

Editorial

Strengthening Public Health Awareness and Preparedness for Future Pandemics

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Pandemics remain one of the most persistent and complex threats to global health. Despite remarkable advances in medicine and microbiology, recent decades have demonstrated that the world is far from immune to large-scale outbreaks. A modelling study by the Joint Research Centre (JRC), integrating machine learning with satellite data, estimates that approximately 9.3% of the Earth's land surface is at high or very high risk of disease outbreaks, including Ebola, Zika, and Crimean-Congo haemorrhagic fever.⁽¹⁾ Recognizing the limitations of global research capacity, the World Health Organization (WHO) has developed a prioritized list of pathogens under its R&D Blueprint.⁽²⁾ This framework focuses on diseases with epidemic potential and insufficient countermeasures, including COVID-19, Ebola and Marburg virus diseases, Lassa fever, MERS and SARS, Nipah virus, Rift Valley fever, Zika, and the hypothetical "Disease X." The latter represents the possibility of an unknown pathogen triggering a future pandemic, emphasizing the importance of flexible and forward-looking preparedness systems.

A growing body of evidence highlights that human-driven environmental changes are central to the emergence of infectious diseases. Climate change, deforestation, agricultural intensification, and biodiversity loss collectively alter ecosystems and increase the likelihood of zoonotic spillover—where pathogens jump from animals to humans. Expanding human settlements into forested areas, rising livestock density, and inadequate biosecurity further amplify these risks. Notably, regions experiencing significant forest loss have become hotspots for emerging infectious diseases, with an estimated two novel zoonotic viruses spilling over into humans each year.⁽³⁾ Historical and recent pandemics illustrate the evolving nature of these threats. From the devastating impacts of the bubonic plague and the 1918 influenza pandemic to more recent outbreaks such as SARS, MERS, and COVID-19, infectious diseases continue to exploit vulnerabilities in modern societies. Globalization, urban crowding, and increased mobility have inadvertently created conditions conducive to rapid disease transmission. Several viral diseases with pandemic potential remain of particular concern. Arboviruses such as chikungunya, dengue, and Zika are expanding geographically, driven in part by climate change and vector proliferation.⁽⁴⁾ Dengue alone now threatens nearly half of the global population, yet lacks specific antiviral treatment, relying primarily on supportive care and vector control. Similarly, chikungunya and Zika present ongoing challenges due to limited treatment options and the absence or early-stage development of effective vaccines. Highly

pathogenic avian influenza strains, including H5N1, further highlight the risk of high-fatality zoonotic infections with pandemic potential.

Preparedness for future pandemics must therefore adopt a multidisciplinary approach. Vaccine development remains a cornerstone strategy, encompassing both traditional platforms and newer technologies such as mRNA and viral vectors. At the same time, the development of antiviral therapies, improved diagnostics, and reliable correlates of immunity is essential. The COVID-19 pandemic demonstrated the value of both novel drug discovery and the repurposing of existing medications. Equally important are upstream prevention strategies. Reducing deforestation, regulating wildlife trade, and strengthening surveillance systems can significantly lower the risk of zoonotic spillover. Dobson et al. (2020) estimate that an annual investment of \$22–31 billion in such preventive measures could substantially reduce pandemic risk—far less than the economic and human costs of global outbreaks.⁽³⁾ Enhancing public education on disease transmission, sanitation, and sustainable environmental practices is also critical. Pandemics are not isolated biological events but the result of complex interactions between human activity, environmental change, and microbial evolution. Strengthening public health awareness, investing in research and prevention, and fostering global collaboration are essential steps toward mitigating future pandemic threats.

Competing Interests

The authors declare no conflict of interest.

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