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Deadly Voyage: The Hantavirus Outbreak at Sea

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Abstract

Hantaviruses are emerging rodent-borne pathogens that can cause severe human illnesses, including hantavirus pulmonary syndrome (HPS) and hemorrhagic fever with renal syndrome (HFRS). Rodents such as mice and rats serve as the primary natural reservoirs, shedding the virus through urine, saliva, and feces. Human infection commonly occurs through inhalation of aerosolized viral particles in contaminated environments. Cruise ships may represent a unique environment for hantavirus exposure due to enclosed spaces, food storage areas, waste accumulation, and potential rodent infestations in ports or onboard facilities. Increased international travel and close human contact may further enhance the risk of disease transmission and outbreak occurrence in maritime settings. Clinical manifestations range from fever, myalgia, and fatigue to severe respiratory distress and renal complications. Currently, no specific FDA-approved antiviral therapy exists for hantavirus infection, and treatment mainly relies on supportive care, oxygen therapy, fluid management, and intensive care support in severe cases. Preventive measures remain critical and include strict rodent control programs, environmental sanitation, proper food storage, use of personal protective equipment during cleaning of contaminated areas, and public health surveillance. A recent outbreak in the cruise ship MV Hondius highlighted the global public health concern associated with hantavirus infections. Investigations suggested that a Dutch couple from Argentina likely acquired the infection during a bird-watching excursion in Ushuaia before boarding the vessel, possibly through exposure to rodent-contaminated environments. Subsequent suspected person-to-person transmission involving the Andes virus strain, a rare hantavirus capable of limited human transmission, contributed to multiple infections and fatalities among passengers and crew. This outbreak emphasized the importance of early diagnosis, international surveillance, rapid contact tracing, and strict infection-control measures in cruise ship settings to minimize the risk of emerging infectious disease spread.

Keywords

Hantavirus, HFRS, HCPS. Cruise Ship Outbreak, One Health, RNA Virus

1. Introduction

Hantaviruses are enveloped, negative-sense RNA viruses belonging to the genus Orthohantavirus within the family Hantaviridae [1]. These zoonotic pathogens are primarily maintained in nature through persistent infections in rodent reservoirs, although insectivores and bats have also been identified as hosts for certain hantavirus species [1]. Human infection occurs accidentally through exposure to aerosolized virus particles present in rodent urine, feces, or saliva [2]-[5]. Hantaviruses are responsible for two major clinical syndromes: hemorrhagic fever with renal syndrome (HFRS) [5] [6], predominantly reported in Europe and Asia, and hantavirus pulmonary syndrome (HPS), mainly observed in the Americas [7]. Important pathogenic hantaviruses include Hantaan virus, Seoul virus, Puumala virus, Sin Nombre virus, and Andes virus. Among these, Andes virus is unique because limited person-to-person transmission has been documented [7]. The incubation period of hantavirus infection generally ranges from 1 to 8 weeks following exposure [7]. Early symptoms are nonspecific and include fever, chills, severe myalgia, headache, nausea, vomiting, abdominal pain, and fatigue. As the disease progresses, patients may develop thrombocytopenia, vascular leakage, hypotension, acute kidney injury, or severe pulmonary edema and respiratory failure [8]. HPS is associated with rapid cardiopulmonary deterioration and carries a mortality rate of approximately 30% - 40% [8], whereas HFRS mortality varies from less than 1% to nearly 15% depending on the viral strain and healthcare access [9].

Structurally, hantaviruses possess spherical enveloped virions approximately 80 - 120 nm in diameter containing a tripartite RNA genome composed of small (S), medium (M), and large (L) segments [10]. The viral envelope contains glycoproteins Gn and Gc [11], which facilitate host-cell attachment and entry [12], while the nucleocapsid protein protects the viral RNA genome [13]-[15]. Similar to other enveloped viruses, hantaviruses are relatively sensitive to detergents, alcohol-based disinfectants, bleach, and common handwashing agents that disrupt the lipid membrane. Proper hand hygiene and environmental disinfection therefore play an important role in infection prevention. However, hantaviruses may remain infectious for prolonged periods in cool and humid environments, especially in rodent-infested enclosed spaces with poor ventilation [16]. Environmental factors such as climate change, urbanization, deforestation, flooding, and altered rodent ecology have significantly influenced the emergence and spread of hantaviruses worldwide [17].

Traditionally considered rural diseases associated with forests and agricultural settings, hantavirus infections are increasingly being reported in urban and peri-urban environments due to expanding rodent populations, increased human en-

croachment into wildlife habitats, globalization, and international travel [18]. Urban adaptation of rodent species such as Rattus norvegicus has facilitated the spread of Seoul virus in densely populated cities across Asia, Europe, and the Americas [19]. More recently, concerns have emerged regarding hantavirus exposure in maritime and cruise ship environments [20]. Cruise ships provide enclosed conditions, food storage facilities, cargo transport areas, and waste accumulation sites that may support rodent infestations if strict sanitation measures are not maintained. It has been reported that international travel can also facilitate the movement of infected individuals across borders, increasing the possibility of outbreak-associated transmission events [21]. The recent outbreak linked to passengers traveling from Argentina aboard a cruise vessel highlighted the growing importance of hantavirus surveillance in maritime settings [20].

Currently, no universally approved specific antiviral therapy exists for hantavirus infections. Treatment mainly relies on early diagnosis and supportive care, including oxygen supplementation, careful fluid management, mechanical ventilation, vasopressor support, and intensive care monitoring in severe cases [22]. Ribavirin has shown some benefit in certain HFRS cases when administered early, although its efficacy in HPS remains limited [23] [24]. Vaccine development has progressed in several countries, particularly for HFRS-associated hantaviruses in China and South Korea, where inactivated vaccines are used in high-risk populations, but no globally licensed vaccine is currently available for widespread prevention of HPS [25]. Hantavirus infections have been reported across diverse geographical regions including China, Russia, Finland, Sweden, Germany, United States, Canada, Argentina, Chile, and Brazil [26]. The expanding ecological range of rodent hosts, coupled with climate variability and increased human mobility, suggests that hantaviruses will remain significant emerging infectious disease threats requiring continued surveillance, public health preparedness, and global collaborative research efforts [26].

2. Reservoirs and Spillover Hosts

Hantaviruses are naturally maintained in the environment through specific rodent reservoir hosts (**Figure 1**), which play a central role in their ecology and long-term persistence [27]. Each hantavirus species is typically associated with a particular rodent species, showing a highly adapted relationship where the virus persists in the host without causing severe disease [9]. For example, in North America, the deer mouse (Peromyscus maniculatus) is the primary reservoir for Sin Nombre virus, which is the main cause of hantavirus pulmonary syndrome (HPS). In other parts of the world, different rodents serve as reservoirs, such as rats (Rattus species) for Seoul virus and various voles and field mice for other hantaviruses across Europe and Asia [28]. Infected rodents shed the virus in urine, feces, and saliva, often for prolonged periods, allowing environmental contamination of soil, dust, and surfaces. The virus can remain stable in dried rodent excreta under cool and humid conditions, increasing the risk of human exposure in enclosed or

poorly ventilated spaces such as cabins, storage areas, or rural dwellings [10].

Transmission to humans and other non-reservoir species occurs through spillover events, which are accidental infections resulting from exposure to contaminated environments [10]. Humans are considered dead-end hosts, meaning that although they can develop severe disease after infection, they do not transmit the virus further to other people under normal circumstances, except Andes virus species [27]. Spillover typically occurs when virus containing particles become aerosolized, for example, during sweeping of rodent-infested areas or disturbing contaminated dust, and are inhaled into the lungs [27]. While rodents are the primary reservoirs, occasional infections in other mammals may occur, but these species do not sustain transmission chains. The tight ecological relationship between hantaviruses and their rodent hosts is strongly influenced by environmental factors such as climate, food availability, and rodent population density, which can increase the likelihood of human exposure during outbreaks.

3. Transmission to Humans

Hantaviruses are primarily transmitted from animals to humans through exposure to infected rodents (**Figure 1**), which serve as the natural reservoirs for most pathogenic strains [10]. The virus is shed by infected rodents in their urine, feces, and saliva, and humans become infected mainly through inhalation of aerosolized viral particles when these excreta are disturbed in enclosed or poorly ventilated environments [10]. Activities such as cleaning rodent-infested buildings, sweeping contaminated surfaces, or occupying closed spaces like cabins, sheds, or warehouses can generate infectious aerosols, making airborne transmission the dominant route of human infection [29]. Direct contact with rodents or their excreta can also lead to infection if contaminated material comes into contact with broken skin, mucous membranes, or is inadvertently transferred to the mouth or nose [27] [29]. In some cases, bites from infected rodents have been implicated, although this is considered a less common route [28]. Human-to-human transmission is rare and has only been documented for certain hantavirus species, such as those associated with the Andes virus in South America (**Figure 1**), where close contact with infected individuals in healthcare or household settings has occasionally led to secondary cases [10].The risk of transmission is strongly influenced by environmental and ecological factors. Rodent population surges, often driven by seasonal changes, food availability, or climatic conditions, can increase viral shedding into the environment and elevate the likelihood of human exposure[10]. Rural and peri-domestic settings are particularly important, but urban spillover events have also been reported when rodent control is inadequate. Once inhaled, the virus initially infects endothelial cells, leading to systemic vascular dysfunction that underlies severe clinical syndromes such as Hantavirus Pulmonary Syndrome [30]. Preventing transmission relies heavily on minimizing contact with rodents and their habitats. Effective rodent control, safe cleaning practices using wet disinfection methods to avoid aerosolization, and protective equipment in high-risk en-

vironments are key strategies. Understanding the ecological interface between rodents and humans is essential for reducing spillover events and controlling the spread of hantavirus infections. Andes virus (ANDV) is the only hantavirus with well-documented person-to-person transmission [31]. Since the first recognized outbreak in Argentina in 1996, multiple investigations in Argentina and Chile have identified secondary and tertiary cases among household contacts, sexual partners, caregivers, and healthcare workers following close exposure to symptomatic patients [32]. These outbreaks were supported by consistent epidemiologic links, incubation periods of approximately 2 - 6 weeks, the absence of shared rodent exposure, and viral genome sequencing demonstrating nearly identical viral strains among linked cases [32]. The largest documented outbreak, which occurred in Epuyén, Argentina (2018-2019), involved 34 confirmed cases and multiple generations of transmission, providing compelling evidence that ANDV can sustain limited human-to-human spread under conditions of close contact [33].

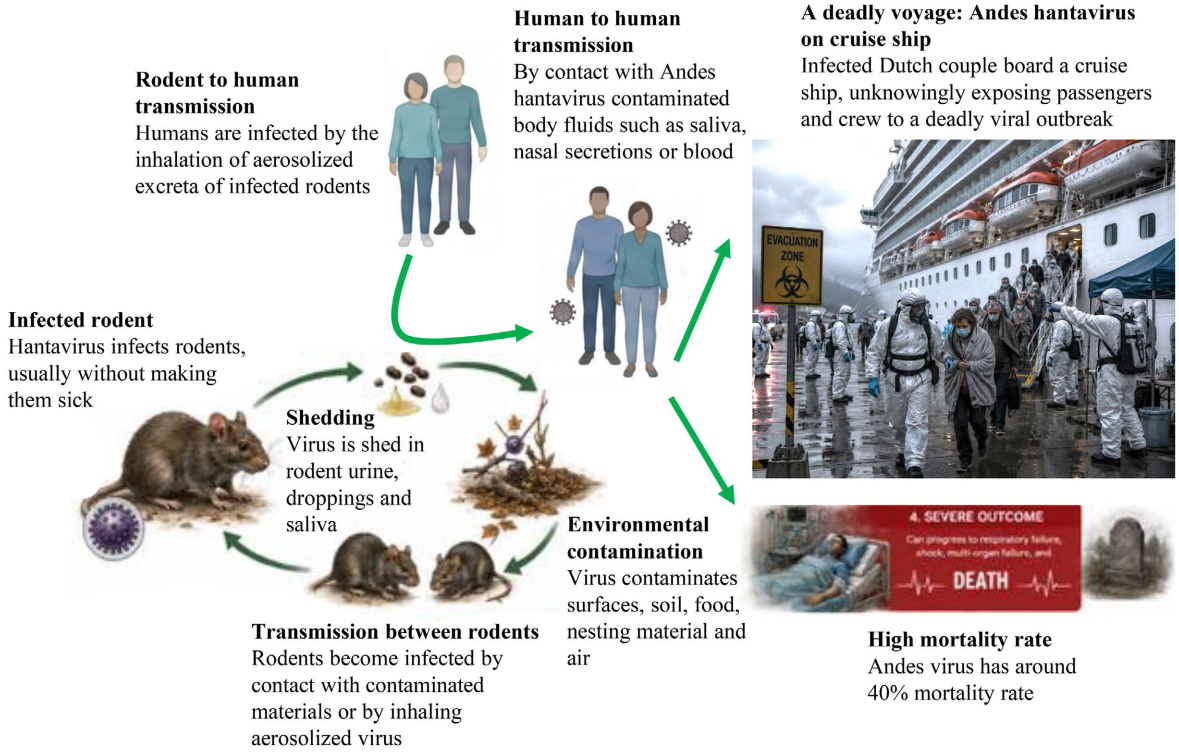

Figure 1. Hantavirus ecological cycle and deadly spillover to humans.

4. Hantavirus Disease

Hantavirus disease refers to a group of illnesses caused by hantaviruses, primarily presenting in two major clinical forms: Hantavirus Pulmonary Syndrome (HPS) [34], more common in the Americas, and Hemorrhagic Fever with Renal Syndrome (HFRS), seen mainly in Europe and Asia [35]. These infections are zoonotic and are typically acquired through inhalation of aerosolized particles from rodent excreta, leading to systemic viral infection after initial respiratory entry. The

clinical presentation of HPS often begins with a nonspecific prodromal phase that resembles influenza. Early symptoms include fever, fatigue, myalgia (especially in large muscle groups), headache, dizziness, and sometimes gastrointestinal symptoms such as nausea, vomiting, or abdominal pain. Within a few days, the disease can rapidly progress to a cardiopulmonary phase characterized by cough, shortness of breath, and pulmonary edema due to increased vascular permeability [34]. This can lead to severe respiratory distress and shock. In contrast, HFRS is marked more prominently by fever, hemorrhagic manifestations, and acute kidney injury, including flank pain, oliguria, and in severe cases, renal failure [35].

Diagnosis of hantavirus infection relies on a combination of clinical suspicion, epidemiological exposure history, and laboratory testing. Serological assays detecting IgM and IgG antibodies are commonly used and are highly useful in confirming recent infection [36]. Reverse transcription polymerase chain reaction (RT-PCR) can detect viral RNA in blood or tissue samples during the early phase of illness and is particularly valuable for rapid diagnosis [36]. Routine laboratory findings often show thrombocytopenia, elevated hematocrit due to plasma leakage, and signs of organ dysfunction depending on disease severity [36]. There is currently no specific antiviral therapy approved universally for hantavirus infections, and treatment is primarily supportive. Patients with HPS often require intensive care management, including oxygen supplementation, mechanical ventilation, and careful fluid balance to manage pulmonary edema and shock [37]. In some cases, extracorporeal membrane oxygenation (ECMO) has been used for severe respiratory failure [38]. Ribavirin has shown some benefit in HFRS if administered early, but its efficacy in HPS remains uncertain [39]. Early recognition and prompt supportive care are critical in improving survival outcomes, as severe forms of hantavirus disease can have high mortality rates.

5. Hantavirus Emergence in Cruise Ship

Recent hantavirus emergence highlights how a traditionally rural, rodent associated infection is increasingly appearing in unusual and high-traffic human environments, including urban spillover settings and even cruise ships (**Figure 1**) [20]. Historically, hantaviruses were largely confined to rural or peri-domestic areas where humans come into contact with infected rodents. However, changing land use, climate variability, and increased human mobility are contributing to more frequent spillover events into densely populated or mobile populations. Urban spillover refers to the movement of infection risk from natural rodent habitats into cities, industrial zones, and human-made environments where rodent populations thrive unnoticed. Poor waste management, crowded housing, construction activity, and food availability can increase rodent density, raising the likelihood of human exposure to contaminated urine, feces, or saliva. In such environments, aerosolization of viral particles during cleaning or disturbance of infested areas becomes a key transmission risk. These shifts suggest that hantavirus is no longer strictly a rural disease, but one that can emerge wherever rodent-human interfaces inten-

sify. A particularly striking recent development has been the detection of hantavirus outbreaks in cruise ship settings [20]. Multiple case reports in 2026 describe clusters of severe respiratory illness aboard international cruise vessels, with confirmed hantavirus infections and associated deaths [20]. Investigations have identified the Andes virus strain in some cases, which is notable because it is one of the few hantaviruses with documented potential for limited human-to-human transmission under close contact conditions [40]. In confined environments such as cruise ships, where passengers share cabins, dining spaces, and prolonged indoor exposure, this creates a unique setting for secondary transmission once an index case is introduced [40]. The 2026 MV Hondius hantavirus outbreak involved 13 laboratory-confirmed Andes virus infections and three deaths. Epidemiologic investigations indicated that the outbreak most likely originated from one or more zoonotic introductions, followed by limited person-to-person transmission among passengers with prolonged close contact. Evidence supporting secondary transmission included the temporal sequence of illness, absence of rodent exposure in several secondary cases, identification of Andes virus by PCR and sequencing, and genomic analyses consistent with a single outbreak strain.

These outbreaks have triggered complex international public health responses, including evacuation of critically ill passengers, onboard isolation measures, and large-scale contact tracing across multiple countries [40]. Despite the severity of individual cases, health agencies such as WHO have emphasized that the overall global risk remains low, since sustained transmission between humans is uncommon and most hantavirus infections still originate from rodent exposure rather than person-to-person spread [20]. Overall, these emerging patterns underscore how globalization, mobility, and environmental change are reshaping the epidemiology of hantaviruses. Continuous surveillance in both urban environments and high-density travel settings is becoming increasingly important to detect and contain such rare but high-impact spillover events early.

6. Misconceptions about Hantaviruses

A common misconception about hantaviruses is that they spread easily between people and could trigger a pandemic similar to COVID-19. In reality, most hantaviruses are transmitted to humans from infected rodents through inhalation of aerosolized urine, droppings, or saliva, and human-to-human transmission is extremely rare, documented only for specific strains such as Andes virus in limited close-contact settings [33]. Another misunderstanding is that hantaviruses are newly emerging or rapidly spreading globally; instead, they are long-established zoonotic viruses with transmission tightly linked to rodent ecology and environmental exposure rather than sustained community spread. Because of these biological constraints, particularly the lack of efficient respiratory transmission between humans, hantaviruses are not considered to have pandemic potential in the same way as highly transmissible airborne viruses like SARS-CoV-2.

7. Conclusions, Surveillance and One Health Perspective

In conclusion, hantavirus infections illustrate how closely human health is linked to environmental change, animal reservoirs, and human behavior. Although these viruses were historically associated with rural rodent exposure, their emergence in urban spillover events and high-mobility settings such as cruise ships highlights a shifting epidemiological landscape (**Figure 1**) [41]. This shift underscores the need for sustained vigilance rather than viewing hantavirus as a geographically or occupationally limited infection [41].

Effective control and prevention depend heavily on robust surveillance systems. Early detection of rodent population changes, viral circulation in wildlife reservoirs, and human case clusters can provide critical warning signals before large outbreaks occur [32]. Integrated surveillance that combines clinical reporting, laboratory diagnostics, and environmental monitoring is essential for identifying spillover risks in both rural and urban settings [10]. In particular, molecular surveillance using RT-PCR-based tools and serological screening in high-risk populations can improve early case identification and reduce delays in response [10]. A One Health perspective is central to understanding and managing hantavirus threats (**Figure 1**) [32]. This approach recognizes that human health is inseparable from the health of animals and ecosystems. Rodents, as natural reservoirs, are influenced by environmental factors such as climate variability, food availability, urbanization, and land-use changes, all of which can directly affect viral transmission dynamics [32]. Coordinated efforts between public health agencies, veterinary services, wildlife ecologists, and environmental scientists are therefore essential to monitor rodent populations and mitigate human exposure risks [42].

Prevention strategies under a One Health framework include improving urban sanitation, controlling rodent populations, designing rodent-resistant infrastructure, and educating communities about safe cleaning practices in contaminated environments [42]. Strengthening international collaboration is also important, as increased travel and trade can facilitate the spread of both rodents and pathogens across borders [10] [42]. Ultimately, hantavirus control requires moving beyond reactive outbreak management toward proactive, ecosystem-based surveillance and prevention. By integrating human, animal, and environmental health systems, a One Health approach offers the most comprehensive strategy to reduce spillover risk, detect emerging threats early, and prevent future outbreaks [10] [42].

Although the reported hantavirus outbreak associated with a cruise ship raises the possibility of transmission in a maritime setting, the evidence is limited to a small number of epidemiologically linked cases. Given the absence of additional well-documented outbreaks on cruise ships, these findings should be interpreted cautiously and should not be generalized to maritime settings as a whole.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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