Assessment of Emergence, Economic Losses and Prevention of Zoonotic Infections

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ABSTRACT

Zoonotic diseases are emerging infections which can transmitted from animals to human and vice versa. Since decades, zoonotic infections such as monkeypox, buffalopox, camelpox, Covid-19, avian influenza virus, West Nile virus and Swine Influenza pose significant health concern which leading to substantial economic losses. This chapter will discuss all the aspects of zoonotic diseases regarding the emergence, economic losses, and preventive measures. The emergence of zoonotic diseases is a complicated process which is influenced by various sorts of factors such as climate, urbanization, deforestation, wildlife trafficking and human-animal interactions. The outbreak of zoonotic infections results in economic losses such as treatment, medical expenses, containment efforts, low productivity, trade restrictions and limited tourism. The pandemic Covid-19 serves as glaring example which adversely effect the world economies. Therefore, the prevention of these infections is indispensable to maintain the livelihood of human and animals. Various strategical measures such as surveillance, early detection systems, social distancing, isolation from infected person or animal, and vaccination can mitigate the risk of getting zoonotic diseases. Furthermore, strong collaboration between animal and human health sectors can facilitate the timely sharing of resources and information. Moreover, enhancing biosecurity measures such as trade of livestock and wildlife, animal trafficking, research and development of vaccines, modern diagnostic techniques and various sorts of therapeutic agents can limit the development of zoonotic diseases. In conclusion, zoonotic outbreaks have emerged, challenging, and inflicting substantial economic losses as well as affecting human health. However, by following aforementioned strategical measures, we can strive toward minimizing the occurrence of zoonotic diseases.

Key words: Zoonotic infections, Covid-19, Economic losses, preventive measures, Pandemic

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1. INTRODUCTION

The word zoonosis is derived from two Greek words “Zoon” and “nosos”, which means animal illness. Any infection that is naturally transmissible from humans to vertebrate animals and from animals to humans is referred to as a zoonotic disease (Morand et al. 2014). The zoonotic diseases are further classified into anthropozoonosis, zooanthroponosis, amphixenosis, and euzoonosis (Messenger et al. 2014). Anthropozoonosis are those infections that can be transmitted to humans, such as rabies while zooanthroponosis refers to those diseases that are transmitted from human to animals such as tuberculosis can be transmitted to cats and monkeys. Whereas Amphizoonosis infections have the potential to spread bidirectionally such as infections spreading due to staphylococcus bacteria (Rahman et al. 2020) (Fig. 1).

It is documented that there are numerous pathogens underlying the development as well as progression of zoonotic diseases (Wang and Crameri 2014). On the basis of diseases etiology, zoonotic infections are apportioned into various categories such as viral zoonosis (AIDs, rabies), fungal zoonosis (Malaria, trichinosis), bacterial zoonosis (Plague, lyme disease) mycoplasma zoonosis, rickettsial zoonosis, protozoal zoonosis as well as non-viral pathogenic species such mad cow infection (Rahman et al. 2020). Asokan et al. (2011) summarized the data of infectious species which are referred to as pathogenic to humans. They recognized 1,415 species which include 217 viruses and prions, 307 fungi, 538 bacteria and rickettsia, 66 protozoa while 287 helminths. Zoonotic infections take place via three primary routes such as fecal, oral (by food and water) and via direct physical contact with infected animal or human (Balloux et al. 2017) (Fig. 2).

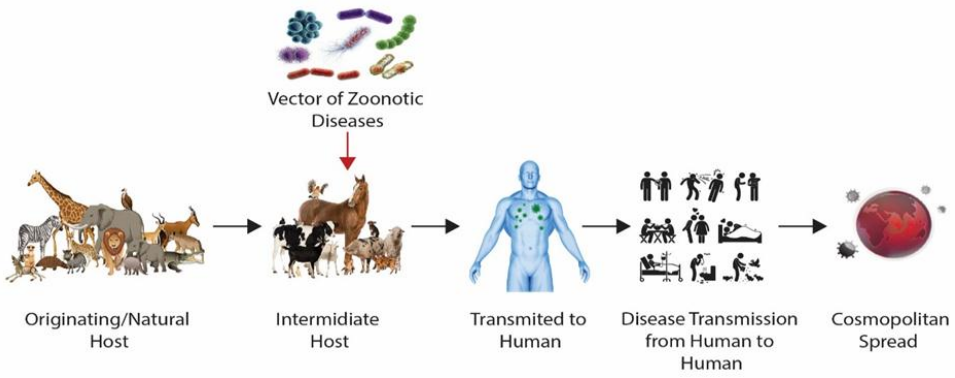

Fig. 1: General layout of various zoonotic infections transmission among various hosts

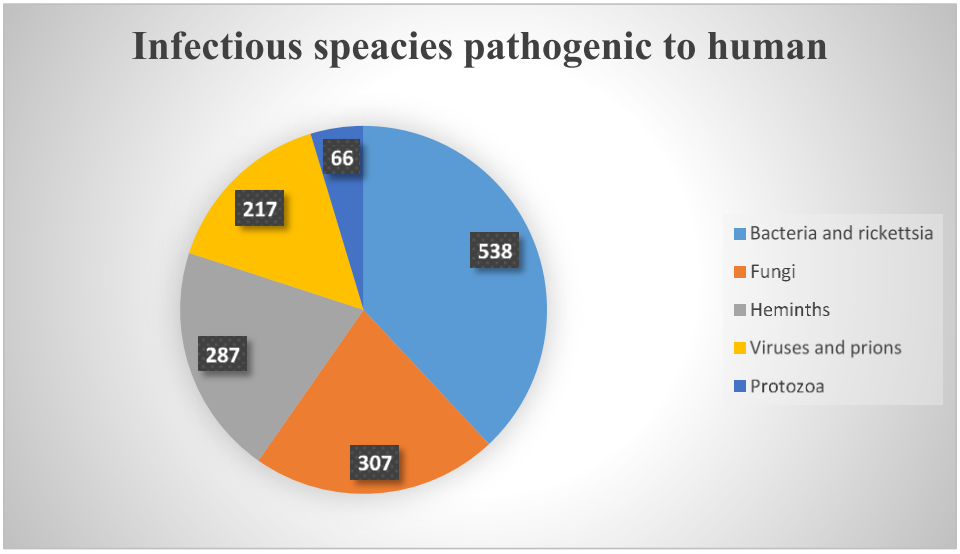

Fig. 2: Prevalence of various pathogenic species and their potential to infect humans

Zoonotic diseases are one of the most emerging infections around the world. Infectious diseases not only affect the health of the animals but also lead to severe economic losses (Alvi et al. 2023). An emerging zoonotic disease is referred to as newly identified, recently evolved, or previously observed infection that exhibits an increase in incidence or an extension in geographical, host, or vector range (WHO 2020). It is estimated that about two-thirds of newly and emerging infections are zoonotic diseases (Rahman et al. 2020). Over the past 70 years, approximately 250 zoonotic diseases have been reported as emerging infections. Owing to high incidence ratio and geographical distribution, many diseases have spread quickly over the globe (Woolhouse and Eleanor 2005). According to statistical data, almost 335 emerging infectious diseases (EID) are reported between 1940-2004. Moreover, COVID-19 and SARS-CoV-2 are also enlisted as EID of recent times (Yoo and Yoo 2020).

Various factors are responsible for the transmission of zoonotic infections such as adaptability of pathogenic species, habitat, behavior of animals and humans, vector biology, hygienic practices in animal yards, production systems of livestock, climate alterations, deforestation, urbanization, and food safety (Lindahl and Delia 2015). Wildlife is considered as the key reservoir for zoonotic infections which leads to the emergence and progression of zoonotic diseases (Kruse et al. 2004; Alvi et al. 2021). It is evidenced that up to 60,000 annual deaths are reported due to rabies and other diseases such as, the Elbola virus, Rift valley fever and Avian Influenza which exert a negative impact on the health of humans and animals (Grace et al. 2012). Most prominent emerging zoonotic diseases include Covid-19, thrombocytopenia syndrome, Ebola virus, encephalopathy, Nile fever, rabies, norovirus, leptospirosis, monkeypox, camelpox, hantavirus, MRSA infections and rotavirus diseases (Chomel et al. 2009; Kruse et al. 2004; Wang et al. 2020). While, rabies, brucellosis and tuberculosis (*M. bovis*), are considered as re-emerging zoonotic diseases (Table 1).

Table 1: Major outbreaks of zoonotic diseases and their way of transmission

Zoonotic diseases	Pathogen	Host	Mode of transmission	References
Monkeypox	Orthopox virus	Human, Dogs, Chimpanzee	By direct contact and sexual transmission	(Nuzzo et al. 2022)
cowpox	Orthopox virus	Human, Cat, Rat, Cattle	By direct contact with infected cow and other animals	(William et al. 2020)
camelpox	Orthopox viral disease	Human, camel	Direct contact with skin lesion, Air bone saliva droplets	(Khalafalla et al. 2017).
Avian Influenza	Type A viruses	Poultry	Exposure to infectious animals or environment	(Hill et al. 2022)
Swine Influenza	Type A influenza virus	Pig	Spread through air in droplets, contact with pig	(Meng et al. 2022)
Chikungunya virus	Viral disease	Small animals (like bats) along with non-human primates	By the bite of infected *Aedes mosquitoes*	(Burt et al. 2012)
West Nile virus	Single stranded RNA virus	Bats, birds, hors	Mosquitoes between birds and mammals.	(Suthar et al. 2013)
MERS-CoV	Infectious diseases	Bat	Unknown	(Reusken et al. 2013)
Filoviruses (Ebola and Marburg diseases)	Ebola and Marburg viruses	African fruit bats	Activities related to bushmeat, such as capturing and killing wild animals	(Amman et al. 2013)
Hendra virus	Bat born virus	Australian flying foxes, horse	Humans who had close contact with infected horse	(Clayton et al. 2013)
Nipah virus	Bat borne virus	Bat	Transmission from a bat directly to a human and vice versa.	(Homaira et al. 2010)
Crimean-Congo haemorrhagic fever virus	CCHF virus	Ticks	By tick bites that are infected or direct contact with tissues and blood	(Bente et al. 2013)

2. VARIOUS VIRAL ZOONOTIC DISEASES

2.1. MONKEYPOX

Monkeypox is termed as the most recent emerging disease which occurs owing to a DNA virus called "Monkeypox". The transmission of monkeypox is attributed to different factors such as physical contact with infected animals, people, or contaminated objects such as direct contact with monkeypox rash, scabs, large respiratory droplets, contaminated bedsheets, skin lesions or body fluids from an infected person with (Nuzzo et al. 2022). Monkeypox develops various sorts of complications such as pneumonitis, encephalitis, keratitis, and secondary bacterial infections. (WHO 2022).
The infection rate of monkeypox is observed to be high in individuals age less than 50 years while 69% of infected individuals were male. Monkeypox is considered a cosmopolitan disease owing to its prevalence in various regions of the world such as Europe, the Eastern Mediterranean, the Americas, and the Western Pacific (Simpson et al. 2020). More than 1,500 cases have been documented in 43 countries including Europe and North America by June 2022. Although the monkeypox virus is common in central and western Africa, its occurrence in the industrialized world has raised alarming indicators for its potential global emergence (Kumar et al. 2022). Studies show that the risk of serious consequences is higher in infants as well as in those individuals who have very low immunity such as people with HIV (Kozlov 2022).

2.2. BUFFALOPOX

Buffalopox is a common zoonotic disease found in buffaloes such as *Bubalus babalis* and rarely in cows due to viral infection. The primary causative agent of buffalopox is buffalopox virus which is the core member of Orthopoxvirus and closely resembles to Vaccinia virus. In the last 40 years, the prevalence of buffalopox has become high with a morbidity rate of 80% among domestic buffalo herds and cows (Singh et al. 2007; Yadav et al. 2010). Venkatesan et al. (2010) elaborated that it has been found in both young and old buffaloes. India is considered the origin of buffalopox but later it was spread to various other countries including Eastern and Western Europe. Milkers become highly susceptible to buffalopox owing to their physical connection with animals (Eltom et al. 2020). Clinical signs of buffalopox include wartline lesions on the udder, teats, inguinal region, and base of the ears (Borisevich et al. 2016). After infection, the infected person developed pyrexia, axillary lymphadenopathy, and general malaise along with pox-like local lesions on their hands, forearms, and forehead (Essbauer et al. 2010).

2.3. COWPOX

Cowpox (CPXY) is a rare zoonotic infection that is spread through physical contact with infected cows and other animals such as rats as well as cats in the workplace (William et al. 2020). It can infect milkers, resulting in a pustular eruption on the face, hands, or forearms, as well as a mild fever and lymphadenitis. Due to the wide range of hosts, this zoonotic disease can spread to unintended hosts such as rats, cats, cattle, horses, llamas, zoo animals, and humans, and frequently recorded a high ratio of incidence in Europe. Direct exposure to an affected cat, zoo animals, or pet rats has been the predominant method of CPXV zoonotic transmission (Switaj et al. 2015). There have been multiple cases of CPXV which transmit from cows, cats, and rats to people (Switaj et al. 2015; Lapa et al. 2019). Humans infected with CPXV frequently experience a restricted external lesion along with fatigue fever, lymphadenopathy as well as sores on the hands, fingers, and rarely on other parts of the body (Grönemeyer et al. 2017).

2.4. CAMELPOX

Since 2014, a plethora of evidence has demonstrated the transmission of camelpox virus (CMLV) from camels to humans in Eastern Sudan (Bera et al. 2019). Humans develop various symptoms of infections including fever, malaise, itching, and erythema, which ultimately lead to the development of nodules after 7–10 days. In 2012, Saudi Arabia recognized the first case of CMLV and in a few days' infection, approximately 1500 people were infected while 580 fatalities were reported (Al-Ahmadi et al. 2019). The number of cases was higher in those countries that are involved in rearing domestic camels such as Iran. It is reported that the milk as well as the meat of infected camels are contagious to humans and have potential to develop roots of CMLV. Furthermore, improper importation or smuggling of camels from nearby nations such as Afghanistan, Pakistan, and the United Arab Emirates (UAE) are major factors underlying the progression of CMLV. It is documented that camels having an age under 2 years are highly susceptible to CMLV with a fatality rate of 12-25% (Joseph et al. 2021). The camelpox virus (CMLV) in dromedary camels (*Camelus dromedarius*) and Bactrian camels (*C. bactrianus*) can cause respiratory distress, gastrointestinal distress, fever, nasal discharge, as well as the appearance of lesions on the head, neck, mouth, lips, limbs, inguinal and perianal areas, as well as in scrotum (Bera et al. 2011; Joseph et al. 2021).

2.5. CORONA VIRUS

Three catastrophic Coronavirus outbreaks have occurred in the previous 20 years, including the most recent pandemic of Coronavirus Disease 2019 (COVID-19) in China. Coronaviruses are diverse group positive sense, single stranded RNA as well as enveloped viruses (Zumla et al. 2016). Various evidence from infected individuals determined the mode of transmission. It is reported that COVID-19 transmits from human to human primarily through physical contact or respiratory droplets (Li et al. 2020; Chan et al. 2020). Severe respiratory problems are largely caused by this virally induced inflammatory illness of the lungs and airways. More than 200 nations and regions have recorded millions of incidences of COVID-19, which have caused health problems, fatalities, and financial losses (Ahmad et al. 2022). As discussed earlier, zoonotic infections have the potential to spread from animals to *Homo sapiens* such as infection of severe acute respiratory syndrome coronavirus 2. There is a substantial difference between the transmission of viral infection, potential to spread, death rates in various species as well and potential to adapt to a new habitat and ensure their persistence in population. The potential of corona virus to adapt and survive in a population as well as the pace at which they disseminate, escalates the rate of sickness and death in human (Kelvin and Salvatore 2020) (Table 2).

3. ASSESSMENT OF ECONOMIC LOSSES DUE TO ZOONOTIC DISEASES

A strong relationship exists between poverty and zoonotic diseases everywhere particularly where livestock is the main source of income (Cleaveland et al. 2017). Over the past 10 years, it is estimated that zoonotic infections account for more than 220$ billion in losses to growing economies (Narrod et al. 2012). Recent widespread pandemics such as COVID-19, H1N1, Swine flu, Ebola, and Nipah virus have had an impact on both animals and human health as well as their livelihoods. Buffalopox virus BPXV infection is currently becoming more prevalent and disseminated throughout Punjab, Pakistan. It is declared that annually approximately 6455$ USD in financial losses are owed to BPXV (Usmani et al. 2022). More than 1350 cases of monkeypox have been documented from 31 nonendemic states globally till June 09, 2022 (Guarner et al. 2022). Similarly, highly pathogenic avian influenza viruses (AIVs) are able to significantly increase bird fatality rates. About 1533 new cases out of which 607 human demises had been formally

Table 2: Various zoonotic diseases, their vector, host, and early symptoms of infection

Diseases	Caused by	Symptoms	Reference
Monkeypox	Monkey	Begins with fever and leads to pneumonitis, encephalitis, keratitis, and secondary bacterial infections	(World Health Organization 2022)
Buffalopox	Milch buffaloes (Bubalus Bubalis) and, rarely, cows.	The following symptoms include lymphadenopathy, fever, and malaise, severe blisters on the extremities of the body, face, and mouth.	(Borisevich et al. 2016)
Cowpox	Cattle, cats, dogs, horses, gerbils, voles, rats, mice	Lethargy, anorexia, dyspnea, eye discharge, and sneezing. Additionally, Observed abdominal distention and pneumonia.	(William et al. 2020)
Camelpox	Bactrian camels (*C. bactrianus*) and Dromedary camels (Camelus dromedarius).	Fever, nasal discharge, shingles on the limbs, inguinal and perianal regions, and scrotum; respiratory distress; and digestive discomfort.	(Bera et al. 2019)
Coronavirus	Wild cats, pigs, dogs, and chickens, bat species (Rousettus aegyptiacus).	2–5 days of malaise, headache, and fever. Lesion on the scrotum, vulva, or mouth.	(Ahmad et al. 2020)

documented till September 27, 2017 (Virlogeux et al. 2018). According to the European Commission, the EU economy would decline by more than 10% in 2020 due to the Covid-19 pandemic. The statistical data of 2020 revealed that the pandemic substantially decreased approximately 147 million full-time jobs which resulted in an economic loss of 3.8 billion dollars globally (Agovino and Gaetano 2022). Since 2020, COVID-19 collapsed the livestock as well as crop industries of China by about 2.3% and 1.1% respectively (Gong et al. 2021). Similarly, in 2014, the Ebola virus adversely affected the production of coffee (50%) and rice production (20%) in Ghana, thus ultimately reducing the agricultural economic growth (Zhang et al. 2020). In terms of socioeconomic impact, camelpox is noteworthy due to the immense losses attributed to sickness, death, abortion, weight loss, and decreased milk production. Rabies claims 60,000 lives each year, resulting in an 8.6-billion-dollar economic loss each year when direct and indirect costs are taken into consideration (Hampson et al. 2015).

4. PREVENTIVE MEASURES

The management of newly emerging and re-emerging zoonotic diseases requires ongoing, focused, and multidisciplinary approaches. Surveillance, laboratory testing, preparedness planning, and outbreak response are suitable approaches to mitigate the influence of zoonotic diseases (Van der Giessen et al. 2010; Kheirallah et al. 2021). Fig. 3 shows general layout to trace and control zoonotic infections.

According to WHO guidelines, a patient with moderate to severe infection of monkeypox should be isolated from other household members and appropriate infection prevention should be followed. Antipyretics and painkillers should be given to patients as symptomatic therapies, while malnourished individuals require sufficient diet and water (Ahmed et al. 2023). The United Nations System Coordinator for Combating Avian and Human Influenza (UNSIC) and the World Health Organization (WHO) collaborated to establish an international strategy for minimizing the risk of emerging zoonotic diseases with a greater emphasis on animal and human health issues. (Feng et al. 2014). It is reported that poultry incubation and vaccinations may prevent the progression of various zoonotic infections (Gao et al. 2014). It is documented that personal safety precautions are performed to mitigate the prevalence of respiratory viruses such as COVID-19, particularly prior to the availability of vaccines (Qualls et al. 2017). The five basic personal precautions recommended by the WHO against COVID-19 are "self-isolation," "frequent

handwashing," "maintaining social distance," "avoid touching the eyes, nose, or mouth," and "respiratory etiquette". Similarly, the cost-efficient and most practical way to control and eradicate camelpox is on-time immunization as well as maintaining distance from infected animals (Narnaware et al. 2021). Targeting stray dogs as well as immunization of dogs significantly (70%) reduced rabies-based mortalities around the world (Fitzpatrick et al. 2016). Canine rabies vaccination is advised by the World Health Organization (WHO) to eradicate the illness in canine populations and subsequently in human populations (Schneider et al. 2007).

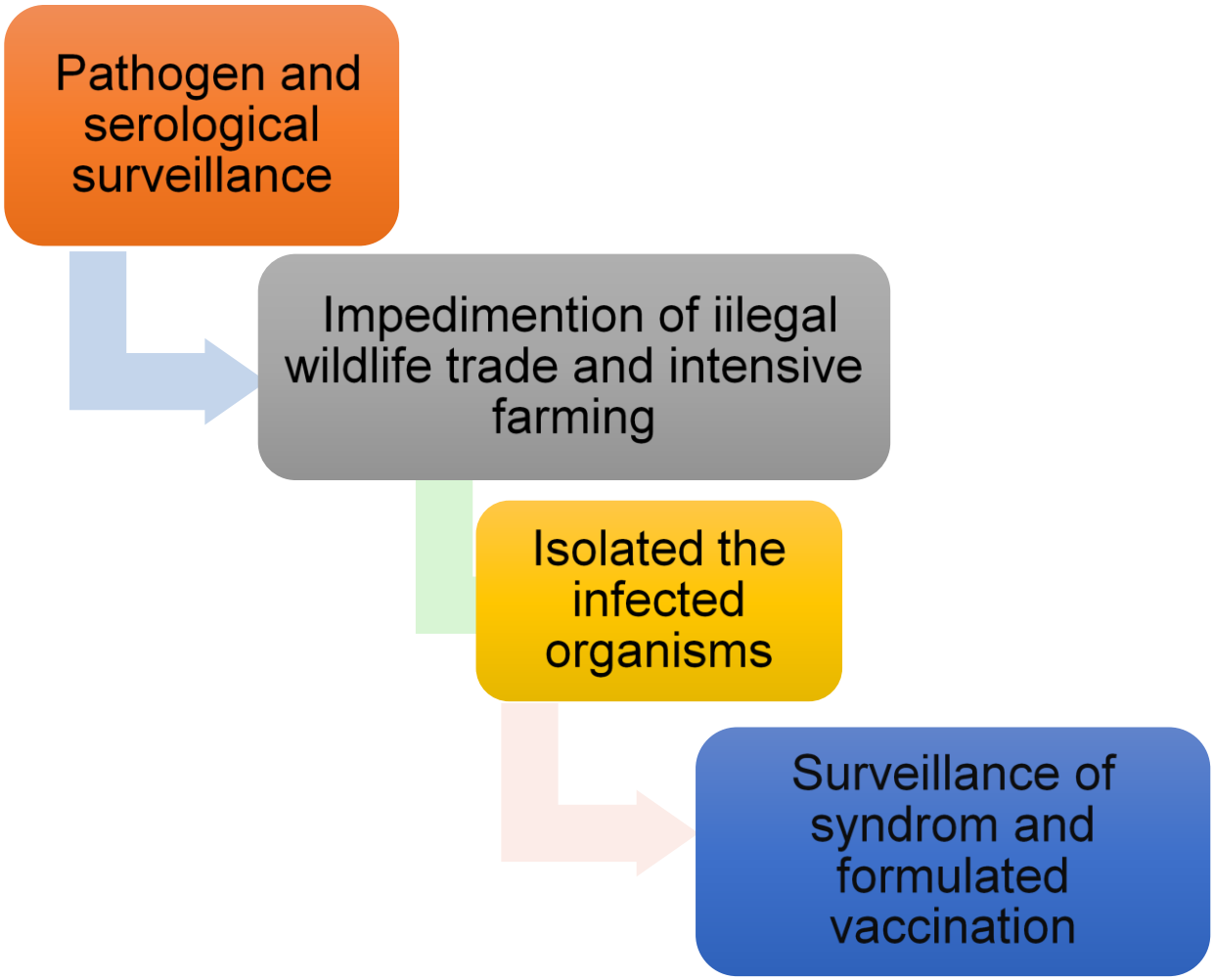

Fig. 3: A general layout to trace and control Zoonotic infections

5. CONCLUSION

In conclusion, the intricate relationship between humans and animals in our ecosystems has underscored the prevalence of various zoonotic diseases. The occurrence of various zoonotic diseases such as monkeypox, cowpox, buffalopox, camelpox, and COVID-19 established a vulnerable co-existence between animals and humans in the same place. These zoonotic diseases exert profound impacts on our economy and remarkably disrupt the balance of financial assets. To overcome the risks of these infections, multifaceted preventive measures are the dire need of the current era. These strategies involved

monitoring and surveillance, wildlife management, rigorous hygiene practices, and the development of robust vaccines. Furthermore, a strong collaboration among environmental scientists, policymakers, health professionals, and communities is a pivotal part of preventive measures and control.

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