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Hantavirus: A Silent Emerging Zoonotic Threat to Global Health

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Abstract:

Hantavirus infection is an emerging zoonotic disease caused by RNA viruses of the family Hantaviridae, primarily transmitted through aerosolized excreta of infected rodents. The infection manifests mainly as Hantavirus Cardiopulmonary Syndrome (HCPS) and Hemorrhagic Fever with Renal Syndrome (HFRS), both associated with high morbidity and mortality. Clinical features range from nonspecific febrile illness to severe pulmonary edema, respiratory failure, shock, and acute renal impairment. Pathogenesis involves endothelial dysfunction, immune-mediated vascular injury, and increased capillary permeability leading to plasma leakage and multi-organ involvement. Diagnosis is based on serological assays, RT PCR, clinical findings, and exposure history. Currently, no universally approved vaccine or specific antiviral therapy is available; therefore, management remains primarily supportive. Preventive strategies including rodent control, environmental sanitation, public health surveillance, and community awareness are essential for reducing transmission and outbreak risk.

Keywords: Hantavirus, Rodent, Aerosols, Zoonotic, Endothelial dysfunction.

Introduction:

Hantavirus infection is a highly significant emerging zoonotic disease caused by RNA viruses belonging to the family Hantaviridae. Despite its relatively low incidence, the infection is associated with severe clinical outcomes and high case fatality rates, making it a major global public health concern. The disease primarily manifests in two forms: Hemorrhagic Fever with Renal Syndrome (HFRS), commonly reported in Asia and Europe, and Hantavirus Cardiopulmonary Syndrome (HCPS), predominantly observed in the Americas. Both syndromes are characterized by acute vascular leakage, multi-organ involvement, and potentially fatal complications.

The history of hantavirus dates back to the Korean War during the early 1950s, when thousands of soldiers developed a severe febrile illness later identified as HFRS. However, hantavirus gained worldwide

scientific attention in 1993 following a fatal outbreak of acute respiratory disease in the Four Corners region of the United States. Investigations identified a novel strain, Sin Nombre virus, transmitted by infected deer mice, establishing hantavirus as an important emerging infectious pathogen (MacNeil et al., 2011). Since then, numerous hantavirus species have been recognized globally, each associated with specific rodent reservoirs and geographic distributions (Jonsson et al., 2010).

Hantaviruses are enveloped, single-stranded negative-sense RNA viruses maintained in nature through persistent asymptomatic infection in rodents. Humans act as accidental hosts and become infected mainly through inhalation of aerosolized particles contaminated with rodent urine, saliva, or feces. Although transmission between humans is rare, limited person-to-person spread has been documented with Andes virus in South America (Vaheri et al., 2013).

The epidemiology of hantavirus infection is strongly influenced by environmental, ecological, and occupational factors. Individuals involved in farming, forestry, military activities, construction work, and outdoor recreation are at increased risk due to frequent exposure to rodent habitats. Rapid urbanization, climate change, deforestation, and altered agricultural practices have significantly increased rodent-human interaction, thereby enhancing the risk of outbreaks (Tian and Stenseth, 2019). Seasonal fluctuations in rainfall and food availability further influence rodent population density and viral transmission dynamics.

Clinically, hantavirus infection begins with nonspecific prodromal symptoms such as fever, headache, myalgia, fatigue, nausea, and abdominal discomfort. Disease progression may rapidly lead to severe respiratory distress, pulmonary edema, hypotension, shock, hemorrhage, and acute renal failure. The nonspecific nature of early symptoms often results in delayed diagnosis and confusion with diseases such as influenza, dengue, leptospirosis, malaria, and COVID-19 (Ibrahim et al., 2019).

The hallmark of hantavirus pathogenesis is endothelial dysfunction leading to increased capillary permeability and vascular leakage. Viral replication and exaggerated immune responses result in pulmonary and renal tissue damage, contributing to multi-organ dysfunction. Histopathological findings commonly include diffuse alveolar damage, pulmonary congestion, interstitial pneumonitis, and renal tubular necrosis (Vaheri et al., 2013).

Currently, there is no universally approved vaccine or definitive antiviral therapy for hantavirus infection. Management remains primarily supportive and includes oxygen therapy, fluid balance management, mechanical ventilation, and intensive care support in severe cases. Early diagnosis and prompt supportive treatment are critical for reducing mortality. Therefore, prevention remains the most effective strategy and includes rodent control, environmental sanitation, safe waste handling, public awareness, and strengthened disease surveillance systems.

In the context of increasing ecological disturbances and emerging infectious diseases, hantavirus

continues to represent a silent yet potentially lethal threat. Strengthening global surveillance, improving diagnostic capacity, promoting public health education, and adopting integrated One Health approaches are essential for effective prevention and future outbreak control.

Etiology and Recent Outbreak:

Hantaviruses are enveloped, single-stranded, negative-sense RNA viruses classified under the family Hantaviridae, genus Orthohantavirus. Each hantavirus species is closely linked to a specific rodent reservoir, which plays a key role in maintaining viral circulation in nature. Humans are incidental hosts and acquire infection through exposure to infected rodent excreta.

Major pathogenic strains and their reservoirs include:

- **Sin Nombre virus (SNV):** carried by the deer mouse (Peromyscus maniculatus) in North America; causes Hantavirus Cardiopulmonary Syndrome (HCPS).
- **Hantaan virus and Seoul virus:** associated with rats and field mice in Asia and Europe; cause Hemorrhagic Fever with Renal Syndrome (HFRS).
- **Andes virus (ANDV):** found in South America; notable for its ability to transmit between humans in rare cases.

The disease is broadly categorized into:

1. Hemorrhagic Fever with Renal Syndrome (HFRS) – common in Europe and Asia.
2. Hantavirus Cardiopulmonary Syndrome (HCPS) – mainly reported in the Americas.

Recent outbreaks have highlighted the re-emergence of hantavirus as a public health threat. In May 2026, WHO reported a suspected outbreak aboard the cruise ship MV Hondius traveling between Argentina and Cape Verde. Three deaths and several confirmed cases were associated with probable Andes virus exposure (WHO, 2026).

Environmental disturbances, rodent migration, climate variability, and increased human encroachment into wildlife habitats are major contributors to recent outbreaks (Tian and Stenseth, 2019).

Transmission and Spread:

Transmission of hantavirus infection occurs mainly through inhalation of aerosolized particles contaminated with infected rodent urine, faces, or saliva. Direct contact with contaminated surfaces, rodent bites, and ingestion of contaminated food may also transmit infection (CDC, 2024).

High-risk activities include:

- Cleaning rodent-infested areas.
- Farming and forestry work.
- Camping in rural areas and exposure to poorly ventilated environments.

Human-to-human transmission is extremely rare but has been documented with Andes virus in South America (Vaheri et al., 2013). Occupational and environmental exposure remains the primary mode

of spread globally.

Pathogenesis:

Stage	Pathogenic Event	Clinical Outcome
1.	Entry through inhalation of contaminated aerosols	Initial viral infection
2.	Viral replication in endothelial cells	Viremia develops
3.	Immune activation and cytokine release	Fever and myalgia
4.	Increased capillary permeability	Plasma leakage
5.	Pulmonary edema or renal injury	Respiratory distress/HFRS
6.	Hypotension and shock	Multi-organ dysfunction
7.	Recovery or fatal outcome	Clinical resolution/death

Key mechanisms include endothelial dysfunction, immune-mediated vascular injury, and excessive inflammatory cytokine production (Vaheri et al., 2013).

Gross and Microscopic Changes:

Gross examination commonly reveals heavy edematous lungs, pleural effusion, pulmonary congestion, and petechial hemorrhages. Kidneys may appear enlarged with cortical hemorrhage in HFRS cases (CDC, 2024), Spleen may appear enlarged and soft.

Microscopically, diffuse alveolar damage, interstitial pneumonitis, mononuclear infiltrates, capillary congestion, and endothelial swelling are observed. Renal pathology shows tubular necrosis and interstitial hemorrhage.

Signs and Symptoms:

The incubation period of hantavirus infection ranges from 1–8 weeks after exposure (WHO, 2026). Early symptoms are nonspecific and resemble influenza-like illness.

Clinical manifestations vary between HPS and HFRS:

Syndrome	Early Symptoms	Severe Phase
HFRS	Fever, chills, headache, back pain, abdominal pain	Hypotension, oliguria, hemorrhage, acute kidney injury
HPS	Fever, myalgia, gastrointestinal upset	Cough, shortness of breath, pulmonary edema, respiratory failure

Severe disease may progress rapidly within 24–48 hours. Cardiogenic shock, hypoxemia, and multi-organ failure contribute to high mortality (MacNeil et al., 2011). Mortality rates vary: HFRS averages 5–15%, whereas HPS can exceed 35%.

Diagnosis:

Early diagnosis of hantavirus infection is challenging due to nonspecific symptoms. A detailed history of rodent exposure, travel, or occupational risk is essential (WHO, 2026).

Laboratory Diagnosis:

- ELISA for hantavirus-specific IgM and IgG antibodies.
- RT-PCR for viral RNA detection.
- Immunohistochemistry in tissue samples.

Hematology Findings:

- Thrombocytopenia, Hemoconcentration, Elevated hematocrit and Leukocytosis.

Chest radiographs may show bilateral interstitial infiltrates and pulmonary edema. Differential diagnoses include dengue, leptospirosis, influenza, sepsis, and COVID-19 (Ibrahim et al., 2019).

Prevention and Control:

Prevention remains the cornerstone of controlling hantavirus infection because no universally approved vaccine or specific antiviral therapy exists (WHO, 2026).

Preventive Measures	Cleaning Practices	Public Health Strategies
Rodent control programs	Avoid dry sweeping or vacuuming rodent droppings	Early outbreak detection
Safe food storage	Use disinfectants before cleaning	Surveillance and reporting
Sealing rodent entry points	Wear gloves and masks in contaminated areas	Community education
Proper waste disposal		Healthcare worker training
Maintaining environmental sanitation		Isolation and contact monitoring during outbreaks

WHO recommends a One Health approach integrating environmental, animal, and human health sectors for sustainable control measures. Public awareness campaigns in endemic regions are essential to reduce exposure risks (Tian and Stenseth, 2019).

Conclusion:

Hantavirus remains a silent yet formidable threat, especially in regions where human–rodent interaction is unavoidable. With no definitive cure, the best defense lies in prevention, early recognition, and strong public health strategies. Strengthening research into cross-protective vaccines and monitoring emerging strains are crucial steps toward containing this elusive zoonotic disease.

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