Emerging Zoonoses: Ebola, SARS and Animal-Human Interface

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Abstract

This chapter explores the critical issue of emerging zoonotic diseases, focusing on two significant examples: Severe Acute Respiratory Syndrome (Pisarski) and Ebola Virus Disease. It reviews the etiology and spillover pathways of these diseases such that they originate from animal hosts and involve zoonotic routes to introduce infections into human populations. Pathogen ecology is emphasized, including genetic diversity and environmental conditions influencing disease emergence. Zoonotic diseases have a substantial economic impact on healthcare systems, productivity, and food, tourism, and trade sectors, leading to outbreaks that stress healthcare systems and disrupt economies. The chapter urges for robust public health responses, including effective surveillance systems and international collaboration. Preventive strategies include policy changes, community education, vaccination campaigns, and wildlife monitoring. The chapter also calls for future research into zoonotic pathogens and their transmission dynamics. It also highlights the importance of technology innovations in surveillance and response. The chapter concludes by promoting collaborative approaches in One Health initiatives, emphasizing the interconnectedness of human, animal, and environmental health.

Keywords: SARS, Ebola, Animal-Human Interface, Emerging Zoonosis, Spillover

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Introduction

The important relationship between humans and animals, most recently highlighted by emerging zoonoses such as Severe Acute Respiratory Syndrome (Pisarski) and and Ebola, has become increasingly fragile owing to environmental changes and human activities (Debnath et al., 2021). And these diseases commonly start as what are called 'zoonotic spillover events,' when pathogens jump from animal hosts into human ones. Disrupting their environment and increasing interactions between humans and animals usually facilitates this process. For example, forests are cleared to make way for agriculture of urban development and animals are forced closer to human populations into smaller areas of land as their habitat is destroyed. Such increased interaction is giving diseases new species to jump from (Ellwanger & Chies, 2021). Research has shown that ecological changes can dramatically transform the likelihood that spillover events occur. New boundaries created through changes in land cover because of human activity can increase disease transmission. For instance, other research has also found linkages between nearby species with overlapping ranges and with a huge variety of habitats to the frequency of Ebola outbreaks. Like live animal markets and densely populated urban areas, they are also important hotspots for zoonotic transmission. But early cases in Wuhan, China, which had many such market outbreaks, have been traced to exposure to animals, possibly including the origin of SARS-CoV-2, the virus that causes COVID-19 (Ellwanger & Chies, 2021; Ellwanger et al., 2022). Zoonotic diseases have a huge influence on global health. Zoonotic infectious diseases cause approximately 60% of human infectious diseases and 75% of emerging diseases originate from animals (Jones et al., 2008; Rahman et al., 2020). The COVID-19 pandemic reminds us how severe the global health threat from these diseases can be, and how important international cooperation is, to avoid further outbreaks. Zoonotic diseases also cost both human and animal health plenty; billions of dollars go to healthcare and prevention of these diseases every year (Taghizade et al., 2021). Though much attention is paid to emerging zoonoses, reverse zoonoses (pathogens from humans infect animal population) must also be considered. The dynamics of disease transmission are complicated by this phenomenon, and the requirement for total monitoring of human and animal health only strengthens this. If we understand these interwoven relationships and the drivers of zoonotic spillover events, we can have more effective strategies to prevent and respond to zoonotic spillover events that protect human and animal health in a changing world. This chapter explores the global public health challenges of zoonotic diseases like SARS and Ebola, emphasizing the interconnectedness of human, animal, and environmental health. It examines transmission pathways, economic impacts, and effectiveness of public health responses. The research identifies gaps in existing research and suggests policy changes and community education to prevent future outbreaks. It aims to generate knowledge to protect public health and minimize future zoonotic risks.

Classification of Zoonoses

Diseases and illnesses that are naturally spread from vertebrate animals to humans are known as zoonoses (Singh et al., 2023). The three classes are as follows:

1. **Endemic Zoonoses**

Endemic zoonoses are diseases that circulate in particular geographical areas and have adapted so well to their animal hosts. Typically, the transmission pattern of these diseases is stable within some regions (Maudlin et al., 2009). Examples include Rabies and Leptospirosis. Rabies is a well-known disease which spreads from infected animals, usually from bites from stray dogs in high density locations. Rabies is endemic in many parts of the world and is particularly so in areas where vaccination of domestic animals is limited (Lavan et al., 2017). Leptospirosis is common in tropical regions and caused by bacteria found in water polluted with urine shed by infected animals. You can get infected by touching contaminated soil or water (Karpagam & Ganesh, 2020).

2. **Epidemic Zoonoses**

Sporadic but can have great outbreaks, epidemic zoonoses are. Such diseases may be absent in all cases but may appear under special conditions (Lipkin, 2014). Examples include Hantavirus Pulmonary Syndrome and West Nile Virus. Hantavirus Pulmonary Syndrome outbreaks have mostly hit rural areas of the United States, and this disease is associated with rodent populations. The virus is shed by infected rodents in their droppings, urine, and saliva and can be carried to humans when these items become airborne (Carver et al., 2015). The West Nile Virus is transmitted by mosquitoes which feed on infected birds and periodically outbreaks across North America. Some individuals can have serious neurological disease caused by the virus (Ronca et al., 2021)

Emerging and Re-emerging Zoonoses

Newly identified (Van de Voorde & Vlerick) or previously known and now detected more frequently in animals and people (re-emerging) zoonoses are infections (Rahman et al., 2020). Most of these diseases present themselves in new forms to public health (Pal, 2013). Examples include SARS-CoV and Ebola Virus. SARS-CoV emerged in 2002 as a global pandemic of major mortality. It's believed the virus came from bats and was passed to humans through an intermediate host (Prasad et al., 2020). Ebola was first identified in 1976, and has reappeared in deadly outbreaks several times, most often in Africa. This virus gets spread through direct contact with bodily fluids, from infected individuals or animals shown in Fig. 1= (Dong & Soong, 2021).

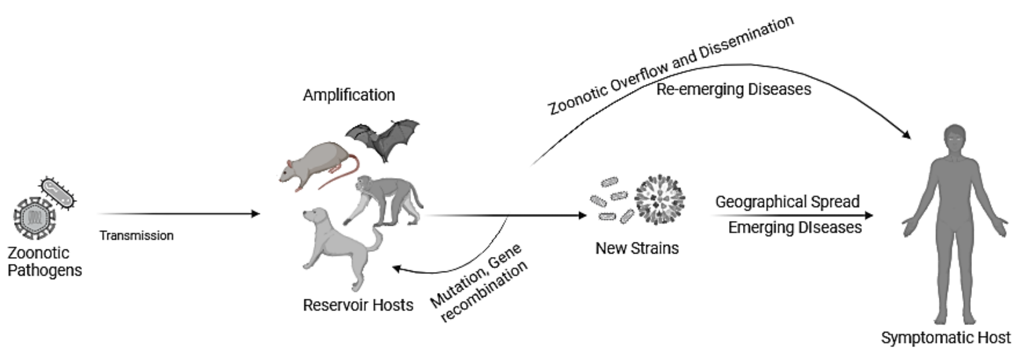

Fig. 1: Concept of Emerging and Re-emerging Zoonoses (Retrieved from Biorender).

The Animal-Human Interface

The animal human interface is the term used for contacts between humans and animals that can cause disease spread (Reperant & Osterhaus, 2014). To understand how diseases that jump from animals to humans, called zoonotic diseases, emerge and spread, you need to understand this interface. Direct Contact is one of the main ways that these diseases are transmitted. It can happen in different situations such as when people go hunting, working on farms and keep pets. If humans come into close contact with wildlife or domestic animals that carry germs, it is possible to spread disease. For example, an infected animal might be handled by someone who inadvertently brings a pathogen to themselves. Environmental changes are another important factor. Wildlife is increasingly forced into closer contact with human populations as cities grow, and as natural habitats are destroyed. The process of urbanization – that is, sprawling cities filled with people across previously wild spaces – upsets ecosystems and increases the likelihood of people running into animals more often. The increased contact means there are a greater chance of zoonotic diseases to leak from animals to humans (Graham et al., 2008; Mackenzie et al., 2013; Marrana, 2022).

Factors Influencing Zoonotic Disease Emergence

Several key factors contribute to the emergence of zoonotic diseases:

Increased Human Animal Contact

One major factor is the increase in human-animal contact due to various activities:

- **Urbanization:** But as cities rapidly extend their borders, wildlife habitats are often invaded. Animals living in forests or fields may adapt to becoming closer to human settlement looking for food or shelter. The result can be more human–wildlife encounters with the risk of disease transmission further increasing (Usmani et al., 2023).
- **Wildlife Trade:** As the global trade in wildlife to be eaten, for traditional medicine, or as exotic pets increases, the risk of zoonotic diseases also rises. Live animal's markets can become hotspots for disease transmission. Stress and illness can rise when animals are kept crowded or transported over long distances, and pathogens are spread easier (Smith et al., 2012).

Changes in Land Use

Another factor influencing zoonotic disease emergence is changes in land use:

- **Agricultural Expansion:** Forest to farmland converts destroys natural habitats where wildlife lives. The more humans expand their activities as farmers, the closer they come to wildlife which may carry diseases. Farm practices can disturb animal populations and enhance the chances of spillover events, for example (Jones et al., 2013).
- **Deforestation:** Both cutting forests for agriculture or for use in urban development and bringing humans into closer proximity with potential sources of zoonotic diseases reduce biodiversity. When such as bats or rodents escape from the forest and migrate to human communities, the risk of disease transmission is increased (White & Razgour, 2020).

Globalization

Globalization also plays a significant role in the spread of zoonotic diseases:

- **Travel:** Infectious agents can now travel quickly across borders as a consequence of increased international travel. Imagine a person who becomes infected in one part of the world can travel easily to another region where they can spread new pathogens to populations that have never seen them before (Saker et al., 2004; Sönmez et al., 2019).
- **Trade:** Animal and animal product movement across global borders can incorporate pathogens into new environments where they may not exist before. For example, importing exotic pets or livestock from other areas could introduce diseases that may be harmful to those of local locales and to humankind (Wu et al., 2017).

SARS (Severe Acute Respiratory Syndrome)

Origin and Transmission

In late 2002 Severe Acute Respiratory Syndrome (Pisarski) emerged for the first time in the Chinese province of Guangdong. SARS-CoV emerged as a newly discovered coronavirus that caused the disease (Bchetnia et al., 2020). The various types of viruses trigger respiratory diseases throughout both human and animal populations. Scientists believe bats serve as natural coronavirus hosts before transferring the virus to humans through exposure with bats. Science confirms that humans acquired the virus from civet cats who maintained an intermediate role in transmission shown in Figure 2 (Al-Qahtani, 2020).

Zoonotic Pathway

The movement of SARS-CoV through zoonotic transmission pathways shows multiple steps of virus transmission between animals and humans (Guo et al., 2020). The initial origin of SARS-CoV took place within bat species before civets served as intermediate hosts in Guangdong China's live animal markets. The SARS-CoV spike (S) protein penetrates human cells through receptor mediated endocytosis by specifically binding to angiotensin converting enzyme 2 (ACE2) receptors. Through evolutionary changes over time S protein mutations defined how well the virus could hold onto human ACE2 which facilitated person-to-person transmission during the outbreak period (Sheahan et al., 2008; Hou et al., 2010; Lu et al., 2015).

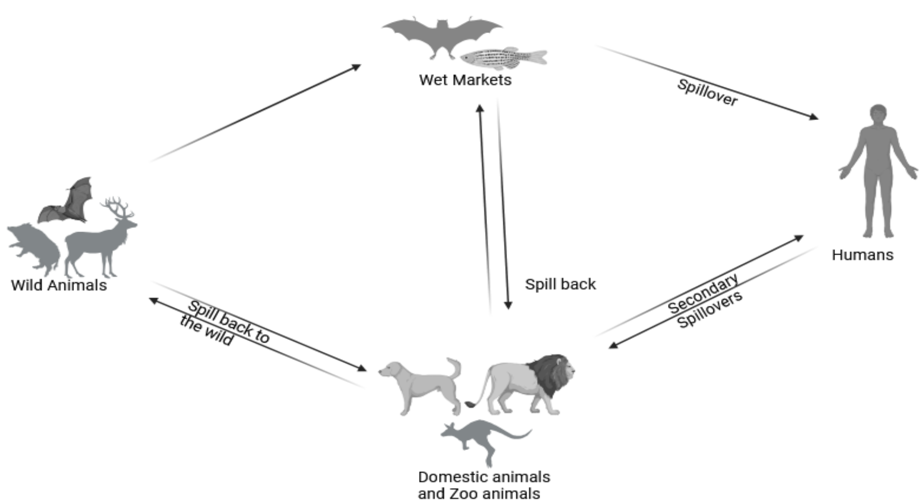

Fig. 2: Schematic diagram for the known and inferred transmission pathways for SARS-CoV-2 (Retrieved from Biorender).

Human-to-Human Transmission

When the virus moved into the human population it spread most of all through respiratory droplets. That means that if an infected person coughed, sneezed or even just spoke, tiny droplets containing the virus could be released into the air. These droplets can be inhaled by people nearby who become infected themselves. A recent study reported that ocular surface does have the potential to carry SARS-CoV-2 and therefore can transmit the infection. The disease could be spread through close contact with people who were infected (Chan et al., 2020; Guo et al., 2020; Lu et al., 2020).

Epidemiology

SARS spread quickly and dramatically around the world. Just a few months after its appearance some 8,000 cases were reported in 29 countries before it was brought under control in mid-2003. Around 10 percent of people infected with SARS died, a substantial number did die (Teo et al., 2005). International travel was largely responsible for rapidly global spread of SARS. Many cases of outbreak in other countries were related to the infected travellers from affected areas. Take, for instance, how travellers from China brought the virus to places such as Hong Kong and Toronto which spread outbreaks in localized fashion. A hotel turned into a centre of transmission in Hong Kong when an infected guest passed the virus on to those staying there (Hung et al., 2018; Gössling et al., 2020).

Containment Efforts

In order to contain the outbreak and minimize further transmission, public health officials took a number of steps. The virus was isolated from infected individuals to prevent spreading to healthy people. Contact tracing was done to find out who has been in close contact with infected people, and they were asked to be monitored to see if they develop any symptoms and if they so, then tested. Travelers arriving from affected regions were subject to increased screening, but no confirmed cases have been recorded in South Africa yet. Educational campaigns were undertaken to inform people about how SARS spread and what steps people could take to avoid getting or spreading the disease (Cetron et al., 2004; Wilder-Smith & Freedman, 2020).

Impact on Healthcare Systems

It put pressure on healthcare systems around the world. This meant hospitals were overcrowded or they were running out of protective equipment for health care workers treating infected patients. The problems caused by this crisis also spurred improvements in readiness to respond to future infectious disease threats. In following the SARS, many countries updated their public health infrastructure and developed improved protocols for handling outbreaks. That included investing in research for vaccines and treatments for coronaviruses and improving surveillance systems to watch for possible zoonotic disease threats more effectively. SARS, all in all, brought home a very important point about how tightly meshed our world is and how easy it is for diseases to jump from animals to humans (Chu et al., 2008; Dol et al., 2022).

Ebola Virus Disease

Origin and Transmission

Ebola virus disease (Dawood et al.) develops as a serious condition that first appears in fruit bats who function as natural hosts for the virus. Lab tests confirm that bat species which spread Ebola do not suffer from illness. The path of viral transmission to human populations begins when people handle either the fluids of sick people or the animals that carry the infection directly shown in Figure 3 (Olivero et al., 2020).

Zoonotic Pathway

Research shows that fruit bats function as virus reservoirs which initiate the zoonotic transmission route of Ebola virus disease (Dawood et al.). Humans can become infected if they come into contact with the virus when exposed to blood, organs, bodily fluids or open wounds of infected bats, chimpanzees, gorillas, and forest antelopes. The initiation of this spillover event is necessary for the emergence of Ebola in human populations (Leroy et al., 2009).

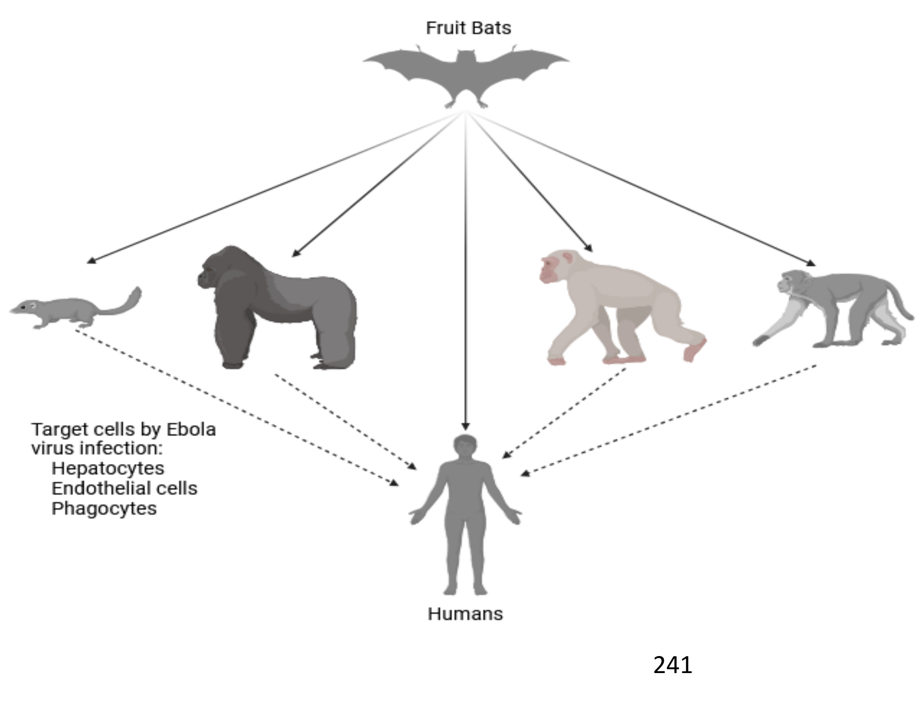

Fig. 3: Mode of transmission of Ebola virus infection (Retrieved from Biorender)

Human-to-Human Transmission

Once the virus has spread, it can be passed on to people through contact with the bodily fluids of an infected person, such as blood, saliva, sweat, vomit or semen (El Sayed et al., 2016). There is a higher risk of transmission during care of infected individuals or following handling of the bodies of people who died of EVD. It is also worth noting that in some cases Ebola can persist in a patient's body fluids even after the patient has recovered, and especially in semen which puts the patient at risk to sexually transmit the virus. To implement effective public health measures to control outbreaks and prevent future transmissions we need to understand these pathways (Leroy et al., 2009; Ohimain, 2016).

Epidemiology

Between 2014 and 2016, the region of West Africa saw the largest outbreak of Ebola. It is one of history's deadliest outbreaks, as this outbreak caused over 28,000 cases and more than 11,000 deaths in several countries (Vetter et al., 2016; Chiquoine, 2017). This outbreak also severely affected countries such as Guinea, Liberia, and Sierra Leone. Due to its fast-paced disease transmission the weak health systems in these areas experienced extensive difficulties. The limited availability of resources prevented both patient care services and effective disease prevention measures (Shoman et al., 2017).

Mortality Rates

EVD proves deadly because over 50 percent of patients die from it. During specific outbreaks death rates reached terrifying levels of up to 90 percent. Health authorities worldwide must take immediate decisive action against Ebola because of its alarming mortality rate (Weyer et al., 2015).

Vaccination Strategies

Scientists developed the experimental vaccine rVSV-ZEBOV at high speed throughout the outbreak. The deployment of this vaccine occurred during subsequent outbreaks and has demonstrated its ability to lower transmission rates in at risk populations. Since the outbreak areas health staff members and local residents received vaccinations (Sridhar, 2015; Malik et al., 2023).

Impact on Healthcare Systems

The Ebola outbreak affected countries' healthcare systems. Ebola patients streamed into the country forcing healthcare resources to the limit, limiting availability of important health services like vaccinations and routine healthcare for diseases like malaria and HIV/AIDS (Davtyan et al., 2014). A significant fraction of this reduction was responsible for higher mortality rates from non-Ebola related illnesses, during and after the outbreak. In addition, healthcare facilities faced a dearth of supplies, trained staff shortages, and inadequate infrastructure to deal with infectious diseases. Internationally coordinated responses during the crisis emphasized two main elements comprised of facility development together with staff training in infection prevention procedures and critical medical supply distribution and broad diagnostics expansion in vulnerable regions. Future disease protection efforts must improve through better public health strategies by analysing the origins and transmission routes of Ebola and learning from previous epidemic experiences (Elston et al., 2016; Meyer et al., 2018).

Public Health Implications

Healthcare Costs

During outbreaks, the resources are often diverted from routine care to attend the crisis. During the 2014–2016 Ebola outbreak in the West African nations faced overwhelmed numbers of patients, causing shortages of medical supplies and personnel. The diversion of a certain amount of resources from one part of the problem to another part can mean delays in treating other problems, increase healthcare costs, and ultimately diminish public health (Karlsen & Kruke, 2018).

Economic Disruption

Outbreaks can result in great losses in tourists' revenue when travel restrictions are imposed during such outbreaks. Take a moment to think about the Ebola outbreak and the travel bans or advisories many countries made that discouraged tourists from visiting those regions. And it had a knock-on effect for local economies, which are completely dependent on tourism. Moreover, trade bans on livelihoods such as livestock or animal products can disrupt food supply chains and cause food insecurity in agricultural sectors. The economic impact of the outbreak alone is estimated to be from $2.8 billion to $32.6 billion in lost gross domestic product (GDP), alone, in the affected countries (ZARABA & KOUBIDA, 2020). Just as SARS, the estimated economic loss was around $40 billion, as fewer people travel and trade globally (McKibbin, 2004).

Strategies for Prevention

Reducing the risk of zoonotic diseases such as SARS and Ebola from emerging or re-emerging requires preventive strategies.

Policy Changes

One way to decrease the risk of spillover of zoonotic disease is by implementing stringent Jewish wildlife markets regulations. Limits on wild animal hunting and trade can reduce human exposure to potential pathogens. Take for example, the SARS outbreak – after which many countries endeavoured to close live animal markets where the virus is thought to have emerged (Segata et al., 2021).

Education Programs

Community based education initiatives can also inform the public about safe practices with regards to interacting with animals and consuming animal products. It teaches people who live in communities about the risks of zoonotic diseases so they can protect themselves and also protect the health of others (Chomel, 2003).

Vaccination Campaigns

Significant transmission risk can be reduced through vaccination campaigns for both humans and for animals. Vaccines, for example, can protect humans from rabies infection by preventing pet and livestock infections. When Ebola hit, experimental vaccines were created and widely deployed in response to new cases (Teshome & Addis, 2019).

Wildlife Monitoring

Wildlife populations can be subjected to regular health assessment, which will help identify potential reservoirs of human health before they become a problem. By monitoring wildlife for signs of disease public health officials can take measures to prevent spillover events before they occur. Consequently, the public health implications of emerging zoonotic diseases such as SARS and Ebola need to be understood in order to develop effective strategies to manage these threats. (Chomel, 2003; Qin et al., 2021).

Future Directions

Research Needs

Many zoonotic pathogens that cause diseases such as SARS and Ebola remain incompletely understood by scientists. Future outbreaks require extensive research to perform across multiple essential domains for optimal outbreak readiness. Scientists need additional research to determine the natural environment of coronaviruses and their circulation between animal sources and human populations for SARS (Khanna et al., 2020). Research investigating Ebola should identify potential host reservoirs and define environmental elements that lead to viral spillover events. The investigation must focus on studying how fruit bats and additional wildlife behave when they transport the virus. Examining transformation patterns of disease dissemination stands as an essential component in understanding how climate change and habitat destruction affect pathogen spread. Knowledge gaps need to be filled because this information strengthens our ability to develop prevention strategies for upcoming outbreaks (Kapata et al., 2020).

Innovations in Surveillance and Response

Improved technologies generate new possibilities which strengthen our capability to identify zoonotic diseases that spread like SARS and Ebola during their emergence. Genomic sequencing represents a fundamental technological advancement that permits rapid pathogen genetic analysis. The technology can discover new viruses while providing a method to monitor their evolutionary behaviour. Through data analytics we gain better insights into disease pattern formation. Many different data sources including healthcare records together with environmental data and social media data enable public health officials to find early outbreaks and respond more rapidly. Collectively, these technological breakthroughs will generate integrated surveillance systems that monitor human health as well as the health of wildlife populations. Such systems can identify possible threats before they become widespread outbreaks (Li et al., 2021).

Collaborative Approaches

Addressing zoonotic threats to human health, such as SARS and Ebola through a collaboration that recognizes the connection between human, animal and environmental health. One Health initiatives bring together veterinarians, healthcare providers, ecologists, policymakers, and communities, in order to promote interdisciplinary collaboration. For example, wildlife experts and public health officials must work together to monitor animal populations that could carry zoonotic pathogens. Together, these professionals can learn about disease risk and develop ways to reduce human exposure to potential threats. Preventing outbreaks also needs involvement of the community.

Conclusion

Severe Acute Respiratory Syndrome (Pisarski) and Ebola Virus Disease (Dawood et al.), reveal several important points on transmission and impact. It outlines the intricate pathways by which these diseases flow and highlights the important animal hosts and environmental factors that allow spillover events into human populations. It turns out genetic diversity and ecological conditions are big determinants of the ability of animals such as SARS-CoV and Ebola virus to jump from animals to humans, according to the research. The study also highlights the huge economic effect of these zoonotic diseases, reporting that outbreaks put pressure on the healthcare system and result in the big loss in tourism and agriculture resulting from travel restrictions. The past outbreak effectiveness is also evaluated, and findings indicate that the public health responses during past outbreaks have been most effective when supported by robust surveillance systems and international collaboration for early outbreak detection and timely response. Moreover, the study points to gaps in existing research into zoonotic pathogens and urges further study of their ecology and transmission dynamics. Emphasized are preventive strategies such as policies that regulate wildlife trade, community education to raise knowledge of risk for zoonotic diseases and campaigns to vaccinate humans and animals.

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