

Building resilience to emerging and re-emerging infectious diseases through strengthened control programme and research

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Abstract

The 21st century has witnessed a surge in emerging and re-emerging diseases, posing a grave threat to global public health and economies. Outbreaks such as SARS, swine flu, Ebola, and the COVID-19 pandemic have had profound and devastating impacts on lives and livelihoods worldwide. India, in particular, is vulnerable to emerging and re-emerging infectious diseases, and is designated as a global hotspot for these diseases. These infectious diseases are driven by a complex interplay of ecological, environmental, and climatic factors and is augmented by various factors which include anthropogenic activities, urbanization, globalization, travel, trade, antimicrobial resistance, and shifting demographics. Understanding the multifaceted factors contributing to the emergence of infectious diseases is paramount for effective prevention, prediction, and response. The interconnectedness of the various factors contributing to the emergence and spread of infectious diseases underscores the importance of a collaborative and holistic approach towards the emergence of these infectious diseases. Recognizing the intricate interconnectedness of human, animal, and ecosystem health, the One Health approach has gained prominence as a comprehensive and pragmatic strategy. One Health underscores collaboration, communication, and coordination among these sectors to proactively address global health threats. In an era marked by a global surge in emerging infectious diseases, India has also emerged as a steadfast advocate for the One Health approach. Prioritizing research in One Health can help towards developing evidence-based interventions, developing collaborative efforts among stakeholders, enhancing preparedness and response to infectious disease and securing the health and well-being of its population.

Keywords: One health; emerging and re-emerging diseases; Research priority; India; ICMR

Introduction

The twenty-first century has seen a significant increase in the number of outbreaks caused by emerging and re-emerging diseases threatening the health of millions of lives and livelihoods around the globe.^[1] The emergence of outbreaks and novel infectious diseases not only poses a significant threat to public health but also exerts a substantial burden on global economies. The emerging and re-emerging diseases outbreaks of infectious diseases such as avian influenza (H5N1) (1996), Nipah (1999), SARS (Severe Acute Respiratory Syndrome) (2003), swine flu (H1N1 influenza) (2009), MERS (Middle East Respiratory Syndrome) (2012), Ebola (2013–2016), Zika virus (2015), and the most recent COVID-19 pandemic (2019) have collectively had a profound and devastating impact on lives and livelihoods around the globe.^[2] These diseases have a multi-faceted and wide-ranging impact on not only on public health, but also livestock, wildlife, food and nutrition security and the economic security. According to the report published by World Bank, it is reported that the global economy in 2020 contracted by 4.4 % amounting to about US\$3.6 trillion worth of lost goods, services, and other outputs from the impacts of the COVID-19 economic shutdown.^[3]

The emergence of infectious diseases, especially of zoonotic origin is a complex process and is influenced

by several interconnected factors which include ecological, environmental and climatic changes, increased scale of anthropogenic activities, urbanization, globalization, travel and trade, antimicrobial resistance and demographic shifts.^[4] Majority of the emerging infectious diseases and all known human pandemics in the past century have been reported to be caused by the zoonotic spill-over, principally, from wildlife reservoirs.^[5] It is reported that the pace of spread of the emerging infectious diseases (EIDs) has accelerated at an annual rate of 6.7% from 1980, with the number of outbreaks growing to several hundred every year since 2000.^[3]

Zoonotic diseases are estimated to constitute 60% of all EIDs, of which more than 75% are reported to be associated with or originating from wildlife.^[6] South East Asia has recently been described as one of the main hotspots for emerging infectious diseases, including those diseases with pandemic potential.^[7] India has also been designated as a global hotspot of emerging infectious diseases risk due to various factors such as the country's rich biodiversity, high rates of deforestation, change in land-use and agricultural practices, high human population growth and density, rapid urbanization, high livestock population densities and spatial overlap between human and wildlife populations, and also due to the underperforming healthcare systems.^[7]

These diseases are caused by either bacterial, viral or parasitic pathogens and can cause different types of infections in human and animals, ranging from mild to serious illness and even death.^[6] The health of humans, animals, and ecosystems is intricately connected, and this interdependence have profound implications for the emergence and spread of these diseases. The interconnectedness of factors contributing to the emergence and spread of infectious diseases underscores the importance of a collaborative and holistic approach. “One Health”, is a concept that has gained increasing recognition and is considered a pragmatic and comprehensive approach to address these complex challenges. It is considered as holistic and collaborative approach that recognizes the interconnection between human health, animal health, and the health of ecosystems underscoring the importance of collaboration, communication, and coordination among these sectors. The One Health approach is particularly important towards strengthening partnership and accelerating coordinated strategy on human, animal and ecosystem health to prevent, predict, detect, and respond to global health threat.^[9] In recent decades, the One Health approach has gained significant traction and has become increasingly important in combatting the complex and interconnected health challenges at the human–animal–environment interface. In light of the various disease outbreaks in the recent years, the One Health strategy has gained substantial momentum at both the national and global levels, and it has garnered widespread support and endorsement from leading international agencies such as the Food and Agriculture Organization (FAO), the World Organisation for Animal Health (OIE), and the World Health Organization (WHO) giving an additional impetus to the need for cross-sectoral engagements.^[9]

In line with the World Health Organization (WHO) and other organizations, India has also initiated efforts towards mitigate health challenges more effectively implementing the One Health approach. Adopting the One Health approach can be a significant step toward mitigating health challenges more effectively, particularly in a country as diverse and complex as India.

For example, in line with the global strategic plan to eliminate dog-mediated rabies by 2030, India has also set the target of eliminating dog mediated rabies by 2030 through One Health Approach. In 2021, a joint inter-ministerial declaration support was made for the elimination of dog mediated rabies from India by 2030 through one health approach.^[11] The launch of India's first 'One Health' consortium by the Department of Biotechnology (DBT) in 2021 is a significant development in the promotion of the One Health

approach in the country. The consortium consists of 27 organizations from various sectors, with a budget allocation of Rs. 31.1 crores for a period of 3 years, the primary objective of the consortium was to establish a network of laboratories at both the central and field levels.^[11] The consortium's primary aim was to study the prevalence and analyze the risks of ten selected zoonotic diseases across the country and also to focus on five trans-boundary animal diseases, primarily from the northeast boundary states of India. Moreover, the consortium was envisaged to initiate a One Health strategy towards establishing a cross-cutting collaborations between animal, human and wildlife health stakeholders.^[12]

The approval of the ‘National One Health Mission’ by the Prime Minister’s Science, Technology, and Innovation Advisory Council (PM-STIAC) in 2022 is also a significant step toward addressing health challenges holistically in India through a ‘One Health Approach’.^[13] The mission aims towards addressing health challenges of both human and animal sectors and coordinate towards achieving overall pandemic preparedness and integrated disease control against priority diseases. The mission’s objectives reflect a comprehensive One health approach to emerging epidemic or pandemic threats with a strong emphasis on early warning systems and response readiness. The launch of the Animal Health System Support for One Health (AHSSOH) and the Animal Pandemic Preparedness Initiative (APPI) in 2023 aligning with the One Health approach for Animal Health System Support is also another a significant step towards enhancing the country’s preparedness and response readiness to potential animal pandemics.^[14]

The decision to establish the ‘Centre for One Health’ [now being called as National Institute of One Health (NIOH)] at Nagpur, Maharashtra under the aegis of Indian Council of Medical Research (ICMR) was taken in 2019 and, is a significant milestone for India as a substantial boost to the country's health research and infrastructure. The ICMR has indeed initiated the preparatory activities for establishment of the institute which will also house a biosafety level 4 (BSL-4) laboratory facility.^[12] This infrastructure underscores the commitment of ICMR to the One Health approach and its dedication to addressing the complex health challenges posed by infectious and emerging diseases. The institute will employ the comprehensive and integrated approach of the One Health strategy and will be an important infrastructural milestone for India with focus on increasing preparedness and laboratory capabilities for investigation of outbreaks and novel/unknown disease agents. It will help in expediting India's efforts towards enhancing health research and addressing the needs of vulnerable populations. The

upcoming National Institute of One Health (NIOH) is being developed in the campus and close proximity of Maharashtra Animal and Fishery Science University (MAFSU), Nagpur.

Collaboration forms an essential component of the One Health approach, it recognizes the interconnectedness across disciplines, sectors, and organizations which is essential towards successful implementation of One Health approach. The existing and thriving collaboration between different partners like the ICMR and the Indian Council of Agricultural Research (ICAR) serves as an exemplary example of how collaboration can be instrumental in implementing the One Health approach effectively. As a part of collaborative research activities between ICMR and ICAR, three collaborative research projects were initiated in 2015 - 2019 at Nagpur Veterinary College (NVC), Nagpur, Mahatma Gandhi Institute of Medical Sciences (MGIMS), Sewagram, and Central India Institute of Medical Research (CIIMS), Nagpur, to carry out the epidemiological surveillance of selected zoonotic diseases (brucellosis, listeriosis, tuberculosis, leptospirosis and scrub typhus).^[15] The joint research work on these diseases funded by ICMR and ICAR paved the way for robust future collaborations. The collaboration between different partners/stakeholders like the Indian ICAR, ICMR, and the Department of Animal Husbandry and Dairying under the One Health consortium through various programmes has led to research in the area of surveillance and epidemiology of various zoonotic and trans-boundary diseases.^[12]

Such collaborations are crucial and essential in addressing complex health challenges that involve both human and animal health, as well as agriculture. The apex organizations of ICMR and ICAR were actively committed and involved towards the creation of the NIOH at MAFSU, Nagpur.^[15] The involvement of apex organizations, often government agencies, regulatory agencies or institutions at the highest level of authority, play a crucial role in facilitating necessary support, expertise, and resources towards advancing research.

Under the Prime Minister-Ayushman Bharat Health Infrastructure Mission (PM-ABHIM), the ICMR is collaborating with eight premier scientific organisations in India to establish the NIOH to roll out the National One Health Mission across the country in order to strengthen multidisciplinary approaches in health research. In addition, ICMR is also working towards expanding its network of BSL-3 and BSL-4 laboratories, to strengthen diagnostic infrastructure and enhance access to laboratory services across nation.^[16]

In order to strengthen multidisciplinary approaches in health research, the ICMR is working with eight of India's top scientific organizations to establish the NIOH and implement the National One Health Mission throughout the nation under the Prime Minister-Ayushman Bharat Health Infrastructure Mission (PM-ABHIM). To improve access to laboratory services across the country and reinforce diagnostic infrastructure, ICMR is also striving to grow its network of BSL-3 and BSL-4 facilities.^[16]

These initiatives reflect a proactive approach towards addressing the complex challenges posed by emerging infectious diseases especially in a country as diverse and populous as India. Identifying and understanding specific factors that precipitate disease emergence are also crucial for preventing and mitigating the impact of such diseases. To effectively combat these diseases, it is imperative to establish robust research priorities that considers the country's specific challenges, ecological diversity, and public health needs. Research priorities for infectious and emerging diseases are paramount for safeguarding public health, strengthening healthcare infrastructure, and contributing to health security. These priorities encompass a wide spectrum of challenges, and addressing them effectively often requires a multidisciplinary approach involving experts from various fields.

Safeguarding public health and preparing for future health crises, especially in the context of infectious and emerging diseases, requires addressing key research priorities. These priorities should focus on understanding, preventing, and responding to infectious disease threats effectively. Some key research priorities include

1. Disease surveillance and early warning systems:

Disease surveillance and early warning systems are of paramount importance as a preventive and control tool for any infectious diseases especially emerging zoonotic diseases where animal and environment systems are involved in the transmission chain. This includes creating mechanisms for jointly reporting and tracking outbreaks, as well as establishing early warning systems to detect and respond to potential outbreak of a known or new infectious condition. Some specific aspects that could be addressed in research on disease surveillance and early warning systems include, (a) enhancing surveillance networks (b) data sharing and integration (c) harnessing of advanced technologies (d) sentinel surveillance (e) risk mapping and (f) predictive modeling. These aspects of disease monitoring and early alert systems research, can strengthen the preparedness for tackling infectious diseases effectively and efficiently.

2. Pathogen discovery and characterization for development of robust diagnostics:

Understanding the nature of pathogens, their reservoirs, and transmission routes is crucial for effective disease prevention, diagnosis, and control. Prioritizing research in pathogen discovery and characterization such as identifying new and emerging pathogens, understanding the transmission dynamics, assessing host range and reservoirs, evaluating virulence factors can help towards gaining a deeper understanding of the agents responsible for these diseases and developing evidence-based strategies to prevent and control them effectively. Research in enhancing diagnostic capabilities of diseases can significantly improve the preparedness and response to infectious disease threats. Some of the important research areas which can be looked into diagnostics includes (a)improving diagnostic capabilities for identification of emerging pathogens (b) enhancing diagnostic tools for differentiation of similar diseases (c) developing diagnostic capabilities for monitoring of antimicrobial resistance(d) developing point-of-care testing (e)validating and improving the performance of new diagnostic technologies.

3. Antimicrobial resistance (AMR): emergence and spread of AMR in humans or animals poses a significant public health threat especially in the in low and middle-income countries. Prioritizing research is essential to investigate the prevalence and mechanisms of antimicrobial resistance, devising targeted interventions to prevent the spread of resistant strains, advocating the responsible use of antibiotics thereby ensuring the availability of effective treatment options.

4. The priority areas requiring essential research in antimicrobial resistance include (a) assessment of treatment/drug efficacy studies (b) monitoring the transmission of resistant strains (c) understanding the reservoirs and routes of transmission of AMR (d) impact on food Safety (e) AMR in environmental reservoirs (f) investigating alternate treatment options. This research is essential for safeguarding public health, promoting responsible antimicrobial use, and mitigating the impact of AMR on global health security.

5. One Health Approach: One Health approach is considered a pragmatic strategy to address the challenges of emerging and re-emerging diseases effectively as it emphasizes collaboration, data integration, and a holistic understanding of disease dynamics. Prioritizing research under the One Health framework for diseases can yield numerous benefits such as (a) early detection of diseases (b) understanding disease transmission dynamics (c) identifying reservoirs and amplifiers (d) assessing environmental determinants (e) cross-sectoral policy development.

6. Risk factors and behavioral studies: Understanding risk factors and behaviors is crucial and essential for designing effective prevention and control strategies. Analyzing the several social, cultural, and behavioral factors influencing the transmission pattern of these diseases can help towards identifying/developing targeted interventions and awareness campaigns. Some of the areas which can be studied include the identification of high-risk activities, assessment of cultural practices, migration patterns and understanding the impact of livestock farming practices, urbanization, deforestation and preventive risk perception.

7. Development of drugs and vaccines: Developing targeted drugs/vaccines and investing in drug development are essential components of a comprehensive strategy to prevent and respond to future emerging threats/outbreaks effectively. The key priority towards newer drug development include identification of potential targets, drug screening, investigating combination therapies, developing novel drug delivery systems, monitoring antimicrobial resistance and drug efficacy studies. The research priorities in the area of vaccines and vaccination strategies include the development of innovative and versatile vaccines/vaccine technologies, optimizing vaccine schedules, evaluating vaccine safety and adverse effects for successful implementation of vaccination programmes and understanding public attitudes and perceptions about vaccines.

8. Capacity Building: Prioritizing research in capacity building can have several significant impacts such as focusing on improving disease surveillance and reporting systems, identifying gaps in knowledge and training needs among healthcare professionals and researchers, developing expertise in field epidemiology and outbreak responses, establishing and strengthening laboratory networks, improving risk communication and public awareness campaigns, antimicrobial stewardship for addressing the responsible use of antimicrobials and developing evidence-based policies and implementation. Prioritizing research and investing in capacity building can help in fostering long-term improvements in disease management and contribute to a safer and healthier society.

9. Public awareness and education: Research to develop and identify the best model to enhance public awareness and education for emerging diseases can go a long way to help empowering communities for proactive measures in timely prevention and management of infectious diseases. Research priority in this area includes : research in knowledge and understanding can help in identifying gaps and misconceptions, perception of risk, cultural relevance

influencing disease transmission and prevention, Identifying high risk groups; factors influencing behavioral changes in response to disease awareness campaigns; development of innovative and effective communication channels/mediums; measuring impact of public awareness and education initiatives /interventions; developing strategies for outreaching the vulnerable populations and reporting of illness.

Conclusion

India's status as a global hotspot for emerging and re-emerging infectious diseases underscores the critical importance of addressing these health challenges comprehensively to safeguard the health of its vast population and its diverse ecosystems. The country's unique socio-environmental context necessitates an inclusive and tailored approach to mitigate on these emerging and infectious diseases. The One Health approach can play a crucial role, particularly in a country as diverse and complex as India in its efforts to mitigate infectious and emerging diseases. The holistic and collaborative nature of this approach is well-suited to address the complex and interconnected challenges posed by various infectious diseases in a country with such diverse ecosystems and a vast population. A multi-pronged One Health approach, is instrumental in India's efforts to address and combat emerging and infectious diseases. By adopting this approach, India can enhance its preparedness, response capabilities and ability to safeguard public health, its ecosystems, and contribute to global efforts in addressing emerging infectious disease threats.

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Conflicts of Interest

None.

References

1. Baker RE, Mahmud AS, Miller IF, Rajeev M, Rasambainarivo F, Rice BL, Takahashi S, Tatem AJ, Wagner CE, Wang LF, Wesolowski A. Infectious disease in an era of global change. *Nature Reviews Microbiology*. 2022 Apr;20(4):193-205.
2. Piret J, Boivin G. Pandemics throughout history. *Frontiers in microbiology*. 2021 Jan 15;11:631736.
3. World Bank. 2022. "Putting Pandemics Behind Us: Investing in One Health to Reduce Risks of Emerging Infectious Diseases." Washington, DC: World Bank.
<https://documents1.worldbank.org/curated/en/099530010212241754/pdf/P17840200ca7ff098091b7014001a08952e.pdf>. Accessed 20th Sep2023
4. Spervasilis N, Tsiodras S, Poulakou G. Emerging and re-emerging infectious diseases: humankind's companions and competitors. *Microorganisms*. 2022 Jan 4;10(1):98.
5. Weiss RA, Sankaran N. Emergence of epidemic diseases: Zoonoses and other origins. *Faculty Reviews*. 2022;11.
6. Centres for Disease Control and Prevention. Zoonotic Diseases. Last Reviewed: July , 2021. Available.
<https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html>. Accessed 20th Sep 2023.
7. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, Daszak P. Global trends in emerging infectious diseases. *Nature*. 2008 Feb;451(7181):990-3.
8. Burthe, S.J., Schäfer, S.M., Asaaga, F.A., Balakrishnan, N., Chanda, M.M., Darshan, N., Hoti, S.L., Kiran, S.K., Seshadri, T., Srinivas, P.N. and Vanak, A.T., 2021. Reviewing the ecological evidence base for management of emerging tropical zoonoses: Kyasanur Forest Disease in India as a case study. *PLoS neglected tropical diseases*, 15(4), p.e0009243.
9. World Health Organization (WHO). One Health Published 21 September 2017.
<https://www.who.int/news-room/questions-and-answers/item/one-health>. Accessed 20th Sep 2023.
10. Ministry of Health and Family Welfare. Press Information Bureau (PIB); Press Release. National Action Plan for dog Mediated Rabies Elimination by 2030. Published 28 Sep 2021.
<https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1758964>
11. Ministry of Science & Technology. Department of Biotechnology. Country's first 'One Health' consortium launched by D/o Biotechnology, Post COVID 19. Published. 4 Oct 2021. <https://dbtindia.gov.in/dbt-press/country%E2%80%99s-first-%E2%80%99one-health%E2%80%99-consortium-launched-do-biotechnology-post-covid-19>. Accessed 20th Sep 2023.
12. Ministry of Science & Technology. One Health Consortium. Press Information Bureau (PIB); Published 9 Dec 2021.
<https://pib.gov.in/PressReleasePage.aspx?PRID=1779757>. Accessed 20th Sep 2023.

13. Office of the Principal Scientific Adviser to the Government of India. One Health.

<https://www.psa.gov.in/innerPage/psa-initiatives-covid/one-health-mission/4053>. Accessed 20th Sep 2023

14. Ministry of Fisheries, Animal Husbandry & Dairying. Press Information Bureau (PIB); Animal Pandemic Preparedness Initiatives and World Bank-funded Animal Health System Support for One Health. Press Release. Published 14 April 2023.

<https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1916531>. Accessed 20th Sep 2023.

15. Chaudhari SP, Kalorey DR, Awandkar SP, Kurkure NV, Narang R, Kashyap RS, Rahi M, Barbuddhe SB. Journey towards National Institute of One Health in India. The Indian Journal of Medical Research. 2021 Mar;153(3):320.

16. Indian Council of Medical Research. Press Release. Published 15 September 2023:

https://main.icmr.nic.in/sites/default/files/press_release_files/Press_Release_ICMR_15_September.pdf. Accessed 20th Sep 2023.