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Opinion Article

# Zoonotic Transmission of Viral and Fungal Agents in Changing Ecosystems

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## DESCRIPTION

The increasing frequency of zoonotic transmissions, particularly involving viral and fungal pathogens, underscores a critical intersection between ecological change and emerging infectious diseases. As ecosystems undergo transformations due to climate change, urbanization, deforestation, and agricultural expansion, the natural barriers between wildlife and human populations are eroding, facilitating closer interactions that enhance the risk of pathogen spillover. Viral zoonoses such as Ebola, SARS, MERS, and most recently COVID-19, are stark reminders of the global impact such transmissions can have. However, fungal zoonoses, though often underappreciated, are also rising, with examples including Histoplasma capsulatum, Cryptococcus gattii, and certain dermatophytes that can be transmitted from animals to humans under changing ecological and environmental conditions.

In disturbed ecosystems, wildlife species are often displaced or adapt to urban and peri-urban environments, increasing their contact with humans and domestic animals. Bats, rodents, and birds frequent reservoirs of zoonotic viruses are particularly adaptable and act as key players in this interface. For example, bats serve as natural reservoirs for a wide range of viruses, including coronaviruses, filoviruses, and paramyxoviruses. Their unique physiology, migratory behavior, and social roosting make them ideal for viral maintenance and dissemination. On the fungal front, birds and bats also contribute to the environmental accumulation of infectious spores such as Histoplasma, especially in their droppings. These spores can be aerosolized and inhaled by humans engaging in agricultural, cave exploration, or construction activities, leading to severe pulmonary infections. As environmental conditions such as temperature and humidity fluctuate with climate change, the geographic ranges of both vectors and fungal pathogens are expanding into new areas previously unexposed to such risks.

Anthropogenic pressures on ecosystems are also altering host-pathogen dynamics. Intensive livestock farming, wildlife trade, and bushmeat consumption increase the potential for cross-species pathogen transmission. The global trade in exotic pets, for instance, has facilitated the spread of fungal infections like Trichophyton species in both animals and humans. Simultaneously, agricultural fungicides exert selective pressure on environmental fungi, contributing to the emergence of azole-resistant strains of Aspergillus fumigatus, which may originate in the soil but find their way into immunocompromised human hosts. This dual interface of environmental and clinical resistance is a growing public health concern. Moreover, fungal pathogens such as Coccidioides are emerging in areas undergoing desertification, with spores becoming airborne due to droughts and soil disruption, further linking ecosystem degradation to human disease.

Zoonotic potential is not merely a factor of pathogen presence but also of host susceptibility and transmission efficiency. Immunocompromised individuals, including those with HIV/AIDS, cancer, or organ transplants, are particularly vulnerable to invasive fungal infections that may have originated from environmental sources. Viral zoonoses, meanwhile, often achieve pandemic potential when they evolve the ability for sustained human-to-human transmission following a zoonotic jump. This makes the early detection and monitoring of such pathogens in animal reservoirs a crucial element of global health security. Hungary and the Central European region, with their rich biodiversity and rapidly urbanizing landscapes, serve as critical case studies in understanding how changing ecosystems influence zoonotic dynamics. The Carpathian Basin, in particular, harbors both endemic fungal species and migratory bird pathways, creating unique ecological interactions with potential for zoonotic spillover.

To address these growing threats, a transdisciplinary approach rooted in the One Health concept is essential. This approach integrates human, animal, and environmental health to create comprehensive surveillance and response systems. Field studies involving wildlife sampling, environmental monitoring, and pathogen sequencing can help identify emerging threats before they cross into human populations. Additionally, promoting responsible land use, preserving biodiversity, and regulating wildlife trade are vital preventive strategies. Public health initiatives must also focus on educating communities at the frontlines of zoonotic risk such as farmers, forest workers, and

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those involved in animal husbandry about protective behaviors and early symptom recognition.

In conclusion, the zoonotic transmission of viral and fungal agents is deeply influenced by ecological changes that disrupt the delicate balance between humans, animals, and the environment. As our ecosystems continue to change, the opportunities for cross-species transmission of pathogens are likely to increase, with potentially devastating consequences. Vigilance through ecological surveillance, proactive policymaking, and international cooperation will be crucial in mitigating future zoonotic outbreaks. Investing in research that bridges virology, mycology, ecology, and public health will not only enhance preparedness but also promote resilience in the face of future pandemics and fungal epidemics.