

Hantavirus: A Zoonotic Pathogen and Its Role in Achieving Sustainable Development

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ABSTRACT

Zoonoses meaning the transmission of infections between animals and humans, remain a challenge for human and veterinary health institutions worldwide. Despite advancements in various medical fields, there are still failures in eradicating zoonotic pathogens and preventing their recurring outbreaks, especially viral ones. Among these zoonotic virus is Hantavirus (single-stranded RNA), that emergence has caused panic and fears due to its high mortality rate. The infection is primarily transmitted to humans through rodents such as mice, causing serious illnesses such as hemorrhagic fever with renal syndrome and Hantavirus pulmonary syndrome. Therefore, reviewing basic information about this infection, the role of environmental factors, and modes of transmission is crucial for prevention, enabling to avoid infection and mitigate human, animal, and economic losses. One of the most important strategies for infection control is the implementation of the One Health approach, which closely integrates human, animal, and environmental health—the golden triad—and is linked to achieving the Sustainable Development Goals (SDGs). This approach aims for comprehensive improvements in the environment, veterinary care, and human well-being.

KEYWORDS: Zoonotic pathogens, Hantavirus, infection, One Health.

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INTRODUCTION

Zoonoses, being always at the interface of human and animal health, remain among the most life-threatening infectious risks and hazards today. Zoonotic infection is thus one of the most important threats to human health and the environment today because it has great impacts on the fate of humans and animals [1-3]. Most human infections are zoonotic, which means that there is a strong association between the animal reservoirs and human infections. This is in line with the World Health Organization which states that about 60% of new infectious diseases are zoonotic, derived from transmission events [4,5]. The continuous polygenic transmission of diseases from animals, directly or indirectly, is an essential element in the establishment of new zoonotic infections and their subsequent transmission to humans [6]. This process is further facilitated by changes in agricultural practices and environmental conditions that bring humans into contact with numerous animal species, expanding the opportunities for inter-species transmission [7].

Zoonoses are a wide variety of infectious agents; viruses, bacteria, parasites, fungi, and even prions that can be transmitted between animals and humans [8,9]. In assessments that highlight increased risks of intensive livestock production and other stressors, we underscore this treatment gap and the need for approaches to disease emergence and the management of therapeutic resources, especially antimicrobials [10].

Environmental interconnectedness has over the years ramped up the risk of zoonotic viral pathogens at a global scale. This, therefore, will require sustained surveillance, knowledge of viral evolution, effective public health response, and proactive prevention to lower infection and fatality rates [11,12]. Hantavirus is one of these viral zoonotic infections; it is a highly pathogenic and transmissible pathogen that relates to human, animal, and environmental health. Hantaviruses are zoonotic RNA viruses having a global distribution, wherein pathogenic strains infect several species of rodents [13].

In altered habitats hanta virus is mainly spread by rodents and can lead to severe respiratory and kidney problems in humans. Changes in the environment and in the rodent populations directly influence the risks of human exposure, leading to less predictable patterns of transmission and a closer association with environmental disturbance [14]. Frequently, the mode of transmission is through contact with contaminated rodent saliva, faeces or urine, and perhaps augmented by inhalation of aerosols in places recently occupied by rats or during activities that generate contaminated dust. The principles of hanta virus have a

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worldwide impact in the general trend of infection risks and the perpetual requirement of surveillance [15,16]. This article reviews basic principles needed to understand and focuses on reservoirs of infection and transmission pathways, assessing risks and applying preventive measures, tying them to the achievement of the Sustainable Development goals.

Emergence of Hantavirus

Hantavirus is becoming increasingly significant due to various interrelated factors:

- 1-Climate Change: This upsets ecological equilibrium by compelling rodents to relocate towards human settlements, so facilitating the influx of the virus into their populations. Droughts compel rodents to travel towards human settlements, where the principal reservoir sources sustenance from their populations. This compelled relocation directly affects individuals [17].
2. Urbanization and Deforestation: The danger of coming into contact with disease vectors from animals has undoubtedly increased with urban sprawl and deforestation [18].
- 3- Increased health risks: The high mortality rate, which can reach 40% in some respiratory syndromes, is a serious threat to global health security, particularly in the absence of specialized treatments or approved vaccines [19].

HANTAVIRUS STRUCTURE

It belongs to the order Bunyvirales and family Hantaviridae (genus Orthohantavirus), the outline is as follows:

- Viral envelope: It is a virus that is being enveloped with a spherical or oval form, with a lipid bilayer derived from the host cell membrane.
- Surface Proteins: The envelope carries protruding glycoprotein projections termed Gn and Gc. These enable the virus to bind to host cell receptors and assist in the entry of the virus into the cells [20].

GENETIC MATERIAL (GENOME)

The virus has a genome consisting of single-stranded RNA of negative sense as illustrate in figure (1).

Genome segments The genome is made up of three major segments, or a tripartite genome:

- 1- The small segment (S): it houses the information for the nucleocapsid protein that RNA is protected with.
- 2- The medium segment (M): this segment contains information for the envelope glycoproteins (Gn and Gc).
- 3- The large segment (L): codes for the viral replication enzyme (RNA-dependent RNA polymerase) [21].

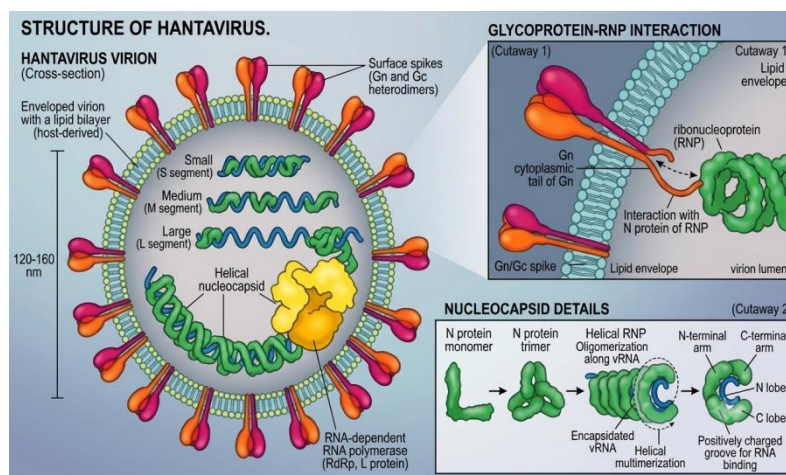


Figure 1 : Structure of Hantavirus.

VIRUS RESERVOIRS

Humans are not a host for the Hantavirus. Instead, the virus is transmitted to humans from specific animal hosts that include:

- 1-Rodents: These are the primary host and vector and include field mice and rats (such as the deer mouse and the Norway rat). Interestingly, rodents infected with the virus do not show any symptoms but carry and shed it throughout their lives as a chronic infection [22].
- 2-Insectivores and Bats: Recent research has shown that some types of shrews, moles and bats also act as [23].

TRANSMISSION TO HUMANS

The virus is transmitted to humans in several ways (Figure 2), most notably:

- 1- Inhalation as the primary route: This is the case when aerosols contaminated with small droplets from the urine, feces, or saliva of infected rodents is inhaled. Such aerosols are commonly generated during the cleaning of warehouses, abandoned houses, or fields.

- 2- Direct contact: This involves touching the hand of a person who has contacted contaminated secretions and then touching one's eyes, nose, or mouth [24].
- 3- Bites: This is a direct bite from an infected rodent (a less common route) [25].
- 4- Human-to-human transmission: This is very rare and has only been clearly documented in a specific strain known as the Andes virus in South America [26].

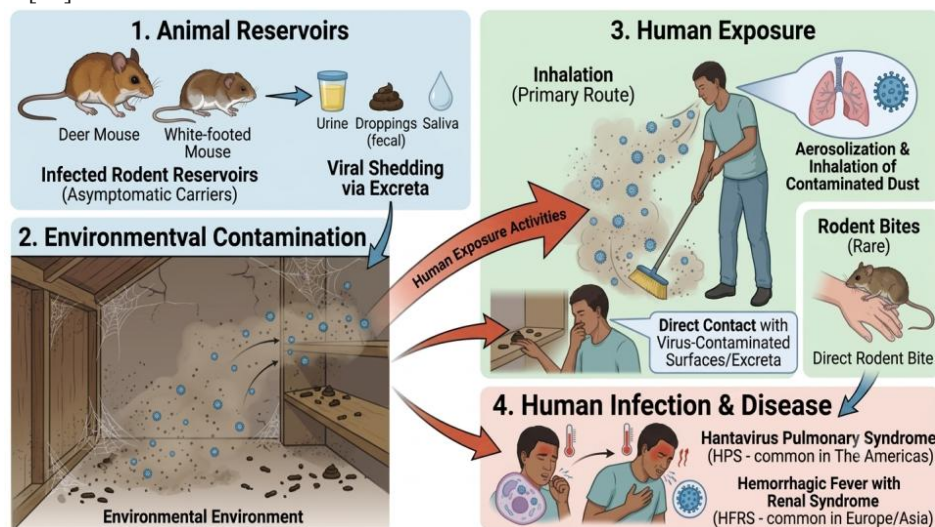


Figure 2: Mode of Hantavirus transmission to humans.

PATHOGENESIS

After the virus has entered the body via the respiratory system, it focuses on endothelial cells that line blood vessels, specifically in the lungs and kidneys. The cells are not killed directly by the virus but by the body's own immune response (cytokine storm) that goes out of control, leading to increased vascular permeability and leakage of fluid [27].

The diseases are mainly two, according to the viral strain and geographical location:

- 1- Hemorrhagic Fever with Renal Syndrome (HFRS) "Old World" (Europe and Asia): It starts with fever, headache, and back pain. Later, hypotension, bleeding, and acute kidney failure develop.
- 2- Hanta Pulmonary Syndrome (HPS) "New World" (Americas): flu-like symptoms at the onset that rapidly progresses (within days) to acute respiratory failure as a result of fluid in the alveoli, leading to cardiogenic shock and severe hypoxia [28].

PREVENTION AND CONTROL

In general, environmentally sound practices must be adopted to prevent transmission between humans and rodent vectors within the surrounding environment [29]. Undoubtedly, proper preventive measures remain the first and last line of defense (Figure 3). Here are three important preventative measures:

- 1- Rodent control can be achieved through various methods, especially by eliminating rodent-proof living areas, whether in homes or workplaces, and by cleaning the surrounding environment of debris and waste to prevent rodent hiding places [30].
- 2- Safe cleaning of contaminated areas is critical step to avoid inhaling the virus. Ventilation is essential before cleaning begins, and the area should be sprayed with a household disinfectant solution (chlorine), according to the recommended instructions. It is advisable to wear rubber or plastic gloves and a strong mask. After cleaning, wash your hands thoroughly with soap and water after removing the gloves [31].
- 3- Community awareness and vulnerable individuals especially farmers, sanitation workers, and hunters in the wild [32].



Figure 3: Preventing Hantavirus infection: A Guide to safety.

The One Health Approach

At the core of this ecosystem lies the One Health triad, this virus cannot be addressed through medicine alone since its survival depends on three interconnected pillars:

- Human Health: Lung and kidney vulnerabilities to the virus.
- Animal Health: Rodents harboring and chronically disseminating the pathogen.
- Environmental Health: Ecosystems and climate conditions that govern rodent habitats [33,34].

The link between combating Hantavirus and achieving the UN Sustainable Development Goals is deeply rooted in the One Health approach [35]. Controlling a zoonotic infection requires more than just hospitals; it necessitates comprehensive improvements in society, the economy, and the environment. On the other hand the relationship between controlling Hantavirus and achieving the United Nations' Sustainable Development Goals (SDGs) is deeply rooted in the "One Health" approach. This concept recognizes that human health, animal health, and environmental health are all intrinsically connected [36].

Here is a breakdown of how managing Hantavirus directly supports specific SDGs (Figure 4):

1. Core Concept: The One Health Synergy

The circles that intersect are Human Health, Animal Health (rodents), and Environmental Health (forests/water). The virus in the environment and animal populations is stopped so it never gets a chance to spillover into humans by dealing with its root causes [37].

2. Direct Health & Economic Impacts

• SDG 3: Good Health & Well-Being

The Link: Better disease tracking, spotting cases earlier, and getting the public to understand things like not breathing in dust from rodent droppings can cut how many people get Hantavirus Pulmonary Syndrome (HPS) and Hemorrhagic Fever with Renal Syndrome (HFRS) and die from those diseases.

The Goal: Strengthening global health systems and reducing the number of deaths that can be prevented [38].

• SDG 8: Decent Work & Economic Growth

The Link: People suffering from long-term or chronic illnesses such as HPS or HFRS are taken out of work either temporarily or permanently. In this case, by preventing the diseases, the community will have a healthier and more productive workforce.

The Goal: Mitigating the economic impact of disease on local economies and sustaining labor participation [39].

• SDG 1: No Poverty

The Link: In many parts of the world, a severe medical situation can lead to unplayable medical bills or take away the main earner for a household.

The Goal: Protecting at-risk groups from health-related poverty by preventing crippling illnesses that can lead to financial ruin [40].

3. Infrastructure & Environmental Management

• SDG 11: Sustainable Cities & Communities

The Link: Urban and rural planning is a big part of virus control. Good waste management, building structures that keep out rodents, and overall cleanliness lower human-rodent contact.

The Goal: Safe, disease-resistant housing and urban environments [41].

• SDG 15: Life on Land

The Link: An ecosystem that is healthy and in balance will be able to manage itself naturally. Therefore, support for the maintenance of natural habitats would automatically result in the presence of rodents' natural predators, such as owls, hawks, and foxes, to keep their population in check.

The Goal: Promoting biodiversity and managing ecological habitats to prevent a significant rise in carrier rodents [42].

SDG 13: Climate Action

The Link: Unseasonal weather creates unbalances in the ecosystem. For example, heavy rainfall followed by a period of drought can lead to massive booms in food supplies for rodents. This in turn leads to population explosions among rodents - and subsequent spikes in human Hantavirus cases.

The Goal is to predict these climate-induced ecological changes and build environmental resistance in order to be able to forecast and control zoonotic disease outbreaks [43].

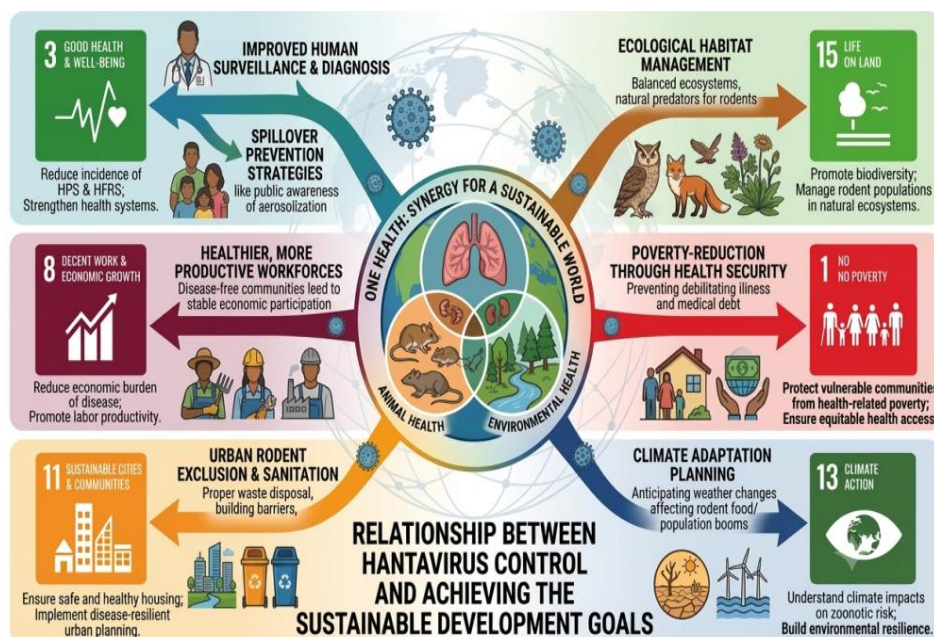


Figure 4: Linking Hantavirus Infection to Achieving Sustainable Development.

CONCLUSION

This will enable us to build a more sustainable and resilient world in multiple development fronts by taking a holistic approach to Hantavirus in terms of ecology, urban sanitation, climate tracking, and healthcare. Such viewing of Hantavirus, not just as a medical crisis but as an environmental and systemic challenge, will help the global health initiatives to hit multiple developmental goals at the same time.

REFERENCES

- 1) Hamilton-West C, Di Pillo F, Dietze K, Gonzalez JL. Emerging zoonotic diseases: understanding and mitigating risks at animal-human interfaces. *Frontiers in Veterinary Science*. 2026 Apr 2;13:1799435.
- 2) Ghareeb OA. Rabies: A Neglected Tropical Zoonotic Disease; Implementation of A One Health Approach for Urgent Control. *International Journal of Multidisciplinary and Innovative Research*. 2026 Mar;3(3):209-215.
- 3) Dell CA, Pavelich A, Woodsworth J, Mumford E, Gillett J, Wu H, Carver L. One Health zoecyia in our asocial age: A transdisciplinary and systems approach to the human-animal bond. *CABI One Health*. 2026 Mar 27;5(1):0008.
- 4) Ghareeb OA, Sultan AI. Crimean-Congo Hemorrhagic Fever: A Re-emerging Zoonosis. *An Overview of Disease and Health Research Vol. 2*. 2025 Jun 2;2:37-47.
- 5) Qi Y, Wang L, Wu S, Meng C, Chu Y, Yin Y, Jiao H. Autophagy in emerging and highly concerned severe zoonotic infectious diseases. *Frontiers in Immunology*. 2026;17: 571.
- 6) Pooley CM, Marion G, Prentice J, Pong-Wong R, Bishop SC, Doeschl-Wilson A. SIRE 2.0: a novel method for estimating polygenic host effects underlying infectious disease transmission, and analytical expressions for prediction accuracies. *Genetics Selection Evolution*. 2025 Apr 1;57(1):17.
- 7) García-Moreno J. Zoonoses in a changing world. *BioScience*. 2023 Oct;73(10):711-20.
- 8) Ghareeb OA, Ali QA. Waterborne bacterial pathogen: A global health issue for sustainable development. *Disease and Health: Research Developments*. 2024 Dec 18;2:58-69.

- 9) Ghareeb OA. Ebola-a fatal emerging zoonotic disease: a review. *Annals of the Romanian Society for Cell Biology*. 2021;25(6):8748-54. *International Journal of Advanced Engineering Research and Science*. 2025;12(11):640951.
- 10) Trinchera M, De Gaetano S, Sole E, Midiri A, Silvestro S, Mancuso G, Catalano T, Biondo C. Antimicrobials in livestock farming and resistance: public health implications. *Antibiotics*. 2025 Jun 14;14(6):606.
- 11) Banik, Anirban, and Soumya Basu. "Drivers and Consequences of Viral Zoonoses: Public Health and Economic Perspectives." *Zoonotic Diseases* 5.4 (2025): 32.
- 12) Carvalho RL, Anjos D, Harmange C, Pinter A, Faust C, Streicker D, Lorenz C, Prist PR, Metzger JP. Unpacking the risks of zoonotic and vector-borne pathogen transmission to humans in the context of environmental change. *One Earth*. 2025 Aug 15;8(8).
- 13) Chen RX, Gong HY, Wang X, Sun MH, Ji YF, Tan SM, Chen JM, Shao JW, Liao M. Zoonotic Hantaviridae with global public health significance. *Viruses*. 2023 Aug 8;15(8):1705.
- 14) Vitiello A, Zovi A. Hantavirus infections in a changing world: epidemiology, pathogenesis, and one health challenges. *Infection*. 2026 Jul 10:1-1.
- 15) Samples OM, Arowolo J. Hantavirus (Hantavirus spp.). *The One Health Model as Applied to Zoonotic Diseases*. 2025 Mar 27:253-6.
- 16) Vial PA, Ferrés M, Vial C, Klingström J, Ahlm C, López R, Le Corre N, Mertz GJ. Hantavirus in humans: a review of clinical aspects and management. *The Lancet Infectious Diseases*. 2023 Sep 1;23(9):e371-82.
- 17) Douglas KO, Payne K, Sabino-Santos Jr G, Agard J. Influence of climatic factors on human hantavirus infections in Latin America and the Caribbean: a systematic review. *Pathogens*. 2021 Dec 23;11(1):15.
- 18) Moirano G, Botta A, Yang M, Mangeruga M, Murray K, Vineis P. Land-cover, land-use and human hantavirus infection risk: a systematic review. *Pathogens and Global Health*. 2024 Jul 3;118(5):361-75.
- 19) Llah ST, Mir S, Sharif S, Khan S, Mir MA. Hantavirus induced cardiopulmonary syndrome: A public health concern. *Journal of medical virology*. 2018 Jun;90(6):1003-9.
- 20) Serris A, Stass R, Bignon EA, Muena NA, Manuguerra JC, Jangra RK, Li S, Chandran K, Tischler ND, Huiskonen JT, Rey FA. The hantavirus surface glycoprotein lattice and its fusion control mechanism. *Cell*. 2020 Oct 15;183(2):442-56.
- 21) Meier K, Thorkelsson SR, Quemin ER, Rosenthal M. Hantavirus replication cycle—an updated structural virology perspective. *Viruses*. 2021 Aug 6;13(8):1561.
- 22) Prist PR, Prado A, Tambosi LR, Umetsu F, de Arruda Bueno A, Pardini R, Metzger JP. Moving to healthier landscapes: Forest restoration decreases the abundance of Hantavirus reservoir rodents in tropical forests. *Science of the Total Environment*. 2021 Jan 15;752:141967.
- 23) Rangel CL, Fontes SD, Silva MV, Fernandes J, Mansur JF, Vilar EM, da Costa-Neto SF, Novaes RL, Cordeiro-Estrela P, Moratelli R, de Lemos ER. Serological evidence of hantavirus in bats from the Brazilian Atlantic forest: an investigation of seroreactivity and cross-reactivity of neotropical bat samples using nucleoproteins of rodent-and bat-borne hantaviruses. *Viruses*. 2024 Nov 29;16(12):1857.
- 24) Singh S, Numan A, Sharma D, Shukla R, Alexander A, Jain GK, Ahmad FJ, Kesharwani P. Epidemiology, virology and clinical aspects of hantavirus infections: an overview. *International Journal of Environmental Health Research*. 2022 Aug 3;32(8):1815-26.
- 25) Shehata AA, Parvin R, Tasnim S, Duarte PM, Rodriguez-Morales AJ, Basiouni S. The hidden threat: rodent-borne viruses and their impact on public health. *Viruses*. 2025 Jun 2;17(6):809.
- 26) Toledo J, Haby MM, Reveiz L, Sosa Leon L, Angerami R, Aldighieri S. Evidence for human-to-human transmission of hantavirus: a systematic review. *The Journal of infectious diseases*. 2022 Oct 15;226(8):1362-71.
- 27) Yang B, Yang KD. Immunopathogenesis of different emerging viral infections: evasion, fatal mechanism, and prevention. *Frontiers in Immunology*. 2021 Jul 15;12:690976.
- 28) Munir N, Jahangeer M, Hussain S, Mahmood Z, Ashiq M, Ehsan F, Akram M, Ali Shah SM, Riaz M, Sana A. Hantavirus diseases pathophysiology, their diagnostic strategies and therapeutic approaches: A review. *Clinical and Experimental Pharmacology and Physiology*. 2021 Jan;48(1):20-34.
- 29) Ali QA, Ghareeb OA. Proposed solutions to improve deterioration of drinking water quality. *Global Scientific Review*. 2024 Jan 24;23:34-46.
- 30) Moustafa M. Cost-Effectiveness and Optimal Control of Hantavirus Transmission in Rodent Populations. *Jambura Journal of Biomathematics (JJBM)*. 2026 Mar;7(1):123-35.
- 31) Iheukwumere IH, Iheukwumere CM, Unaeze BC, Ike VE, Nnadozie HC, Onyema SO. Hantaviruses, Transmission Dynamics, Clinical Outcomes, and Preventive Approaches: A Review. *IPS Journal of Basic and Clinical Medicine*. 2025;2(4):115-21.

- 32) Vitiello A, Zovi A. Hantavirus infections in a changing world: epidemiology, pathogenesis, and one health challenges. *Infection*. 2026 Jul 10:1-1.
- 33) Ghareeb OA, Ali QA, Ramadhan SA, Sultan AI. Concepts of one health approach and achieving sustainable development. *European Journal Pharmaceutical and Medical Research*. 2024;11(4):383-9.
- 34) Ramos-Nino ME, Chiem NT, Ramdass PV. Hantavirus Emergence in a Changing World: Virology, Pathogenesis, Surveillance, and One Health Preparedness. *Microorganisms*. 2026 Jun 13;14(6):1326.
- 35) Ali QA, Ghareeb OA. Wastewater management and its role in achieving the various goals of sustainable development: A review. *Emerging Issues in Environment, Geography and Earth Science*. 2024 Feb 7;7:135-49.
- 36) Raji AO, Lawal HA, Suleiman ZA, Olayiwola AE, Muiz W, Tinuke OP, Okesanya OJ, Olaniyi OO, Okikiola AL, Tajudeen NO, Sulyman A. Integrative One Health strategies for the surveillance, control, and prevention of vector-borne and zoonotic diseases: bridging human, animal, and environmental health in a changing world. *Journal of Global Health Science*. 2025 Dec 19;8.
- 37) Ellwanger JH, Veiga AB, Kaminski VD, Valverde-Villegas JM, Freitas AW, Chies JA. Control and prevention of infectious diseases from a One Health perspective. *Genetics and Molecular Biology*. 2021 Jan 29;44(1 Suppl 1):e20200256.
- 38) Burrell DN. Hantavirus pulmonary syndrome (HPS), native communities and public health epidemic surveillance in the United States. *Arab Gulf Journal of Scientific Research*. 2024 Nov 28;42(4):1271-86.
- 39) Montecino-Latorre D, Joly DO, Suwanpakdee S, Lyons NA, Olson SH, Pruvot M. Essential contributions of wildlife health surveillance to the United Nations Sustainable Development Goals. *One Health Outlook* .2025.
- 40) Magalhães AR, Codeço CT, Svenning JC, Escobar LE, Van de Vuurst P, Gonçalves-Souza T. Neglected tropical diseases risk correlates with poverty and early ecosystem destruction. *Infectious Diseases of Poverty*. 2023 Apr 10;12(1):32.
- 41) Connolly J. Global crisis leadership for disease-induced threats: One Health and urbanisation. *Global policy*. 2020 May;11(3):283-92.
- 42) Rulli MC, D'Odorico P, Galli N, John RS, Muylaert RL, Santini M, Hayman DT. Land use change and infectious disease emergence. *Reviews of Geophysics*. 2025 Jun;63(2):e2022RG000785.
- 43) Douglas KO, Payne K, Sabino-Santos Jr G, Agard J. Influence of climatic factors on human hantavirus infections in Latin America and the Caribbean: a systematic review. *Pathogens*. 2021 Dec 23;11(1):15.