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Moon Moon Satpathy
Department of Veterinary Microbiology, GADVASU, Ludhiana, Punjab, India

Corresponding Author:
Moon Moon Satpathy
Department of Veterinary Microbiology, GADVASU, Ludhiana, Punjab, India

Zoonotic viral diseases

Moon Moon Satpathy

Abstract
In the present scenario, zoonosis has become a significant public health concern. Increased interactions between humans and animals through various means have led to the emergence of many zoonotic pathogens that cross species barrier and infect humans. Activities like poaching, hunting, deforestation, eating uncooked meats of wild animals, drinking contaminated water or drinks, handling raw meats by abattoir workers, handling of excreta or urine of infected animals, improper sanitation and hand hygiene while handling animals, etc has given rise to many zoonotic diseases. Some of the zoonotic diseases are potentially harmful to human health and at the same time can become global pandemic. Vectors like rodents and bats can also act as reservoir hosts for many significant zoonotic disease causing viruses. Sometimes, insect vectors also play a significant role in diseases transmission from amplifier host to the dead-end host like humans. Public awareness on zoonosis and its threat to the humanity is very significant to control future outbreaks.

Keywords: Reservoirs, transmission, vectors, virus, zoonosis

Introduction
The word ‘zoonosis’ was coined by Rudolf Virchow. It comes from two Greek words, ‘zoon’, animals and ‘noson’ means disease. In other words, zoonosis refers to any infectious disease that is naturally transmissible from a non-human animal, especially a vertebrate to a human. Various infectious agents capable of causing zoonotic diseases are bacteria, virus, parasite, protozoa, fungi or prion. Zooanthroponosis refers to diseases that are transmitted to human by animals like rabies, brucellosis and Ebola. Anthropozoonosis are diseases that are transmitted to animals from humans like tuberculosis, Salmonellosis etc. As per WHO, about 61% of all human diseases are zoonotic in nature and 75% of new diseases discovered in the last decade are zoonotic.

Reasons behind emerging zoonotic diseases
Looking back into history, the early man was basically a hunter and food gatherer. He gradually got accustomed to a more civilized way of living when he discovered fire, he settled down near the banks of river and cultivated food crops, domesticated animals and cooked food that he ate. The man today has reached a very a very significant place in terms of development and achievements. He keeps animals as pets as well as for meat and milk purposes, consumes a variety of animal product, etc. The life of man has always been associated with animals since time immemorial. The man of today has converted forest areas into huge infrastructures like shopping malls, buildings and companies and so on, thus destroying the natural habitat of many wild animals and birds, making them to come into human inhabitation areas, increasing their proximity to human. Some animals share the same habitat as that of man like dogs, cats, rodents, etc. Some animals have so many similarities to man in terms of metabolism and other biological functions that they are often used as laboratory animals to study mechanism of action of any drug, vaccine or cosmetics, before being implemented for human use. Handling of many laboratory animals for research and experimentation purpose has also been a significant reason for jumping of viruses to humans. Treating various wild and domestic animals by health care professionals, as well as handling the carcass of slaughtered animals by abattoir workers, activities like poaching and hunting for meat and game purpose has also increased the risk of spread of viruses. This type of close association between man and animals has resulted into jumping of many harmful pathogens from both sides. Sometimes some animals can act as mixing vessels for many infectious agents. The changing food habits of man like eating raw or improperly cooked meat and other products of livestock and wild animals has also resulted into emergence of many zoonotic diseases.

Animals are also imported for breeding and livestock purposes. The travel and other facilities have increased in the recent years which have led to the fast spread of diseases from animals to humans and between humans as well. The risk of zoonotic infections have risen with increasing number of animal viruses that adopt human beings by crossing the species barriers more easily due to ecological changes and greater contact between humans and animals. This has become a major public health concern and a significant factor for causing heavy monetary loss to the government in terms of trade and commerce.

Reservoir of the viruses

Animals are important reservoirs for many infectious viruses. Common animal reservoirs are bats, rats, mice, monkeys. Bats are known as the reservoir host for Lyssaviruses, Henipaviruses, Menagle and Tiloman viruses, SAARS and Ebola viruses, etc. Monkeys are the reservoir hosts for Zika viruses. Ducks are the reservoir host for Influenza A virus. Bats harbor many viruses but are seldom affected. They get affected only by a limited number of diseases that include ectoparasite infestations like flees, mites, bugs, fungal diseases like white nose syndrome. Body fluids like blood, saliva, urine and faeces of the infected bats are potent source of viruses from where humans can get infection. Infection can also spread from intermediate hosts, insect vectors or environmental exposure. Human food habits also play a significant role in transmission. Some of the high impact zoonotic outbreaks involving bats are Australian bat lyssa virus and rabies from bites of vampire bats, Hendra and Nipah virus from urine of bats or contaminated fruits and forage, toddy. SARS, MERS and Ebola viruses are also linked to bats.

Zoonotic viruses

Viruses are classified into seven groups depending upon their nucleic acid according to the Baltimore classification. These include double-stranded DNA viruses, single-stranded DNA viruses, double-stranded RNA viruses, positive sense single-stranded RNA viruses, negative sense single-stranded RNA viruses, single-stranded RNA viruses with Reverse Transcriptase and double-stranded DNA viruses with Reverse Transcriptase. Virus responsible for causing zoonotic infections can belong to any of the mentioned category. There has been a significant increase in the zoonotic viruses since past few years. Some of them are Nipah virus, Hendra virus, Influenza virus, Marburg virus, Ebola virus, Rift Valley Fever virus, Crimean-Congo hemorrhagic fever virus, Hantavirus, Lymphocytic choriomeningitis virus, Lassa virus, Junin, Machupo, Guanarito, and Sabia Arenaviruses, Severe Acute Respiratory Syndrome virus, Middle East Respiratory Syndrome virus, Eastern Equine Encephalitis (EEE) virus and Western Equine Encephalitis (WEE) virus, Venezuelan Equine Encephalitis (VEE) virus, Japanese encephalitis virus, St. Louis encephalitis virus, Murray Valley encephalitis virus, West Nile fever virus, Zika virus, Kyasanur Forest Disease (KFD) virus, Mokola virus, Lagos bat virus and Duvenhage virus, Australian bat Lyssavirus, Cowpox virus, Camelpox virus, Monkeypox virus, Parapox virus, Pseudocowpox virus, Bovine popular stomatitis virus, Yabapox virus, Tanapox virus, Colorado tick fever virus, B viruses (Cercopithecine herpesvirus). Nipah and Hendra virus belong to the family *Paramyxoviridae*. Nipah virus outbreak was discovered in Nipah, Malaysia (September 1998- May 1999). It was earlier misdiagnosed as Japanese Encephalitis. Many outbreaks of Nipah virus was recognised between central and west Bangladesh between the years 2001-2009. In India, Nipah virus outbreak was reported for the first time in the year 2001 and 2007 in Siliguri district of West Bengal. Another outbreak was reported from Kozhikode and Mallapuram district of Kerala state, on 19th May, 2018, probably due to consumption of contaminated toddy drink. The Nipah virus is thought to be transmitted to humans from the secretions of pig or by consumption of fruit or fruit products contaminated with urine or saliva from infected bats (*Pteropodidae* family). It can also be transmitted from one human to another. The virus causes symptoms that are variable in nature, starting from asymptomatic infection to acute respiratory illness and fatal encephalitis. Hendra virus was discovered in 1994, following an outbreak of illness in horses and humans in the suburb of Hendra in Brisbane, Australia. The natural host of the virus is large fruit bat (flying foxes), from where the virus can occasionally spread to horses and from horses to humans who handle them. Menangle virus was first recognised in a reproductive disease outbreak in swine in a large piggery in Menangle near Sydney in 1997. It is believed that flying foxes are the natural host for the virus. This virus is also thought to be zoonotic as some people who were in close contact developed self limited influenza like disease. Influenza A, Influenza B, Influenza C and Thogotavirus belong to family *Orthomyxoviridae*. Influenza A affects birds, horses, swine, humans, etc; Influenza B infects only humans, whereas, Influenza C infects humans and pigs. Influenza A viruses have significant zoonotic potential as they have wide host range from where they can be transmitted to humans (Mostafa *et al* 2018) [1]. Aquatic birds like ducks, shorebirds and gulls are the reservoir of Influenza viruses. Swine often acts as a mixing vessel for the virus. The virus undergoes genetic shift and drift resulting into new variants. Some examples of global pandemics due to Influenza A viruses are 1889-1890 flu pandemic (Asiatic or Russian flu) possibly due to subtypes H3N8 or H2N2, 1918 Spanish flu caused by H1N1 Asian flu (1957–1958) caused by H2N2, Hong Kong flu (1968-1969), caused by H3N2 and 2009 flu pandemic caused by H1N1 etc. Marburg and Ebola virus come under the family *Filoviridae.* The Marburg virus was identified for the first time from two simultaneous outbreaks; one in Marburg and Frankfurt in Germany and other in Belgrade, Serbia in the year 1967. These outbreaks occurred from handling the African green monkeys that were imported from Uganda. The natural host for the disease is thought to be *Rousettus aegyptiacus*, fruit bats of *Pteropodidae* family. Transmission of the virus to humans can be due to prolong exposure to bat's cave, direct or indirect contact with the blood, secretions, and other body fluid of the infected indivisual. Sexual transmission is also a possible means of infection. The Ebola virus was identified for the first time in the year 1976 from two simultaneous outbreaks in Nzara South Sudan and Yambuku, DRC which is near Ebola River. It spreads through close contact with the body fluids of the infected animals commonly the fruit bats and bush meat. Spread from one human to another occurs through direct contact with broken skin or mucous or indirectly by blood or other body fluids, faeces, vomits of person infected with it. These viruses are known to cause hemorrhagic fever in man and primates which is very devastating. Rift Valley Fever virus, Crimean-Congo hemorrhagic fever virus and Hantavirus belong to family *Bunyaviridae*. Rift Valley Fever virus belongs to the genus

Phlebovirus. It causes acute haemorrhagic fever in domesticated animals like cattle, buffalo, sheep, goats, etc. Rift Valley Fever virus spreads to people through contact with infected body fluids including blood, handling infected tissues, and also from mosquito bite. The disease is mostly found in Africa. Crimean-Congo hemorrhagic fever virus is transmitted from livestock to humans by the ticks. In India, it was reported for the first time in the year 2011 from Gujarat. It is also reported from India in the year 2020 from Palghar, Maharashtra. Hantavirus is spread to people mostly by urine, faeces, saliva or rarely bites of infected rodents. The arthropod vector can be mosquitoes, midges, ticks, culicoides and flies. The arthropods can remain persistently infected. In Hantavirus infection, rodents remain persistently infected. The virus is very specific for both insect and vertebrate host; hence they remain restricted to a narrow geographical niche. In humans, these viruses can cause encephalitis, hepatitis, respiratory problems and can also cause multiorgan failure. Lymphocytic choriomeningitis virus and Lassa virus are the Arenavirus of zoonotic importance. House mouse is the reservoir host for the Lymphocytic choriomeningitis virus, whereas, Natal multimammate mouse is the reservoir for Lassa virus. These viruses are maintained in the nature by persistent infection in the mouse population and shed in the urine, faeces and saliva of the infected mice, which becomes a source of infection for the humans. LCMV causes influenza like symptoms and Lassa virus causes Lassa fever in humans. Argentine, Bolivian, Venezuelan and Brazilian Hemorrhagic fevers, commonly known as South American hemorrhagic fevers are also zoonotic diseases caused by Junin, Machupo, Guanarito, and Sabia Arenaviruses respectively. Under the family *Coronaviridae*, Beta Coronaviruses like Severe Acute Respiratory Syndrome, Middle East Respiratory Syndrome etc cause zoonotic infections in humans. The zoonotic viruses under the family *Togaviridae* are Eastern Equine Encephalitis (EEE) and Western Equine Encephalitis (WEE) virus, found in the eastern and western States of the USA and Venezuelan Equine Encephalitis (VEE) virus, found in Venezuela. Equine encephalitis is zoonotic in nature and can cause infection in humans. EEE is more fatal as compared to the other two. Japanese encephalitis virus, Murray Valley encephalitis virus, St. Louis encephalitis virus, West Nile fever virus, Kyasanur Forest Disease (KFD) virus, Louping ill virus are some zoonotic viruses under the family Flaviviridae. Japanese encephalitis is one of the most significant causes of viral encephalitis in Asia being reported for the first time in the year 1871 from Japan. The disease is most prevalent in China, Korea, Thailand, and Indonesia. It has also been reported from India as well. The virus is maintained by a mosquito and vertebrate host (mostly pigs and wading birds) cycle. Pigs are considered as an important amplifier host and are mostly asymptomatic for the disease. Humans are the dead end host for the virus as they can't produce sufficient viremia to infect the mosquitoes (*Culex tritaeniorhynchus*) which breeds in the freshwater and irrigated rice fields mostly during the warm seasons. Murray Valley encephalitis is also a zoonotic disease caused by mosquito vector. The reservoir hosts are mostly the water birds and the most common vector is *Culex annulirostris* endemic to northwestern Australia and Papua New Guinea. St. Louis encephalitis is also a mosquito born disease prevalent in the United States. West Nile fever virus is transmitted by mosquitoes to humans. The mosquitoes are believed to feed on a vertebrate host (birds), in which viremia is observed. Mosquitoes transmit the virus to humans which often serve as dead end host. Zika virus is transmitted to humans through the bite of infected mosquito mostly Aedes aegypti. It is also transmitted through sexual contact, from mother to foetus, via blood transfusion. Kyasanur Forest Disease (KFD) is another zoonotic tick born viral haemorrhagic fever reported for the first time in India from Kyasanur forest of Karnataka in March 1957. The disease was earlier reported from monkeys, hence commonly known as Monkey fever. Later on, it was also reported from humans. It is thought to be transmitted by the bite of ticks, commonly *Haemaphysalis spinigera*, which act as main reservoir host of KFDV. Monkeys are the amplifying host for the virus and humans are the terminal host. Louping ill is transmitted to humans by the ticks or due to contact with infected sheep and sheep tissues. Under the family *Rhabdoviridae*, the viruses of zoonotic importance are Rabies and other closely related virus like Mokola virus, Lagos bat virus and Duvenhage virus, Australian bat Lyssavirus etc capable of causing Rabies like disease in animals and human. These viruses are often isolated from bats. Foxes, raccoons, cats, dogs, and bats are common host for the virus. Dog is the most important host for human infection. They can infect humans by their bite, scratch and saliva. Infection from aerosols of bat can also occur. Colorado tick fever virus is a zoonotic virus belonging to the genus Coltivirus under the family *Reoviridae*. It is transmitted by Rocky Mountain wood tick of North America, *Dermacentor andersonii*. The reservoir hosts are possibly squirrels, rodents, etc. Cowpox virus, Camelpox virus (Jezek *et al*, 1983) [2], Parapox virus, Pseudocowpox virus, Monkeypox virus, Yabapox and Tanapox virus are zoonotic viruses belonging to family Poxviridae. Cowpox was first observed in milkmaids who handled infected cows. In humans, it causes maculopapular eruptions on neck, hands, face. Rodents are the reservoir host for the virus from where cow, cats, humans and zoo animals get infected. If the Parapox virus infection is acquired from milking cow, it is known as 'milker's nodule'; if it is acquired from sheep, it is known as 'orf'. Both Pseudocowpox and Bovine popular stomatitis virus are capable of causing occupational zoonosis. Yabapox and Tanapox viruses occur naturally in Africa. Both the viruses are zoonotic. B viruses (Cercopithecine herpesvirus) can be transmitted from macaques to humans and hence is a zoonotic virus under the family *Herpesviridae* (Woźniakowski *et al* 2015) [3]. Studies show the existence of zoonotic Adenoviruses. HAdV-B76, an emergent human adenovirus that caused fatality in 1965, shows genomic identity with two recently identified simian adenoviruses having cross species genome recombination events from chimpanzee, human and bonobo. This might have occurred due to zoonosis and anthropozoonosis (Dehghan *et al* 2019) [4]. HIV viruses which have much similarity to SIV, is being thought to have originated from monkeys, but the evidence is scarce regarding this.

Conclusion

Zoonoses pose a significant threat to both health and economy. We can help to prevent the spread of zoonosis through personal, environmental and herd hygiene. One must wash hands before and after handling animals, animal products or animal wastes. One should avoid frequent touching of face, mouth or eating in the animal premises. Sick animals must not be handled with bare hands. Gloves and mask should always be used by veterinarians while treating sick animals. Pests like rodents should be controlled and

proper hygiene of the dwelling or working area should be maintained. Insect vectors like ticks, mites, mosquitoes should be controlled by using mosquito nets, insecticide spray, etc. One should keep the sheds of animals clean and provide clean drinking water and feed to the animals in separate utensils to prevent the spread of disease in between animals. Unhealthy and sick animals can be shifted to isolation wards. Some healthy practices like cooking the food before eating, washing hands frequently with mild soap, and handling of animal products carefully can also prevent the infection. As prevention is better than cure, so, it must be taken care of to the utmost level to prevent a disease from spreading.

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