

The Threat of Impending Pandemics: Lessons from The Past and Strategies for Future

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Introduction

Since time immemorial, the human race has been exposed to a plethora of microbes that have caused deadly outbreaks, epidemics, and pandemics that continue to challenge us in ways that can cripple even the most advanced healthcare systems. Emerging and re-emerging infectious pathogens and their spread have caused serious jeopardy and led to an increased incidence of outbreaks and pandemics over the last decade. Studies document the emergence of a new human infectious disease every eight months approximately, with more than 35 emerging infectious diseases infecting humans surfacing since the 1980s (Priyadarsini *et al.*, 2023). In contrast, the prediction of future pandemics, their control, and outbreak investigations have been largely ignored and underfunded. Artificial Intelligence (AI) can improve early disease detection through the analysis of large volumes of data, enabling more effective epidemiological surveillance. Additionally, AI models can predict disease spread and assist experts in making informed decisions regarding control measures. AI also plays a crucial role in the development of vaccines and drugs, accelerating the discovery and optimization process. Furthermore, AI can support remote healthcare by facilitating telemedicine and real-time patient monitoring. While there are ethical and privacy challenges associated with the use of AI, it is evident that this technology can play a fundamental role in preparing for and responding to future pandemics, significantly improving global health and societal well-being (Nicolas Castillo, 2023).

A pandemic is defined as —an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people. All

pandemics start as localized disease outbreaks that then begin spreading rapidly, and eventually around the world. (CDC, 2021)

The past few decades have seen the emergence of many novel agents that have caused pandemics like severe acute respiratory syndrome (SARS), Middle East Respiratory Syndrome (MERS), Ebola, flu viruses, and the most recent Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The emergence of these novel pandemic agents has never been predicted before their first appearance (Morse *et al.*, 2012). However, the patterns of their origins and spread need to be studied as part of the surveillance strategy. The occurrence of pandemics has substantially increased over time and is dominated by zoonoses (60%), of which almost 72% originate in wildlife. Thus, the threat posed by zoonoses-infectious diseases that jump from animals to humans-is rising. And the risk of a new pandemic is higher now than ever before, with the most likely scenario for the next pandemic being a new strain of Influenza, like the Avian Influenza A (H7N9) "bird flu" virus, or a newly identified virus such as another novel coronavirus, all of which are zoonotic. These lethal novel zoonotic agents have high pandemic potential and continue to threaten global health security (Mishra *et al.*, 2023).

Timeline of Pandemics

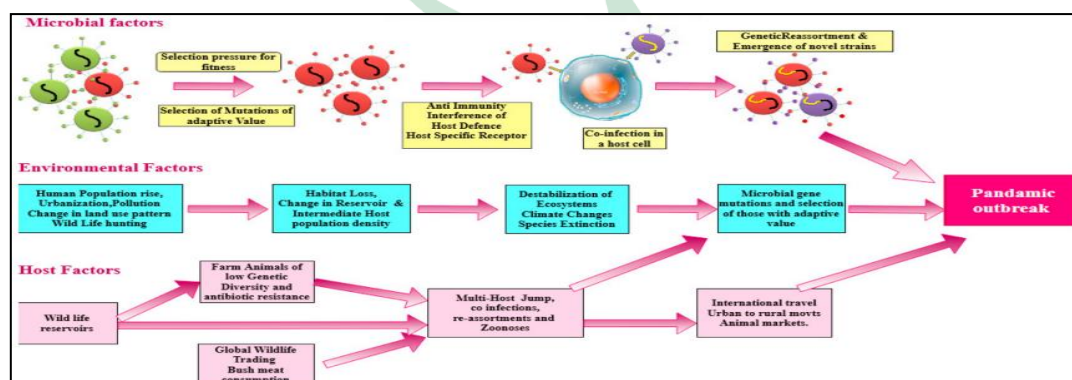
List of some of the pandemics that occurred throughout history

Pandemic	Timeline	Area of emergence	Pathogen	Vector	Death toll
Athenian Plague	430-26 B.C.	Ethiopia	Unknown	Unknown	Unknown
Antonine Plague	165-180	Iraq	Variola virus	Humans	5 million
Justinian Plague	541-543	Egypt	Yersinia pestis	Rodents' associated fleas	30-50 million
Black Death	1347-1351	Central Asia	Yersinia pestis	Rodents' associated fleas	200 million
The Seven Cholera Pandemics	1817-present	India	Vibrio cholerae	Contaminated water	40 million

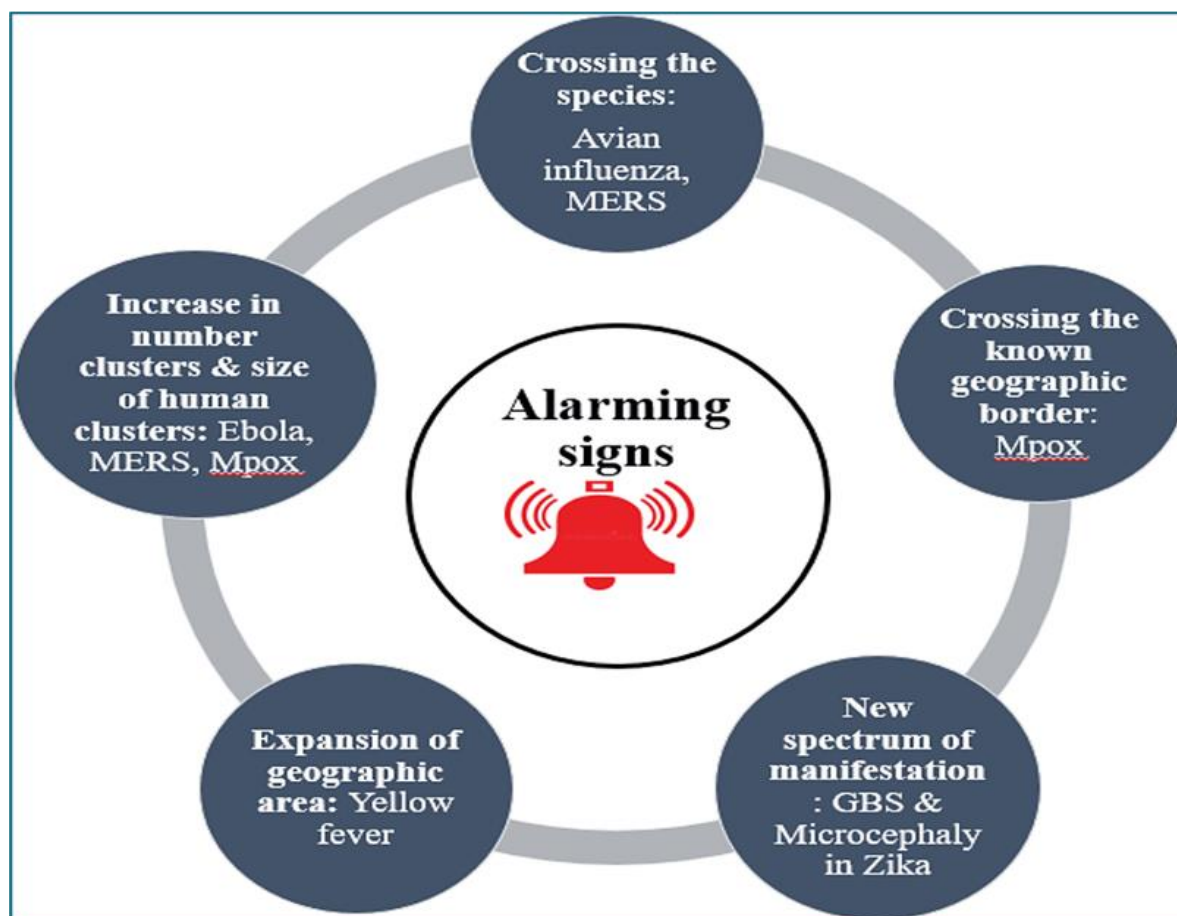
Spanish Flu	1918-1919	USA	Influenza A (H1N1)		50 million
Asian Flu	1957-1958	China	Influenza A (H2N2)		>1 million
Hong Kong Flu	1968	China	Influenza A (H3N2)		1-4 million
HIV/AIDS	1981-present	Central Africa	HIV		36 million
Severe acute respiratory syndrome coronavirus	2002-2003	China	Severe acute respiratory syndrome coronavirus	Bats	774
Swine Flu	2009-2010	Mexico	Influenza A (H1N1)		148000-249000
Ebola	2014-2016	Central Africa	Ebola virus	Unknown	11000
COVID-19	2019- July 2021 (ongoing)	China	SARS-Cov-2	Unknown	>4 million (ongoing)

What Leads to A Pandemic?

Major reasons for the occurrence of these pandemics include new infectious organisms crossing the species barrier from animals to humans, prolonged survival in debilitated and susceptible immune-suppressed cohorts, evolving and mutating microbes, mass population emigration, enhanced livestock production, an upsurge in wildlife trade, deforestation, expanding cities with exploding population statistics, increased travel, climate change, and escalated human-animal interactions(Lawler *et al.*, 2021).



Alarming Signs of Pandemic



The main alarming signs of pandemics are a sudden increase in the number of cases and bigger clusters of cases beyond familiar geographical areas, the occurrence of diseases beyond known species, and the appearance of newer, unrecognized clinical manifestations.

WHO Identified Pathogens that Could Cause Future Outbreaks and Pandemics

WHO launched a global scientific process to update the list of priority pathogens agents that can cause outbreaks or pandemics to guide global investment, research and development (R&D), especially in vaccines, tests and treatments.

WHO studied over 25 virus families and bacteria in order to identify pathogens of critical importance with regards to pandemics, including an unknown agent- “Disease X”, that could cause a serious international epidemic. The experts will recommend a list of priority pathogens that need further research and investment. The process will include both scientific and public health criteria, as well as criteria related to socioeconomic impact, access, and equity.

The list was first published in 2017 and the last prioritization exercise was done in 2018. The current list includes COVID-19, Crimean-Cong haemorrhagic fever, Ebola virus disease and Marburg virus disease, Lassa fever, Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS), Nipah and henipaviral diseases, Rift Valley fever, Zika and Disease X.

Pandemic Preparedness

Pandemic preparedness is a key function of any healthcare facility. Activities pertaining to pandemic preparedness should be developed and maintained within a broader emergency management plan. The use of a Hospital Incident Command System can centralize coordination of the response and facilitate internal and external communication (Srivastava *et al.*, 2022). Since the World Health Organization (WHO) declared COVID - 19 a Public Health Emergency of International concern in January 2020, there has been no shortage of assessments of pandemic preparedness and response (Smith *et al.*, 2022). Strengthening our global health architecture will require country commitment and effective governance, effective use of increased financing, robust technical support, and the support of strong and accountable global leadership (Frieden *et al.*, 2021).

Preparedness and Resilience for Emerging Threats (PRET)

The Preparedness and Resilience for Emerging Threats (PRET) initiative is an innovative approach to improving disease pandemic preparedness. It recognizes that the same systems, capacities, knowledge, and tools can be leveraged and applied for groups of pathogens based on their mode of transmission (respiratory, vector-borne, foodborne etc.).



Steps for respiratory pathogen pandemic planning



Monitoring preparedness

Member States with a respiratory pathogen pandemic preparedness plan that accounts for lessons from COVID-19*

80% by 2031
70% by 2029
50% by 2027
30% by 2025

*Plan developed or updated since the publication of PRET Module #1 on respiratory pathogens in April 2023



India's Pandemic Preparedness Plan

India has taken significant strides in its efforts to prepare for future respiratory pandemics through the development of the National Pandemic Preparedness Plan (NPPP) for Respiratory Viruses using a multisectoral approach. Since one of the key weaknesses during the COVID-19 crisis was the inadequacy of institutions and systems, the program - the Pradhan Mantri Ayushman Bharat Health Infrastructure Mission (PM-ABHIM) - seeks to fill the gaps at both the national and state level. India has also moved forward on the One Health agenda by bringing several ministries – including health, animal husbandry, forests, biotechnology and


others - under the Principal Scientific Advisor. This was one of the major shortcomings during the pandemic as, in most countries, the COVID-19 response was hampered by overlapping mandates and weak coordination between key institutions. There is consensus among experts that India 's response to COVID - 19 pandemic has been successful thus far. India acted early and acted decisively.

More recently, India laid the foundation for the National Institute for One Health in Nagpur. The institute will identify hotspots for endemic and emerging zoonotic diseases to contain their spread early on. Even so, success will depend on how well these strategies are implemented on the ground.


During the pandemic, India was able to create a formidable network of these institutions in a very short time. This can now be complemented with wider testing of wastewater and samples from incoming ships and aircraft. These surveillance systems will also need to be extended to other South Asian countries, as no country is safe unless its neighbors are safe.

Given the importance of India's efforts, the World Bank has recently augmented its support to the country's health sector to a total of \$3.5 billion. India is working with PM-ABHIM to build institutions and systems for preventing and responding to future pandemics. There is also improvement in the provision of primary health care by supporting the Ayushman Bharat Health and Wellness Centers under the National Health Mission at the center and in seven states. (Mamta Murthi, 2023).


**COVID-19 and Smart Cities:
Emergency response and resurgence**
How city governments are harnessing the power of technology to track, test, monitor, communicate and contain.




TRACKING and MONITORING
Many cities are utilizing their Smart Cities resources or deploying mobile apps and dashboards for rapid response.




DIAGNOSTICS
From drive-through testing to telemedicine, cities are testing different platforms to lessen the burden on hospitals.



SANITIZATION and WASTE MANAGEMENT
All cities are conducting regular sanitization drives across the city and also work to sanitize vehicles for public use.

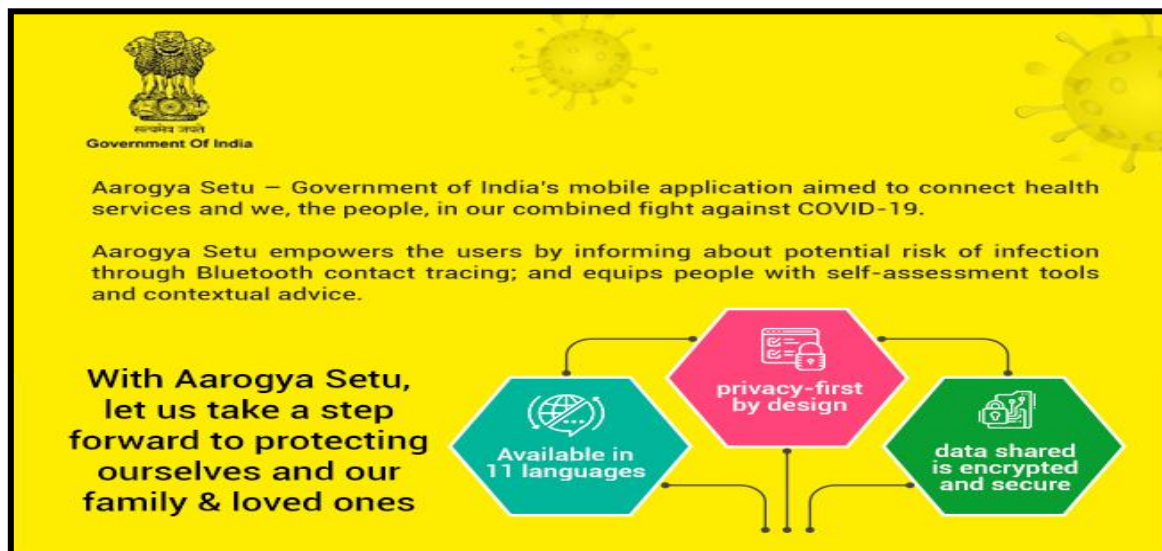


AWARENESS and CAPACITY BUILDING
Social media, public address systems, mass media and apps are being used to convey facts along with online capacity building modules for officials.



CITIZEN SUPPORT
Websites, helplines and ingenious apps that connect the vulnerable with help are some of the many ways cities are supporting citizens.

The Launch of The Aarogya Setu Application During the Covid-19 Outbreak Allows Communities to Participate in Disease Surveillance



Role of Artificial Intelligence (AI) In Predicting Future Pandemics

Pandemics pose one of the greatest threats to global health and socio-economic stability. As the world grapples with the reality of future public health crises, it is crucial to explore how emerging technologies can play a transformative role in their prevention and mitigation. In this context, artificial intelligence (AI) has emerged as a promising tool that can have a significant positive impact on future pandemics. AI, an interdisciplinary field seeking to develop systems capable of mimicking human intelligent behavior, has experienced rapid advancements in recent decades. Its ability to analyze vast amounts of data, detect hidden patterns, and generate actionable insights makes it a powerful ally in the fight against large-scale infectious diseases.

Though AI is supremely advanced, AI language models like ChatGPT are not a replacement for human knowledge, experience, and interpretation. These models might deliver valuable insights and predictions of potential outbreaks on the basis of published or available data but it is ultimately the job of public health experts and policymakers to make necessary decisions based on these predictions, experiences, and feedback from the researchers. Moreover, the application of this AI tool in the prediction model is yet to be explored further by mapping the dimensions of various challenges. (Jana *et al.*, 2023)



It is important to note that guessing the future pandemic is a multidimensional and challenging assignment, and there are limitations to what AI language models like ChatGPT and EVEscape can accomplish. The tool, EVEscape, developed by researchers at Harvard Medical School and the University of Oxford, can make accurate predictions regarding viral variants of Covid-19 as well as other viruses such as Influenza and HIV. EVEscape could revolutionize the way health professionals, policymakers, government officials and educators prepare for the next pandemic.

Conclusion

To solve this problem, two major reformations were recommended:

- Invest heavily and continuously into development of countermeasures to control emerging pathogens that cause massive population infections.
- Build multiple international and state - level research centers to deal with the next pandemics. Additionally improved governance, more money, greater technical skill and operational excellence is the need of hour.

Incessant land use changes, exploding population statistics, continuous genetic evolution at the pathogen level, and extravagant human-flora-fauna interaction in the ecological niches induce unavoidable zoonotic spills, which require a hawk-eye vigil to seize them at an early phase to prevent socio-economic and health chaos. Thus, a highly dedicated one-health approach that is collaborative, interdisciplinary, multi-sectoral, and implemented across international borders is the ultimate need of the hour for the prevention of future threats. A workable multi-sectoral accountability framework and program reforms are also needed for the prevention of futuristic threats, in addition to carefully following the steps of an outbreak or pandemic investigation. AI can be harnessed for forecasting the spread of virus and developing Early Warning System by extracting information from social media platforms, calls and news sites and provide useful information about the vulnerable regions and for prediction of morbidity and mortality.

The critical lesson learned from past experiences and the new pandemic infection is that we cannot continue to do the same as we have done before. Instead, we genuinely need urgent, radical, and fundamental change for preparedness for the next pandemic.

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