# Future Prospects of Zoonotic Health Threats: Their Risk Factors, Preventive and Control Measures

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## ABSTRACT

Zoonotic diseases originate from microbes with natural transmission potential from livestock to public sector. The current prevalence of zoonotic diseases imposes vital intimidations to human health due to close contact with domestic or wild animals. These diseases are mainly spread from animals to humans directly or indirectly. Global climate changes, growing populations, shifting trend of rural towards urbanization, livestock transhumance and traveling are the key factors in emerging zoonotic diseases. In most developing countries such as India, Pakistan and Bangladesh, policies like public health interventions and mass vaccination of livestock are not much effective due to lack of collaborations among policies makers, livestock and public health centers for disease outbreak. Literature cited that there are almost 13 different zoonotic diseases which are very alarming to livestock community, growing animals population, public health and economy of country. In sub-continent, major portion of population belongs to poor community which depends on livestock farming for income source. To mitigate these emerging diseases, the aptitude of local and global circle needs a factual assessment for the global health safeguard. For supportable public health program for detection, prevention, and control of these diseases in the region, the present condition in the region triggers a clear-cut and coherent need. Public health approach is combination of a joint coordination procedure, mutual planning, joint application, community input, capacity building and joint monitoring. The strategic plan for control of zoonotic diseases needs the stakeholders to start and consolidate measures for integrating technical, social, political, policy and regulatory issues to improve their capacities sufficiently to lessen the public health hazard and economic impact. The application of a worthwhile strategy is the mode onward for mitigation of emerging and re-emerging zoonotic diseases in the region. Active mitigation program presents an opportunity for covering health risks of international relevancy and make the world safer from the novel pathogens.

**Keywords:** Emerging disease; Epidemiology; Mitigation program; Pathogens; Zoonoses

## CITATION

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## 1. INTRODUCTION

Zoonotic diseases are produced by microbes having potential of transmission naturally from livestock to public sector. The current prevalence of zoonotic diseases imposes vital intimidations to human health, particularly those who live in impoverished areas and have close contact with domestic or wild animals (Yasmeen et al. 2022). These diseases are mainly spread from animals to humans directly or indirectly (Fig. 1). Global climate changes, growing populations, shifting trend of rural towards urbanization, livestock transhumance and traveling are the key factors in emerging zoonotic diseases (Rahman et al. 2020).

Several zoonotic diseases have been described in detail in Table 1. In most developing countries such as India, Pakistan and Bangladesh, policies like public health interventions and mass vaccination of livestock are not much effective due to lack of collaborations among policies makers for disease outbreak, livestock and public health centers. In general, it has been noticed that much more concentration is given on preventive and control measures with very little attention to transmission and control work plan (Narrod et al. 2012). According to a survey conducted by Grace et al. (2012), there are almost 13 different zoonotic diseases which are very alarming to livestock community, growing animal's population, public health and economy of country. In sub-continent, major portion of population belongs to poor community which depends on livestock farming for income source (Zia 2009). Improper survey, immense assessment, lack of investigation activities and diminutive field-diagnostic services have been the likely reasons of hindrance in declaring exact prevalence of zoonotic diseases and their pathogens in the region (Grace et al. 2012). In such circumstances, some wise approach should be followed to eradicate negative impacts of zoonotic diseases at their initial stages and their further propagation (Abbas et al. 2014). A vivid investigation of the situation generates different assumptions which should be evaluated. Originally, this chapter will explore possible avenues in depth for expected public health threats of zoonotic diseases in future, risk factors and their control measures.

### 1.1. EXPOSURE OF HUMANS TO ZOONOTIC EFFECTS

More than 200 different forms of zoonotic diseases have been documented, which have considerable disease share in human population (WHO 2020). About 75% of emerging diseases are of animal origin while 60% from human source (Mohammadpour et al. 2020). Literature indicates that 0.6 million deaths occur in human population in a year mainly due to Rabies, Avian flu and Rift Valley fever. These diseases have hazards on human and animal health sectors and consequently cause poor performance in livestock and or finally death, which thus influence the economy of farming community and country (Thormaehlen 2021). Worldwide, there are 13 important widespread zoonotic diseases in low and middle economy countries which annually cause 200 million disease cases and approximately 3 million deaths in human population (Rahman et al. 2020). Professionally human population can be exposed to hazard effects of zoonotic diseases via following means:

- Endemic zoonotic diseases are most prevalent in poor human population and cause billions of sickness and millions of mortalities every year. These diseases commonly include cysticercosis, brucellosis, bovine tuberculosis, leptospirosis, and foodborne disease.
- Epidemic diseases usually occur rarely, which are few in number such as anthrax, rabies, Rift Valley fever, and leishmaniasis however, they may also occur in susceptible populations under favorable factors like sickness, starvation, change in climate, flooding, and poor immune system. Their incidence shows a high degree of chronological and spatial unpredictability (Grace et al. 2021).
- Arising zoonotic diseases probably occur repeatedly in the area (Grace et al. 2021). According to literature, zoonotic diseases are attributed $2^{nd}$-$3^{rd}$ of all emerging diseases (Fong 2017). Around

335 cases of zoonotic diseases have been reported based on literature published from 1940 to 2004 (Haider et al. 2020).

- Currently zoonotic diseases are exclusively spread via human-to-human transmission. These diseases mainly include AIDS, pneumonia, malaria, measles, and dengue fever and their intensity can be compared with endemic zoonotic diseases (Grace et al. 2021).

## 1.2. CLASSIFICATION OF ZOONOTIC DISEASES

Zoonotic diseases are usually classified based on etiological agents, reservoir hosts and pathogen transmission cycle (Table 1).

Classification according to etiological agents includes different microorganisms (Table 1) which cause zoonotic diseases. Important bacterial, viral, parasitic, protozoal, fungal/mycotic rickettsial and chlamydial zoonotic diseases along with their hosts and main effects are described in Table 1.

Zoonotic diseases based on reservoir hosts are anthrapozoonoses, zooanthroponoses and amphixenoses. Anthrapozoonotic diseases mainly occur naturally in domestic and wild animals. Leptospirosis, Rift valley Fever and rabies are the major examples of anthrapozoones. Zooanthroponoses like tuberculosis and amoebias, spread usually from humans to animals. Amphixenoses transmit from human to animals and vice versa**.** Streptococcosis and staphylococcosis are grouped under amphixenoses.

Based on pathogen transmission cycle and epidemiology, zoonotic diseases are classified into orthozoonoses, cyclozoonoses, metazoonoses and saprozoonoses. Orthozoonoses propagate from diseased vertebrates to susceptible vertebrates either directly or indirectly. Brucellosis, rabies and trichinosis are its some important diseases. Spread of cyclozoonotic diseases need two or more host vertebrates for transmission of infectious agent. These diseases are subdivided into euzoonoses and non-obligatory. In euzoonoses, life cycle of agent does need human as a host for disease transmission. Taenia solium and taenia saginata are typical examples. In non-obligatory cyclozoonoses, transmission of disease and completion of life cycle of causing agent involve human as a host by accident. Hydatid disease and toxoplasmosis are examples. Spread of metazoonotic diseases needs two hosts: vertebrate and invertebrate for disease transmission. However, in invertebrate host, infectious agents may multiply, develop and remain dominant. Based on involvement of hosts, metazoonoses are further sub-divided into metazoonoses type I, II, III and IV. In metazoonoses type I, one host each from vertebrate and invertebrate is involved for transmission disease. This type includes yellow fever and plague. Type II needs three hosts, one host from vertebrate and two hosts from invertebrate for disease transmission such as Paragonimiasis disease. Metazoonoses type III also needs three hosts, two vertebrates and one invertebrate for agent transmission. Clonorchiasis is only one example of this disease. Metazoonoses type IV is transovarian transmission and its common example is tick borne encephalitis. Saprozoonotic diseases, in addition to vertebrate and invertebrate hosts necessitate substance site or reservoir such as plants, soil and some foods for completion of agent life cycle and transmission of disease. These diseases are sub-divided into saproanthrapozoonoses, saproamphixenoses *and* saprometanthrapozoonoses. Saproanthrapozoonoses require substance other than animal for transmission into humans. Cutaneous larva migrans and ancylostomiasis are its typical examples. Saproamphixenoses are equally shared in nature by man and animals. However, these are transmitted via non-animate substance. Major examples of this disease are histoplasmosis and fungal infections. For completion of life cycle of agent and transmission of saprometanthrapozoonoses, vertebrate and invertebrate hosts in addition to substance are required. Fascioliasis is the only one example of this disease.

Some important sources of transmission of zoonotic diseases are presented in Fig. 1 and 2 show people at more risk and most susceptible groups, respectively.

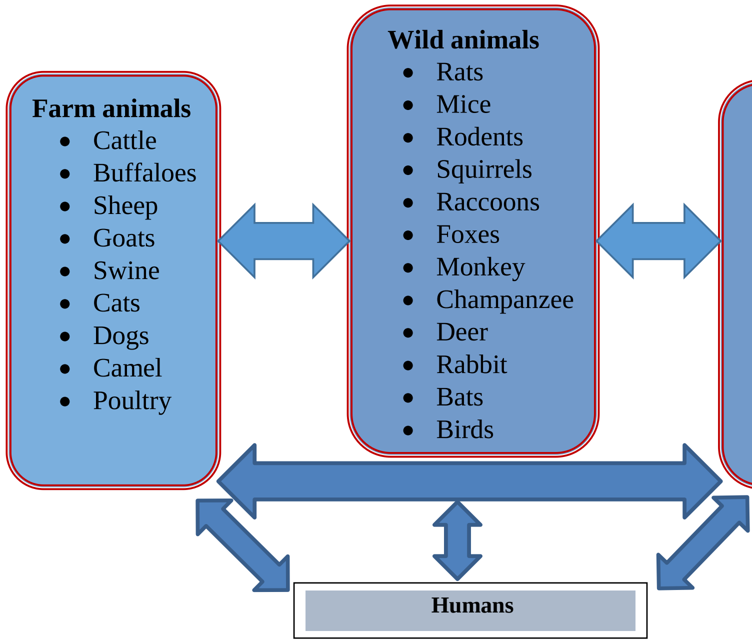


**Fig. 1:** Sources of zoonotic diseases transmission

## 1.3. ZOONOTIC DISEASES IN FRAME OF ENVIRONMENTAL DYNAMICS

Rising zoonotic diseases are by description in a flux process, which occur, multiply in host or geographically, or change. in pathogenicity, virulence, and or additional drivers are involved. Indeed, anthropogenic and environmental variations are essential zoonotic drivers which include deforestation agricultural encroachment, urban sprawl, climate change, and anthropogenic change like biodiversity loss (Anderson et al. 2004). Their mode of action is mostly through multifarious alleyways that are not well understood. This can be cleared from examples like, fragmentation, which can be due to, residential growth, which usually causes biodiversity loss; linked to Lyme disease risk (Allan et al. 2003).

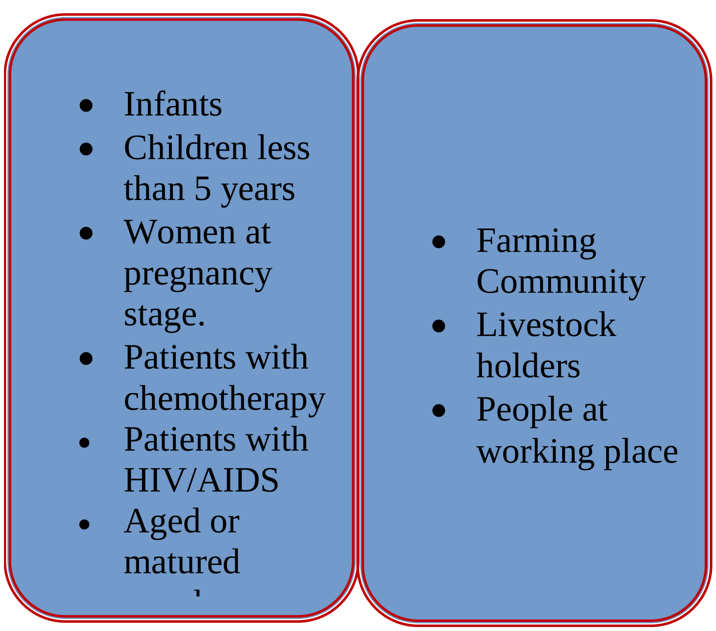


**Fig. 2:** People at more risk

Deforestation has increased quickly since the commencement of the 20th century. Though reforestation, has been accomplished in certain advanced nations, like the US and some zones of Europe, and up to 3% of global forests lose every year with maximum losses in tropical countries. Deforestation causes various ecosystem consequences such as it reduces habitat existing for wildlife creatures. It also alters the environmental frame, i.e. by segmenting habitats into little patches, separated by agricultural events. Deforestation and changes in land-use and human settlement patterns have caused higher prevalence of malaria and its vectors (Bauhoff and Buch 2020). Clearance of forests by road construction causes erosion and makes areas to be publically colonized (Caliskan 2013). Cleared lands and channels under roadways collect rainwater are favorable for malaria transmission- anopheline mosquitoes (Suwonkerd et al. 2013). Deforestation and water logging usually expose people and- animals to new pathogens in the area of bush meat hunting. Later, variations in land-use carry some of these pathogens and migrate them to increase the susceptibility of habitats and populations.

Fragmentation of wildlife habitat is unique anthropogenic land-use variation, changing host composition in an environment and basic microbial ecology. Little patches usually remained after fragmentation lessens target populations, by predators' destruction and an increase in the target mass. Slighter fragments in the forests of some developed belt like US have some animal predators and enhanced bulk of white-footed mice, which is a big reservoir for Lyme disease pathogen such as *Borrelia burgdorferi*, where people have higher risk of this disease. In habitats with less modification, alternative and less competent reservoirs diversity overcome diluting effect (Johnson and Thieltges 2010). Diluting effect is a buffering effect for risk of disease that is vanished during habitat fragmentation. Agriculture covers plenty of the world's productive land and consumes more than 2/3 (67%) of the world's fresh water (Tang et al. 2021). Increasing irrigation shrinks water supply for other purposes and therefore enhances breeding locations for disease vectors.

Growth in international trade of food has caused many disease outbreaks and the incidence of new agents. Import of strawberries, by US from Mexico, raspberries from, Guatemala, carrots, from Peru, and coconut milk, from Thailand has caused some outbreaks recently such as food-borne diseases in meat and vegetables. This accounts for more than 7 million sicknesses, 323,000 hospitalzations, and 5,100 causalities in US annually (CDC 2005) in the frame of essentiality of food security.

Some lesser health impacts on agricultural production coming from pathogen tolerance against antibiotics use in animal residues in groundwater from farm- run-off, and micro-dams for irrigation, in Ethiopia promoted in malaria up to seven folds (Gerald et al. 2009).

Modifications in natural resources and ecosystems are also causing agents for incidence of diseases. Human infringement on wildlife habitat may cause probability for occurrence of new and emergence of known communicable diseases (McLennan and Plumptre 2012). We take the example of rabies in animals, and has adapted, to, urban environment. Bats habitats: skunks, and raccoons, are the important breeds of dog and hunt human waste; and in several states, street dogs, are the main causing agent for infection in humans (Singh et al. 2001).

Climate Change in greenhouse warming forecast can cause cholera, malaria, dengue and leishmaniasis which are water and vector borne diseases, respectively, which are mainly determined by an increase in rainfall causing good conditions for vectors, intermediate and reservoir hosts (Campbell-Lendrum et al. 2015). Furthermore, a robust linkage occurs between El Niño-Southern Oscillation (ENSO) and prevalence of RVF, cholera and hantavirus (Anyamba et al. 2009). ENSO cycles are at extreme due to climate change, cause extensive and greater effect. Secondly, growth of vectors responsible for bluetongue and African Horse Sickness in Northern Europe will expose Europe to outbreak of these diseases (Wilson et al. 2009).

**Table 1:** Etiology, animal host, zoonoses and major organs and effects in human

| Etiology | Animal host | Zoonosis | Organs/systems/ effects involved in humans | Type of microbe | References |
|---|---|---|---|---|---|
| *Brucella abortus, Brucella melitensis, Brucella suis, Brucella canis,* | Cattle, sheep, goats, pigs and dogs | Brucellosis | Poor appetite, Body weight loss, high fever in afternoon, pain in back and joints | Bacterial | (Hayoun et al. 2023) |
| *Bacillus anthracis* | Horses, ruminants (cattle, sheep and goats), wild animals (mink, bison, elks, white-tailed deer), pig and dogs | Anthrax | Skin, organs interlinked with respiratory system and gastro-intestinal tract | Bacterial | (WHO 2008) |
| *Mycobacterium bovis, Mycobacterium caprae, Mycobacterium microti* | Cattle, sheep, pigs, deer, wild boars, camels and bison | Tuberculosis | Lungs, bones (bone marrow) and nervous system | Bacterial | (Heemskerk et al. 2015) |
| *Mycobacterium leprae* | Mouse, rat, cat and monkey | Leprosy | Lesions in skin | Bacterial | (Truman et al. 2011) |
| *Arcobacter butzleri, Arcobacter cryaerophilus, Arcobacter skirrowii* | Cattle, sheep, swine and poultry | Arcobacter infections | Pain in abdominal, vomiting and fever | Bacterial | (Vandenberg et al. 2004) |
| Actinomyces bovis | Cattle, sheep, horses, pigs, dogs, and other mammals | Actinomycosis | Swelling of soft tissues, lymphatic nodes, skin, and abscess | Bacterial | (Valour et al. 2014) |
| *Borrelia burgdorferi* | Horses, dogs and cat | Lyme disease or Borreliosis | Fever, headache, rashes on skin or erythema migrans | Bacterial | (Radolf et al. 2021) |
| *Campylobacter jejuni, Campylobacter coli* | Cattle and sheep as main ruminants, poultry, swine, dogs, cats, mink and ferrets | Campylobacter enteritis | Enteric disorders like diarrhea, fever, stomach cramps, sometime nausea and vomiting | Bacterial | (Igwaren and Okoh 2019) |
| *Corynobacterium ulcerans, Corynobacterium, Pseudotuberculosis* | Cattle, dog and cat | Corynebacterium ulcerans and Corynebacterium pseudotuberculosis infections | Difficult breathing, heart rhythm problems, and even death may occur | Bacterial | (Dias et al. 2011) |

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| *E coli O157:H7* | Cattle, sheep, pigs, deer, dogs, and poultry | Enterohemorrhagic Escherichia coli infections | Enteritis and Hemolytic–uremic syndrome (HUS) | Bacterial | (Fatima and Aziz 2023) |
| *Helicobacter pullorum, Helicobacter suis* | Poultry and pigs | Helicobacter infection | Peptic ulcer | Bacterial | Kusters et al. 2006) |
| *Vibrio parahaemolyticus* | Most common farm animals | Vibriosis | Enteritis | Bacterial | (Bell and Bott 2021) |
| *Salmonella enterica, Salmonella bongor* | Cattle, sheep, goat, horse, pigs, rabbits, cat, dog and chickens | Salmonellosis | Enteritis | Bacterial | (Grünberg 2020) |
| Pastuerella multocida | Cattle, buffaloes, sheep, goats, deer, poultry, pigs, cats and dogs, | Pasteurellosis | Fever, vomiting, diarrhea and gangrene | Bacterial | (Wilson and Ho 2013) |
| Influenza A virus Genus—Alphainfluenzavirus Family—Orthomyxoviridae | Ducks, chickens, turkeys, wild birds, dogs, cats pigs, whales, horses and, pinnipeds | Avian influenza | Flu, diarrhea, and pneumonia | Viral | (Capua and Alexander 2004) |
| Rabies virus, Genus—Lyssavirus Family—Rhabdoviridae | Dogs, wolves, cats, bats, monkey and cattle | Rabies | Affected nervous system/CNS | Viral | (Koury and Warrington 2023) |
| Paramyxovirus, Genus—Avilavirus Family—Paramyxoviridae | Poultry and wild birds | Newcastle disease (ND) | Conjunctivitis, loss of appetite, coughing, gasping, nasal discharge, watery eyes, bright green and diarrhea | Viral | (Alexander 2009) |
| Dengue virus Genus—Flavivirus Family—Flaviviridae | Monkeys and dogs | Dengue fever | High temperature, rashes and hemorrhages in skin hemorrhage, and depressed | Viral | (Hasan et al. 2016) |
| Hantavirus Genus—Orthohantavirus Family—Hantaviridae | Mice, rats, shrews, and moles, house mice, roof rats and Norway rats | Hantavirus Pulmonary Syndrome (HPS) | Breathing issues and affected lungs, fatigue, fever and muscle aches, dizziness, chills, nausea, vomiting, diarrhea, and abdominal pain. | Viral | (Moore and Griffen 2023) |

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| Rift Valley fever virus Genus—Phlebovirus Family—Bunyaviridae | Buffaloes, cattle, sheep, goat and camels | Rift Valley fever (RVF) | Fever, muscle and joint pain, and headache | Viral | (Paweska 2014) |
| SARS coronavirus (SARS-CoV) Genus—Coronavirus Family—Coronaviridae | Bats, dogs, cats, ferrets, minks, tigers, and lions | Severe acute respiratory syndrome (SARS) | Fever, pain in muscle, respiratory disease and pneumonia | Viral | (Hodgens and Gupta 2023) |
| *Monkeypox virus* Genus—*Orthopoxvirus* Family—*Poxviridae* | Squirrels, Gambian poached rats, dormice and monkeys | Monkey pox | Skin with pox lesions and fever | Viral | (Moore et al. 2023) |
| *Trichinella spp* (nematode). e,g. *T. spiralis* | Pets (dogs and cats), pigs, mice and wild animals | Trichinosis | Vomiting, diarrhea, anorexia, pain in abdomen and myalgia | Parasitic | (Furhad and Buchari 2023) |
| *Fasciola hepatica, Fasciola gigantica* | Large and small ruminants | Fascioliasis | More bleeding, fever, nausea, inflamed liver, lesions/rashes on skin, and severe pain in abdomen | Parasitic | (Good and Scherback 2023) |
| *Cryptococcus neoformans* | Cattle, sheep, goats, horses, dogs and birds | Cryptococcosis | Issues in lungs, fever, nausea, and vomiting | Parasitic | (Del Poeta and Casadevall 2012) |
| *Coccidioides immitis, Coccidioides posadasii* | Dogs, farm animals, deer, horses and pigs, | Coccidioidomycosis | Coughing,low appetite, limping, enlarged joints, fever, diarrhea, abscesses, draining lesions), fever, and weight loss | Fungal/mycotic | (Dobos et al. 2021) |
| *Sporothrix schenckii* | Common pets (dogs and cats), horses, mules, ruminants (cows and goats), camels, swine, birds, rats and dolphins fish, | Sporotrichosis | Lesions ulcerate and discharge a serohemorrhagic exudate. lesions on head, nose and pinnae (cat), fever, listlessness, and depression and respiratory signs may occur | Fungal/mycotic | (Barros et al. 2010) |
| *Cryptococcus neoformis* | Common pets (cats and dogs), horse, ruminants, birds, and Other forest animals | Cryptococcosis | Inflamed membranes of brain and spinal cord, illness, fatigue, headache, neck rigorousness, photophobia, cough, nausea, and vomiting | Fungal/mycotic | (Chayakulkeeree and Perfect 2008) |

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| *Histoplasma capsulatum, var. capsulatum* | Pets (cat, dogs), rabbits (bucks and does), and mice | Histoplasmosis | Mostly affected but no symptoms, sickness, cough, pain in chest, loss in body weight, infected liver cells, and disturbance in hematology | Fungal/mycotic | (Develoux et al. 2021) |
| *Rickettsia prowazekii* | Dogs, young ruminants, donkeys young camels | Louse-borne typhus, also called epidemic typhus | Increase fever, cephalalgia (headache), fast breathing, pain in body and muscle, rashes, cough, nervous system manifestations, nausea and vomiting | Rickettsial | (Ogrzewalska et al. 2017) |
| *Orientia tsutsugamushi* | Mice, rats, squirrels, prairie dogs, porcupines, beavers, guinea pigs, and hamsters | Scrub typhus | Pyrexia, dermatitis, body and muscle aches, increased rate of breathing, cough, and diarrhea | Rickettsial | (Rapsang and Bhattacharya 2013) |
| *Coxiella burnetti* | Ruminants, pets mainly dogs and cats, poultry commonly chickens, and wildmammals | Q-Fever | High temperature and rashes on skin | Rickettsial | (Mostafavi et al. 2012) |
| *Rickettsia rickettsia* | Mice, rats, squirrels, dogs, guinea pigs, and hamsters | Tick borne typhus/rocky mountain spotted fever | High temperature, headache, rashes on skin, myalgia, abnormally decreased body weight, nausea, vomiting, pain in abdomen and eyes sensitivity to light | Rickettsial | (Graves and Stenos 2017) |
| *Chlamydia felis, Chlamydia trachomatis* | Very common in cats and mice | Chlamydia | Conjunctivitis, inflammation of urethra, cervix and pelvic, disturbed pregnancy, infertility, inflamed epididymis and arthritis | Chlamydial | (Bressan et al. 2021) |
| *Chlamydia abortus* | Cattle., horses, sheep, rabbits, pigs and, cats | Enzootic abortion | Typically characterized by abortion | Chlamydial | (Al-Ahmed and Salman 2020) |
| *Trypanosoma brucei* | Eland antelope, cattle, camels, and horses | African sleeping sickness | Increased fever, headache, nausea, vomiting, and development of erythematous (reddish) plaque | Protozoal | (Checchi and Barrett 2008) |
| *Trypanosoma brucei* | Antelopes, cattle, camels, and horses | Trypanosomiasis | Prolonged fever, headache, itching, swollen lymph nodes, swollen and enlarged liver and spleen, and disturbance in sleep | Protozoal | (Algehani et al. 2021) |
| *Leishmania infantum* | Bats, cats, dogs, and horses | Leishmaniasis | Lesions on skin, Swollen and enlarged liver and spleen, and wasting | Protozoal | (Mcgwire and Satoskar 2014) |
| *Toxoplasma gondii* | Swine, small ruminants including rabbits and Poultry birds | Toxoplasmosis | Swollen lymph glands, muscle aches and pains, headache, fever, inflammation of the lungs, heart muscle and eyes | Protozoal | (Dubey 2009) |

| | | | | | |
|---|---|---|---|---|---|
| *Prion protein* | Ruminants, mink, deer, and elks | Mad Cow Disease, also known as Bovine spongiform | Memory loss, changed personality, lack of coordination, unclear language, blindness, abnormal and shaking movements and brain and mobility loss. | Acellular non-viral pathogenic agents | (Setbon et al. 2005) |

## 1.4. ECONOMIC IMPACT OF ZOONOTIC DISEASES

Generally, an increase in population, urbanization and per capita income results in increased utilization of animal feed source. This not only encourages livestock producers and other channels, but also expands and improves their businesses sector to fulfill consumer demand (ASL2050 2017a). In a business environment, which is being speedily changed, profits are often unreliable due to competitive, operational, legal and financial and other risk factors having greater impact on profitability of livestock industry. In such circumstances, some livestock farmers and enterprises are successful, and they will survive and expand business; while others relieve themselves from livestock industry due to failure. For the livestock business sector, the vital part for any administration is to implement some rules and regulations that make successful transformation of the sector in the future. If the government fails to consider the above keys, then it may cause degradation of grasslands, microbial water pollution, emission of greenhouse gas ($CH_4$), epidemics and zoonoses, which damage livestock industry and diminish wellbeing in society.

Zoonotic diseases targeting animal-human boarder are a major hazard for society by attack on livestock industry and therefore diminish human capital (Ari et al. 2022). This reduction in capital could be estimated by a zoonotic disease like avian influenza, during its peak, reduced chicken meat production, up to one third in China (Huang et al. 2017), and the 2009 swine flu pandemic, in Mexico infected over 100 million people with a death toll of about 20 000, (Nathason 2016).

The fiscal impact of the zoonotic diseases on livestock and public health sectors is determined by taking the sum of the losses (cost in US dollars):

- Loss of livestock
- Production loss due to infected livestock
- Loss of humans due to mortality (social cost)
- Number of morbid humans (social cost)

In cattle farming systems, a diseased animal will either be dead, be discarded, be slaughtered, or live with poor productivity at infected stage. Cost of animals' loss as well as cost of reduced production due to prevalence of disease in animal can be computed.

The cost of treatment (sick animals) is not usually considered because of negligible expenditure of farmers and veterinary services (CAHI 2015). So in such case, cost of animal loss is determined by sum of

- Number of dead animals multiplied by price of an adult animal at farm
- Number of condemned carcasses multiplied by price of an adult animal at farm.
- Number of carcasses from partially/not condemned animals multiplied by 30% discount in farm price of an adult animal
- Number of unborn calves (due to reduced fertility) multiplied by price of young animal at farm.

Cost of reduced production in survivors is estimated by taking sum of:

- Number of lactation periods loss (number of unborn calves/diseased and infertile females multiplied by milk yield per lactation
- Price of 1 lit milk in market

- Number of female infected and with no fertility loss multiplied by av. reduction in milk (lit) and market price of I liter milk.
- Number of survivors multiplied by av. dressed weight lost and market price of 1 kg beef.

In poultry farming systems, diseased birds may die, be culled or slaughtered, or suffer from reduced production (meat and or egg production). For some fatal diseases with high risk, the whole bird flock might be slaughtered precautionary and therefore such birds are not included in infected/diseased birds. In case of slaughtering, the birds can still be consumed, although they likely have not reached full slaughter weight. The treatment cost of sick birds is not considered due to the factors described above under cattle system while calculating economic losses.
Cost calculation of Loss of meat purpose birds is determined by taking sum of:

- Number of diseased killed multiplied by cost of live bird at farm
- Number of culled birds multiplied by cost of live bird at farm
- Number of slaughtered birds multiplied by price of live bird at farm.

Economic loss due to reduced egg production in surviving laying hens is quantified from number of surviving hens multiplied by reduction in eggs produced (number) and market price of egg.
By considering humans, transmission of zoonotic diseases from animals to humans occurs via direct and indirect contact, vectors and food consumption. Therefore, different groups of people face different risks of these diseases. To estimate the impact of morbidity and mortality of zoonotic diseases in public health sector, we have split the population at risk in three extensive groups (i) non-livestock holder and non-consumers of animal source foods (ii) non-livestock holders but consumers of animal source foods (iii) livestock holders and consumers of animal source foods. In such case, Economic loss in humans due to zoonotic diseases by taking sum of:

- Total number of survivors multiplied by number of working days lost and the daily weight measuring the severity of the disease and minimum wage/head/annum
- Total number of deaths multiplied by years of life lost

## 1.5. PREVENTION AND CONTROL MEASURES OF ZOONOTIC DISEASES

For minimizing the hazards of zoonoses in different sectors, the most suitable guidelines for the authorized bodies in that region are to develop plan for disease mitigation. The strategic plan should include the following considerations:

- Operative Structure Between Livestock and Human Health Sectors

To fight against sudden emerging of zoonotic disease, it is essential to establish strong coordination, between livestock and human health sectors. This alliance will enhance linkage, network and communication between public and organization sectors (Rahman et al. 2020). The task force developed from this collaboration can lead this practice towards building up strong agreement and partnerships through joint field investigation and share institutional resources for active mitigation measure at the animal–human level.

- Successful Investigation for Early Detection of Disease

Because of pool of emerging zoonoses in animals or/and in arthropods and difficulty in prediction exactly, investigation at the first sign of a new disease emergence in livestock is specifically important to detect disease threats (Meurens et al. 2021.

- Consolidation of Diagnostic Capacities for New Pathogens

Laboratory services should be strengthened with diagnostic potential be effective in detection of zoonotic disease in the region. Establishing laboratory networks inland and outland can enhance fast delivery of samples for timely analysis (Belay et al. 2017).

- Standardization in Case Management/Case Definition and Disease Mitigation

Health care facilities for disease threats should be ensured. An effective program with standard precautions for disease control should be exercised prior to disease occurrence. Most transmission through exposure to blood and body fluid can be prevented through standard precautionary measures before any zoonotic disease is recognized (Fesseha et al. 2022).

- Assimilating Management of Vector Mitigation

To optimize the use of resources for effective vector control, an integrated vector control management (IVM) strategy should be considered for all arthropod-borne viruses. This approach encourages interventions usage, either alone or in combination, which is based on confirmation and integrated management of mosquito's vectors. IVM is, therefore, most active effective stratagem for vector mitigation, responsible for transmission, of arthropod-borne viral hemorrhagic fever.

- Role of Social and Behavioral Interventions in Diminishing Transmission

The behavioral response of exposed populations determines the success or failure of interrupting the intermediate vertebrate hosts for most of the new zoonotic diseases. Awareness of the community's risk and, how this relate to intended behavior, socio- or psycho-cognitive factors need to be considered to plan appropriate social and behavioral interventions for disease threats (Vrba et al.2020).

- Evolving Epidemic Vigilance and Capacity Building for Novel Zoonotic Diseases

There should be a national plan including all key stakeholders. This plan should focus on distribution of zoonotic diseases in the region via, geographic information systems, other information technologies and risk assessment (Yasmeen et al. 2022). Also, identification of regions at high risk, improvement in investigation on human, animal and vectors and linkage of their data and then dissemination are very important in order to exchange important information on risks through well-established mechanism on a regular basis between these sectors.

Lastly, it is also important to monitor and evaluate the progress of this strategic plan for disease mitigation; officials should consider the following elements:

- Augmenting political commitment, national planning and coordination mechanisms
- Strengthening vigilance, surveillance and response
- Building national capacity and promoting research
- Improving regional and international cooperation and collaboration
- Linkage among health education, risk communication and social mobilization

## 1.6. USE OF ONE HEALTH APPROACH

For mitigation of zoonotic diseases, international organizations and researchers developed the liaison among public, livestock and environment sectors. This relationship is accepted and approved as a concept which is called "One Health Concept or Approach". This approach is designed to manage global health issues (Bidaisee and Macpherson 2014). One Health Approach inspires collaborations among different professionals like wildlife biologists, veterinarians, physicians, agriculturists, ecologists, microbiologists, epidemiologists, and biomedical engineers to warrant health for livestock, public and environment (One Health Commission 2020). In developing countries, this approach through control of zoonotic diseases has broad effects on poverty and food and health security. For preventing prevalence of zoonotic diseases, the partnerships of multi-sectors are intensively needed for maintaining surveillance among the human, animals, and environment. For control of zoonotic diseases, one health approach recommends (1) establishing "Zoonotic Disease Unit" for health security of above sectors (2) developing national plan for "Zoonotic Disease Unit"; (3) involving leadership from multi-sectors and relevant personnel to conduct zoonotic disease research; (4) implementing veterinary public health policies with collaborators from outlands and (5) reviewing the zoonotic diseases on routine basis to address prevalence of diseases through surveillance, epidemiologically and laboratory tests (Pieracci et al. 2016).

In summary, the one health approach plays a vital role in addressing the prevalence and mitigation of zoonotic diseases among humans, animals, and environment sectors to make the globe free from intimidations of these diseases.

## 1.7. CONCLUSIONS AND FUTURE PERSPECTIVES

The region is now carried by effects of different zoonotic diseases. Therefore, these novel diseases occur as unexpected and unpredictable events. Secondly it has been observed that prevalence of any disease today could be a serious issue tomorrow for the globe and it appears to continue to provoke the resilience of National Health Authority and timely response. Similarly, to mitigate these emerging diseases, aptitude of local, and global circle will be a factual assessment -for the global health safeguard. In spite of global efforts to bridge the present gap in information related with the origination and transmission of several zoonotic diseases novel in the region, regional teamwork with greater focus would be required to safeguard, the public health. For supportable public health programme for detection, prevention and control of these diseases in the region, the present condition in the region regarding response to these diseases triggers a clear-cut and coherent need.

"Public Health" approach comprising a joint coordination procedure, mutual planning, joint application, community input, capacity building and joint monitoring and evaluation program, for livestock -human health sectors should be the basis for task-plan of team work for mitigation. This approach should also highlight following key areas, where public health approach is expected to make a difference:

- Sharing health resources between the medical and veterinary sectors
- Mitigating zoonotic diseases in animal reservoirs
- Quick identification and action against developing diseases.
- Prevention of epidemics and pandemics
- Generating awareness and value addition to health research and development.

The strategic plan also needs the stakeholders, to start and consolidate measures- for integrating technical, social, political, policy and regulatory issues to improve their capacities sufficiently to lessen the public health hazard and economic impact. The application of a worthwhile strategy is the mode onward for mitigation of emerging and re-emerging zoonotic diseases in the region. We suggest The Regional Main Power to consider and adopt the strategic guidelines described here. Active mitigation programs will present an opportunity for covering health risks of international relevancy and make the world safer from novel pathogens.

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