



Recurring Zoonotic Outbreaks Highlight Global Gaps in Surveillance, Vaccines, One Health Preparedness and Pandemic Response

Published On: 31-07-2026

Recent Developments:

- Recent outbreaks involving **Ebola Virus Disease**, **Hantavirus** and **Nipah Virus** demonstrate that **zoonotic diseases** are emerging with increasing frequency at the interface of humans, animals and ecosystems, posing significant global public health challenges.
- Recent **Nipah Virus** events in **India** and **Bangladesh**, together with international concern over **Ebola** and **Hantavirus**, have reinforced the need for stronger **One Health**, genomic surveillance, equitable vaccine access and coordinated global preparedness.

Understanding Zoonotic Diseases:

What are Zoonotic Diseases?

- Zoonotic diseases (Zoonoses)** are infectious diseases that naturally spread between vertebrate animals and humans through direct contact, contaminated food or water, vectors or environmental exposure.
- More than **60%** of known human infectious diseases and nearly **75%** of emerging infectious diseases originate from animals, making zoonotic spillover a major global health concern.
- Rapid urbanisation, deforestation, climate change, wildlife trade and increased human-animal interaction have accelerated the emergence of zoonotic pathogens worldwide.

Major Zoonotic Viruses of Concern:

Ebola Virus Disease:

- Ebola Virus Disease (EVD)** is a severe viral haemorrhagic fever with an average **case-fatality rate** of nearly **50%**, although mortality varies across outbreaks.
- Human-to-human transmission occurs through direct contact with infected blood, body fluids or contaminated materials.
- Recent outbreaks in **Central Africa** demonstrate that armed conflict, population displacement, weak health systems, unsafe burial practices and community mistrust significantly hinder outbreak containment.
- Licensed vaccines are available only against the **Zaire ebolavirus** species, while vaccines for other Ebola species remain under development.

Hantavirus:

- Hantavirus** is primarily transmitted through exposure to infected rodent urine, saliva or droppings and is named after the **Hantaan River** region of **South Korea**.
- Infection may cause **Haemorrhagic Fever with Renal Syndrome (HFRS)** or **Hantavirus Pulmonary Syndrome (HPS)**, both of which can rapidly progress to life-threatening complications.

- Most hantaviruses do not spread between humans; however, the **Andes Hantavirus** strain is capable of limited person-to-person transmission.
- The **MV Hondius** outbreak illustrated how international travel and enclosed environments can transform a local outbreak into a multinational public health event requiring extensive contact tracing.

Nipah Virus:

- **Nipah Virus (NiV)** is a highly fatal zoonotic disease naturally carried by **fruit bats (Pteropus species)** and can cause severe respiratory illness and acute encephalitis.
- The estimated **case-fatality rate** ranges from **40% to 75%**, depending on outbreak circumstances and healthcare capacity.
- Transmission occurs through infected animals, contaminated food products such as raw date palm sap and close human-to-human contact, particularly in healthcare settings.
- Recurrent outbreaks in **India** and **Bangladesh** indicate that the virus remains an important regional public health threat with epidemic potential.
- No licensed vaccine or specific antiviral therapy is currently available for human use against **Nipah Virus**.

Vaccine Preparedness and Research Pipeline:

Current Vaccine Status:

- A licensed vaccine is currently available only for one major species of the **Ebola Virus**, while **Nipah Virus**, **Hantavirus** and several Ebola species still lack approved human vaccines.
- The absence of reliable curative therapies makes early diagnosis, rapid isolation, infection prevention and supportive clinical care essential during outbreaks.

Stages of Vaccine Development:

- **Basic research**, Publicly funded universities and research laboratories identify pathogen biology, immune responses and potential vaccine targets.
- **Industrial translation**, Pharmaceutical manufacturers convert laboratory discoveries into vaccines through formulation, clinical trials, quality assurance, regulatory approval, large-scale production and cold-chain distribution.
- **Advanced technologies, Artificial Intelligence (AI), mRNA platforms**, viral vector vaccines and recombinant protein technologies have significantly accelerated vaccine design, although biological validation and regulatory evaluation remain indispensable.

Why Vaccine Development Remains Challenging:

Major Constraints:

- **Unpredictable outbreaks**, Sporadic disease occurrence limits the feasibility of conventional large-scale clinical trials and often requires adaptive or emergency trial designs.
- **Technology barriers**, Advanced vaccine platforms remain protected by patents, specialised manufacturing expertise and proprietary technologies that are not universally accessible.
- **Limited commercial incentives**, Pharmaceutical companies may invest less in diseases affecting smaller populations or low-income regions despite their significant public health impact.
- **Regulatory complexity**, Vaccine development requires extensive safety evaluation, ethical approval and post-marketing surveillance before widespread deployment.

Factors Increasing Zoonotic Spillover Risk:

Emerging Drivers:

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- **Deforestation**, habitat fragmentation and biodiversity loss increase contact between wildlife, livestock and humans.
- **Climate change** alters the geographical distribution of disease vectors and wildlife reservoirs, facilitating pathogen emergence.
- **Wildlife trade**, intensive livestock farming and expanding urbanisation create new opportunities for cross-species transmission.
- Increased global travel and trade enable infectious diseases to spread rapidly across international borders within short periods.

One Health Approach to Zoonotic Diseases:

Concept and Significance:

- **One Health** recognises that human health, animal health and environmental health are closely interconnected and require integrated policy responses.
- Effective zoonotic disease control requires collaboration among public health authorities, veterinary services, wildlife experts, environmental agencies and research institutions.
- Strengthening **One Health** surveillance improves early detection of spillover events and enhances pandemic preparedness.

Building Future Preparedness:

Priority Measures:

- **Academia-industry partnerships**, Universities should provide scientific research while industry should support vaccine manufacturing, quality assurance and large-scale distribution.
- **Shared-risk financing**, Governments, multilateral organisations and private partners should jointly finance epidemic vaccine development through advance purchase commitments, technology transfer and regional manufacturing hubs.
- **Strengthening surveillance**, Integrated genomic surveillance, laboratory capacity and cross-border disease reporting systems should be expanded.
- **Addressing vaccine hesitancy**, Transparent risk communication, community engagement and trusted local leadership should be strengthened before public health emergencies arise.
- **Strengthening international cooperation**, Equitable access to diagnostics, therapeutics and vaccines should become a core objective of global health governance.

India's Preparedness Against Zoonotic Diseases:

Major Initiatives:

- **Integrated Disease Surveillance Programme (IDSP)** strengthens early detection and reporting of infectious disease outbreaks.
- **National Centre for Disease Control (NCDC)** coordinates epidemiological surveillance and outbreak response across the country.
- **Indian Council of Medical Research (ICMR)** supports laboratory diagnosis, pathogen research and development of indigenous diagnostic technologies.
- India has strengthened **One Health** coordination involving the health, animal husbandry, wildlife and environmental sectors to improve preparedness against emerging zoonotic diseases.

Way Forward:

Strategic Priorities:

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- Strengthen **One Health** governance by integrating human, animal and environmental surveillance systems.
- Expand regional vaccine manufacturing capacity and encourage equitable technology transfer.
- Improve genomic surveillance, rapid diagnostics and emergency response infrastructure for emerging pathogens.
- Promote international collaboration in vaccine research, pathogen surveillance and equitable access to medical countermeasures.
- Build resilient public health systems capable of responding rapidly to future zoonotic outbreaks while maintaining public trust.

Value Addition for UPSC:

Important Facts for Prelims and Mains:

- **Zoonosis:** Disease naturally transmitted between animals and humans.
- **Natural Reservoir of Nipah Virus: Fruit Bats (Pteropus species).**
- **Only Hantavirus with Human-to-Human Transmission: Andes Hantavirus** (limited transmission).
- **Licensed Human Vaccine Available:** Only for **Zaire Ebola Virus**.
- **No Licensed Human Vaccine: Nipah Virus, Hantavirus** and several non-Zaire Ebola species.
- **WHO Priority Pathogens: Nipah Virus** is included due to its epidemic potential and absence of licensed vaccines or specific treatment.
- **One Health:** Integrated approach recognising the interdependence of **human, animal** and **environmental** health.
- **Major Drivers of Zoonotic Spillover: Deforestation, Climate Change, Wildlife Trade, Urbanisation, Global Travel** and **Biodiversity Loss**