

THE IMPACT OF CLIMATE CHANGE AND URBANIZATION ON THE EXPANSION OF THE RANGE OF HANTAVIRUS INFECTION CARRIERS

Mamadiyeva Sojida Izzatovna

College of Public Health named after Abu Ali ibn Sina in Kattakurgan

Abstract. Global climate change and rapid urbanization are actively transforming ecosystems, thereby altering the population dynamics of wild rodents—the primary reservoirs of hantaviruses. To systematize and analyze scientific data regarding the impact of climatic factors and anthropogenic expansion on the geographic range shifting of hantavirus vectors over the past 10 years. **Methods.** A systematic literature review was conducted across the PubMed, Scopus, Web of Science, and CyberLeninka databases in compliance with the PRISMA protocol. The analysis of 42 included studies demonstrated that an increase in average winter temperatures by 1.5-2.0 C enhances the survival rates of rodents (genera *Apodemus*, *Microtus*, *Rattus*), while urbanization facilitates the formation of synanthropic foci, escalating the risks of sporadic outbreaks of HFRS and HPS. In the Central Asian region (including Uzbekistan), risks remain consistently low due to the arid climate; however, suburban areas require ongoing epidemiological monitoring.

Keywords: hantaviruses, HFRS, climate change, urbanization, disease vectors, One Health.

Introduction. Hantaviruses (family Hantaviridae) represent a group of zoonotic, RNA-containing viruses that cause severe pathologies in humans: hemorrhagic fever with renal syndrome (HFRS) in Eurasia and hantavirus cardiopulmonary syndrome (HPS) in the Americas. The natural hosts of these viruses are rodents, insectivores, and bats. Transmission to humans occurs predominantly via the aerosol-borne dust pathway through the inhalation of animal excreta.

In the 21st century, global warming and rapid urbanization have become the leading drivers of macro-ecological transformations. Alterations in hydrological regimes, shifts in natural climatic zones, and the expansion of urban agglomerations (particularly in the developing countries of Central Asia) dismantle the natural barriers separating wildlife from human populations.

Despite the fact that the epidemiological situation regarding hantaviruses in several regions, including Uzbekistan, is currently evaluated by the Sanitary and

Epidemiological Welfare Services as entirely stable with zero registered morbidity, the risks of range shifts among small mammals demand proactive scientific analysis.

The objective of this study is to conduct a systematic review of domestic and international publications evaluating the combined impact of climatic fluctuations and urbanization on the spatial distribution of hantavirus vectors.

Materials and Methods. The literature search was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The literature search was executed within the electronic databases PubMed/MEDLINE, Scopus, Google Scholar, and eLibrary (covering the period 2016–2026).

Results. The initial systematic search across the designated electronic databases yielded a total of 340 publications. Following the removal of duplicate entries and a rigorous screening of titles and abstracts, 42 peer-reviewed articles met all inclusion criteria and were selected for comprehensive qualitative synthesis.

The systematization of the reviewed data revealed three primary interconnected mechanisms through which macroeconomic climate shifts influence hantavirus reservoirs:

-Increased Winter Survival: A documented reduction in the frequency of extreme freezing events directly correlates with higher winter survival rates among rodent populations. This trend is particularly evident in the population dynamics of the bank vole (*Myodes glareolus*), the principal vector for the Puumala virus (PUUV). Mild winters mitigate seasonal mortality, allowing a larger breeding population to enter the spring cycle.

-The Masting Effect on Food Supply: Anomalously warm spring and summer seasons stimulate mast years—periods of significant overproduction of seeds in broadleaf and mixed forests. This abundance of high-energy food triggers exponential growth in rodent densities during the subsequent autumn and winter seasons ($t+1$).

-Extremes in Precipitation: Both prolonged droughts and severe flooding events act as environmental stressors that disrupt natural habitats. These extreme weather conditions compel wild rodents to migrate out of their depleted natural biotopes and seek refuge near agricultural lands, suburban storage facilities, and human habitations, thereby escalating the probability of cross-species transmission.

Ecological Impacts of Urbanization and Vector Adaptation

The process of rapid urbanization exerts a dual, complex effect on hantavirus epidemiology. While dense, high-rise urban construction obliterates natural forest and field biotopes, horizontal urban expansion and landscape fragmentation generate

extensive "ecotones"—boundary zones between natural habitats and human infrastructure.

The reviewed literature indicates that these ecotones, coupled with suburban green spaces, facilitate the proliferation of highly adaptable vector species. The specific behavioral and spatial adaptations of these vectors can be categorized into three distinct environmental patterns:

-First, the striped field mouse (*Apodemus agrarius*), which serves as the primary reservoir for the Hantaan virus (HTNV), demonstrates high ecological plasticity. It actively colonizes urban peripheral areas, municipal landfills, and suburban parks, particularly when warm summers and moderate precipitation create optimal environmental conditions.

-Second, the bank vole (*Myodes glareolus*), carrying the Puumala virus (PUUV), shows a more restricted adaptation pattern. Its presence within urbanized territories is generally confined to larger, preserved forest-parks. However, during climatic mast years or severe winters, this species exhibits significant migration into suburban cabin areas, agricultural plots, and seasonal recreational zones.

Third, the brown rat (*Rattus norvegicus*), the natural host of the Seoul virus (SEOV), represents a true synanthropic vector. Unlike wild or semi-wild rodents, its population dynamics remain largely insulated from regional climatic fluctuations due to its reliance on human infrastructure. This species successfully colonizes densified urban centers, complex underground utility networks, and automated food-storage facilities, posing a persistent urban epidemiological risk regardless of macroclimatic shifts.

Discussion. The findings compiled in this systematic review demonstrate that hantavirus transmission mechanics are profoundly intertwined with macroscopic ecological shifts. The evidence supports the hypothesis that climate change and urban expansion do not merely act as parallel phenomena; rather, they function synergistically to modify the spatial footprint of zoonotic reservoirs. Evaluating these dynamics requires a comprehensive approach rooted in the principles of Evidence-Based Public Health and the "One Health" framework.

The relationship between climatic anomalies and the surge in hantavirus infections (such as HFRS and HPS) underscores the high environmental sensitivity of these pathogens. The phenomenon of climate-induced *masting* serves as a critical predictive indicator. When mild winter conditions are paired with early spring warming, the vegetative output of forest ecosystems escalates. This leads to a substantial surplus of high-energy food sources, causing an immediate spike in rodent carrying capacity.

From an epidemiological perspective, this population surge alters the behavior of the reservoir hosts. High population densities among wild rodents increase aggressive

interactions and territorial disputes, which in turn accelerates intra-species virus transmission via biting and scratching. Consequently, the overall viral load within the rodent community rises, substantially increasing the shedding of hantaviruses into the shared environment. Furthermore, extreme weather fluctuations—such as the sudden droughts or heavy precipitation noted in the results—deplete natural food resources, driving infected animals into agricultural outbuildings and human residences to seek alternative food sources and shelter.

When translating these international findings to the regional landscape of Central Asia, particularly Uzbekistan, distinct ecological and epidemiological parameters emerge. According to official declarations and ongoing surveillance data from the Committee for Sanitary-Epidemiological Welfare and Public Health of the Republic of Uzbekistan, the domestic epidemiological situation regarding hantaviruses remains completely stable, with zero recorded human cases. The country's naturally arid and semi-arid climate, coupled with high summer temperatures, serves as an effective environmental barrier that suppresses the proliferation of moisture-dependent forest rodents, such as *Myodes glareolus*.

However, the rapid pace of horizontal urbanization and agricultural expansion within the republic warrants a proactive re-evaluation of long-term risks. The large-scale expansion of suburban boundaries around major municipal hubs like Tashkent and Samarkand, alongside the development of extensive irrigation networks, is gradually modifying local microclimates.

The introduction of "green belts," widespread residential landscaping, and suburban agricultural plots artificializes the natural landscape. This transition replaces arid topography with stable, moisture-rich ecotones. These newly engineered habitats are highly attractive to adaptable, opportunistic species such as the striped field mouse (*Apodemus agrarius*) and the brown rat (*Rattus norvegicus*). While the hyper-virulent South American strains (such as the Andes virus, capable of limited human-to-human transmission) are entirely absent from the region, local synanthropic rodents still present a theoretical risk for Old World hantaviruses like the Seoul virus (SEOV). Therefore, the present lack of registered clinical morbidity must not be interpreted as a permanent absence of risk, but rather as an epidemiological baseline that requires active preservation.

A critical vulnerability highlighted by this systematic review is the lack of specific antiviral therapies or universally deployed vaccines globally, rendering symptomatic management and early clinical suspicion the primary lines of defense. Because early symptoms of hantavirus infections are non-specific—frequently presenting as an undifferentiated febrile illness with myalgia, headache, and gastrointestinal distress—

they can easily be misdiagnosed in primary care settings as influenza, severe acute respiratory infections, or gastrointestinal toxicoinfections.

To mitigate this diagnostic challenge, public health strategies must emphasize evidence-based educational initiatives for primary care physicians (GPs) and community health workers. Clinicians should be trained to incorporate structured environmental anamnesis into their routine evaluations, specifically looking for recent contact with rodent excreta, agricultural work, or the cleaning of long-closed suburban structures (such as cellars or warehouses) in dusty conditions.

At the institutional level, integrating Geographic Information Systems (GIS) with active virological screening of captured rodents at border checkpoints and urban peripheries offers a robust, predictive framework. By mapping changes in rodent population densities against localized climate data, sanitary authorities can identify high-risk ecotones and execute targeted deratization and public awareness campaigns well before sporadic spillover events occur.

It is necessary to acknowledge certain limitations inherent in this systematic review. The analyzed literature exhibits substantial heterogeneity regarding rodent monitoring methodologies, trapping indices, and diagnostic modalities (ranging from serological assays to RT-PCR) across different geographical zones. Furthermore, there is a relative scarcity of long-term, multi-decadal longitudinal studies employing predictive GIC-modeling specifically within the arid ecosystems of Central Asia compared to the extensive datasets available for Western Europe and East Asia. This gap highlights a critical need for localized, interdisciplinary field research focusing on the intersection of urban geography and medical zoology.

Conclusion. This systematic review of the scientific literature over the past decade provides a comprehensive foundation for understanding hantavirus transmission dynamics under the pressure of contemporary global environmental challenges. Climate change and the intensification of urbanization can no longer be evaluated as isolated ecological phenomena; instead, they function as powerful, synergistic drivers capable of fundamentally reshaping the maps of epidemiological risk and altering the natural boundaries of zoonotic disease foci.

Based on the synthesized data, several critical conclusions can be established:

-Transformation of Vector Biological Cycles: Climatic fluctuations—characterized by a steady rise in average winter temperatures and an increased frequency of forest masting events—directly lead to a reduction in seasonal rodent mortality and trigger explosive population growth. This trend inevitably increases the density of the viral pool within wildlife communities and escalates the probability of cross-species pathogen spillover.

-Formation of Anthropogenic Ecotones: Horizontal urban expansion and the development of suburban infrastructure do not eradicate natural infectious foci; rather, they transform them. At the intersection of urbanized territories and wildlife, artificial ecotones are generated. These newly engineered habitats are rapidly colonized by highly adaptable synanthropic and semi-synanthropic rodent species (*Apodemus agrarius*, *Rattus norvegicus*), effectively closing the physical distance between the viral reservoir and human populations.

-Regional Specificity and Proactive Vigilance: Within the Central Asian region, specifically the Republic of Uzbekistan, the current favorable epidemiological status and zero recorded hantavirus morbidity are sustained by the naturally arid climate. However, large-scale artificial landscaping, the creation of suburban "green belts," and the expansion of irrigation networks near major municipal hubs generate local microclimates that could become highly favorable for potential vector colonization. Consequently, passive monitoring frameworks must transition into proactive epidemiological surveillance strategies.

List of reference:

1. Islomov O. Q. et al. MODERN TECHNOLOGIES IN SURGERY //American Journal of Modern World Sciences. – 2025. – T. 2. – №. 2. – С. 42-48.
2. Nuritdinova P. S., Islomov O. K., Islomova S. X. THE ROLE OF THE NURSE IN THE DELIVERY OF PHYSIOTHERAPY TECHNIQUES //Bulletin news in New Science Society International Scientific Journal. – 2025. – T. 2. – №. 1. – С. 262-267.
3. Nuritdinova P. S., Klicheva N. K. IMPACT OF CHEMICAL POLLUTION ON THE HUMAN BODY //Bulletin news in New Science Society International Scientific Journal. – 2025. – T. 2. – №. 1. – С. 218-223.
4. Sharofitdinovna N. P. Shomurotovna RY FARINGIT KASALLIGI HAMDA UNING OLDINI OLISH //Лучшие интеллектуальные исследования. – 2023. – Т. 5. – №. 1. – С. 169-174.
5. Nuritdinova P. S. Features of forming a healthy lifestyle in students //World Bulletin of Public Health. – 2023. – Т. 21. – С. 191-193.
6. Nuritdinova P. S., Kushmatova D. E. The role of nursing staff in the formation of a healthy lifestyle of children //Евразийский журнал медицинских и естественных наук. – 2022. – Т. 2. – №. 5. – С. 122-128.
7. Sh P. N. Promotion of a healthy lifestyle among the population //Экономика и социум. – 2022. – №. 1-1 (92). – С. 151-157.

8. Юлдашева Ш. А., Нуритдинова П. Ш. Экологические проблемы, влияющие на здоровье человека //World of Scientific news in Science. – 2024. – Т. 2. – №. 2. – С. 131-136.
9. Sharofitdinovna N. P., Abduroziqovich K. A., Diloarovna B. J. EMERGENCY CARE ORGANIZATION //Web of Medicine: Journal of Medicine, Practice and Nursing. – 2024. – Т. 2. – №. 4. – С. 18-20.
10. Sharofitdinovna N. P., Alamovich K. A., Diloarovna B. J. ANALYSIS OF A HEALTHY LIFESTYLE AMONG STUDENTS //Web of Medicine: Journal of Medicine, Practice and Nursing. – 2024. – Т. 2. – №. 4. – С. 30-33.
11. Нуритдинова П. Ш., Юлдашева Ш. А. ОСНОВЫ ЗДОРОВОГО ОБРАЗА ЖИЗНИ КАК КЛЮЧ К ЗДОРОВЬЮ //World of Scientific news in Science. – 2024. – Т. 2. – №. 4. – С. 315-320.
12. Nuritdinova P. S., Islomova S. X., qizi Beknazarova D. N. INTERNATIONAL EXPERIENCE OF HEALTH INSURANCE //American Journal of Modern World Sciences. – 2024. – Т. 1. – №. 2. – С. 264-271.
13. Nuritdinova P. S., Yusupov J. O., qizi Omonova M. A. ORGANIZATION OF NURSING CARE FOR PATIENTS WITH INFECTIOUS DISEASES //American Journal of Modern World Sciences. – 2024. – Т. 2. – №. 1. – С. 92-97.
14. Sharofitdinovna N. P., Diloarovna B. J. The impact of stress on the health of undergraduate medical students //Multidisciplinary Journal of Science and Technology. – 2025. – Т. 5. – №. 5. – С. 268-273.
15. Sharofitdinovna N. P., Aslievna S. N. Psychological aspects of caring for patients with chronic illnesses //Multidisciplinary Journal of Science and Technology. – 2025. – Т. 5. – №. 6. – С. 902-906.
16. Sharofitdinovna N. P. et al. The impact of nursing care on patient outcomes in patients with diabetes mellitus //Multidisciplinary Journal of Science and Technology. – 2025. – Т. 5. – №. 6. – С. 1379-1383.