Zoonotic Diseases: Emerging Threats to Public Health and Livestock Production

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ABSTRACT

Zoonoses are diseases that transmit between humans and animals. The three types include endemic, epidemic, and emerging/re-emerging. Endemic diseases are common and affect many people and animals. Epidemic diseases occur sporadically. Emerging/re-emerging diseases are new or expanding rapidly in incidence or geographic range. This study investigates the intricate relationships between people, animals, and the environment, and the ongoing threat to human health posed by zoonotic illnesses. The research examines the factors leading to the emergence, spread, and global impact of these diseases. These include globalization, habitat degradation, climate change, increased human-animal contact, and antibiotic resistance. Early detection and treatment of infections are hindered by the fast development and adaptability of pathogens. Effective response plans require international collaboration and multidisciplinary approaches. To prevent future outbreaks, it is crucial to understand the ecological, socioeconomic, and environmental factors that contribute to zoonotic diseases. This chapter discusses various zoonotic diseases, their causes, transmission mechanisms, and prevention practices. It emphasizes the importance of international collaboration and multidisciplinary methods in reducing the risks of emerging zoonotic illnesses and safeguarding global public health.

Keywords: Antibiotic resistance, climate change, ecosystem change, habitat degradation, one health, pandemic, zoonotic disease

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1. INTRODUCTION

Zoonosis accounts for approximately two-thirds of human infections and roughly three-quarters of newly emerging and re-emerging human diseases (Ear 2012). Some of the emerging diseases that have gotten much attention from the media and, in the case of pandemic influenza A H1N1 and avian influenza, many resources include West Nile virus, Bovine Spongiform Encephalopathy (BSE), SARS, and Nipah virus (Lashley 2006). A complex interplay of various factors influences the rise of new infectious diseases. These include population growth, changes in dietary habits, agricultural practices, commercial activities, and land use alterations, such as rapid urbanization, deforestation, and encroachment on wildlife habitats (Bousfield and Brown 2011).

Moreover, certain historical zoonotic diseases like anthrax, rabies, brucellosis, zoonotic trypanosomiasis, bovine tuberculosis, and disorders related to tapeworm infections are re-emerging and becoming more prevalent. This resurgence can be attributed to several interconnected reasons, one of which is the transmission of pathogens from wild animals to domestic animals (Elelu et al. 2019; Rahman et al. 2020). With the increasing complexity of food chains and various systems involved in food production and preparation, the importance of food-borne zoonotic diseases like Salmonella, Escherichia coli, and Campylobacter infections, all associated with livestock production and processing, is growing (Abebe et al. 2020). However, this is expected to impact pathogen diversity, range, distribution, and potential morbidity (Ali and Alsayeqh 2022). The exact influence of climate change on this intricate interplay of factors remains uncertain.

These findings elicit two critical questions. Why do these problems keep getting worse and worse? And how should we control and manage them? We also offer a conceptual framework for an analytical approach that may be used to direct research into so-called one-health concerns and guide legislation. We emphasize the significant transformations in livestock systems and how they impact infectious diseases. To achieve optimal health outcomes for humans, animals, and the environment, various disciplines must collaborate across local, national, and international borders. One-health's integrated approach represents the initiative to address these interconnected health challenges (Coker et al. 2011).

The interconnectedness of wildlife, people, domestic animals, and the environment is crucial in maintaining and spreading infectious diseases (Thompson and Polley 2014). For a long time, wildlife has been singled out as the main culprit for the emergence of zoonotic illnesses in humans, though this accusation may not be entirely fair (Blancou et al. 2005). In recent times, the fields of medicine, veterinary medicine, and wildlife science have come to understand that the transmission of diseases is more intricate and not strictly one-sided. The distribution of species and the ecological interactions between humans, animals, and habitats are drastically changing due to anthropogenically altered landscapes and climate change (Thompson 2013). At a rate unmatched in history, purposeful and accidental globalization is simultaneously spreading organisms throughout the globe. These changes risk human health, wildlife, and animal production systems (Thompson and Kutz 2019). Fig. 1 shows the zoonotic transfer of the pathogens.

The science of wildlife parasitology has developed into a considerably more complicated discipline due to increased knowledge of the significance of parasites as evolutionary drivers and determinants of population health. Previously, it was primarily concerned with classical parasitology, taxonomy, and case studies. A deeper understanding of the parasitological interactions between people and animals has been gained thanks to increased disease monitoring in wildlife, advanced disease ecology modeling, and the widespread use of genetic technologies. Findings support the idea that wildlife may not always be the source of zoonoses and frequently become the unwitting victims of interspecies parasite transmission, spill-back, or reverse zoonotic (zooanthroponotic) transmission (Lloyd-Smith et al. 2009). These findings show a much higher diversity of parasites than was previously believed.

2. EMERGING ZOONOTIC DISEASES

2.1. BACTERIAL ZOONOSES

There are several methods through which bacterial zoonotic infections can be transmitted from animals to people (Cantas and Suer 2014). Zoonotic bacteria from food animals can infect humans through direct fecal-oral routes, contaminated animal products, improper food handling, and inadequate cooking (Ali and Alsayeqh 2022; Logue et al. 2017; Roe and Pillai 2003). Animal health professionals (veterinarians) and farmers are more likely to come into contact with some zoonotic infections, contract them, and perhaps spread them to others. In soil and water contaminated with manure, there is a wide variety of zoonotic bacteria, which raises the risk of zoonotic infections and expands the pool of resistance genes available for the transmission of bacteria responsible for human diseases (Polley et al. 2022; Schauss et al. 2009).

Bacterial infections are zoonotic diseases that can resurface even after being considered eliminated or controlled. Another worldwide public health issue that is getting worse is the emergence of antimicrobial resistance from excessive or improper use of antibiotics. These illnesses have a detrimental effect on international trade, travel, and the economy. Antibiotic-resistant zoonotic bacterial infections are particularly relevant for at-risk populations in most industrialized countries, including the young, aged, pregnant women, and impaired immune systems (Acha and Szyfres 2001). In the past, bacterial zoonotic diseases such as bovine TB, the bubonic plague, and glanders caused millions of human deaths before hygiene regulations, vaccinations, and antibiotics were introduced. Today, there is a global rise in the prevalence and importance of several bacterial zoonoses. To ensure the most effective preventive measures for public health, many developing nations are investing more resources in enhancing the screening of animal products and bacterial reservoirs or vectors (Blancou et al. 2005).

The detection of newly developing zoonotic illnesses has risen due to advancements in monitoring and diagnostics. Here, changes in our way of life and increased animal interactions have exacerbated or brought back several bacterial illnesses. Recent research indicates that the risk of contracting bacterial zoonotic diseases is higher than ever (Messenger et al. 2014). This is likely due to increased interactions with adopted small animals that have become part of households and are treated like family members. On the other hand, in our modern globalized world, intensified animal farms play a significant role in the food supply, making them primary sources of food-borne bacterial zoonotic diseases (Logue et al. 2017; Roe and Pillai 2003; Zambori et al. 2013).

People with close contact with many animals, such as farmers, slaughterhouse workers, zoo/pet store employees, and veterinarians, are more susceptible to zoonotic diseases. The zoonoses that household pets can spread pose a threat to the general public as well. Humans are frequently exposed to zoonotic bacterial illnesses through animal bites and scratches. Pit bull breeds, malamutes, chows, rottweilers,

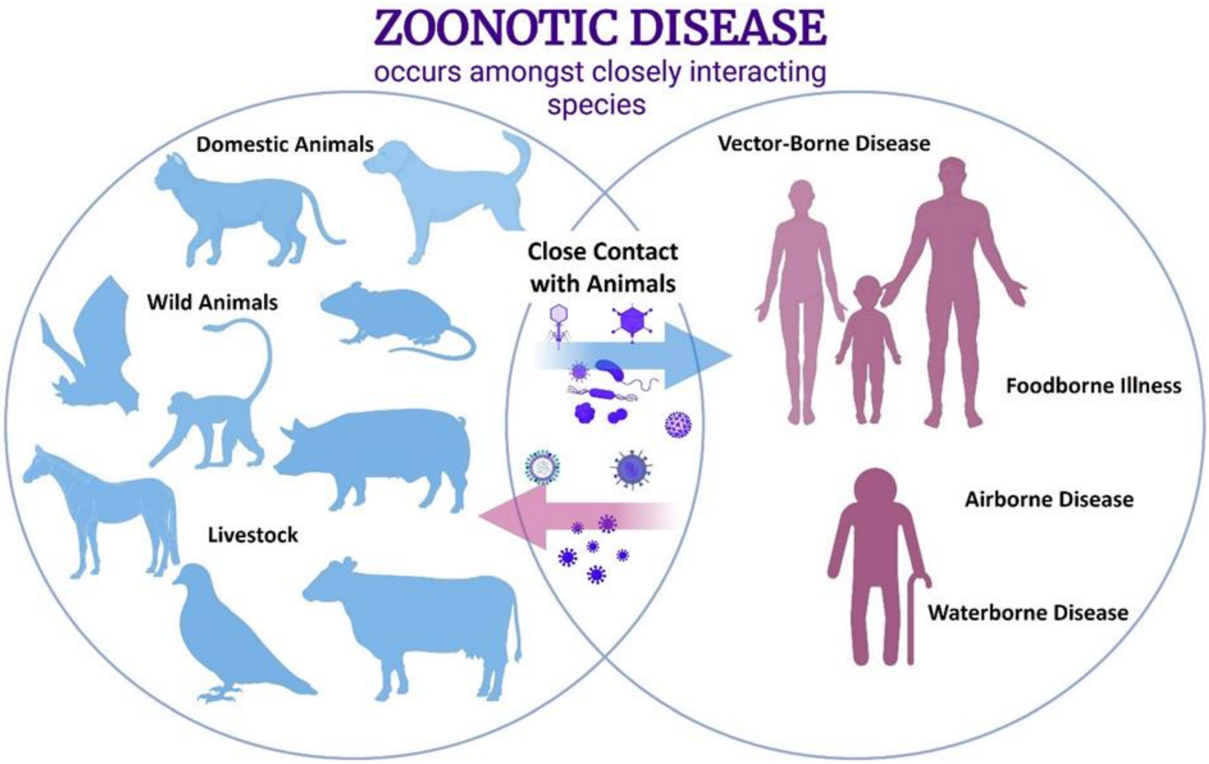

Fig. 1: Zoonotic transfer of pathogens occurs when close contact encourages species-jumping transmission between animals such as domestics, wildlife, or livestock—and humans. This transmission can be in the form of vector intermediates, ingestion of contaminated food or drinks, or the inhalation of droplets. (Esposito et al. 2022).

huskies, German shepherds, and wolf hybrids are only a few of the dog breeds that have been identified for their role in stopping dog bite assaults (Cantas and Suer 2014). In the USA, nearly half of the zoonotic diseases resulting from dog bites were caused by pit bull breeds, which are 3 times more common than German shepherds. Healthy dogs and cats carry hundreds of harmful bacteria, including Pasteurella sp, in their oral cavities. Overall, only 20% of dog bites lead to infections, while cat bites result in infections about 60% of the time (Bula-Rudas and Olcott 2018).

A cat bite carries a ten times greater chance of contracting *Pasteurella multocida* infection than a dog bite. Bite wounds infected with *P. multocida* typically develop within 8 hours (Morgan, 2005; Morgan and Palmer, 2007). Human infections from animal bites or scratches are thought to occur in about 20% of cases (Zambori et al. 2013). Human pet bite diseases are reported to include bacteria like the animals' oral microbiota. *P. multocida* (50%), *Staphylococcus sp* (46%), together with alpha-hemolytic *Streptococcus sp* (46%), *Neisseria sp* (32%), and *Corynebacterium sp* (12%), typically dominate infections in dog bite wounds. However, *Fusobacterium nucleatum* (16%), *Propionibacterium acnes* (14%), *Prevotella heparinolytica* (14%), *Peptostreptococcus anaerobius* (8%), and *Prevotella intermedia* (8%), and are also isolated from infected wounds (Morgan and Palmer 2007).

In people who have been bitten, the bacteria causing the infection often differ from the normal bacteria found on human skin or other environmental germs (Abrahamian and Goldstein 2011; Morgan and Palmer 2007).

An infection develops 8 to 24 hours after an animal assault, with varying degrees of discomfort at the injured site. Pus-containing discharge, which can occasionally smell bad, may come after the cellulitis. Patients with immune suppression, diabetes, or liver disease are particularly vulnerable to developing life-threatening illnesses due to animal bites. Patients could have bacteremia in certain circumstances and perish away more quickly (Zambori et al. 2013). Bites that penetrate near the joints and bones can lead to conditions like septic arthritis and osteomyelitis. To comprehend the chronicity of human wounds, it is crucial to understand how dental plaque biofilm develops in dogs' mouths (Kirketerp et al. 2011; Zambori et al. 2013).

In individuals, a clinical illness known as cat-scratch disease has been documented for over a century. But *Bartonella henselae*, the etiological agent that caused cat scratches and bites, wasn't discovered until 1992 (Stechenberg 2011). Bartonellosis can also be brought on by touching cat saliva on open sores or sclera. The earliest warning signs of a cat scratch are papules and pustules at the injury site. A persistent, non-healing wound, infrequent fever, weakened local lymphatic drainage, and abscession are possible disease-progression symptoms. The most at-risk groups are cat owners and veterinarians (Cantas and Suer 2014). Most of the time, individuals with weakened immune systems require comprehensive medical care. Otherwise, granulomatous conjunctivitis, osteomyelitis, and encephalopathy might manifest (Slater 2000).

Since the beginning of time, people and horses have had a strong association for recreational, athletic, and professional purposes. Over the past ten years, the number of horses per person in Europe has remained steady. Sweden has the most horses per person in the EU, whereas Germany and Great Britain have the most significant horse populations. In Europe, 3-5% of horse bite wounds are thought to be infectious (Cantas and Suer 2014). Horse bites are believed to make up as much as 20% of all animal bites in Turkey and come in second behind dog bites (70%) in frequency (Emet et al. 2009).

In contrast to small animal bites, most horse assaults may result in more severe muscular injury. Horse bites on humans have produced a variety of aerobic and anaerobic microbes often dominated by *Actinobacillus lignieresii* (Abrahamian and Goldstein 2011). E. coli and Bacteroides species have also been found in human illnesses with unpleasant odors and pus discharge from horse bites (Rycroft and Garside 2000).

Escherichia coli, Salmonella sp., *Shigella sp., Leptospira sp.,* and *Campylobacter sp.,* which cause infectious diarrhea in companion animals, can also spread to people via the fecal-oral route. Estimating the spread of these pervasive microbes is challenging. Nevertheless, it is widely recognized that these bacteria can exist in many healthy animals and persist long in their feces (Ahmad et al. 2023). In 2009, human cases of campylobacteriosis ranked as the most reported zoonotic bacterial infections among EU members (Lahuerta et al. 2011). They can induce gastroenteritis (vomiting and diarrhea), headaches, depression, and occasionally even death like many other entero-pathogens can. Feeding pets a raw food diet dramatically increases the chance that humans may become infected with gastrointestinal diseases and zoonotic bacterial enteropathogens (Cantas and Suer 2014).

Companion birds, also known as songbirds (such as finches, canaries, and sparrows) and Psittaciformes (such as parakeets, parrots, budgerigars, and love birds), are pretty common in Europe and are potential zoonotic disease vectors (Evans 2011). Some of them, such as chlamydophilosis (Vanrompay et al. 2007), campylobacteriosis (Wedderkopp et al. 2003), and salmonellosis (Carlson et al. 2011), may have a significant effect on human health. Birds' respiratory systems are home to the intracellular bacterium *Chlamydia psittaci,* which causes parrot fever (chlamydophilosis). The primary method of transmission to humans is by inhalation of the dander, dust, and nasal secretions of infected birds (Circella et al. 2011). Infected people may suffer moderate to severe flu-like symptoms, which might lead to a false-positive influenza diagnosis (Evans 2011).

In Europe, there are now more than 200 million animals raised for food on farms (including cattle, pigs, sheep, goats, and chickens). Farm animals are reservoirs for various zoonotic infections that affect humans (Wells et al. 2001; Lahuerta et al. 2011). However, each year, a significant number of pharmaceuticals are used around the globe to produce enough food to support a fast-expanding global population (Carvalho

2017). Farm animals worldwide consume a staggering 8 million kilograms of antibiotics yearly, while only one million kilograms are used annually in human medicine. Shockingly, 70% of the antibiotics used in animals are for non-therapeutic purposes such as growth promotion, a practice banned in the EU since January 2006. Additionally, some antibiotics are used for disease prevention in animals (Done et al. 2015). *Mycobacterium bovis (M. bovis)*, the cause of bovine TB, has been recognized globally. The infection's prevalence has significantly decreased due to decades of disease management activities. However, the USA continues to record hundreds of new cases of human TB (Miller and Sweeney 2013). The European badger in the United Kingdom (De la Rua-Domenech 2006), the elk in Canada (Wobeser 2009), and the white-tailed deer in the USA are three examples of wildlife where *M. bovis* has spread. Experience in Europe and the USA has demonstrated that *M. bovis* may be confined in cattle, but eradication is impossible once it has done so (O'Brien et al. 2006).

2.2. VIRAL ZOONOTIC DISEASE

According to the World Health Organization and most infectious disease specialists, wildlife is increasingly considered the primary source of zoonotic diseases that might cause the next human pandemic. While specific zoonoses originating in wildlife, such as rabies and avian influenza, are well documented, others have only recently arisen or been connected to animal reservoir species. The latter is exemplified by the Ebola virus, which was recently related to African cave-dwelling bats after decades of investigation. Like the SARS coronavirus, which killed over 800 people worldwide and cost over $60 billion, the SARS virus first appeared in civets and bats before spreading to humans in the wet markets and eateries of southern China (Leroy et al. 2005; Li et al. 2005). Middle East respiratory syndrome (MERS), which has recently emerged, serves as a reminder that while we must remain vigilant against known pathogens with pandemic potential, the next deadly pandemic could result from a zoonotic agent that is currently unknown or from one of the thousands of genetically identified agents with unknown pathogenic potential (Zaki et al. 2012).

There are several ways that zoonotic viruses might spread. They are "direct" or "indirect" contact (such as the rabies virus), "nosocomial" (such as the Ebola virus), "aerosol transmission" (such as the SARS coronavirus), "vertical" (in utero) (such as the Zika virus) and "vector- or arthropod-borne" (such as the yellow fever virus and the West Nile virus). All continents, save for maybe Antarctica, experience the spread of viral zoonotic diseases. Some can be discovered all over the world in various ecological environments. Others are confined to a small number of ecological and geographical focuses. Despite the number of zoonotic disease viruses in the hundreds, the significance of many of these viruses is unknown (Reed 2018).

Emerging infection outbreaks have occurred often since the turn of the century. Adenovirus, Middle East Respiratory Syndrome (MERS), Ebola Virus Disease (EVD), Coronavirus Disease 2019 (COVID-19), Monkeypox (MPOX), Lassa Virus (LASV), and Zika virus are only a few of the illnesses that are mainly brought on by animals (Manirambona et al. 2022; Alarcon-Valdes et al. 2022; Ahmad et al. 2023). These illnesses used to be known to harm animals, but today, they also affect people. We believe that important contributing causes to the origin and spread of viral zoonotic diseases include human activities, land use, livestock management practices, as well as the effects of climate change. We may lessen the danger of further epidemics and enhance public health by addressing these underlying causes (Haruna et al. 2023).

In December 2019, Wuhan, China, reported the first human case of COVID-19. Following the virus's global spread, almost 6.6 million people have died, and over 650 million COVID-19 infections have been confirmed (WHO 2022). The World Health Organization (WHO) labeled it a worldwide pandemic on the 20th of March 2020. This illness also worsens the health of those who already have coexisting diseases and interrupts socioeconomic activity, leading to economic downturns, the loss of employment, and other sources of income. Another epidemic of the monkeypox virus appeared and expanded rapidly while the COVID-19 pandemic was still causing devastation. As of the 22nd of December 2022, there were around 83,434 confirmed cases and 110 fatalities worldwide, according to the Centers for Disease Control and Prevention. Surprisingly, most instances occur in regions where the illness has never seen an outbreak. Similar to how deaths from monkeypox have also happened in non-endemic areas (CDC 2022). As a result, the WHO deemed it a Public Health Emergency of International Concern (PHEIC) on the 23rd of July, 2022. On 17th of July 2022, Ghana announced an outbreak of the zoonotic illness *Langya henipavirus* (LayV), linked to the Marburg and Nipah viruses and other zoonotic diseases of public health significance. EVD and the Marburg virus illness are connected. The EVD outbreak from 2013 to 2016 was the worst in recorded history, with most infections occurring in Guinea, Liberia, and Sierra Leone (WHO 2014). There are no particular therapies or vaccinations to help contain these viruses, even though they are unpredictable and have a high potential for epidemics. In addition to their strain on health systems, they alarmingly have a high case-fatality ratio (WHO 2014). Therefore, it is essential to address the causes of the overflow of these diseases as they continue to cross international borders and diseases that were formerly regional become global.

According to Alimi et al. (2021), the reasons that hasten the introduction of these illnesses include increased human-animal contact brought on by fast urbanization, the degradation of natural habitats, wildlife hunting, livestock raising, climate change, domestication of animals, and shifting ecosystems. Nipah virus (NiV) has been linked to many ailments. For instance, it may result in mild to severe encephalitis. Infecting people's respiratory systems and animals might lead to deadly infections. NiV can be spread between individuals and humans by bats or domestic animals (Ghareeb and Sultan 2021).

3. PARASITIC ZOONOTIC DISEASE

3.1. ZOONOTIC DISEASES CAUSED BY CESTODES, NEMATODES, AND TREMATODES:

3.1.1. CESTODES ZOONOSES

It is possible to define cestode zoonoses as "those cestode diseases which are naturally transmitted between (other) vertebrate animals and man." The Taeniidae family of zoonotic cestodes is of utmost significance in the developing world. For *Echinococcus granulosus*, most food-producing animals, including cattle, buffalo, sheep, goats, pigs, and several other mammals, serve as intermediate hosts (Xiao et al. 2013). Accidental ingestion of eggs secreted by Echinococcus species in the feces of the specific carnivorous host/animal might result in human infection (Dhaliwal et al. 2013). Taeniasis is a genuine zoonotic infection (Euzoonoses) in which humans serve as the definitive/final hosts.

In contrast, pigs and cattle serve as intermediate hosts for *Taenia solium* and *Taenia saginata*, respectively (Hemphill and Lundström-Stadelmann 2021). More than 100 human cases of coenurosis, a rare zoonosis, have been documented worldwide. Parasites like *Spirometra mansoni* and *Diphyllobothrium latum* are other significant cestodes (Dhaliwal et al. 2013). Epidemiological patterns of diphyllobothriasis have been recorded in different parts of the world. *Dipylidium caninum*, a parasite, can infect domestic dogs, cats, some wild predators, and on rare occasions, people. Sparganosis is an uncommon cestode zoonosis that can affect humans (Conboy 2009). The parasite has been discovered worldwide but is most frequently encountered in eastern Asia. Important cestodes, including *T. solium, E. granulosus*, and *D. latum,* are spread by food and water (Dorny et al. 2009).

3.1.2. NEMATODES ZOONOSES

Endemic angiostrongylosis is present in South Asia, the Pacific Islands, Australia, China, and the Caribbean Islands. At the same time, zoonotic ascariasis caused by *Ascarissuum* has been widely documented in North America and certain European nations. Raccoons' intestinal roundworm *Baylisascaris procyonis* has been linked to severe neurologic illness in humans (Roepstorff et al. 2011; Ahmad et al. 2023). Cutaneous larva migrans (CLM) in humans may result from the subcutaneous migration of animal hookworms. A zoonosis that is significant for public health is gnathostomiasis. Except for the deserts, most regions of the world have documented cases of trichinellosis. Non-industrialized nations must provide safe food and water to prevent and manage these illnesses (Otranto and Deplazes 2019). *Ancylostoma, Baylisascaris, Capillaria, Uncinaria, Strongyloides, Toxocara, Trichinella*, as well as arthropod vectors including *Dirofilaria spp., Onchocerca spp.,* and *Thelazia spp*. provides a danger of transmitting zoonotic nematodes from wild predators to people through food, water, and soil (Otranto and Deplazes 2019).

3.1.3. TREMATODES ZOONOSES

Several neglected trematode zoonotic infections are now thought to be severe human illnesses. Cercarial dermatitis results from the invasion of human skin by avian *schistosome cercariae*. The two main heterophyids that can transmit zoonotic diseases are *Metagonimusyokogawai* and *Heterophesheterophes*. Pigs appear to be the only proper natural host of the human disease-causing parasite Gastrodiscushominis. Fasciolosis affects animals mainly; however, 42 nations have also documented humans (Alba et al. 2021). Fasciolopsisbuski is a common parasite in several Southeast Asian countries. *Dicrocoelium dendriticum*-infected ants accidentally eaten by humans might make them sick. *Clonorchis sinensis* is East Asia's most significant fish-borne zoonoses among all liver flukes. Human fascioliasis is now categorized as a plant/food-borne trematode infection among zoonotic parasitic illnesses, with a greater frequency observed in agricultural communities in low-income countries (Mera y Sierra et al. 2011; Soliman 2008). The *Fasciola hepatica, Fasciola gigantica, Faciolopsis buski* (family Fasciolidae), *Watsonius watsoni, Gastrodiscoides hominis* (family Gastrodiscidae), and *Fischoederius elongatus* (family Paramphistomidae) are among the plant- and food-borne trematodes. The liver is infected with *Fasciola hepatica* and *F. gigantica* (Carrique-Mas and Bryant 2013).

3.1.4. FUNGAL ZOONOSES

Zoonotic fungi can pose serious public health risks and spread naturally between animals and people. Several mycoses linked to zoonotic transmission are among the most prevalent fungal infections globally. However, it is noteworthy that several fungal infections with zoonotic potential have yet to receive enough attention in global public health initiatives, resulting in inadequate attention to their preventative tactics (Seyedmousavi et al. 2015). Fungi infections linked to zoonotic and saprozoic transmission represent a significant public health issue (Akritidis 2011). Some of these infections are among the most prevalent fungal disorders, including histoplasmosis (Bonifaz et al. 2011), sporotrichosis (Barros et al. 2011; Yegneswaran et al. 2009), and dermatophytosis (Moretti et al. 2013). In this regard, it is noteworthy that several zoonotic-potential fungal infections have yet to receive enough attention from worldwide public health initiatives, resulting in a lack of focus on preventative measures. Mycotic infectious agents can be either true pathogens or opportunists from an evolutionary point of view (Köhler et al. 2017). From the same perspective, pathogens can be divided into obligatory pathogens (having host-to-host transmission) and environmental pathogens (having a saprobic but infectious phase in the environment). Infected tissue may develop invasive systemic environmental pathogenic fungus forms, such as Coccidioides' spherule or

Histoplasma's intracellular yeast (Bonifaz et al. 2011). Almost all fungi can survive for long periods in their environment, but diseases have an evolutionary advantage since they can employ vertebrate hosts as a vector for a portion of their life cycle. Humans are often only a secondary host for the fungus, with other animals serving as its primary target (Seyedmousavi et al. 2015).

3.1.5. PROTOZOAL ZOONOSES

A developing zoonotic protozoan illness called cryptosporidiosis has been found in both human and animal populations worldwide. The primary method of transmission is through the consumption of tainted food and water, and the illness is external in origin. In ambient water, where they can live for months, Cryptosporidium oocysts are numerous and spreading. It favors the epithelial cells present in the digestive tracts of various hosts (Pal et al. 2016). Several countries have had outbreaks worldwide due to waterborne transmission through drinking water or swimming pools. The illness may appear sporadic or widespread. Both immune-competent and immune-compromised persons have contracted the sickness (Pal et al. 2021).

A developing ciliated protozoan parasite of zoonotic significance called *Balantidium coli* (*B. coli*) causes the illness balantidiasis in a wide range of host animals, including swine, camels, ruminants, equines, and even humans. Due to ideal geo-climatic circumstances for the establishment and survival of the parasite, this illness has a worldwide distribution with high incidence rates in tropical and sub-tropical parts of the world (Ponce-Gordo and García-Rodríguez 2021). Pigs and other animals are the principal reservoir hosts for this disease; humans often become infected by consuming contaminated food or water. The afflicted animal displays anorexia, dehydration, excessive watery stool, and stunted development as clinical indicators (Ahmed et al. 2020).

3.1.6. RICKETTSIAL ZOONOSES

Globally, *Rickettsia felis,* an obligate intracellular microorganism, is becoming more widely acknowledged as the cause of human rickettsial illness (Brown and Macaluso 2016). There is currently no agreement on the pathogen's vertebrate reservoirs, which is essential for the continued existence of this agent in nature. The bite of an infected vector transmits the agent, the *Ctenocephalides felis* cat flea (Ng-Nguyen et al. 2020). As a re-emerging zoonosis of public health significance, epidemic typhus is brought on by the bioterrorist *Rickettsia prowazekii*. Millions of people died from epidemic typhus in previous ages in various regions of the world. The illness, spread by contaminated body louse feces, causes large outbreaks in congested and filthy populations. Several nations, including Burundi, have reported epidemic typhus outbreaks by louse bites—Uganda and the African countries of Ethiopia, Nigeria, Peru, and Rwanda. The main clinical symptoms of the illness include rash, headache, and fever. Test results must confirm the clinical diagnosis and must be distinguished from other diseases that cause febrile fever (Pal and Dave 2019).

3.1.7. MYCOPLASMA ZOONOSES

Infections in vertebrates that don't cause hemotropic mycoplasmas cause any symptoms. Some species, including *Mycoplasma haemofelis* in felines, *Mycoplasma haemomuris* in rodents, *Mycoplasma ovis* in caprines, and *Mycoplasma suis* in swine, can also produce moderate to putatively deadly hemolytic anemia (Neimark et al. 2001). Finally, many bats have hemotropic mycoplasmas (Volokhov et al. 2017). Hemotropic mycoplasmas, hitherto considered to be exclusive to animals, were first recognized to be human infections in the United States in 1972 (Jelani G et al. 2023). Haemobartonella-like forms were observed in the blood of patients with systemic lupus erythematosus.

4. FACTORS CONTRIBUTE TO THE EMERGENCE OF ZOONOSES

The establishment of zoonotic illnesses can be caused by various reasons (Walsh et al. 2020). Growing human and animal populations are frequently linked to increased infectious disease agent spread, making them apparent risk factors for new zoonotic risks. The relationships between viruses and their hosts, including the reservoir in a multi-host system, rely significantly on the environment they inhabit, and this environment is undergoing rapid changes. It must be emphasized that zoonoses always originate through a multifactorial process (Kosoy 2013). Changes in agricultural and trading techniques, human behavior, the distribution of animal vectors, and the genetics of the microbes and their hosts can all be a part of this process.

Assessing and comprehending the implications of these modifications on the dynamics between harmful microorganisms and their respective hosts, as well as among hosts and other animal populations such as cattle, wildlife, and humans, holds paramount significance. This comprehension will prove invaluable in formulating mitigation plans and expediting efficient responses to emerging scenarios. The pivotal role of these interactions in the resurgence of zoonotic diseases further underscores the necessity for diligent examination and proactive measures.

When the first infected person, known as the index case, spreads the infectious agent to multiple others, an illness can quickly escalate into an epidemic within a human community. To comprehend why certain viruses are more dangerous than others, it might be beneficial to conduct immunological research that examines the quantitative and qualitative variations in the balance between hosts and viruses in animal reservoirs. In local settings, places with frequent human-to-animal contact and heightened transmission risks include wet markets and slaughterhouses, which are vital for providing daily food supplies to billions of people. We observe shifting agricultural techniques or shifting farm management in various parts of the world. This encompasses agricultural modernization, especially in emerging nations, and continuous agrarian intensification in the West for more efficient output. Alongside the intensified agricultural practices, the alteration of habitats for grazing and cropping can significantly impact biodiversity and trigger the re-emergence of infectious diseases (Keesing et al. 2010). These agricultural factors play a pivotal role, yielding diverse outcomes by facilitating interactions between various wildlife species and leading to the cohabitation of wildlife and livestock, thereby creating opportunities for new pathogens to spread among vulnerable and unsuspecting species (Greger 2007).

Furthermore, the global air travel network has emerged as a conduit for the rapid dissemination of diseases across continents, exemplified by the occurrences of SARS-CoV in 2003 and, most recently, SARS-CoV-2. The movement of reservoir hosts and vectors through commerce and international travel can expedite the spread of infections (Morse et al. 2012). As human activities encroach further into virus-endemic regions, the incidence of illnesses caused by vector-borne viruses may increase, along with potential animal infections. Consuming bush meat is a typical traditional practice and dietary source in many countries. However, trading and handling live animals in marketplaces where different species are close can increase the risk of infection transmission (Greatorex et al. 2016). These activities have been linked to the initial transmission of SARS-CoV from a Chiroptera reservoir to amplifying hosts, including masked palm civets (Pagumalarvata). Additionally, according to Li et al. (2020) and Andersen et al. (2020), the transmission of SARS-CoV-2 from the animal reservoir to the human population may have been facilitated in 2019 through a wildlife market.

The life cycles of vectors, reservoirs, and pathogens are influenced by various intricate environmental processes, making them susceptible to the impacts of climate change and weather variations (Zinsstag et al. 2018). Changes to the temperature and environment may significantly affect the range of insect vectors. For instance, a virus previously isolated to one location may spread to another place with naïve populations of both animals and people. Climate change may bring prolonged droughts or heavy downpours, which might spread more mosquitoes. In urban areas, mosquitoes can spread more extensively because of factors like water storage facilities, swimming pools, and the transportation of old tires. As their vectors colonize new environments, zoonotic viruses like West Nile (WNV) and Rift Valley fever (RVFV) are increasingly spreading in many countries. Additionally, climate change can accelerate the release of specific pathogens from frozen soils in the northern regions, including the bacteria *Bacillus anthracis*. For more information on this, you can refer to the section on the bacteria *Bacillus anthracis* (Huber et al. 2020).

Several animal species, including rodents and bats, can carry numerous infections affecting human and veterinary health. Several species can multiply quickly to large populations, which might lead to unforeseen circumstances with substantial disease transmission risks. Environmental alterations, such as urbanization and climate change, significantly impact rodent populations (Bengis et al. 2004).

Wildlife is the primary reservoir and, frequently, the spreading factor for many new zoonotic illnesses (Yon et al. 2019). Some diseases spread to humans through direct contact or by the mediation of vectors. Still, actual pathogen transfer is uncommon, and human-to-human transmission keeps the illness within the community. Viruses can freely transmit between wild and domesticated animals, and commercial animal transportation can contribute to the spread of wild zoonoses (Bengis et al. 2004). Hotspots where zoonotic agents can be transmitted from animals to humans, include places or activities where people often interact with wildlife, such as bush-meat hunting, wet markets, deforestation zones, and bird migratory routes. The significant losses of wildlife habitat and changes in land usage have further increased the potential for transmission between wildlife, cattle, and humans. Human activity has altered more than 77% of the land (excluding Antarctica) and 87% of the water (Allan et al. 2017; Watson et al. 2018). Changes in the remaining high biodiversity regions in Africa, Asia, Central America, and South America can significantly increase interactions between livestock and wildlife species and promote the occurrence of (re)emerging diseases.

Apart from wild animals, pets, and cattle, urban fauna can also act as reservoirs for zoonotic diseases. In Western countries, it is estimated that over 60% of families have pets. Many urban areas have more stray and partially domesticated dogs than usual. As populations grow, urbanize, and become more affluent, livestock is one of the fastest-expanding agricultural subsectors in emerging nations (FAO, 2020).

5. CONCLUSION

Zoonotic diseases are a major public health threat, and they are becoming increasingly prevalent. This is due to several factors, including changes in land use, agricultural practices, and human behavior. Zoonotic diseases can cause a wide range of illnesses, from mild to severe, and they can even be fatal. Many things can be done to prevent the spread of zoonotic diseases. These include routinely improving sanitation and hygiene practices in surrounding areas, vaccinating animals against zoonotic diseases, following proper and timely vaccination schedules, and educating the public about zoonotic diseases. The emergence of new zoonotic diseases is a serious threat to global health. However, by preventing the spread of these diseases, we can help protect ourselves and our loved ones.

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