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Review

Hantaviruses: An Emerging Global Challenge in Modern Public Health - Mini Review

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Abstract

Hantaviruses are emerging zoonotic pathogens that represent a significant global threat due to their expanding geographic distribution, broad host range, and potential to cause severe disease in humans. These viruses are primarily transmitted via aerosolized excreta from infected rodents, although insectivores and bats have also been identified as potential reservoirs. Human infections can lead to two main clinical syndromes: hemorrhagic fever with renal syndrome (HFRS), which is predominantly reported in Europe and Asia, and hantavirus cardiopulmonary syndrome (HCPS), primarily occurring in the Americas. Several factors contribute to the rising incidence and spread of hantavirus infections worldwide, including climate change, environmental disturbances, urbanization, habitat alteration, and increased human-animal interactions. This mini-review synthesizes current understanding of hantavirus epidemiology, pathogenesis, diagnosis, treatment, and prevention, highlighting their growing importance within the One Health framework.

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Introduction

Hantavirus infection is an important group of zoonotic diseases caused by viruses in the genus *Orthohantavirus*, family *Hantaviridae* (Zerbini et al., 2023). Hantaviruses are enveloped, single-stranded, negative-sense RNA viruses maintained in nature through persistent infection in rodent reservoirs (Jonsson et al., 2010; Samples and Arowolo, 2025).

The first recognized outbreaks occurred during the Korean War in the early 1950s, when thousands of soldiers developed Korean hemorrhagic fever (Lee et al., 1978; Lee et al., 2004). Since then, numerous hantavirus species have been identified worldwide. The emergence of hantavirus cardiopulmonary syndrome in the United States in 1993 further underscored the severe zoonotic potential of these pathogens (Nichol et al., 1993; Lee et al., 2004).

Today, hantaviruses are increasingly recognised as a major public health challenge because of climate change, ecological disturbances, expanding rodent populations, urbanisation, increased human–wildlife interaction, and lack of specific antiviral therapies (Schmaljohn et al., 1997; Klempa, 2009; Kruger et al., 2015; Samples and Arowolo, 2025).

Taxonomy and Virology

Orthohantaviruses belong to the order Bunyavirales and possess three genomic RNA segments designated small (S), medium (M), and large (L) (Pljusnin and Elliott, 2011; Bradfute et al., 2024).

The S segment encodes the nucleocapsid protein, the M segment encodes viral glycoproteins Gn and Gc, and the L segment encodes RNA-dependent RNA polymerase (Jonsson et al., 2010; Bradfute et al., 2024).

Different hantavirus species are associated with specific rodent reservoirs (Klempa et al., 2013; Vaheri et al., 2013):

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- *Hantaan virus* – striped field mouse (*Apodemus agrarius*);
- *Puumala virus* – bank vole (*Myodes glareolus*);
- *Dobrava-Belgrade virus* – yellow-necked mouse (*Apodemus flavicollis*);
- *Sin Nombre virus* – deer mouse (*Peromyscus maniculatus*);
- *Andes virus* – long-tailed pygmy rice rat (*Oligoryzomys longicaudatus*).

Among these, the *Andes virus* is unique because limited human-to-human transmission has been documented (Martinez-Valdebenito et al., 2014; Bradfute et al., 2024).

Transmission and Zoonotic Potential

Human infection with hantaviruses primarily occurs through the inhalation of aerosolized particles that are contaminated with the excreta of infected rodents, including urine, saliva, or feces (Jonsson et al., 2010). This mode of transmission highlights the respiratory route as a significant pathway for virus entry into the human host, particularly in settings where rodent populations are prevalent. Less commonly, transmission can occur via direct rodent bites or through contact with mucous membranes or open wounds contaminated with infected rodent secretions (Guo et al., 2013; Vaheri et al., 2013; Kruger et al., 2015; Samples and Arowolo, 2025).

Occupational exposure poses a considerable risk for certain groups of individuals. Activities that disturb environments infested with rodents, such as sweeping, cleaning, or renovating poorly ventilated structures—like barns, basements, and storage facilities—can aerosolize virus-laden particles, significantly increasing the likelihood of human infection (Vapalahti et al., 2003). Those at heightened risk include farmers, veterinarians, forestry workers, military personnel, emergency responders, and laboratory staff who may work with rodent populations or their biological materials (Clement et al., 2014). The prevalence of hantavirus infection in specific occupational settings underscores the need for heightened awareness and preventive measures among these vulnerable groups (Tian and Stenseth, 2019; Samples and Arowolo, 2025).

The zoonotic potential of hantaviruses warrants considerable attention due to the fact that infected rodent species can act as asymptomatic carriers, perpetually contaminating their environment with the virus (Jonsson et al., 2010). This continuous environmental contamination increases the likelihood of human exposure over time. It is important to note that while most hantaviruses are not transmitted between humans, notable exceptions exist; for instance, the Andes virus has exhibited limited human-to-human transmission, particularly in certain regions of South America, as documented by Martinez-Valdebenito et al. (2014). This potential for limited person-to-person transmission further complicates the epidemiology of hantavirus infections and underscores the importance of ongoing surveillance and research to understand and mitigate the risks posed by these pathogens (Watson et al., 2014; Samples and Arowolo, 2025).

Pathogenesis of Hantavirus Infections and Clinical Manifestations in Humans

Hantaviruses, a genus within the family *Hantaviridae*, predominantly target endothelial cells lining blood vessels. This cellular tropism leads to a marked increase in vascular permeability and capillary leakage, contributing to the hallmark symptoms observed in hantavirus-related diseases (Schonrich et al., 2015). The pathophysiological basis of these symptoms is significantly influenced by the host immune response, which, while necessary for combating the viral infection, can also culminate in severe clinical outcomes. Excessive cytokine release and subsequent inflammatory dysregulation are pivotal in determining disease severity, often resulting in a cytokine storm that exacerbates tissue injury (Krautkramer and Zeier, 2008).

Two major clinical syndromes arising from hantavirus infection have been recognized: HFRS and HCPS, each with distinct epidemiological and clinical characteristics (Vaheri et al., 2013).

Importantly, the clinical manifestations of hantavirus infections vary depending on the specific hantavirus species involved. In Hemorrhagic Fever with Renal Syndrome (HFRS), renal dysfunction emerges as a predominant feature, whereas Hantavirus Cardiopulmonary Syndrome (HCPS) is characterized by respiratory distress, often culminating in cardiopulmonary collapse (Vial et al., 2023).

HFRS is predominantly observed in Europe and Asia and is associated with a constellation of symptoms that may include high fever, severe headaches, abdominal pain, thrombocytopenia (reduced platelet count), haemorrhagic manifestations, and acute kidney injury (Huggins et al., 1991). The severity of HFRS can vary notably based on the specific viral strain involved in the infection. For instance, infection with the *Puumala virus* typically triggers a milder clinical picture known as nephropathia epidemica, which is characterized by less severe symptoms. In contrast, *Hantaan* and *Dobrava-Belgrade* viruses are associated with more severe clinical presentations and an increased risk of morbidity and mortality (Klempa et al., 2013; Kruger et al., 2015; Vapalahti et al., 2003).

On the other hand, HCPS is primarily observed in the Americas and is characterised by an initial onset of nonspecific influenza-like symptoms, such as fever, myalgia, and fatigue. However, this initial phase can rapidly progress to pulmonary oedema, respiratory failure, hypotension, and ultimately cardiogenic shock in severe cases. The mortality rate for HCPS can be alarmingly high, exceeding 30% in those presenting with severe disease manifestations (Jonsson et al., 2010; Vial et al., 2023).

These clinical profiles highlight the significant heterogeneity in disease presentation and severity, underscoring the importance of understanding the specific hantavirus species involved in infection for effective diagnosis and management (Samples and Arowolo, 2025).

Diagnosis

Diagnostic procedures for viral infections rely heavily on a combination of epidemiological history, clinical findings, and laboratory tests to ensure accurate identification of the pathogen involved. According to Kruger et al. (2015), this multifaceted approach enhances the reliability of the diagnosis by integrating different types of evidence.

One of the primary diagnostic tools is serological assays, which are designed to detect specific immunoglobulin M (IgM) and immunoglobulin G (IgG) antibodies against the virus in question. The presence of IgM typically indicates a recent infection, while IgG suggests past exposure, making these assays invaluable for establishing the timing and severity of the infection (Vapalahti et al., 2003). Serological testing is widely used due to its relatively straightforward execution and ability to provide results that can guide clinical management and public health responses.

In addition to serological methods, molecular diagnostics, particularly reverse transcription polymerase chain reaction (RT-PCR), play a crucial role during the acute phase of infection. RT-PCR detects viral RNA, which can be present in high quantities soon after infection. This method is particularly advantageous for early diagnosis and can facilitate rapid epidemiological investigations, as highlighted by Jonsson et al. (2010). The ability to detect viral genetic material promptly can significantly influence treatment decisions and outbreak control measures.

Patients with certain viral infections may exhibit laboratory abnormalities that provide further insight into the disease process. Common findings can include thrombocytopaenia (low platelet count), leukocytosis (increased white blood cell count), elevated liver enzymes indicative of liver inflammation or damage, proteinuria (presence of protein in urine), and impaired renal function (Vaheri et al., 2013). These laboratory abnormalities not only support the diagnosis but also help assess the severity of the infection and monitor the patient’s response to treatment.

In summary, a comprehensive approach to diagnosis—integrating epidemiological context with serological and molecular testing, alongside careful evaluation of clinical and laboratory findings—is essential for the effective management of viral infections (Vial et al., 2023).

Treatment

Currently, there is no universally recognized and specific antiviral treatment for hantavirus infections, as highlighted by Kruger et al. (2015). Management of these infections primarily revolves

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around supportive care, which may necessitate interventions such as intensive care monitoring, oxygen therapy, mechanical ventilation, hemodynamic stabilization, and even dialysis in cases of severe renal impairment (Vial et al., 2023).

Preventive strategies are critically focused on minimizing exposure to rodent populations and environments that may be contaminated with their excreta. According to Jonsson et al. (2010), effective rodent control measures, the secure storage of food items and animal feed, proper management of waste products, and the thorough disinfection of surfaces exposed to potential contamination are essential components of an integrated prevention plan (Clement et al., 2014).

Moreover, when undertaking cleaning activities in areas known to harbor rodent infestations, it is imperative to utilize appropriate wet disinfection methods combined with personal protective equipment (PPE). These practices are crucial for reducing the risk of aerosolization of pathogens, as pointed out by Kruger et al. (2015). By implementing these comprehensive measures, the risk of hantavirus transmission can be significantly mitigated.

One Health Importance

The concept of One Health is critical for understanding and addressing complex health issues arising from the interconnectedness of human, animal, and environmental health. A compelling illustration of this principle can be found in the epidemiology of hantavirus infections. These infections exemplify the intricate relationships among wildlife reservoirs, environmental factors, and human activities. According to Destoumieux-Garzón et al. (2018), the emergence of hantavirus infections is often linked to several ecological and anthropogenic influences.

Factors such as climate change, urbanization, and habitat modification significantly alter the dynamics of ecosystems, which, in turn, can facilitate the transmission of these viruses from wildlife to humans. For example, as human encroachment into natural habitats increases, so does the likelihood of contact with wildlife that may harbor zoonotic pathogens, including hantaviruses (Clement et al., 2014). This relationship underscores the necessity of examining health issues through a multidisciplinary lens, recognizing that human health is inextricably linked to the health of animals and the environment.

To effectively combat the threat posed by hantavirus infections and similar zoonotic diseases, an integrated surveillance system is imperative. This system should encompass various stakeholders, including healthcare providers, veterinarians, ecologists, microbiologists, and public health authorities. Collaborative efforts among these groups are crucial for the early detection, prevention, and control of outbreaks. By sharing data and expertise, these diverse professionals can contribute to a more comprehensive understanding of the factors that drive disease emergence, ultimately leading to more effective public health interventions (Destoumieux-Garzón et al., 2018). In conclusion, recognizing and implementing the One Health approach is essential for mitigating the risks posed by zoonotic diseases like hantavirus, thereby safeguarding both human health and the integrity of the ecosystems we depend on.

Conclusion

Hantaviruses are critical zoonotic pathogens that pose substantial public health risks worldwide. The transmission dynamics of these viruses are closely tied to their persistence in rodent reservoirs, the contamination of environments where humans may come into contact with infected rodents, and direct human exposure to rodent habitats. While hantavirus infections are not common, they can cause severe, and even fatal, disease in affected individuals. Effective prevention strategies, including rodent population management, maintaining environmental cleanliness, public education initiatives, and comprehensive One Health surveillance, are essential for minimizing the risk of hantavirus infections in human populations.

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