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Transboundary Zoonotic Diseases: Indian Perspective

Siddhant Parkar[1], Sanjay Shakya[2], Anil Patyal[3], Tripti Ganjeer[4], Atul Kumar[5], Choodamani Chandrakar[6], Ankit Shukla[7]

Author's Affiliation: [1,4,7]Post Graduate scholars, [2]Professor and Head, [3]Assistant Professor, [6]Ph.D. Scholar, Department of Veterinary Public Health and Epidemiology, College of Veterinary Science & Animal Husbandry, Anjora, Durg, Chhattisgarh 491001, India. [5]Assistant Professor, Department of Veterinary Public Health and Epidemiology, Dr. G.C Negi College of Veterinary and Animal Science, Palampur, Himachal Pradesh 176072, India.

Corresponding Author: Anil Patyal, Assistant Professor,Department of Veterinary Public Health and Epidemiology, College of Veterinary Science and Animal Husbandry, Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Anjora, Durg, Chhattisgarh 491001, India.

E-mail: anilvet01@gmail.com

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Abstract

The existence of zoonotic diseases affecting humans and animals have historically been recorded for over hundreds of years. However, factors such as changes in agro-ecological conditions and international commerce, have led to increase in the incidence of disease outbreaks.With the advancement of technology, livestock production has gained an integral position in the national economy, socioeconomic development, poverty alleviation and nutrition supply for human beings. However, with increase in globalization, challenges in maintaining healthy herds of livestock are arising. The major reason behind the emergence/re-emergence of these diseases is the spread of disease-causing pathogens across borders. Such transboundary diseases have the potential to spread rapidly irrespective ofnational borders and can therefore cause serious socioeconomic consequences. Several new transboundary zoonoses emerge, and old diseases re-emerge, exhibiting increased chances for unexpected spread to new regions, often over great distances. These transboundary diseases adversely affect food safety, rural livelihoods, human health and international trade.Also, the interaction of wildlife with humans and other livestock animals have increased the risk of spread of pathogens across boundaries and consequent disease. Minimizing the movement of animals across the borders is essential and prompt practice of quarantine protocol would help reducing many transboundary diseases. Also, it is important to developscientific and risk-based standards which help in facilitating the international trade in animal commodities. The review focuses on the need for ensuring public awareness for transboundary zoonotic diseases, as an emerging disease may go unnoticed as such, unless it is reported to the concerned authority.

Keywords : Agro-ecological conditions; International trade; Wildlife interaction; Quarantine protocols.

Introduction

Livestock is an important component of the agricultural system as it provides food security, women empowerment in rural parts of the country, improves the quality of human life and make a significant contribution to national economy. Livestock enterprises and animal production also contribute significantly to the source of energy, draft power for crop cultivation, high quality animal proteins and vitamins (meat, milk), manure, raw materials (hides and skins).[1] The infectious diseases which affect farm animals has been recorded for over many years.[2] It is estimated that about 60% of known human infectious diseases originate

from animals, and that 75% of newly emerging diseases affecting humans are zoonotic, with most coming from wildlife.[3] These disease pathogens continuously evolve and adapt themselves to humans and animals alike.[4] However, factors like changes in agro-ecological conditions and global marketing, have led to increase in the incidences of animal diseases which is mainly due to spread of disease-causing pathogens across borders.

Threat from transboundary diseases is intensifying due to climatic changes and with increasing movement of human population, livestock and livestock products, fish and fish products, and plants and plant products within and across countries.[2]

According to FAO, Transboundary Animal Diseases (TADs) may be defined as those epidemic diseases which are highly contagious or transmissible and have the potential for very rapid spread, irrespective of national borders, causing serious socio-economic and possibly public health consequences.[5] Several new transboundary diseases emerge, and old diseases re-emerge, exhibiting increased chances for unexpected spread to new locations, over great distances.[2]

Disease of wildlife have a major impact on public health, conservation, national/regional economies and wildlife diversity. The interaction with other hosts and increasing movement of human population across countries and other areas have led to the spread of pathogens across boundaries which ultimately spreads the disease among animal and human population. The total eradication of these infectious agents is impossible, if the wildlife hosts acting as natural reservoirs are ignored.[6] The diseases adversely affect rural livelihoods, food safety, human health and international trade and it is therefore necessary to effectively manage these transboundary diseases.

The common denominator for minimizing risk and threat management of these diseases is epidemiology and it encompasses efforts into heeding warnings, communication of risk factors, disease recognition, detection and diagnosis, and cross-occupational efforts for response and eventual recovery.[7] An effective quarantine system in place is always advisable to prevent entry and establishment of transboundarydisease.[2]

Hence, the responsibility for prevention, control and elimination of these transboundary zoonotic diseases falls squarely on the shoulders of the public sector, notably government veterinary services and may require high public investment.[8]

Common Ways of Introduction of Transboundary Zoonotic Diseases

There are some common ways through which a transboundary zoonotic disease can be introduced into a new geographical location. The most common ways are through contaminated animal products or live diseased animals offering opportunities for pathogens and vectors to be transported across oceans and continents.[1] Importation of contaminated biological products such as vaccines or germplasm or via entry of infected people have also been reported to spread these diseases. Natural spreading by wind currents or insect vectors, or even migration of animals and birdscould also spread diseases across countries.[2]

Potential of Transboundary Zoonotic Diseases

Economic losses

- Loss of capital.
- Decrease in the output quality.
- Human health costs associated with the disease.
- Restriction in the international trade due to disease and its control policy.
- Other impacts such as effects on rural economicsand tourism
- Environmental consequences by affecting wildlife population in some cases and cause pain and suffering for affected animals.[9,10]

Public health risk

- Cause public health consequences in the case of those transboundary animal diseases which can be transmitted to humans (i.e., zoonoses).[10]

Production risk

- Production losses such as milk, meat and other dairy products, wool and skin and hides.
- Mortality of diseased animals.
- Abortion, delayed conception and delayed reproduction.[9,10]

Food security and nutrition risk

- The diseases can have effects on food availability and quality for poor communities as they raise the issues of food security as well as have negative effects on poverty alleviation.
- It results in reduced supply of high-quality protein such as milk, meat and eggs due to increase in livestock mortality and morbidity.[9,10]

Environment

- Concern over threats to the environment (either from diseases themselves, which might move into domestic or wildlife population, or from the control measures used to combat these diseases) is arising (e.g., disposal of infected tissues of cattle affected with BSE).[9]

Important Transboundary Zoonotic Diseases with Special Reference to India

Japanese encephalitis

Japanese encephalitis (JE) is a vector (mosquito) borne viral zoonotic disease, caused by an arbovirus (Flavivirus) belonging to family Flaviviridae. The World Health Organization (WHO) has attributed JE to be the most important cause of mosquito borne viral encephalitis in endemic Asian countries. An estimated 67,900 cases of JE are reported annually, with approximately 13,600–20,400 deaths.[11] More than 3 billion persons live in 24 countries that have JE virus transmission risk areas. The majority (75%) of JE cases occur in children aged <15 years. Although most JE cases are asymptomatic, the case fatality rate among patients with encephalitis approaches 30%, and approximately 30%–50% of survivors have long-term neurologic sequelae.[12]

JE was first recognized in Japan in 1924.[13] It is one of the most important forms of epidemic and sporadic encephalitis in the tropical regions of Asia, including Japan, China, Taiwan, Korea, Philippines, Southeastern Asia, and India; however, related neurotropic viruses are spread across the globe. Countries with proven epidemics of JE include India, Pakistan, Nepal, SriLanka, Burma, Laos, Vietnam, Malaysia, Singapore, Philippines, Indonesia, China, maritime Siberia, Korea, and Japan.[14]

In India, the first human case was reported from Tamil Nadu in 1955. The first outbreak of JE was recorded in 1973 from Burdwan and Bankura districts of West Bengal.[13] JEV is endemic in the Gorakhpur and Basti divisions of eastern Uttar Pradesh. The geographic features of this region are conducive for the spread of JEV; an abundance of rice fields and a bowl-shaped landscape allow water to collect in pools. An epidemic of viral encephalitis was reported from July through November 2005 in Gorakhpur, Uttar Pradesh, India. It was the longest and most severe epidemic in 3 decades; 5,737 persons were affected in 7 districts of eastern Uttar Pradesh, and 1,344 persons died.[15]

The disease killed 154 people in Assam in 2019, the highest in the last five years history. In 2015, the number of deaths due to JE stood at 135, in 2016 the number came down to 92 and further decreased to 87 in 2017. In 2018 the state saw 94 deaths due to the vector borne disease. In 2014, the state recorded 165 deaths due to Japanese encephalitis.[16]

Avian influenza

Avian influenza results from infection by viruses belonging to the species InfluenzaA virus, genus Influenzavirus A and family Orthomyxoviridae.[17]

In 1997, first documented infection of humans with avian influenza occurred in Hong Kong. This epidemic due to H5N1 virus caused severe respiratory disease in 18 humans of whom six died. The epidemic in humans coincided with an epidemic of HPAI in birds in Hong Kong also caused by H5N1 virus. It was established that the virus spread primarily from birds to humans especially in live bird markets. Though rare person-to-person infection was noted in health care workers but severe disease did not occur. To control the outbreak, about 1.5 million birds were culled to remove the source of the virus and thus a pandemic was averted.[18] In the period from 25th December, 2020 to 14th January, 2021, 215 new HPAI outbreaks were reported in domestic birds (subtypes H5, H5N1, H5N5, H5N6 and H5N8) in Asia, Europe and Africa and 79 new outbreaks in non-poultry (subtypes H5, H5N1, H5N5 and H5N8) in Asia and Europe. In addition, 794 HPAI outbreaks in poultry and non-poultry are still ongoing in Europe, Asia and Africa, involving different subtypes, namely H5, H5N1, H5N2, H5N3, H5N5, H5N6, H5N8 and H7N9.[19]

In India, first outbreak of H5N1 occurred in Maharashtra and Gujarat in February 2006. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India has reported 25 episodes of AI A(H5N1) in poultry birds in 15 states and union territory (Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh, West Bengal, Bihar, Assam, Meghalaya, Manipur, Tripura, Sikkim, Odisha, Karnataka, Kerala, Chandigarh) till January 2015.[20] Recently, outbreaks of avian influenza have been confirmed in Madhya Pradesh, Haryana, Maharashtra, Chhattisgarh, Himachal Pradesh, Gujarat, Uttar Pradesh, Uttarakhand, Delhi, Rajasthan, Jammu and Kashmir, and Punjab statein crow/migratory/wild birds.[21]

No case of avian influenza in humans is detected in India so far. Integrated Disease Surveillance

Programme working under National Centre for Disease Control, Delhi is keeping surveillance of avian influenza in India.[20]

Crimean Congo haemorrhagic fever

Crimean-Congo haemorrhagic fever (CCHF) is a tick-borne viralzoonotic disease caused by Nairovirus and could be transmitted from animals to humans in nature. The disease causes severe illness in humans (mostly in adults)with case-fatality rate up to 40%.[22]

Crimean-Congo haemorrhagic fever (CCHF) is endemic in many countries of Europe, Africa and Asia. During 2001, cases were recorded in Iran, Pakistan, South Africa and an outbreak was also reported from India. It has also been found in parts of Europe including southern portions of the former USSR (Crimea, Astrakhan, Rostov, Uzbekistan, Kazakhstan, and Tajikistan), Turkey, Bulgaria, Greece, Albania and Kosovo (a province of the former Yugoslavia). Limited serological evidence suggests that the disease might also occur in parts of France, Portugal and Hungary.[23]

The presence of CCHF in India was first time confirmed in Gujarat State during a nosocomial outbreak in 2011. Since then, numerous outbreaks and sporadic cases of this disease have been reported from different districts of Gujarat State. The patients died due to multiple organ failure, specifically failure of the kidney and liver.[24] There were two deaths reported from Rajasthan and one death from the state of Uttar Pradesh upto March 2015.[25] The fatality rate from CCHF depends upon several factors such asstrain of virus, day of diagnosis and treatment etc., with majority of deaths occurring in the second week of illness.[26]

Nipah virus infection

Nipah virus (NiV) infection is an emerging bat-borne zoonotic disease and is caused by an RNA virus belonging to family Paramyxoviridae. The virus belongs to the genus Henipavirus which also contains Hendra virus (HeV) and the recently described Cedar virus. Bats acts as a natural reservoir of Henipaviruses.[27]

Outbreaks of NiV have been reported from countries like Malaysia, Bangladesh, Singapore and India. The first outbreak was reported in Malaysia (1999) and the mode of transmission was direct contact with infected pigs. The outbreaks in Bangladesh and India were due to consumption of fresh date palm sap contaminated by fruit bats. Human-to-human transmission was also recorded in Bangladesh (2004).[28]

The first Nipah virus outbreak in Southern India was reported from the Kozhikode district of Kerala on 19th May, 2018 and there were 18 cases and 17 deaths as of 1st June, 2018. Kozhikode and Malappuram were the two districts affected during the outbreak. It was the third outbreak in India and the earlier outbreaks occurred in 2001 and 2007, both of which occurred in West Bengal. Both the state and the central government agencies have managed and successfully controlled the outbreak.[29]

Plague

Plague is caused by the pathogen Yersinia pestis which circulates in animal reservoirs, particularly in rodents. It is found in all continents except Australia.[30] The disease was earlier known as the "Black death" during 14th century and it caused approximately 50 million deaths in Asia, Africa and in Europe.[31]

In 2013, 783 cases were reported worldwide and led to 126 deaths. According to World Health Organization (WHO), there are 20 countries in Africa, America, and Asia which are identified as natural foci for plague. The three most endemic countries for plague are Madagascar, the Democratic Republic of Congo and Peru. Outbreaks are reportedin Madagascar nearly every year since 1980.[32]

The first case of Bubonic plague was confirmed in Bombay, India (now Mumbai) on 23rdSeptember 1896. The Bombay Plague came in five epidemic waves, turning endemic by the early 1900s. The outbreak in India lasted for more than 20 years and by 1918, it had claimed over 10 million lives in India with over 1.6 lakhs in Bombay alone.[33] Outbreaks of plague were also reported from Mamla village of district Beed, Maharashtra state (bubonic type) and district Surat in Gujarat state (pneumonic type) in September,1994. Subsequently, cases of pneumonic plague were also reported from Varanasi (U.P), Karnataka, Delhi,and other states. A total of 876 cases and 54 deaths were reported.[32]

The Ministry of Health, India has reported a total of 16 cases of pneumonic plague including 4 deaths as of 19th February2002 in Hat Koti village, Shimla district, Himachal Pradesh state, since the onset of the outbreak on 4 February 2002.[31] An outbreak of bubonic plague was reported in 2004 from Dangud village of district Uttar Kashi, Uttarakhand state with 8 cases & 3 deaths.The National Centre for Disease Control (NCDC), Delhi has identified four sylvatic foci (affecting wild animals) in India; the tri-junction of south India (Karnataka, Andhra Pradesh

and Tamil Nadu), Beed belt in Maharashtra, Rohru in Himachal Pradesh and Uttarakhand. Routine surveillance is carried out in these areas by the NCDC.[32]

Management of Transboundary Zoonotic Diseases

Following strategies need to be implemented in order to prevent and control transboundary zoonotic diseases.

- The movement of animals across the border should be minimized and effective quarantine protocol would help to reduce transboundary diseases. Use of remote sensing and Geographic information system (GIS) can help in surveillance, early warning systems and control of infectious diseases.
- Prevent and control man-made disasters which have adverse effects on the climate.
- Breaking the human-livestock-wildlife cycle of transmission of infection to control the spread of diseases.
- Enhancing thetechnology development, agricultural/animal research and training, and by improving the government policies.
- Creating appropriate preparedness plan and response capacity to prevent any emerging disease.
- International co-operation to minimize the spread of transboundary diseases cross the boundaries is very essential.[2]

Role of International Organisations

- FAO deals with transboundary zoonotic diseases through animal disease emergency response mechanisms: The Emergency Prevention System (EMPRES) develops strategies for intervention and improved management for animal health. It monitors and give early warning and hence ultimately helps to prevent animal diseases.The Emergency Centre for Transboundary Animal Diseases (ECTAD) is FAO's corporate centre for the planning and deliveringveterinary assistance to FAO member countries responding to the threat of transboundary animal health crises. The Emergency Management Centre for Animal Health (EMC-AH) is another rapid response unit to animal disease emergencies.[34]
- The Global Framework for Progressive Control of Transboundary Animal Diseases (GF-TADs)is a joint FAO/OIE initiative combining the strengths of both organisations to achieve agreed common objectives. GF-TADs is a facilitating mechanism that will endeavour to empower regional alliances in the fight against transboundary animal diseases (TADs), to provide for capacity building and to assist in establishing programmes for the specific control of certain TADs based on regional priorities.[35]
- The Global Early Warning and Response System for Major Animal Diseases including Zoonoses (GLEWS) is a joint FAO, OIE and WHO initiative which combines the strengths of the three organizations to achieve common objectives. Through sharing of information on animal disease outbreaks and epidemiological analysis the GLEWS initiative aims at improving global early warning as well as transparency among countries.[36]

Organizations in India

- NIHSAD (National Institute of High Security Animal Diseases) - is a premier institute of India for research on exotic and emerging pathogens of animals. The institute has contributed significantly by detecting many animal diseases of exotic origin and preventing them from entering our country.[37]
- NCDC (National Centre for Disease Control) functions as the nodal agency in the country for disease surveillance facilitating prevention and control of communicable diseases. In coordination with the State Governments, NCDC has the capacity and capability for disease surveillance, outbreak investigation, and rapid response to contain and combat outbreaks.[38]

Challenges in Dealing with Transboundary Zoonotic Diseases

Transboundary zoonotic diseases have major economic consequences as the cost of the measures taken at individual, collective and international levels in order to prevent or control the disease outbreaks are very high. Several challenges confront the strategies to combat these diseases. There is a requirement of novel system having capacity of real-time surveillance of emerging diseases and need driven research and service oriented scientific technology is necessary at regional levels. There is a need for epidemiological methods of real-time utility for assessment of the dynamics of infections in the self and neighbouring countries/regions.[39] It is important to research and developdisease diagnostic reagents which are

easily available and affordable and which do not need refrigeration (cold chain). It is necessary to produce vaccines in sufficient quantities as lack of vaccine or insufficiency hampers the disease control programs. Also, availability of cost-effective intervention or disease control strategies is required. There is a need for ensuring public awareness about epidemic animal diseases.Shortage of government and private funding for research on emerging animal diseaseshampers the disease control programmes. Due to inadequate regulatory standards, international trade of livestock and livestock products still pose a risk and is unsafe.[2]

Conclusion

There is an associated risk of movement of transboundary diseases which is emerging with increasing globalization andas livestock rearing constitutes a significant share in the national economy of a developing country like India, it is important to take up disease control initiatives.Also, livestock producers in less developed countries are particularly at risk because livestock not only provides income, but also food, draught power and various social functions. Hence, development of scientific and risk-based standards that facilitate the international trade and control of these diseases in wildlife population too could prevent the spread of these transboundary zoonotic diseases.

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Table 1: Origin of important transboundary zoonotic diseases, its spread in India and mode of transmission.

Name of Disease	Origin	Year of Spread to India	Mode of Transmission	Reference
Japanese encephalitis	Originated from an ancestral virus in the area of the Malay Archipelago. 1st clinical case reported in 1871 in Japan.	First human case of JE reported in Tamil Nadu in 1955.	Through mosquitoes C. tritaeniorhynchus, reservoir host such as egrets and pond herons, amplifying host such as pigs.	[40]
Crimean Congo Haemorrhagic Fever	Crimea region in 1944 and Congo region in 1969.	First confirmed in 2011 in the state of Gujarat.	Contact with infected tick or animal blood and human-to-human transmission occurs by infectious blood or body fluids.	[41]; [24]
Nipah Virus Disease	First recognized in Malaysia in 1999	First evidence of human-to-human transmission was seen in Siliguri, West Bengal in 2001.	Via unprotected exposure to secretions from the pigs, or unprotected contact with the tissue of a sick animal, consumption of fruits or fruit products (such as raw date palm juice) contaminated with urine or saliva from infected fruit bats.	[42]; [28]
Zika virus disease	First human infection reported in 1952 in Uganda.	First case reported in Gujarat in 2017.	Bite of infected mosquito (mainly Aedes aegypti), mother to foetus transmission during pregnancy, sexual contact etc.	[43]; [44]
Avian Influenza	First described in 1878 in Italy and first outbreak of highly pathogenic H5N1 outbreak reported in Hong Kong in 1997.	First report of H5N1 outbreak in domestic birds was reported in Maharashtra in April 2006.	Through faeces and respiratory secretions, direct contact with secretions from infected birds, through contaminated feed and water	[45]; [17]; [46].
Plague	Originated in Central Africa as Justinian Plague in 542 A.D to 750 A.D	First epidemic of plague reported in Bombay in 1896.	Through bite of an infected flea, handling tissues or body fluids of plague infected animal, infectious droplets.	[47]; [48]; [49].
West Nile Virus	First human case reported in West Nile district of Northern Uganda in 1937.	Presence of antibodies in humans was first reported in 1952 in Mumbai.	Through bite of an infected mosquito; it can also spread through blood transfusion and organ donation, mother to baby transmission during pregnancy, delivery or breast feeding.	[50]; [51]; [52].

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