



Challenges of Emerging and Re-Emerging Zoonoses and Strategies for Their Prevention and Control

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Abstract

The problems of emerging and re-emerging zoonoses are increasing globally. There are many emerging and re-emerging zoonotic diseases that have serious impact on health of public as well as animals and economy worldwide. The factors influencing the occurrence of emerging and re-emerging zoonoses include environmental (ecological) changes, changes in farming practices, changes in human demographics and behavior, microbial adaptation and change, technological changes and industrialization, establishment of human settlements in formerly uninhabited areas, intensification of animal production, social and cultural factors, breakdown of host's defenses, breakdown of public health measures, deficiencies in public health infrastructure, and international travel and trade. The emerging and re-emerging zoonoses can be effectively prevented and controlled by epidemiological investigation of diseases, identification of etiological agents, development of diagnostic tools, collaboration, cooperation, interdisciplinary approach, advancement of laboratories, training of the occupational groups, awareness and effective communication.

Keywords: Control, Emerging, Prevention, Re-Emerging, Zoonoses

Introduction

An emerging zoonosis is “a zoonosis that is newly recognized or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range”. There are many emerging zoonotic diseases such as avian influenza, severe acute respiratory syndrome, bovine spongiform encephalopathy, *Nipah* virus infection, *Hanta* virus infections, salmonellosis, campylobacteriosis, enterohemorrhagic *E. coli* infection etc. Multidrug-resistant *Salmonella* Typhimurium DT 104 emerged in cattle in 1988 in England and Wales, equine *Morbillivirus* in Australia in 1994, rabies in the United States in 1995 and in Australia and the United Kingdom in 1996 (Meslin, 1997). *Nipah* virus infections, Crimean-Congo haemorrhagic fever and avian influenza A(H5N1) are examples of diseases that have recently emerged (World Health Organization, 2014).

Re-emerging disease is an already known disease that either shifts its geographical settings or expands its host range or significantly increases its prevalence. The contact with wildlife during hunting, fishing or ecotourism has led to the re-emergence of *Leptospira* spp., *Bartonella* spp. and *Francisella tularensis*. Re-emergence of disease is mainly due to international travel and trade. Emerging and re-emerging zoonotic diseases have potentially serious human health and economic impact and their current upwards trends are likely to continue. Venezuelan equine encephalitis (VEE) emerged in Colombia and Venezuela in 1995, leptospirosis in Nicaragua in 1995 and Enterohemorrhagic *E. coli* (EHEC) infection in Japan in 1996 (Meslin, 1997). Malaria is re-emerging in Africa. Chikungunya fever is re-emerging disease in Asia. In India, anthrax, *Escherichia coli* infection, leptospirosis, listeriosis, melioidosis, plague, chikungunya fever, dengue fever, Japanese encephalitis, *Nipah* virus disease, buffalo pox etc. are emerging and re-emerging zoonoses (Pal, 2013). The important challenges in the prevention and control of emerging and re-emerging infectious diseases range from understanding the impact of factors that is necessary for the emergence, to development of strengthened surveillance systems that can mitigate human suffering and death (Mourya *et al.*, 2019).

Factors Influencing the Occurrence of Emerging and Re-Emerging Zoonoses

The following factors or conditions favour the occurrence of emerging and re-emerging zoonoses-

1. Environmental (Ecological) Changes

Ecological changes due to agricultural and economic development are among the most frequently identified factors in the emergence of zoonoses. Ecological factors usually precipitate emergence by placing people in contact with a natural reservoir or by changing conditions so as to favour an increased population of the microbe or its natural host (Morse, 1991). The outbreak of *Hantavirus* pulmonary syndrome (HPS) in the south western United States in 1993 was due to large-scale climatic effects (Levins *et al.*, 1993). In India, the deforestation in Karnataka state and grazing of cattle by this deforested area led to emergence of Kyasanur forest disease. Accelerated degradation of the natural environment, notably in developed countries by deforestation, building of dams, land consolidation may cause wildlife species to move to new areas, favouring their relocation in sub-urban zones, therefore entering into contact with humans (Chomel, 1998).

2. Changes in Farming Practices

The integrated pig-duck agriculture, an extremely efficient food production system traditionally practiced in certain parts of China for several centuries, puts these two species in contact and provides a natural laboratory for making new influenza recombinants (Scholtissek and Naylor, 1988). The evidence indicates that waterfowl, such as ducks, are major reservoirs of influenza and that pigs can serve as mixing vessels for new mammalian influenza strains (Webster *et al.*, 1992).

Irrigation may be associated with the emergence of mosquito-borne diseases and snail infestation. Infections transmitted by mosquitoes or other arthropods (World Health Organization, 1989) are often stimulated by expansion of standing water. The use of excess fertilizers in the rice fields lead to propagation of mosquitoes and lead to spread of Japanese encephalitis. Moreover, the use of pesticides in intensive farming practices leads to the development of resistance in many vectors and lead to spread of many zoonotic diseases.

Hantaan virus (causes Korean hemorrhagic fever) is a natural infection of the field mouse *Apodemus agrarius*. The

rodent flourishes in rice fields; people usually contract the disease during the rice harvest from contact with infected rodents. Junin virus causes Argentine hemorrhagic fever. Conversion of grassland to maize cultivation favoured a rodent that was the natural host for this virus, and human cases increased in proportion with expansion of maize agriculture (Johnson, 1993).

3. Changes in Human Demographics and Behavior

Human population movements due to migration or war may lead to emergence of disease. Increased number of HIV cases in Asia is mainly due to mass movement of workers from rural areas to cities. In industrialized countries, like the United States, tuberculosis can spread through high-population density settings like day care centers or prisons (Bloom and Murray, 1992). Dengue hemorrhagic fever (DHF) is common in some cities in Asia, where the high prevalence of infection is attributed to the proliferation of mosquitoes in water containers (Monath, 1993).

The close contact between human and livestock populations have led to the outbreaks of *M. bovis* in wildlife in Kruger National Park, whose onset originated from an infected cattle herd (de Lisle *et al.*, 2001). The outbreaks of highly pathogenic avian influenza in Southeast Asia have been demonstrated to be dependent on rice production, duck densities, and human population density (Gilbert *et al.*, 2008). Human behaviour can have important effects on disease dissemination, e.g., sexually transmitted diseases and the ways in which such human behaviour as sex or intravenous drug use have contributed to the emergence of HIV are now well known.

4. Microbial Adaptation and Change

Microbial adaptation is one of the most important factors associated with the emergence of zoonoses. The emergence of antibiotic-resistant bacteria as a result of the ubiquity of antimicrobials in the environment is an evolutionary lesson on microbial adaptation, as well as a demonstration of the power of natural selection and sometimes inappropriate use of antimicrobial drugs in a variety of applications (Neu, 1992). Antigenic drift in influenza virus, genetic changes in severe acute respiratory syndrome (SARS) corona virus in humans, development of antimicrobial resistance in HIV, multi-drug resistant TB and chloroquine resistant malaria are few examples of microbial changes. Genetic alterations in pathogens have also been responsible for outbreaks of emerging diseases, to a significant extent (Sarma, 2017).

5. Technological Changes and Industrialization

Technological changes include the changes in food production, processing and packaging and globalization of food supply can increase the chances of accidental contamination and amplify the effects of such contamination. The industrialization provides the opportunity to introduce agents from far away e.g., contamination of hamburger meat by *E. coli* strains. Bovine spongiform encephalopathy (BSE), which emerged in Britain, was likely an interspecies transfer of scrapie from sheep to cattle that occurred when changes in rendering processes led to incomplete inactivation of scrapie agent in sheep by-products fed to cattle (Wilesmith *et al.*, 1991). The development of industries in the food production system for animals and humans followed by its worldwide distribution can be also increase the risk of contamination (Arora and Arora, 2008).

6. Establishment of Human Settlements in Formerly Uninhabited Areas

Encroachment of human settlements and agriculture on natural ecosystems results in expansion of ecotones (transition zones between adjacent ecological systems), where species assemblages from different habitats mix. This provides new opportunities for pathogen spillover, genetic diversification, and adaptation. Emergence of disease associated with ecotones includes yellow fever, Lyme disease, *Hantavirus* pulmonary syndrome, *Nipah* virus encephalitis, influenza, rabies, cholera, leptospirosis, malaria, and human African trypanosomiasis (Despommier *et al.*, 2006).

Nipah virus was first recognized in 1999 during an outbreak among pig farmers in, Malaysia. It was also recognized in Bangladesh in 2001. The disease has also been identified periodically in eastern India. Other regions may be at risk for infection, as evidence of the virus has been found in the known natural reservoir (*Pteropus* bat species) and several other bat species in Cambodia, Ghana, Indonesia, Madagascar, the Philippines, and Thailand. The case fatality rate is estimated at 40% to 75% (World Health Organization, 2018). *Nipah* virus encephalitis outbreaks in

humans have been reported in Siliguri (2001) and Nadia (2007) districts of West Bengal (Ang *et al.*, 20118). A focal outbreak of *Nipah* virus encephalitis that led to 18 laboratory-confirmed cases and amongst them 16 deaths has been reported in May 2018 in Kozhikode and Malappuram districts of Kerala State in south India (World Health Organization South-East Asia, 2018).

7. Intensification of Animal Production

An outbreak of *Nipah* virus infection occurred in Malaysia during 1998-1999, causing respiratory disease in pigs and high case fatality in humans. Epidemiological outbreak investigation showed that pig and human cases had occurred in 1997 on a large intensive pig farm in northern Malaysia (Epstein *et al.*, 2006). Intensive livestock farming can promote disease transmission through environmental pathways (Graham, 2008). Ventilation systems can expel *Campylobacter* spp. and avian influenza virus into the environment that can lead to increased risk of transmission of these pathogens to domestic and wild animals. Intensification of animal production, especially pigs and poultry, facilitates disease transmission by increasing population size and density (Drew, 2011).

8. Social and Cultural Factors

Social and cultural factors such as food habits and religious beliefs also play important role in the emergence of zoonoses (World Health Organization, 2016).

9. Breakdown of Host's Defenses

An immune depression can result from the breakdown of the host's defences, e.g., human may act as a healthy carrier for certain bacteria which can multiply in AIDS patients and may lead to death.

10. Breakdown of Public Health Measures

Classical public health and sanitation measures have long served to minimize dissemination and human exposure to many pathogens spread by traditional routes such as water or preventable by immunization or vector control. The pathogens often remain in reduced numbers in the reservoir hosts or in the environment, therefore, are often able to take advantage of the opportunity to emerge if there are breakdowns in preventive measures.

11. Deficiencies in Public Health Infrastructure

The rapid spread of cholera in South America may have been abetted by reductions in chlorine levels used to treat water supplies (Moore, 1992). These problems are more severe in developing countries. The US outbreak of waterborne *Cryptosporidium* infection in Milwaukee, Wisconsin, in 1993, with over 400,000 estimated cases, was in part due to a non-functioning water filtration plant (MacKenzie *et al.*, 1994).

12. International Travel and Trade

Worldwide movement of goods and people and air travel leads to the emergence of some diseases, e.g., HIV, dissemination of mosquito vectors (*Aedes albopictus*-Asian tiger mosquito), rat-borne *Hanta* viruses, introduction of cholera in South America and dissemination of *Vibrio cholerae* O139 via ships. *Aedes albopictus* was introduced into the United States, Brazil, and parts of Africa in shipments of used tires from Asia. This mosquito has established itself in at least 18 states of the United States and has acquired local viruses including Eastern equine encephalomyelitis (Centers for Disease Control and Prevention, 1991). International trade has also caused emergence of enteric bacterial pathogens such as *Escherichia coli* O157:H7, *Salmonella* Enteritidis and *Listeria monocytogenes* (World Health Organization, 2003).

Prevention and Control of Emerging and Re-Emerging Zoonoses

The following major steps need to be taken to prevent and control the emerging and re-emerging zoonoses-

1. Epidemiological Investigation of Diseases

It is important to carry out effective and timely epidemiological investigation of diseases in an attempt to make

effective strategies for prevention and control of emerging and re-emerging zoonoses. In order to prevent both human and animal deaths and also to avoid potential economic problems resulted by emerging and re-emerging zoonotic diseases, there should be good surveillance and control methods of these diseases.

2. Identification of Etiological Agents

Etiological agents of emerging and re-emerging zoonoses can be timely and confirmedly identified by experts of the concerned field in the well equipped and advanced molecular laboratories.

3. Development of Diagnostic Tools

There is a need to develop advanced diagnostic tools for rapid and accurate detection of pathogens of emerging and re-emerging zoonoses.

4. Collaboration

Collaboration of multidisciplinary teams with the support of scientists and laboratories staff is important to conduct investigations of emerging and re-emerging zoonoses. Collaboration at national as well as international level among different institutions or organizations concerned with animal health, wildlife health and human health is also an important factor for investigating and identifying emerging and re-emerging zoonoses.

5. Cooperation

Cooperation of international organizations such as the World Organization for Animal Health (OIE), the Food and Agriculture Organization (FAO) of the UN and the World Health Organization (WHO) can play very important role in the detection and management of emerging re-emerging zoonoses.

6. Interdisciplinary Approach

It is important for exploring the interactions among wildlife, domestic animals and humans.

7. Advancement of Laboratories

Reference laboratories fully equipped with molecular biology tools are important for rapid and accurate diagnosis of emerging and re-emerging zoonoses, so that their further spread can be prevented or minimized.

8. Training of the Occupational Groups

The training of professionals in the field of zoonotic diseases is important for better understanding about the diversity of the pathogens involved and the specificity of their reservoirs and enhances the ability to control emerging and re-emerging zoonoses.

9. Awareness

Awareness regarding etiologic agent, pathogenesis, transmission and management of infections in the scientific community, and awareness regarding severity of infections, source of infection, route of transmission, personal and environmental hygiene and precautions regarding prevention of spread of infection in the public in general can help in prevention and control emerging and re-emerging zoonoses.

10. Communication

Efficient communication system is important for timely dissemination of information for prevention and control of emerging and re-emerging zoonoses. Risk communication and risk management strategies will become increasingly important as new diseases may emerge in the future.

Conclusion

In recent years, the problems of emerging and re-emerging zoonotic diseases have increased worldwide. The ecological changes caused destruction of the natural environment increase the exposure of animals and humans to the vectors and reservoirs of unknown pathogenic micro-organisms. In addition to this, weak public health system, natural disasters, absence or weakening of better surveillance and controlling systems against the disease and

unhygienic living conditions are the main factors for the emergence and re-emergence of zoonotic diseases in many countries. There is also the spread of antimicrobial resistance in many emerging and re-emerging zoonotic pathogens become a global public health problem. Epidemiological investigation of diseases, identification of etiological agents, development of diagnostic tools, transfer of technology, related communication and information, training of the occupational groups, awareness, interdisciplinary approach for exploring the interactions among wildlife, domestic animals and humans may be some effective measures for prevention and control of emerging and re-emerging zoonoses.

Conflict of Interests

There is no conflict of interest.

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