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Popular Article

Water-borne zoonotic viral diseases: its control and preventive measures

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Introduction

Water-borne viral zoonotic diseases are an emerging public health concern with profound implications for both human and animal health, particularly in low- and middle-income countries like India, where water pollution and close human-animal interactions are common. These infections are caused by viruses excreted in the faeces, urine, or bodily secretions of infected animals or humans, which then contaminate surface water sources such as rivers, ponds, and wells. Unlike bacterial or parasitic agents, many of these viruses are highly stable in the environment and can survive in water for prolonged periods, often resisting conventional purification methods like chlorination. As a result, ingestion of contaminated drinking water, use of water for irrigation, or contact with recreational water sources can lead to infection. This route of transmission is particularly problematic during the rainy season when flooding and waterlogging cause overflow of sewage and animal waste into public water supplies. Notable viral zoonoses transmitted through water include Hepatitis E virus (HEV), Rotavirus, Adenoviruses, and Nipah virus. HEV is a major cause of acute viral hepatitis in humans, with pigs acting as important animal reservoirs, especially for genotypes 3 and 4. Rotavirus, though primarily a human pathogen, has zoonotic strains shared between animals and humans, contributing to diarrhoea in both calves and children. Adenoviruses, due to their remarkable resistance to water treatment, are frequently found in recreational and drinking water sources and are linked to gastroenteritis and conjunctivitis in humans and respiratory and hepatic diseases in animals. Nipah virus, while less commonly water-borne, poses a unique zoonotic threat through indirect water contamination from bat secretions or infected animals like pigs. These viruses highlight the critical need for integrated surveillance, water safety measures, and veterinary interventions to prevent outbreaks and protect both livestock productivity and public health.

Viral pathogens

- **Hepatitis E Virus (HEV)**

Hepatitis E virus (HEV) is an emerging water-borne zoonotic pathogen that has gained global attention due to its dual transmission patterns via both contaminated water and animal reservoirs. HEV is a single-stranded, non-enveloped RNA virus of the Hepeviridae family, responsible for acute viral hepatitis in humans. In the veterinary context, domestic pigs are recognized as significant reservoirs of zoonotic HEV strains, particularly genotype 3 and 4, which can cross the species barrier and infect humans. Although infection in pigs is often subclinical, they can silently shed the virus into the environment, especially through faecal excretion, thereby contaminating local water bodies. This viral shedding becomes particularly problematic in regions with dense swine populations and poor sanitation infrastructure, where contaminated water is reused for agriculture, livestock consumption, and even household use. In India, HEV is highly endemic and is one of the major causes of acute hepatitis outbreaks, especially during the monsoon season when floodwater often mixes with sewage. Several studies have confirmed the presence of HEV RNA in swine herds across states such as Assam, Uttar Pradesh, Maharashtra, Tamil Nadu, and Punjab, emphasizing the zoonotic and environmental connection. Moreover, reports suggest that rural communities living near pig farms or those consuming undercooked pork are at greater risk. Clinical signs in animals are typically absent, although experimental studies have occasionally reported mild hepatitis and hepatocellular changes. In humans, the infection manifests as fever, malaise, anorexia, jaundice, and hepatomegaly. Pregnant women in their third trimester are particularly vulnerable, with mortality rates reaching up to 25%, mainly due to fulminant hepatic failure. Diagnosis of HEV infection in animals involves detection of viral RNA in faecal or serum samples using reverse transcription PCR (RT-PCR), while serological assays (ELISA) are used for antibody detection. In humans, acute infection is diagnosed by detecting anti-HEV IgM and viral RNA in serum or stool. There is currently no specific antiviral treatment for HEV, management is supportive.

- **Adenoviruses**

Adenoviruses are non-enveloped, double-stranded DNA viruses that belong to the family Adenoviridae. These viruses are remarkably stable in the environment and resistant to conventional water treatment methods such as chlorination, making them important water-borne pathogens. While adenoviruses have long been known to infect a wide range of vertebrate hosts including humans, cattle, pigs, poultry, dogs, and other domestic animals their zoonotic potential has gained attention in recent years, particularly in the context of water contamination. Human adenoviruses (HAdVs), especially those in species A to F, are frequently detected in surface waters, recreational waters, and even treated drinking water due to their high resistance to UV and chemical disinfectants. Water contaminated with faeces from infected humans or animals can harbour infectious adenoviruses, which may survive for extended periods, facilitating indirect zoonotic transmission. In humans, adenoviruses are well-documented pathogens, causing a variety of clinical syndromes depending on the serotype involved. These include acute gastroenteritis (especially in infants and young children), respiratory infections, conjunctivitis (commonly known as pink eye), haemorrhagic cystitis, and, in immunocompromised individuals, life-threatening systemic infections. Transmission through ingestion of contaminated water or contact with infected secretions is well-established. Several outbreaks of adenoviral conjunctivitis and gastrointestinal illness have been linked to contaminated swimming pools and inadequately treated drinking water. HAdV types 40 and 41, in particular, are associated with infantile diarrhoea and are often water-borne. In the veterinary field, adenoviruses also pose serious health concerns. Canine adenovirus type 1 (CAV-1) causes infectious canine hepatitis, a potentially fatal disease characterized by fever, abdominal pain, liver dysfunction, and ocular lesions (Blue eye). CAV-2 causes respiratory illness, often as part of the canine infectious respiratory disease complex (kennel cough). In poultry, fowl adenoviruses (FAdVs) are associated with inclusion body hepatitis and hydropericardium syndrome, causing considerable economic losses. Although these animal adenoviruses are considered largely species-specific, the close genetic and ecological relationship between human and animal adenoviruses raises concerns about potential recombination events or interspecies transmission, especially in areas with high animal-human-water interface, such as rural farms and peri-urban settlements. Diagnosis of adenoviral infections in both humans and animals involves molecular techniques such as polymerase chain reaction (PCR) and enzyme-linked immunosorbent assays (ELISA), which can detect

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adenoviral DNA or antigens in stool, respiratory samples, or environmental water samples. Electron microscopy and virus isolation in cell culture are also used in research laboratories.

- **Rotavirus**

Rotaviruses are among the most common causes of viral diarrhoea in neonatal animals, especially calves and piglets, and are responsible for significant economic losses in livestock industries globally. Belonging to the Reoviridae family, rotaviruses are characterized by their segmented double-stranded RNA genome and high genetic diversity. Several studies have demonstrated the zoonotic potential of animal rotavirus strains, particularly through water contamination in farm settings. The virus is highly stable in the environment and is shed in large quantities in the faeces of infected animals. Improper disposal of faecal waste or runoff from livestock farms into rivers, ponds, or irrigation systems facilitates the transmission of zoonotic strains to humans, particularly children, who may ingest contaminated water or come into contact with infected animals. In India, rotavirus is a leading cause of diarrheal illness in both humans and animals. Studies from regions like Gujarat, Andhra Pradesh, and Haryana have shown that mixed rotavirus infections involving both human and bovine strains are common, suggesting interspecies transmission and environmental spread via water sources. In neonatal calves and piglets, rotavirus infection results in profuse watery diarrhoea, anorexia, and rapid dehydration, which, if untreated, can lead to death. In humans, especially infants and young children, the disease causes acute gastroenteritis characterized by fever, vomiting, and watery diarrhoea, which may last for several days. Diagnosis in both animals and humans is typically carried out through detection of viral antigens in stool samples using enzyme-linked immunosorbent assay (ELISA), latex agglutination tests, or more advanced methods like RT-PCR and genome sequencing for strain typing.

- **Nipah Virus**

Although not conventionally categorized as a water-borne disease, Nipah virus (NiV) possess indirect water-related zoonotic threats through environmental contamination involving bats and domestic animals. NiV is a highly fatal virus from the Paramyxoviridae family and is transmitted from fruit bats (Pteropus spp.) to humans and animals. In natural habitats, bats excrete the virus in their saliva, urine, and faeces, which may contaminate fruits, palm sap, or nearby water sources. Consumption of raw date palm sap contaminated by infected bat excretions has been a recognized route of infection, as reported in Bangladesh and some parts of India. While direct waterborne outbreaks are not frequent, indirect contamination of community water tanks, wells, or open sources through bat droppings is a growing concern in shared environments. In India, Nipah virus outbreaks have occurred in West Bengal (2001 and 2007) and more recently in Kerala (2018, 2019, and 2021). The Kerala outbreaks were associated with high fatality rates and human-to-human transmission in clinical settings. In the 1999 Malaysian outbreak, pigs acted as amplifier hosts, with respiratory and neurological symptoms reported before transmission to humans. Though pig-associated outbreaks have not occurred in India, the potential remains, especially in areas where pig farming overlaps with bat habitats. Infected animals, particularly pigs, may exhibit fever, laboured breathing, tremors, and neurological signs. Human symptoms include acute encephalitis, high-grade fever, altered mental status, and respiratory failure. Case fatality rates can range from 40% to 75%, depending on early detection and care quality. Laboratory diagnosis involves real-time RT-PCR for detection of NiV RNA in serum, cerebrospinal fluid, or nasal/throat swabs. Serological tests such as IgM-capture ELISA are also employed for surveillance. Due to the high biosafety risk, testing must be done in BSL-4 facilities. No antiviral drugs have proven effective against Nipah virus. Treatment is limited to supportive care, oxygen supplementation, and management of complications in intensive care units.

Control and Preventive Measures

Preventing water-borne zoonotic viral diseases requires a multi-layered strategy that addresses animal reservoirs, water treatment, public awareness, and veterinary health systems. The first line of defense lies in ensuring access to safe and treated drinking water. Since HEV, rotavirus, and adenoviruses are resistant to standard chlorination, water treatment protocols must include advanced techniques like ozonation, ultraviolet (UV) irradiation, or membrane filtration, which can effectively inactivate viral particles. In rural and underserved areas, boiling water or using point-of-use water filters with fine pore sizes is a practical household-level intervention. Water sources should be protected from contamination by livestock and wildlife through fencing, covered wells, and separation of animal waste disposal systems from human water sources. Control at the animal level is equally crucial. Pig farms key reservoirs for zoonotic HEV should adopt hygienic waste disposal, limit animal contact with open water, and practice good housing sanitation. Vaccination programs can also help reduce viral transmission: vaccines for rotavirus are available and routinely used in humans and calves, while adenovirus vaccines are used in dogs and poultry to prevent severe disease. Although no commercial vaccine currently exists for HEV or Nipah in animals, experimental vaccines and surveillance studies are ongoing. A recombinant vaccine against HEV (Hecolin) has been developed and licensed in China, but is not yet available in India. From a public health and veterinary policy perspective, integration of "One Health" principles is essential. Coordinated surveillance of human and animal populations, especially during high-risk seasons like monsoon, can help detect emerging threats. Health authorities should establish early warning systems using wastewater surveillance for viruses like HEV and adenoviruses. Educational campaigns focused on hand hygiene, proper cooking of meat (especially pork), and avoidance of raw date palm sap (a known source of Nipah virus contamination) are critical in endemic areas. In the case of Nipah virus, where human-to-human transmission also occurs, rapid isolation, use of personal protective equipment, and strict control of animal movement during outbreaks are vital control measures.

Conclusion

Water-borne viral zoonotic diseases are gaining prominence as major public health and veterinary concerns, especially in countries like India where climatic factors, environmental conditions, and dense human-animal cohabitation facilitate disease transmission. The viruses discussed HEV, rotavirus, adenoviruses, and Nipah virus demonstrate varying degrees of water-borne transmission and zoonotic risk, with substantial implications for both human and animal populations. Control of these diseases cannot rely solely on medical interventions; rather, it requires an integrated strategy combining clean water access, improved animal waste management, livestock vaccination, and community education. Embracing the One Health framework ensures proactive and sustainable solutions by recognizing the interconnections of human, animal, and environmental health. Strengthening diagnostics, surveillance systems, and outbreak preparedness particularly during high-risk monsoon seasons will be essential in mitigating future risks and safeguarding public health.

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