

The microbes, viruses, and bacteria evolved, resulting from mutations and recombination, creating new strains that would pose an even higher threat than previous ones. Bhatt et al. (2013) also claimed that these newly emerging strains can affect many species, including people and animals, and their severity is higher than before (Bhatt et al., 2013). Also, the genetic stock difference within cattle populations might influence susceptibility to disease. Because of the existence of low genetic diversity resulting from the use of intentional breeds for specific traits, the animals can become prone to specified diseases. The probability of disease occurrence and spread within livestock populations is also enhanced, as explained by (de Thoisy et al., 2014). However, the genetic homogeneity of a population may also make some illnesses more transmissible in the animals from one animal to the other. One virus can reach out to other people in a community within the shortest time possible, which increases the chances of a zoonotic event happening. This is even the case if they're located in populations that show slight variation genetically (Ioos et al., 2014).

2.4. PATHOGEN RESERVOIRS

It is vital to note that there are various viruses which can lead to zoonotic infectious diseases, and the livestock population is a source of these infections. These pathogens can indeed be present in animal populations and pass through the animals without making them sick; nonetheless, they can be transmitted to people and cause infections (Alvi et al., 2023). Animals that are kept in close proximity to one another, shed harmful organisms, and distribute them across the environment are higher sources of diseases to people and their excrement as a result of intensive farming procedures. As a consequence of this, there is a higher probability that viruses will be discharged into the environment, including the possibility that they may infect individuals who come into contact with dirty surfaces, water, or air (Binetruy et al., 2020). There are more than a billion individuals who are afflicted with zoonotic infectious illnesses, and each year, more than sixty percent of mortality is documented in humans as well as domestic or wild animals. Zoonoses are responsible for around

seventy-five percent of newly developing infectious illnesses, according to estimates. There is a vast range of vertebrate species, both terrestrial and aquatic, that are capable of transmitting a wide variety of microbial illnesses to humans, either directly or indirectly (Usmani et al., 2022). The enormous spectrum of infectious agents includes a wide variety of microorganisms, such as rickettsiae and mycobacteria, viruses, fungi, parasites (including protozoa, metazoans, and helminths), and prions. These microorganisms are all responsible for the transmission of infectious diseases. Animals have the ability to transmit infectious diseases to humans through various means. These include the transmission of diseases through contaminated food, water, or unwashed hands, as well as through direct contact with animals, whether or not there are bites or scratches. Also, there are communicable diseases, which are transmitted indirectly through vectors like, mosquitoes, sandflies, fleas, and ticks. Besides, there is a likelihood of spillover through environmental exposure to pathogens from animals, for instance, via the breath of dried infected animal faeces (Imran et al., 2023).

2.5. ANTIMICROBIAL RESISTANCE

This is an indication that both the use of antimicrobials in human and animal health and the undue pressure to resist infections eventually lead to the development of infections that are probably harder to treat and manage. This is the same case for human and animal medicinal treatment. Regarding cattle production, the misuse of antibiotics may have a role to play in the emergence of drug-resistant diseases. Antibiotics have to be administered safely and judiciously in the context of veterinary and human medicine operations, which will help delay the creation of antibiotic resistance. The increasing trends in antibiotic resistance and emergency control measures can be determined by constant surveying of antibiotic bacteria resistance in individuals and animals (Mosnier et al., 2020). Such trends may be identified by routine monitoring. Further, the One Health approach collaborates with humans, animals, and the environment, and it is equally a part of recognizing and controlling the development of antibiotic-resistant microorganisms (AMR) in the transition zone between humans, animals, and the environment (Blaizot et al., 2020). Besides, this one-health approach is helping in decreasing the selection pressure for antibiotics in a big way. To this end, we are encouraging the use of organic and sustainable forms of medicinal agents, where it is obvious that we are going to achieve a decrease in the cases of overuse of antibiotics. By so doing, this will be effective in decreasing the rate at which antimicrobial resistance spreads and the general health status of both humans and animals (Mosnier et al., 2020).

2.6. INTENSIVE LIVESTOCK FARMING PRACTICES

A system of rearing animals that involves a large number and fewer species of animals may, in fact, create a situation where diseases would quickly spread among animals being raised for sale. These kinds of systems keep the animals under very high stress, and biosecure measures are compromised, which adversely affects the animals' immunity and production efficiency, as well as raising their susceptibility to diseases. According to Cascio et al., selective breeds are commonly supported within intensive farming since they are characteristically endowed with the right features that enhance production (Cascio et al., 2011). In addition, these animals are often overcrowded and thus provided with minimal space in smaller confined areas. Any factor that stresses an animal, causes overcrowding, poor biosafety, and hygiene could compromise the immune status of animals and hence make them more susceptible to diseases. This is because these conditions increase the chances that animals become ill through diseases and that there are higher chances of zoonotic infections spreading from animals to human beings, and their instances increase. It is also possible for animals to get in touch with various poisons that are present in the byproducts of plants and animals when offered these byproducts. This may lead to the emergence of zoonotic diseases and the introduction of new microbial human and animal pathogens into society (Craddock & Hinchliffe, 2015).

2.7. INADEQUATE DISEASE SURVEILLANCE AND MONITORING SYSTEM

According to Usmani et al. 2022 if no instrument is both rapid and precise for the detection and reporting of evolving infectious diseases, then there is a tendency for the correct diagnosis and proper prevention measures against zoonotic diseases. It may not be instituted early enough, and therefore, the chances that these diseases may spread quickly and widely would be high (Usmani et al., 2022). Early and accurate detection of infection is very crucial to prevent the expansion of such epidemics within a large, granted area. Thus, zoonotic diseases may not be reported or misidentified since there is a lack of diagnostic laboratories, there are few qualified personnel, and the health care system is underdeveloped. The tasks of practical control activities are also frequently hindered daily due to inadequate data on the incidence and dispersion of the disease (Cascio et al., 2011).

2.8. SOCIOECONOMIC FACTORS

Socioeconomic situations are linked with the creation and spread of diseases. They include poverty, this being because many people cannot afford to seek medical help, they cannot easily access medical facilities and poor methods of animal treatment. These may complicate disease surveillance, preventive measures, and timely intercession, hence the spread of illnesses. There are social and external conditions that influence the emergence and dissemination of zoonotic diseases shift of spatial environment, alteration of ecosystems, pathogens' evolution, alteration of farming practices and livestock production systems, anthropogenic pressure such as urbanization, deforestation, and global warming (Cipolla et al., 2015). Eating meats or using animals in some cultural practices and natural cure activities are some of the behavioural patterns that expose people to diseases originating from animals. Some of them include the use of animals in traditional aches and pains medicine. Lack of proper sanitation regimes and hygiene among both people and livestock could likely promote the efficiency of zoonotic infectious diseases and their sustainment in the environment. Also, Poor economy, low nutrient intake, and weak health facilities may play a part in the development and transmission of zoonotic diseases. This means that people with such diseases are likely to have reduced access to medical care reduced, efforts aimed at containing the diseases hampered, and individuals more vulnerable to getting infections (Wood et al., 2016).

2.9. GLOBAL TRADE AND TRAVEL

Infections unknown to the previous generations may find their way to the hitherto unexposed populations through enhanced traffic in persons, animals and animal products across borders. As for the spread of zoonotic diseases, the trade in live animals is especially vulnerable to the phenomenon described. Crossing animals from one country to another, either within the country or across borders step, may also promote disease strain. Referring to de Thoisy et al. (2010) and Hoen et al. (2018) pointed out that the movement of humans associated with the management of livestock, movement of live animals and animals' products may lead to the import of viruses into new areas and increased risk of emergence of diseases (de Thoisy et al., 2010; Hoen et al., 2018).

2.10. CHANGES IN LAND USE AND AGRICULTURE PRACTICES

Wangdi et al. (2015) demonstrated that alterations in land spaying, for instance, areas under cultivation or shifts in grazing practices, affected livestock, wildlife, and people. There is also likely to be increased interaction between livestock and people and animals due to drawing closer to the areas occupied by wildlife or turning over forests to farming (Wangdi et al., 2015). This may enhance the chances of acquiring new diseases in an individual's body system. Most of the animals that are raised are livestock and are usually closely associated with humans, hence making contact easy between humans and animals. Civitello et al. (2015) note that factory farming, for instance, involves rearing large numbers of animals together and hence, different herds get infected easily and concurrently (Civitello et al., 2015).

2.11. WILD ANIMALS AND RE-EMERGING ZOONOSES

Habitat loss, globalization, climate change, the emergence of new diseases, extinction of species, and loss of species diversity can alter the dynamic of one health system. This disturbance may eventually lead to changes in the patterns or presentation of zoonotic diseases that are different from the initial presentations. According to Roux et al. (2013), wild animals, including mammals, reptiles, wild birds, fish, amphibians, and other species, harbour Zoonotic diseases, which are diseases that could be transmitted to man or other different animal species (Roux et al., 2013). This is worrisome because wild animals are assumed to be involved in the genesis or, at the very least, the transmission of zoonotic diseases. Chaisiri et al. (2017) have identified that pathogen type plays a significant role in the patterns of transmission of animal zoonoses and weather factors, including temperature, humidity, and rainfall. These viruses' transmission patterns between birds, livestock, and humans are the determinants of when and if those first appear and if they re-emerge (Chaisiri et al., 2017).

The subsequent elements influence these procedures The possible ways include (1) the increase in the human population rate; (2) consumption of bush meat; (3) increased contact between humans and animals; (4) careless handling and transport of carcasses; (5) wildlife domestication; (6) ease of travelling locally and internationally; and (7) variation in methods of rearing livestock. According to investigations by Zhang, while constructing and recreating novel diseases, human-to-wildlife transmission is relatively standard. Most zoonotic diseases that occur in humans are acquired from wildlife either through contact or indirectly because of the use of vectors. This is so evident with lyssavirus, hantaviruses, the Nipah virus, the WN virus, and the agents that cause leptospirosis and ehrlichiosis, among others. Social transmission is cited as one of the causes of different diseases such as coronavirus the Ebola virus, and HIV is the transmission of the virus from one person to another (Blaizot et al., 2020).

3. Spill-Over and Spill-Back

Infectious agents may spread from reservoir animal populations, which are often farmed animals, to sympatric wildlife via a process known as spill-over. This process is the driving force behind the formation of a wide variety of wildlife EIDs. In the case of endangered species, spill-over poses a particular risk since the presence of infected reservoir hosts might reduce the threshold density of the virus, which can ultimately result in the extinction of the population at the local level. Since the 1960s, there has been a downward trend in the populations of the African wild dog, also known as Lycaon pictus (Bucci et al., 2022). The current population of this species is fewer than 5000 individuals, making it vulnerable to random occurrences such as the spread of illness. As a result, this species is currently considered endangered. In 1991, wild dogs in the Serengeti went extinct, which coincided with the outbreak of epizootic canine distemper in sympatric domestic dogs (Spinage & Spinage, 2012). There have also been cases of rabies that have resulted in the death of wild dogs, and a viral variation that is typical of sympatric domestic dogs has been found in one of these cases. There is a possibility that the appearance and effect of rabies in wild dogs in the Serengeti might be attributed to the geographical expansion of human populations and the subsequent incursion of domestic dog carriers. Spill-over epizootic outbreaks pose a significant risk not only to wild animals but also via the process of reverse spill-over, often known as "spill-back," to sympatric populations of domesticated animals that are vulnerable to the disease (Vicente et al., 2021). The disease known as brucellosis most likely arrived in the United States via cattle. The occurrence of this illness in elk and bison at Yellowstone National Park, which is located in the United States, is regarded to be a possible hazard to domesticated cattle that are grazing inside the park limits. There are also other instances of spill-over illnesses, such as sarcoptic mange in foxes (Europe) and wombats (Australia), as well as bovine TB (an international disease). The latter poses a risk of spreading to domestic cattle and, eventually, to people living in the United States (Daszak et al., 2000).

Table 2: Summary of EIDs with host and factors related to emergence.

Sr. NO	EIDs and class of EID	Pathogen	Host	Factors associated with Emergence
1	Hantavirus pulmonary syndrome 1	Bunyaviruses such as Sin Nombre and other hantavirus strains	Humans, *Peromyscus* spp., and other rodents	ENSO event and human encroachment
2	Cryptosporidiosis 4	*Cryptosporidium Parvum* (protozoan parasite)	Cattle, wild rodents, humans, and other animals	Farming methods, HIV emergence, and interspecies transmission
3	Hendra virus disease 1	Hendra virus (paramyxovirus)	Fruit bat reservoir, humans, and horses	Unknown
4	Marburg virus and Ebola virus hemorrhagic fever 1	Marburg and Ebola	Both nonhuman primates and humans, as well as potential insectivorous or fruit bat reservoirs	Ebola: interaction with infected human or animal corpses or patients; Marburg: transfer of diseased monkeys for laboratory study
5	Canine distemper 3	Canine distemper virus (morbillivirus)	a large variety of carnivores	Spill-over from domesticated dogs
6	Varroasis 2	*Varroa jacobsoni*	Both armed and wild honeybees	Host introduction into the enzootic zone
7	Plague 4	*Yersinia pestis* (bacterium)	Humans and many other mammals, particularly rodents, as hosts	Enzootic foci are remnants of the last panzootic outbreak in
8	Canine parvovirus disease 1	Canine parvovirus	Canids	Evolution of novel strain, contact with domestic dogs
9	Pneumonia	Ophidian paramyxovirus	Snakes	Unknown
10	Sarcoptic mange 2	*Sarcoptes scabiei* (mite)	Mammals	Dispersal of infected wildlife; Domestic dog wildlife interactions
11	Steinhausiosis	*Steinhausia* sp. (protozoan parasite)	*Partula* snails	Unknown
12	Neurotropic velogenic Newcastle disease 2	Newcastle disease Virus (paramyxovirus)	Double-crested cormorants, pelicans, gulls, poultry	Unknown
13	Viral chorioretinitis ÒKangaroo blindness 1	Wallal virus and ossibly Warrego virus; vector-borne orbivirus	Kangaroo spp.	Unknown; possibly weather-related

4. Surveillance and Detection of Emerging Infectious Diseases in Animals

One of the most important aspects of reducing possible risks to public health is the surveillance and detection of EID in animals. A thorough One Health approach is needed due to the intricate relationship of ecosystems, human health, and animal health. In addition to recognizing the reciprocal impact of environmental, animal, and human health, this approach encourages a transdisciplinary, multi-sectoral system for disease surveillance (Asaaga et al., 2022). Effective surveillance is an essential component of rapid disease control, as early detection of emerging occurrences is critical. Whether the disease is present or not will determine the precise goals that should be pursued while formulating and carrying out infectious disease monitoring (Cameron et al., 2014). Species, subpopulations, production systems, or demographic groupings that are more likely to acquire an infection are the focus of risk-based surveillance (Stärk et al., 2006).

4.1. Recent Technological Advancement

New technological developments have greatly improved the ability to detect and monitor infectious diseases in animals. A key instrument in the genomic surveillance of pathogens is whole genome sequencing (WGS). Real-time monitoring and enhanced risk assessment are now possible due to the incorporation of this technology into larger surveillance systems for antimicrobial resistance (AMR) and other diseases (Suminda et al., 2022). Artificial intelligence (AI) and digital tools have also been included in recent surveillance systems to facilitate data sharing, analysis, and acquisition. These technological advancements provide expedited detection of epidemics and accurate estimation of disease propagation. In order to identify errors that can point to the introduction of a novel virus, artificial intelligence (AI) algorithms are able to process enormous volumes of data from a variety of sources, including ecological sensors, veterinary records, and wildlife monitoring (Guo et al., 2023).

4.2. One Health Approach

The One Health concept demonstrates that cross-sectional coordination is essential for surveillance initiatives. This strategy is being used more and more in projects to improve data exchange and standardize practices across various industries, such as environmental agencies, veterinary services, and public health (Bidaisee & Macpherson, 2014). Efficient surveillance systems for One Health enable prompt actions to avert extensive epidemics by facilitating the early detection of zoonotic infections (Singh et al., 2024). The recent identification of avian influenza subtypes like H5N6 and H9N2 in China highlights the ongoing threat posed by zoonotic influenza viruses. When these viruses develop mutations that allow for human-to-human transmission, they have the potential to increase human morbidity and mortality [50] seriously. Further evidence of the crucial requirement for ongoing surveillance and prompt action has come from anthrax outbreaks in African nations like Zambia and Uganda. To effectively manage and restrict such outbreaks, the unrestricted movement of humans and animals between regions requires a coordinated response (Nalishuwa et al., 2024).

Different regions have varying capacities for surveillance, which is one of the main challenges. The infrastructure and funding required for deploying cutting-edge surveillance systems are frequently lacking in developing countries (Buckee et al., 2018). Enhancing laboratory facilities, training staff in contemporary surveillance strategies, and building local capacities all require funding as well as assistance from overseas. It is crucial to manage the ethical implications of data sharing properly. For the betterment of world health, sharing surveillance data is essential, but it must be done in a way that respects individual privacy and adheres to moral principles (Kalkman et al., 2019). The protection of the world's health depends on surveillance and identification of newly emerging infectious diseases in animals. We can improve our capacity to identify and counter these threats by utilizing innovative technology, implementing a One Health strategy, and resolving issues with data exchange and capacity (McArthur, 2019).

5.. Prevention and Control Strategies for Emerging Infectious Diseases in Animals

Protecting the health of animals and the general public requires effective prevention and control measures for newly emerging infectious diseases in animals. Significant strategies include immunization and vaccination campaigns, as well as biosafety procedures and quarantine restrictions.

5.1. Vaccination and Immunization Programs

One of the main preventive strategies is vaccination, which drastically decreases the prevalence and spread of infectious diseases among the populations of animals. These measures limit disease incidence and prevent transfer to humans by increasing immunity within animals. Recombinant and mRNA vaccines, among other recent developments in vaccine manufacturing, provide higher efficacy and flexibility towards emerging infections (Maruggi et al., 2019).

5.1.1. Vaccine Development

The management of diseases affecting poultry and animals depends on widespread immunization campaigns. Fast immunization of large populations is the goal of mass vaccination campaigns, which help to limit the spread of disease and develop herd immunity (Trovato et al., 2020).

Cattle vaccination initiatives against foot-and-mouth disease have contributed to the restoration of trade and economic stability by preventing widespread outbreaks. Strategies for immunizing poultry against avian influenza have also proven crucial in preventing outbreaks and reducing financial losses (He & Kam, 2024).

5.1.2. Vaccination Campaigns

The management of diseases affecting poultry and animals depends on widespread immunization campaigns. Fast immunization of large populations is the goal of mass vaccination campaigns, which help to limit the spread of disease and develop herd immunity [56].

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5.1.3. Booster Programs

Maintaining immunization requires both the establishment of booster programs and ongoing evaluations of vaccine efficacy. Based on surveillance data, booster vaccinations are recommended when new pathogen strains appear in areas with high disease stress (Endale et al., 2022). It is ensured that animal populations are safeguarded against ever-changing threats by routinely updating vaccination methods based on surveillance results.

5.2. Quarantine Measures and Biosafety Protocols

Biosafety procedures and quarantine regulations are essential for managing and preventing the spread of infectious diseases in animals. These measures emphasize controlling animal movement, keeping high standards of hygiene, and isolating afflicted animals in order to prevent the spread of disease (Collett et al., 2020).

5.2.1. Quarantine Measures

Limiting the spread of new EIDs in animals requires the implementation of quarantine measures, which include isolating and restricting animal mobility. In order to prevent the spread of zoonotic diseases to humans and to prevent outbreaks, quarantine is a crucial part of biosecurity approaches (Yadav et al., 2020). It is particularly essential to isolate affected animals in cases of diseases like foot-and-mouth disease, African swine fever, and avian influenza that have high rates

of transmission or severe effects on animal health. Disease outbreaks result from high economic losses due to a decrease in productivity, trade restrictions and the expenses of managing and eliminating diseases (Baker et al., 2022).

5.2.2. Quarantine Implementation

1. The first step of quarantine measures is quick detection and isolation of affected animals through veterinary examinations and diagnostic testing.
2. To stop the spread of contagious diseases, movement limitations must be established. Limiting the movement of animals, animal products, and potentially contaminated items like feed, tools, and automobiles is also included (Collett et al., 2020).
3. Controlled entry and exit points facilitate the management and observation of animal and human activity within quarantine areas.
4. It is essential to conduct ongoing surveillance and monitoring of animals under quarantine in order to monitor the disease's progression and determine whether the quarantine is effective (Li et al., 2021).

Quarantine buildings, testing labs, and skilled staff are some of the necessary infrastructure and resources needed for an effective quarantine. The implementation and maintenance of efficient quarantine measures can be complex in many areas, particularly in poor nations, due to a lack of resources (Benjamin et al., 2006). To ensure compliance, farmers, veterinarians, and animal handlers must be made aware of the significance of quarantine, and regulations must be enforced by inspections and fines (Otte et al., 2004).

5.2.3. Biosafety Protocols

The entry and transmission of infectious diseases within animal populations, as well as from animals to people, are prevented by the implementation of biosafety standards. High standards of hygiene, containment, and biosecurity in animal husbandry and associated operations are ensured by these protocols, which include a broad range of procedures (Neumann, 2012). One essential component of biosafety is the use of personal protective equipment (PPE) by individuals who work with animals. PPE acts as a defense against infections and includes items like gloves, masks, and coveralls (Singh et al., 2020). Biosafety relies on efficient waste management procedures. This concerns the secure disposal of animal carcasses, waste materials, and other possibly infected items. In order to stop infections from waste products from spreading to other animals or the environment, proper disposal techniques like deep burial or incineration are used (Gwyther et al., 2011). In order to prevent infections from entering the food chain, biosafety precautions are also applied throughout the handling and processing of animal products.

6. One Health Approach: Future Directions in Research and Management of Emerging Infectious Diseases in Animals

Animal-borne emerging infectious diseases (EIDs) pose a severe risk to biodiversity, economy, and public health. In order to deal with these issues, the One Health approach—which acknowledges the interdependence of environmental, animal, and human health—is essential (Aiyar & Pingali, 2020). At the cross-section of humans, animals, and the environment, this comprehensive framework fosters multidisciplinary cooperation and integrative approaches for the prevention, detection, and response to infectious disease risks. Through the perspective of the One Health concept, this thorough review examines the future paths in research and management of EIDs in animals, emphasizing crucial issues, including monitoring, diagnostics, immunization, antibiotic resistance, and policy development (Matias, 2024).

6.1. Surveillance and Early Detection

Establishing robust monitoring systems is essential to controlling EIDs in animals. The creation and deployment of resilient, real-time monitoring networks that incorporate data from several sources, such as the veterinary, medical, and environmental domains, must be given top priority in the future of One Health research (Morse et al., 2012). Technological innovations like bioinformatics and genetic sequencing have hitherto unseen possibilities to improve pathogen monitoring and detection. Effective measures are made possible by the swift detection of infections and their routes of transmission made possible by genomic epidemiology (Wolking & Mazet, 2022). Furthermore, surveillance systems that use artificial intelligence (AI) and machine learning (ML) can better predict disease outbreaks. These technologies enable preemptive actions by identifying trends and risk factors linked to EIDs through the analysis of massive databases. In order to improve these models' precision and dependability in forecasting epidemics and directing resource distribution, research should concentrate on enhancing them (Redding et al., 2019)..

6.2. Innovative Diagnostics

Effective therapy of EIDs in animals depends on prompt and precise diagnosis. The creation of quick, affordable, and user-friendly point-of-care diagnostic instruments needs to be the top priority for future research (Parida et al., 2008). Pathogen detection has been transformed by molecular methods such as loop-mediated isothermal amplification (LAMP) and polymerase chain reaction (PCR). Nonetheless, further innovation is required to create multiplex diagnostic systems that can identify many diseases at once (Venkatesan et al., 2022). Biosensors and microfluidic devices are examples of nanotechnology-based diagnostics that show potential for improving diagnostic performance. These methods allow for the identification of low pathogen loads in a variety of samples due to their great sensitivity and specificity (Sulaiman, 2024). Furthermore, the application of metagenomic techniques can offer a comprehensive understanding of the microbial communities connected to EIDs, assisting in the identification of new diseases and comprehension of their ecology (Hasan, 2013).

6.3. Vaccination Strategies

One of the most valuable methods for managing and preventing transmissible diseases is vaccination. Research on One Health should concentrate on creating new vaccines that are effective, reliable, and capable of offering protection across a wide range of conditions in the future. Reverse and structural vaccinology are two advances in vaccine science that make it possible to create vaccinations that target conserved epitopes in a variety of pathogen strains (Plotkin & Plotkin, 2011). Novel vaccine methods for delivery, such as DNA/RNA vaccines and vaccinations based on nanoparticles, should also be investigated in research because they have demonstrated potential in recent trials (Stefanetti et al., 2022). These systems have the potential to improve vaccination immunogenicity, stability, and administration simplicity. Moreover, vaccination campaigns can be streamlined by the creation of multivalent vaccines, which offer simultaneous protection against several infections, especially in environments with limited resources (Khan et al., 2024).

6.4. Addressing Antimicrobial Resistance

Animal EID control is seriously threatened by AMR. The establishment and dissemination of resistant infections are facilitated by the overuse and abuse of antibiotics in veterinary practice. In order to counteract AMR, future research should concentrate on comprehending the mechanisms of resistance and developing substitute tactics (Laxminarayan et al., 2016). The creation of new antimicrobial agents that can target resistant bacteria, such as bacteriophages, antimicrobial peptides, and phytochemicals, is one potential strategy (Wright, 2010). Additionally, one possible tactic to lessen dependency on antibiotics is the use of probiotics and prebiotics to modify the gut microbiota and improve host immunity. Along with developing mitigation plans, research should examine how environmental issues like pollution and climate change contribute to the spread of

AMR (Baquero et al., 2021).

6.5. Integrative Policy Development

Extensive regulations that take into account the health of people, animals, and the environment are necessary for the efficient management of EIDs in animals. The development of evidence-based policies that support One Health concepts locally, nationally, and worldwide should be the main emphasis of future study. This entails fortifying the legal frameworks governing immunization, antibiotic usage, diagnostics, and disease surveillance (Zinsstag et al., 2011). The effective execution of One Health programs necessitates cooperation among stakeholders, including government agencies, non-governmental organizations, academia, and the commercial sector (Gebreyes et al., 2014). One Health task groups and committees are examples of methods that should be investigated in research to improve collaboration and involvement among stakeholders. Furthermore, specialist skill sets and knowledge may be enhanced via capacity-building efforts, including training courses and workshops for those working on One Health projects (Adnyana, 2024).

6.6. Environmental and Ecological Considerations

The wellness of ecosystems is intrinsically related to the health of humans and animals. The natural course of infectious illnesses can be altered by habitat degradation, loss of biodiversity, and changes in the climate, which can promote the formation and spread of EIDs. Future studies should concentrate on comprehending the environmental causes of EIDs and creating plans to lessen their effects (Patz et al., 2004). Techniques for remote sensing and ecological simulation can offer critical new perspectives on the connection between disease progression and changes in the environment. These resources can be used to pinpoint high-risk locations and direct focused efforts (Altizer et al., 2013). Furthermore, conservation initiatives like wildlife preservation and habitat restoration can lower the chance of pathogens spreading from animals to people. The function of ecosystem services, such as pollination and water purification, in preserving health and resistance to EIDs should also be investigated in research (Ostfeld et al., 2020).

6.7. Interdisciplinary Education and Training

A multidisciplinary workforce is necessary for the One Health concept to be implemented successfully. Future studies should concentrate on creating curricula that support practitioners in veterinary medicine, public health, environmental science, and allied professions in acquiring One Health competencies. These courses ought to stress the value of teamwork and include hands-on instruction in AMR management, monitoring, diagnosis, and immunization (Steele, 2021). Additionally, studies should look into cutting-edge approaches to One Health education delivery, such as virtual simulations, online courses, and multidisciplinary workshops. These methods can improve accessibility and involvement, especially in environments with limited resources (Rüegg et al., 2018). Future One Health professionals might benefit from excellent practical experience and cooperation opportunities offered by mentoring programs and cross-disciplinary internships.

6.8. Global Collaboration and Data Sharing

Global cooperation, along with data exchange, is necessary due to the worldwide nature of EIDs. The development of frameworks and platforms that enable the cross-border flow of resources and information should be the main emphasis of future studies (Mackenzie et al., 2013). Creating international databases for pathogen genomes, surveillance information, and trends of antibiotic resistance are some examples of this (Jones & Jeffery, 2023). Coordination and the exchange of best practices may be significantly aided by cooperative organizations like the One Health Global Network and the Global Health Security Agenda (Mazet et al., 2009). Methods to improve the efficiency of these systems, such as regulated data-gathering methods and information exchange between systems, should be the subject of future research. Furthermore, current information collecting, processing, and transmission can be improved through the application of technological

advances like cloud computing and mobile health (mHealth) apps (Berrian et al., 2020).

The One Health strategy provides a thorough framework for handling the intricate problems brought on by newly developing transmissible diseases in animals. Exploration and management efforts should be given high priority to developing cutting-edge instruments for surveillance and diagnosis, creative immunization plans, and other tactics to fight antibiotic resistance in the future. A sustainable One Health plan must include multidisciplinary education, global collaboration, ecological and environmental issues, and integrative policy creation. The international community can protect the well-being of people, animals, and ecosystems by adopting these prospects for the future and strengthening its ability to avoid, recognize, and react to EIDs.

7. Summary

Emerging infectious diseases (EIDs) are contagious illnesses that have been identified or present in the past but are increasing in cases or geographic ranges. Vaccines have the potential to eradicate many diseases and prevent their spread. The interdependence of humans and the natural world is crucial in addressing EIDs, which can have significant impacts on people's health, social, and economic well-being. Factors contributing to the emergence of EIDs include demographic transitions, global travel, business, and climate change. Antimicrobial resistance (AMR) poses a significant threat to animal EID control, and future research should focus on understanding resistance mechanisms and developing alternative tactics. Intensive livestock farming practices can lead to the spread of diseases among animals, as they expose them to high stress, compromised biosecurity measures, and poor biosafety. This can compromise the immune status of animals, increasing their susceptibility to diseases. Inadequate disease surveillance and monitoring systems can also contribute to the spread of diseases. Socioeconomic factors like poverty, poor animal treatment methods, and poor economic conditions can complicate disease surveillance and preventive measures. Global trade and travel can also contribute to the spread of diseases. Changes in land use and agriculture practices can affect livestock, wildlife, and people, increasing the risk of acquiring new diseases. Wild animals, including mammals, reptiles, birds, fish, amphibians, and other species, harbor zoonotic diseases that can be transmitted to humans or other animal species. A sustainable One Health plan should include multidisciplinary education, global collaboration, ecological and environmental issues, and integrative policy creation. Technological advancements have improved the detection and monitoring of infectious diseases in animals, with whole genome sequencing (WGS) and artificial intelligence (AI) playing key roles in genomic surveillance. The One Health approach emphasizes cross-sectional coordination for surveillance initiatives, enabling prompt actions to prevent extensive epidemics. However, developing countries often lack the infrastructure and funding to deploy advanced surveillance systems.

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