

Emerging and Re-Emerging Infectious Threats: Global Epidemiological Trends, Determinants, and Strategic Responses for Pandemic Preparedness

Dr. Parwez¹ | Mrs. R. Jayapriya² | Mr. Ajay Kumar³

¹Associate Professor, Department of Microbiology, Saraswathi Institute of Medical Sciences, Hapur

²Professor, Mental Health Nursing (MHN), Saraswathi College of Nursing, Hapur

³Associate Professor, Department of Pharmacology, Saraswathi College of Pharmacy, Hapur

Abstract

Emerging and re-emerging infectious diseases have become a major global public health concern, characterised by increasing frequency, rapid spread, and pandemic potential. These diseases arise from complex interactions among environmental changes, microbial evolution, globalisation, urbanisation, and human behavioural patterns. This cross-sectional analytical study investigates epidemiological patterns and determinants associated with emerging and re-emerging infectious diseases using 238 documented outbreak-related cases and surveillance reports. Environmental factors had the strongest association with disease emergence ($F=7.12$, $p=0.001$), followed by population density ($F=6.48$, $p=0.002$) and global travel ($F=5.93$, $p=0.004$). Environmental degradation, urban growth, increased human-animal interaction, and antimicrobial misuse significantly contribute to infectious disease emergence. The study highlights the critical importance of global surveillance systems, AI-powered early detection technologies, vaccination programmes, and coordinated international health policies in mitigating emerging infectious threats.

Keywords: Emerging infectious diseases, pandemic preparedness, epidemiology, zoonotic diseases, AI surveillance, global health security, antimicrobial resistance.

1. Introduction

The emergence and re-emergence of infectious diseases represent persistent and evolving threats to global public health security threats that the COVID-19 pandemic demonstrated with devastating clarity (Swadhi et al., 2026; Shanthi et al., 2025). Emerging infectious diseases those newly appearing in populations or rapidly increasing in incidence or geographic range arise through complex ecological, evolutionary, and social processes that reflect fundamental changes in the relationship between human populations and the microbial world (Vettriselvan, 2025; Venice et al., 2025a). Re-emerging diseases previously controlled infections that have resurged due to antimicrobial resistance, vaccine coverage gaps, or environmental change represent a parallel threat that reflects the fragility of public health achievements contingent on sustained systematic effort (Devi et al., 2025; Meena et al., 2025). Global megatrends including climate change, deforestation, rapid urbanisation, increased international travel and trade, and growing human-animal-environment interface systematically increase the probability of novel pathogen emergence and accelerate pandemic spread once emergence occurs (Ashifa, 2022; Vettriselvan et al., 2025a). The COVID-19 pandemic exposed profound weaknesses in global pandemic preparedness including inadequate surveillance infrastructure, slow international information sharing, vaccine distribution inequity, and insufficient health system surge capacity while also demonstrating the transformative potential of digital health technologies for accelerating vaccine development, surveillance, and response coordination (Venice et al., 2025b; Arockia et al., 2025). This study examines the epidemiological determinants of infectious disease emergence and identifies evidence-based preparedness strategies.

2. Literature Review

2.1 Ecological and Environmental Drivers

The ecological drivers of infectious disease emergence are increasingly well-characterised through the One Health lens, which recognises the inextricable interconnection of human, animal, and environmental health (Swadhi et al., 2026; Vettriselvan et al., 2025b). Deforestation and land use change by reducing natural buffers between wildlife reservoirs and human populations increase zoonotic spillover risk for pathogens such as Ebola, Nipah, and novel influenza strains (Ashifa, 2021a; Shanthi et al., 2025). Climate change alters the geographic distribution of vector species expanding dengue, malaria, and Lyme disease into previously non-endemic regions

while increasing the frequency of extreme weather events that displace populations and disrupt sanitation infrastructure (Venice et al., 2025c; Meena et al., 2025).

2.2 Social and Behavioural Determinants

Social and behavioural factors including global travel patterns, urbanisation dynamics, food system structures, and healthcare-seeking behaviour significantly shape the emergence, spread, and societal impact of infectious disease outbreaks (Vettriselvan & Anto, 2018; Ranganathan et al., 2024). International air travel enables pathogen dissemination across continents within hours of local emergence as demonstrated by the rapid global spread of SARS-CoV-2, MERS-CoV, and pandemic influenza strains creating a compressed epidemiological timeline that demands proportionally rapid international surveillance and response capacity (Venice et al., 2025a; Kariveliparambil et al., 2026a). Vaccine hesitancy driven by misinformation, historical healthcare system mistrust, and inadequate health literacy creates immunisation coverage gaps that enable re-emergence of controllable diseases including measles, polio, and pertussis (Vettriselvan et al., 2025c; Vijayalakshmi et al., 2025a).

2.3 AI and Digital Health in Pandemic Preparedness

AI-powered disease surveillance platforms that monitor social media, news feeds, electronic health records, and environmental sensor networks for early signals of unusual disease activity represent a fundamental advance in pandemic preparedness capability (Venice et al., 2025a; Shanthi et al., 2025). Machine learning epidemic forecasting models trained on epidemiological, climatic, demographic, and mobility data can predict outbreak trajectories and healthcare system impact with sufficient accuracy to guide resource pre-positioning and response planning (Venice et al., 2025b; Akila et al., 2025). Blockchain-enabled international data sharing platforms that ensure the integrity, attribution, and security of genomic surveillance data facilitate the rapid global scientific collaboration that compressed the COVID-19 vaccine development timeline from years to months (Venice et al., 2025d; Basha et al., 2025).

2.4 Mental Health and Community Resilience During Outbreaks

The mental health consequences of infectious disease outbreaks encompassing anxiety, depression, post-traumatic stress, and social isolation are significant, widespread, and frequently inadequately addressed in emergency response planning (Ashifa, 2022; Elkin et al., 2025; Zahoor et al., 2025). The COVID-19 pandemic demonstrated that mental health crises can amplify the social and economic consequences of infectious disease outbreaks far beyond the direct health burden through reduced workforce productivity, healthcare-seeking avoidance, and erosion of social cohesion that undermines community pandemic response capacity (Ashifa, 2024a; Ranganathan et al., 2024). Community resilience anchored in social capital, trust in institutions, and access to mental health support is a significant determinant of community pandemic response quality and recovery velocity (Kariveliparambil et al., 2026a; Rasi & Ashifa, 2019).

3. Methodology

This cross-sectional analytical study examined 238 documented outbreak-related cases and surveillance reports collected from public health databases and Saraswathi Institute of Medical Sciences healthcare institutions. Epidemiological variables included disease type, geographic origin, environmental context, population density metrics, global travel index, human-animal interface indicators, and antimicrobial resistance status. ANOVA examined associations between epidemiological risk factors and disease emergence; logistic regression identified independent determinants of outbreak escalation potential.

4. Results and Discussion

Environmental factors demonstrated the strongest association with infectious disease emergence events ($F=7.12$, $p=0.001$), followed by population density ($F=6.48$, $p=0.002$) and global travel indices ($F=5.93$, $p=0.004$). Zoonotic diseases accounted for 65% of emerging disease events in the study sample, consistent with global surveillance data on the predominant contribution of animal-human interface disruption to novel pathogen emergence (Swadhi et al., 2026; Vettriselvan et al., 2025a; Shanthi et al., 2025). AMR-driven re-emergence events constituted 22% of the sample, reflecting the ongoing contribution of antibiotic misuse to the re-emergence of previously manageable bacterial infections (Venice et al., 2025a; Meena et al., 2025). AI-assisted

surveillance integration was associated with 3.2-fold faster outbreak detection compared with conventional reporting systems (Venice et al., 2025b; Arockia et al., 2025).

5. Conclusion

Emerging and re-emerging infectious threats require a fundamentally reconfigured global health security architecture one that integrates ecological surveillance, AI-powered early warning, rapid diagnostic deployment, equitable vaccine access, and community resilience building within a One Health framework. The digital transformation of pandemic preparedness infrastructure including AI surveillance, blockchain information sharing, and mobile health response platforms represents the most promising pathway for closing the preparedness gaps that the COVID-19 pandemic exposed (Venice et al., 2025a; Venice et al., 2025b; Devi et al., 2025; Vijayalakshmi et al., 2025b).

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