Epi-Dis-PHERE (Publication of Health Resilience)

Quarterly e-Journal of National Centre for Disease Control

Volume 01 | Issue 01 | January 2025

Scan here

to read

Epi-Dis-PHERE- Publication of Health Resilience
Quarterly e-Journal of National Centre for Disease Control (NCDC)

About the e-Journal

The Epi-Dis-PHERE (Publication of Health Resilience) is an open access, peer-reviewed double-blinded multidisciplinary quarterly e-Journal of the National Centre for Disease Control. It aims to advance public health in the areas of research, policy, practice and education with special focus on India. It encourages contributions across the whole spectrum of public health research and practice with focus on the timely communication of current, best scientific evidence to public health professionals, researchers, academics, clinicians, policy makers and the public.

The e-Journal publishes reviews/updates, systematic reviews and meta-analyses, original research papers, reports of outbreak investigations, scientific research communications, announcements of conferences, workshops, meetings, courses, summary reports of conferences, book reviews, letters on published articles, and commentaries/short reports on all aspects of the science, philosophy and practice of public health.

Publisher: Sh. Prakash Doval, Assistant Director (Admin),PBA, NCDC, MoH&FW, GoI

CONTENTS

Topic	Page	QR Code
Editoral **Prof. (Dr.) Atul Goel, Director General Health Services (DGHS), MoHFW & Director, National Centre for Disease Control (NCDC)**	**01**	
Perspective **Dr Rajiv Bahl, Secretary, Department of Health Research & Director General, Indian Council of Medical Research (ICMR), Government of India**	**04**	
Dr Himanshu Pathak, Director General, Indian Council of Agriculture Research (ICAR), Government of India	**05**	
Shri. Vibhu Nayar, Secretary, Ministry of Tribal Affairs, Government of India	**06**	
Dr Sanjay Kumar Shukla, Member Secretary, Central Zoo Authority, Ministry of Environment, Forest and Climate Change, Government of India	**08**	
Original Articles **Workforce Capacity Building in One Health : An Innovative Approach in India, 2023** (Debdutta Bhattacharya, Shalu Gupta, Sanghamitra Pati)	**11**	
Review Articles **One Health in Action : National One Health Programme for prevention and control of zoonoses - Need , Strategy, Progress and Challenges** (Simmi Tiwari, Ajit Dadaji Shewale, Aastha Singh, Tushar Nanasaheb Nale, Dipti Mishra)	**15**	
Animal Disease Surveillance: Perspectives & Issues (Abhijit Mitra, Aruna Sharma, Adhiraj Mishra, Abhijit Jha)	**20**	
Unravelling the Secrets of Nature's Health - A Journey into Wild Animal Disease Surveillance and Disease Forecasting (Parag Nigam, Gowri Mallapur)	**25**	
India's Pioneer Initiative for Prevention and Control of Snakebite Envenoming (Ajit Dadaji Shewale, Tushar Nanasaheb Nale, Simmi Tiwari, Aastha Singh)	**29**	
ICMR's Research Initiatives for prevention and control of snakebite envenomation in India (Rahul K Gajbhiye, Joy Kumar Chakma)	**37**	
Prevention & Control of Leptospirosis in India: Human Health Initiatives (Dipti Mishra, Aastha Singh, Ajit Dadaji Shewale, Simmi Tiwari & Tushar Nale)	**42**	

CONTENTS

Topic	Page	QR Code
Review Articles		
Plan for FEP Training in One Health (Dr Meera Dhuria, Dr Priyanka Kundra, Dr Shaileja Yadav, Dr Bhavesh, Dr Anamika Sahu, Dr Dhanalaxmi)	48	
Marching towards Rabies free India: Challenges and way forward (Tushar Nanasaheb Nale, Ajit Dadaji Shewale, Dipti Mishra, Aastha Singh, Simmi Tiwari, Sowntappan Balasubramanian)	50	
One Health Approach for Understanding and Managing Animal Leptospirosis in India (Vinod Kumar Kirubakaran, Prashant Bokade Prajakta, Archana Pal, Swathi M, Chethan Kumar HB, Gulati Baldev Raj, Balamurugan Vinayagamurthy)	56	
Epidemiological Trends of Zoonotic Diseases in India: A Focus on Crimean-Congo Hemorrhagic Fever, Kyasanur Forest Disease, and Nipah Virus (Deepak Y Patil, Anita M. Shete, Rima R. Sahay, Sreelekshmy Mohandas, Pragya D. Yadav)	68	
Strengthening Diagnostic Capacities for Zoonotic Diseases in India (Vishesh Sood, Monil Singhai)	78	
Research Priorities in One Health (Mala Chhabra, Ruchita Chhabra, Nandini Duggal)	86	
Building resilience to emerging and remerging infectious diseases strengthened control programme and research (Manju Rahi, Sam Joy)	95	
Uniting for One Health – The Importance of Community Engagement in One Health (Saumya Deol, Harmanmeet Kaur, Anoop Velayudhan)	101	
Preventing Pandemics: Shifting from Reactive to Proactive One Health approaches (Ritu Singh Chauhan, Prejit Nambiar)	104	
Key One Health Events		
National Conclave on Uniting for One Health - Summary Report & Recommendations (Simmi Tiwari, Ajit Dadaji Shewale, Tushar Nanasaheb Nale, Vineet Srivastava, Preeti Shirin, Dipti Mishra, Aastha Singh)	109	
National Conclave on Augmented Zoonotic Diseases Surveillance at Human Wildlife Interface - Summary Report & Recommendations (Simmi Tiwari, Ajit Dadaji Shewale, Tushar Nanasaheb Nale, Nidhi Khandelwal, Gajendra Singh, Hanul Thukral, Priyanka Khuda)	112	

CONTENTS

Topic	Page	QR Code
Asia-Pacific Quadripartite: One Health workshop (Ajit Dadaji Shewale, Ritu Chauhan, Priyanka Khuda)	119	
Book and Document Review		
FAO: National Framework on One Health	123	
Pioneering a New Era of One Health Collaboration: The Quadripartite Agreement - FAO, WHO, WOAH and UNEP (Mala Chhabra)	125	
Additional Content		
Instructions to Authors, Editorial and Peer Review Process	129	
List of Contributors	130	

Editorial

Uniting for One Health; Better Late than Never

Prof. (Dr.) Atul Goel
Director General of Health Service
Director, National Centre for Disease Control,
Ministry of Health & Family Welfare, Government of India
E-mail: dghs@nic.in

'Human beings' or 'Homo sapiens' are one of the most intelligent species that ever existed on Earth, if not in the Universe. The hallmark of this species has been to first 'create problems' and then try to find 'solutions' to them. Nothing wrong in that approach if we compare it to the approach of 'modern medicine' that talks only about diagnostics and therapeutics, there is hardly any thought given to 'primary passive prevention'. Had there been an approach to preservation of ecosystems, we would not have been addressing 'One Health' separately. Health of all living and non-living parts of an ecosystem was always intertwined and dependent on each other.

Most infectious diseases today originate in animals and can thereafter spread globally, due to increasing animal – human interaction, resulting from encroachment on animal territory by human settlement expansion as well as eating habits in certain parts of the world. Increasing human encroachment on nature has resulted biodiversity loss, ecological disruption, and climate change. These have compounded the infectious public health threats that are more distressing to human health in marginal households, especially in middle- and low-income countries. Recent example has been COVID-19 that significantly impacted the entire World since its first reported case in China in the middle of November 2019, and has since resulted in multiple waves of infections, with millions of confirmed cases and hundreds of thousands of deaths, most of them in the second wave during mid-2021.

Response to COVID-19 was significantly important for our Institution, NCDC, as it showcased the importance of Government Health Institutions, both hospitals and the Public Health Institutions. These Institutions stood behind India's solid response to this grave pandemic. India had followed a flexible, evidence based, and scenario based public health approach to contain COVID and successfully contained it with support from remarkably unified approach from the Federal as well as Government Health and Public Health Sectors in a significant 'One Health approach and policy'. Governments and Officers at all levels deserve accolades for their openness to vary their response to the needs, with an inspiring 'Prime Minister' leading from the front like a 'true General'.

National Centre for Disease Control (NCDC), a premier public health institute in the country, played a pivotal, proactive role in Public Health response since the advent of Covid-19 pandemic, starting from operationalizing the first 24x7 call centre, providing technical expertise and guidance for early detection and response, strengthening surveillance, establishing a National referral laboratory system along with ICMR, infection prevention and control practices, genomic surveillance through INSACOG network, deployment of rapid response teams, case management, logistics, procurement & supply management, risk communication, community engagement, drafting of technical guidelines, SOPs & travel advisories, PIB press releases, inter-sectoral coordination, communication with State Health Departments and International agencies WHO and CDC.

Pandemic outbreak (linked to bats in China) has shown that it is not only about addressing diseases from a human health point of view (zoonoses) but to address the livestock and wildlife also. This has also been evident in outbreaks

of Nipah, Crimean Congo hemorrhagic fever (CCHF) and Scrub typhus, which has clearly demonstrated close connection between humans, animals, through a shared environment. This highlights the need for a One Health approach, which will help in preventing/containing spread of diseases if pre-emptive epidemiological actions are taken. Zoonoses are not new to mankind, malaria being one of the most ancient examples.

Globally, zoonotic diseases affect more than two billion people worldwide and resulting in more than two million deaths every year. In India, approximately 60% of pathogens infecting humans and 75% of all emerging human infections are zoonotic in nature due to its enormous human and animal populations and a complex agrarian economy combined with rapid socio-ecological, environmental and climatic changes. Priority zoonoses in India include Rabies, Anthrax, Scrub Typhus, CCHF, Leptospirosis, Japanese B Encephalitis, Kyasanur forest disease (KFD) to name a few. These are responsible for significant morbidity & mortality in India, along with new emerging zoonoses like Nipah and Zika.

The second important aspect of 'One Health' is Anti-Microbial Resistance (AMR), which is a growing threat globally and in India. The fact that pharmaceutical Industry does not see a significant number of anti-microbials in the pipeline, focus has shifted from promoting antimicrobials to AMR. This shift is only natural. However, this may shift focus to novel approaches like m-RNA vaccines, monoclonal antibodies (for infections like Nipah) and use of bacteriophages. While they may be important, one needs to emphasize in personal and institutional IPC (Infection prevention and Control) practices. India's approach to AMR needs to be different from that of the developed World. Although it is important to tackle inappropriate antimicrobial use in humans, animals as well as plants, taking care of the human health sector will simultaneously prevent inappropriate use in the other two sectors. If not tackled seriously, AMR threatens to compromise all past as well as present individual and public health gains globally, particularly those related to maternal and child health, Tuberculosis, HIV/AIDS, results of surgical interventions including transplant surgeries.

Similarly, food-borne disease caused by poor hygiene, can become problematic due to availability of antimicrobials, environmental contamination and animal husbandry malpractice (related to inappropriate antibiotic use) on animal and poultry farms. In India, for instance, economic loss due to brucellosis in livestock is estimated at an equivalent of 3.4 billion US dollars.

Moreover, increasing climate variability has a significant impact on vector density, transmission cycles, threat of importing vectors or animal reservoirs, which could lead to emergence of zoonotic disease outbreaks. For instance, diseases, such as anthrax, increase in warm weather while leptospirosis increases post rains. It is likely that the source of many of these infections is rooted in the community, and thus will require a multifaceted One Health approach to detect, prevent, and control One Health issues.

Keeping this viewpoint in mind, a One Health Joint Plan of Action was launched by a Quadripartite Agreement between Food and Agriculture Organization (FAO), the United Nations Environment Programme (UNEP), World Health Organization (WHO), and World Organization for Animal Health (WOAH), setting out a common vision for protecting health globally and contributing to sustainable development.

Under India's G20 Presidency 'One Earth, One Family, One Future'; One Health is a key concept that has gained significant attention. NCDC, through its technical divisions, IDSP, AMR, Climate change and Centre for One Health is entrusted to undertake various activities pertaining to pandemic preparedness, likely to emerge from zoonotic threats at human animal and environment interface. National Programmes of the Ministry of Health related to 'one health' are already being implemented through NCDC. Some of them include National One Health Programmes for prevention and Control of Zoonoses (NOHPPCZ), National Rabies Control Programme, Programme for prevention and Control of Leptospirosis, Snake Bite Envenomation Prevention and control, National Programme on AMR Containment, National Programme on Climate Change and Human Health (NPCHH). In addition, a new division of NCDC, on IHR and pandemic preparedness has recently launched 'Sector Connect', an initiative with Animal Husbandry department for frontline epidemiological training of all sectors involved in one health. These interventions are being undertaken through strengthening of surveillance, capacity building for early detection, prevention, diagnosis and treatments of zoonoses, fostering R & D for medical counter measures, advocacy, and community engagement through a One Health approach.

Editorial

In India, the National One Health Mission was recommended during the 21st meeting of the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC) in collaboration with different Ministries. The objective of this mission is to provide universal protection against priority diseases in both human and animal sector through early warning systems based on integrated surveillance system and early response to endemic and emerging epidemic or pandemic threats.

The mission will also address key pillars of preparedness in the form of targeted R & D to develop critical tools such as vaccines, diagnostics and therapeutics in terms of clinical care, and streamlining of data and information. Further One Health Institutes are also being set up for taking forward research agenda on "One Health", first one has come up at Nagpur in Maharashtra.

In view of above, I feel privileged to pen an editorial for this first ever E-Journal from NCDC which very aptly focuses on this recently launched initiative of 'ONE HEALTH' – theme being 'Uniting for One Health'. The Theme focusses on an update of various activities undertaken by NCDC and other agencies namely ICMR and DBT, other relevant ministries; Animal Husbandry, Environment, Forest & Climate Change, WHO & International Organizations & academia working on "One Health". These updates would provide important information to readers on current issues and initiatives by stakeholders on One Health.

I congratulate my NCDC colleagues ably guided by Dr S Venkatesh (formerly DGHS and Director, NCDC) for successfully drafting this publication with best wishes for this and all following issues hereafter. Let us try and make this endeavor a global success.

Before ending this editorial, the clinician in me forces me to issue a 'veiled warning to practitioners of modern medicine'. While we unite for 'one health' across sectors, we continue to dissect human body into pieces for health management. A similar 'one health' approach is absolutely essential to restore the health of humanity. centre to this is 'PREVENTION' of disease in a move away from the current emphasis on 'Diagnostics and Therapeutics'. This prevention should not lay emphasis on 'Vaccines' but on promoting 'positive health' by life-style interventions. As a practitioner of 'modern medicine' with over 35 years of experience, I feel that modern medicine is on its last legs unless it is ready to embrace a 'one health approach' for a patient-centric management of human beings, moving away from a healthcare industry centric approach.

"One-Health" from Indian Council of Medical Research (ICMR)

Dr. Rajiv Bahl
Secretary to Govt. of India
Department of Health Research, Ministry of Health & Family Welfare
Director-General, Indian Council of Medical Research
E-mail: secy-dg@icmr.gov.in

Over the past few decades, numerous infectious diseases of global concern have emerged, such as the outbreak of severe acute respiratory syndrome (SARS) in 2003, the H1N1 influenza pandemic in 2009, and the recent COVID-19 pandemic. The globalization of health risks highlights the value of pre-emptive preparedness for future pandemics and enunciates a One Health approach. While we are threatened by the emergence of infectious diseases, around 75% of which are estimated to be zoonotic origin, the integrated and unifying approach of One Health offers a platform to optimize the health outcomes of humans, animals, and the environment, truly encompassing the spirit of the Indian philosophy 'Vasudeva Kutumbakom' or the 'One world family'.

The National Centre for Disease Control (NCDC) is implementing National One Health Programme for Prevention and Control of Zoonoses (NOHPPCZ) in the country through the Centre for One Health. It has been working over the years on One Health in the domain of rabies, vector-borne diseases and in Sector-Connect, their new field epidemiology training programme.

The upcoming National One Health Institute at Nagpur will be a collaborative Institute where multiple departments will work. Prominent among them will be NCDC and ICMR. Under the leadership of Principal Scientific Adviser to the Government of India, One Health Mission is being launched to prepare India for future pandemics and outbreaks. The Mission will focus on bringing together several Government Departments responsible for human health, livestock and wildlife to conduct R&D for integrated surveillance and development of medical countermeasures to emerging diseases.

Recently, we have come together to set up joint outbreak investigation teams, comprising experts from all sectors, who will investigate outbreaks using the one health approach. We are collaboratively networking selected BSL3 labs to respond to outbreaks between several departments so that outbreaks samples can be tested on priority basis as a national network. We have also planned models of surveillance to be set up in zones of higher human-animal-environment that NCDC can take up and expand. Our latest combined data sharing initiative between VRDLs and IDSP is a testimonial of our solidarity.

I extend my heartiest congratulations to NCDC at the launch of its open access, peer- reviewed double-blinded multidisciplinary, quarterly e-Journal "Epi-Dis-PHERE" that would advance public health in the areas of research, policy, practice, and education with articles on special focus on inter sectoral collaborations.The first issue of the journal is aptly named "Uniting for One Health" and places into context the need for collaboration in India to achieve sustainable health outcomes. The journal will offer a platform for experts to share their experiences and collective wisdom and aid in knowledge dissemination. The content will also promote dissemination of the current best practices in the one health domain and benefit practitioners and policy makers alike. I extend my wishes to NCDC in the endeavor for documenting and sharing knowledge on one health practices in India through their e-Journal.

“One-Health” from Indian Council of Agricultural Research (ICAR)

Dr. Himanshu Pathak
Secretary (DARE) & Director General
Indian Council of Agricultural Research (ICAR)
E-mail: ddgas.icar@nic.in,dg.icar@nic.in

The escalation and widespread occurrence of zoonotic diseases, encompassing infectious agents shared globally between animals and humans, represent a highly concerning threat to human health. It underscores the fact that diagnostic, treatment and prevention strategies should be targeted not only at infected humans but also at the vertebrate hosts (reservoirs) implicated in the transmission of these zoonotic diseases. One Health is defined as 'an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent'.

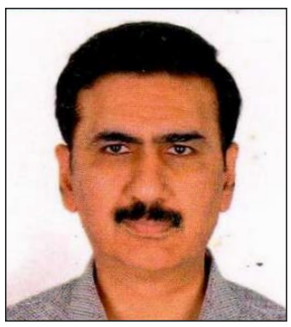
The emergence and dissemination of zoonotic diseases represent a significant menace to human health, necessitating the adoption of a collaborative One Health strategy. The implementation of enhanced diagnostic methods has facilitated swifter and more precise identification of livestock diseases, contributing to advancements in treatment, control and prevention.

Issues at the intersection of human, animal, and environmental health have gained heightened importance in recent years.The expansion of human and animal populations, shifts in climate and land use, and increased international travel and trade have become important drivers for the spread of diseases. The One Health approach necessitates multidisciplinary communication, cooperation, and collaboration. The immediate course of action involves convening conclaves, workshops, symposia, and seminars that bring together experts from human, animal, and ecological domains. The purpose is to collaboratively formulate a framework for the surveillance of zoonotic infections at the interface of animals, humans, and wildlife. These gatherings should establish priorities for an international, national, and interdisciplinary approach. A successful implementation of the One Health approach necessitates a shift in the perspectives and actions of all stakeholders. This entails a reevaluation of various innovative ideas to discover technological solutions, achieved through the sharing of knowledge and experiences.

Veterinary Services in India have a rich history of applying veterinary public health principles to safeguard human health. Significant efforts in the past have focused on addressing zoonotic diseases and food-borne pathogens transmissible through foods of animal origin. NCDC and organizations in the veterinary sector collaborate with various stakeholders to prevent zoonotic diseases of public health significance.

Implementing One Health practices in livestock and aquaculture, particularly through the judicious use of antimicrobials, can mitigate the spread of Antimicrobial Resistance (AMR), a serious threat to both human and animal well-being. The overall health of the livestock and poultry sector plays a pivotal role in protecting the national economy, especially in terms of potential trade restrictions and export bans. Additionally, empowering women in this sector is crucial, contributing to healthier environment, healthier individuals and healthier animals. Gender-responsive interventions are imperative within the "One Health approach" to ensure that no one is left behind.

"One-Health" from Ministry of Tribal Affairs (MoTA)



Shri. Vibhu Nayar
Secretary, Ministry of Tribal Affairs
E-mail: secy-tribal@nic.in

India is among the top geographical hotspots where zoonotic diseases are a major public health issue causing high burden of morbidity and mortality specially in forest areas where mostly the Tribals resides. Zoonoses comprise a large percentage of all newly identified infectious diseases as well as existing infectious diseases. Some important challenges to advancing control of zoonotic diseases and their emergence from wild animals in India include the presence and dependence of large human populations in forests and on forest land, encroachment of stray animals such as dogs and cattle on wildlife habitat, overlapping and shared habitats of humans, livestock and wildlife, and the general lack of appreciation regarding occurrence and dynamics of zoonotic pathogens.

Factors such as climate change, deforestation, expanding human population and agricultural activities, and livestock revolution have led to an increase in interactions at the wildlife–human/livestock interface. This has resulted in an increased risk of emergence and re-emergence of wildlife related zoonotic pathogens in India in the last few decades, such as KFD, Nipah, Influenza, Plague and Leptospirosis. There is a lack of information on zoonotic pathogens present in wildlife and migratory bird populations except when they affect the human or animal populations in the country. Preventing the entry of wildlife related zoonotic pathogens into human and livestock populations is an important challenge for India.

Small-holder and tribal communities face a plethora of challenges including exposure to zoonotic disease risks that significantly constrain their livelihood opportunities and general wellbeing. Within this purview, there is a growing consensus in the 'One Health' literature that reducing vulnerability to endemic and emerging zoonotic diseases is heavily predicated on reducing poverty and existing socio-economic inequalities that impede the individual and collective agency of vulnerable groups.

In tribal areas majority of households do not express worry about contracting zoonotic diseases per se but echoes an underlying sentiment of helplessness in the face of adversity perturbed by the potential impact on their livelihoods and welfare, including loss of income, loved ones, caring for ailing relatives and limited access to medical care. Time is to focus on disease information as a potential determinant at the local level using evidence. This requires adequate and tailored policy and institutional support at the local level. Cross-sector collaboration in terms of wider information dissemination and support networks) are critical for bolstering adaptation for vulnerable groups in the face of emerging disease risks. This invariably requires more empirical evidence to explore the short and long-term impacts of adaptive practices by local stakeholders to better understand the scope and extent of vulnerability within and across groups, especially in forest communities highly dependent on forest-based resources for their livelihoods.

Surveillance using traditional as well as molecular approaches can help to better understand prevalent and emerging wildlife related zoonoses in the country. Close co-ordination among the Ministries will help in gaining the momentum for One Health. As these diseases are much higher in tribal population this One Health will serve and prove to be a blessing for the tribal people.

Though in the Indian context, the OH approach is strategically gaining importance from all stakeholders such as public health professionals, veterinarians, health-care providers, policymakers, and researchers. While animal-to-human transmission is a major threat in the country with several diseases such as avian flu, rabies, a major growing threat is from bovine tuberculosis which is on the increase. In addition, emerging zoonotic diseases are acquired through wild animals, and the OH approach should look into the wild zoonotic diseases also. The successful implementation of the OH model involves integration and collaboration between multiple sectors of agriculture, animal health, and human health. It is important that Coordination between physicians, veterinarians, and epidemiologists should be strengthened. Technology should be used effectively. Each district and state in the country needs to be linked through satellite to the designated national headquarters for collecting real-time data on the activity of pathogens and diseases.

Time is to work in close collaboration to carry out expansive research in the field to prevent and manage the threats of such pandemics. Health approach emerges as a beacon of hope, offering a holistic framework to address emerging infectious diseases and zoonotic threats is essential.

As we are heading towards a new era in public health, the NCDC's initiative to launch the E-Journal of "ONE HEALTH" represents a significant step towards fostering collaboration, disseminating knowledge, and advancing the collective understanding of this transformative paradigm. The importance of a One Health perspective cannot be overstated, especially in the context of our contemporary challenges.

The launch of the E-Journal of "ONE HEALTH" is a commendable stride and we congratulate NCDC, MoHFW for creating a dynamic platform for dialogue and knowledge exchange.

"One Health approach"- Zoonoses in Wildlife from Ministry of Environment, Forest, and Climate Change

Dr. Sanjay Kumar Shukla
Member Secretary, Central Zoo Authority
Ministry of Environment, Forest and Climate Change, Government of India

The intricate web of connection between human, animal, and environmental health underscores the need for a holistic approach to address emerging threats. Within this framework, the One Health concept has gained prominence, emphasizing the interdependence of these three domains. One critical facet of One Health is the management of zoonoses, infectious diseases that can jump from animals to humans. This article explores the significance of adopting a One Health approach to tackle zoonoses in wildlife. The One Health approach recognizes that the health of humans, animals, and the environment in interconnected. Zoonotic diseases, which account for a significant proportion of emerging infectious diseases, highlight the potential consequences of ignoring these interconnections.

Diseases such as Ebola, Zika, and most recently the COVID-19 pandemic have demonstrated the devastating impact of zoonoses on global health. Wildlife plays a crucial role in the transmission of zoonotic diseases. Many pathogens have reservoirs in wild animals, serving as a source of infection for domestic animals and humans. The encroachment of human activities into natural habitats, wildlife trade, and climate change contribute to the increased risk of spillover events where pathogens jump from animals to humans. Effective surveillance and monitoring systems are pivotal components of One Health approach to zoonoses in wildlife. These systems involve regular monitoring of wildlife populations to detect potential outbreaks or unusual patterns of disease. Early detection enables prompt response measures to prevent the spread of zoonotic pathogens and mitigate the risk of human infections.

In-depth research is essential to understand the dynamics of zoonotic diseases in wildlife. This includes studying the ecology of pathogens, their transmission pathways, and the factors influencing their emergence. Collaboration and data sharing across disciplines and institutions facilities a comprehensive understanding of zoonoses, aiding in the development of targeted interventions and preventive strategies. Conservation efforts and sustainable habitat management are integral to the One Health approach. Habitat destruction and fragmentation can increase the likelihood of human-wildlife interactions, facilitating the transmission of zoonotic pathogens. Protecting natural habitats and implementing conservation measures contribute to reducing the risk of zoonotic spillover events. Educating communities, healthcare professionals, wildlife enthusiasts is crucial in preventing and controlling zoonoses.

Public awareness campaigns can highlight the risks associated with certain behaviours, such as consuming wildlife or encroaching on their habitats. Informed communities are more likely to adopt practices that minimizes the risk of zoonosis. Developing and implementing policies that address the root causes of zoonotic diseases is imperative. Regulations governing wildlife trade, land use and environmental protection contribute to minimizing the risk of disease transmission. A cohesive policy framework ensures unified and proactive approach to zoonoses at local, national, and international levels. Zoonotic diseases recognize no borders, emphasizing the importance of collaboration, sharing information, resources, and expertise enhances the global community's ability to respond effectively to emerging threats.

Collaborative efforts can strengthen surveillance, research and response capacities, creating a coordinated defense against zoonotic diseases. In embracing the One Health approach to zoonoses in wildlife, we acknowledge the interconnectedness of human, animal, and environmental health. By promoting collaborative efforts in surveillance, research, conservation, public health education, policy development, and international cooperation, we can build a resilient framework to address the complex challenges posed by zoonotic diseases.

Through a unified commitment to One Health, we strive to protect the well-being of both humans and wildlife, ensuring a harmonious coexistence in our shared ecosystem. We also commend the initiative taken by the NCDC to launch an E-Journal focused on "One Health." This platform will serve to encourage contributions from the realm of public health research, as well as from other institutions such as those involved in environmental and veterinary sectors.

Original Article

Workforce Capacity Building in One Health: An Innovative Approach in India, 2023

Debdutta Bhattacharya[1], Shalu Gupta[1], Sanghamitra Pati[1]*

[1]ICMR- Regional Medical Research Centre, Bhubaneswar.

***Corresponding author**
Dr. Sanghamitra Pati
Addl.DG, ICMR HQs and Director
ICMR- Regional Medical Research Centre, Bhubaneswar
drsanghamitra12@gmail.com

Abstract

The concept of One Health emphasizes the interconnectedness of human, animal, and environmental health and recognizes that the well-being of one is intimately linked to the others. The One Health Certificate Course is a comprehensive educational programme designed to enhance understanding and promote collaborative approaches to address the interconnectedness of triad of human, animal, and environment in the workforce. This course which was developed and conducted with funding from Dept. of Health Research, aims to provide participants with a multidisciplinary perspective on the One Health concept, emphasizing the importance of interdisciplinary collaboration to solve complex global health challenges including zoonotic diseases. In this article we explored the practical aspects of designing and conducting the first of its kind One Health Certificate Course from India, including the delivery format discussing the delivery format, duration, target audience, follow-up methodology and career prospects for sustainability.

Keywords: One Health, Zoonoses, Public health, Capacity building

Introduction

In recent decades, the world has witnessed an increasing number of global health crises, highlighting the co-ordination between human, environmental and animal health. The recognition that the well-being of humans, animals, and ecosystems is closely interconnected has given rise to the One Health approach. This holistic perspective acknowledges the interdependence of human, animal, and environmental health.[1] It highlights the importance of cooperation and integration between various disciplines, including veterinary science, medicine, ecology, and public health.[2] The One Health concept recognizes the interdependence of human, animal, and ecosystem health, emphasizing that addressing health concerns in one domain can yield positive effects in the others.[3]

Recognizing the urgent need for interdisciplinary collaboration, institutions worldwide have responded by introducing comprehensive educational programmes to equip professionals with the knowledge and skills necessary to address these complex health challenges. Approximately 60% of identified infectious diseases and as much as 75% of novel or emerging infectious diseases are believed to have originated from animals, according to estimates.[4-6] Each year, zoonotic diseases contribute to 2.5 billion cases of human illness and result in 2.7 million human deaths globally.[7] The Government of India through its institutional framework is taking all efforts to build capacity on One Health like National centre for Disease Control, New Delhi is having a public health programme on One Health including an Integrated Health Information Platform (IHIP) for surveillance and response; a National Institute of One Health by Indian Council of Medical Research[8]; National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), Bengaluru for keeping a track on animal diseases; Forest Research Institute (FRI), Dehradun involved in training of forest rangers, and National Environmental Engineering Research Institute (NEERI), Nagpur working on leadership in environmental science and engineering for sustainable development.

This article serves as an introduction to the transformative One Health Certificate Course, a multidisciplinary programme that encompasses the fundamental principles of One Health and its practical application in safeguarding the health of our planet. The One Health Certificate Course acts as a cornerstone for individuals seeking to enhance their understanding of the interconnectedness of human, animal, and environmental health. Through an interdisciplinary approach, this course enables participants to explore the complex relationships and interactions that exist within and between these domains. By embracing the holistic One Health perspective, professionals can effectively collaborate across disciplines, bridging the gaps between medicine, veterinary science, ecology, public health, and beyond.

This article will delve into the core components of the One Health Certificate Course, highlighting the diverse range of subjects covered, including zoonotic diseases and its epidemiology, ecosystem health, antimicrobial resistance, climate change, and biodiversity conservation. By providing participants with a comprehensive overview of the challenges we face, this course fosters a deeper understanding of the interconnected nature of our global health issues, empowering individuals to develop innovative, evidence-based strategies for prevention, mitigation, and control of various diseases of public health concern. Furthermore, we will explore the practical aspects of designing and conducting the One Health Certificate Course, discussing the delivery format, duration, target audience, follow-up methodology, and career prospects.

This course is designed to generate a basic understanding of the concept of 'One Health,' among the learners and to develop a trained human resource for adopting One Health approach in management of emerging & re-emerging infectious diseases significant for public health and to recognize the importance of multi-sectoral approach in addressing the disease that are zoonotic in nature. The course is designed for the programme officers working at National, State, District and Sub-district levels, clinicians, policymakers, early career researchers and students can gain insight into One Health and its significance regarding emerging and re-emerging infectious diseases of public health importance.

The course modules are developed after reviewing courses offered by international universities and in consultation with national and international experts. The proposal of the course was submitted for funding under the Human Resource Development (HRD) scheme of the Department of Health Research, Ministry of Health and Family Welfare, Government of India on 10th August, 2019. The proposal underwent rigorous review proves and was finally approved for funding on 1st September, 2020 after one round of revision. The course principal investigator and coordinator then contacted National Programme on Technology Enhanced Learning (NPTEL) for hosting the course in their platform as they have a well-established mechanism of hosting various courses.

NPTEL is a collaborative initiative between the IITs and IISc, supported by the Ministry of Education (MoE) of the Government of India, and was inaugurated in 2003. Originally conceived as an endeavor to bring high-quality education to every part of the nation, NPTEL presently provides nearly 600+ certification courses each semester across approximately 22 disciplines. Massive Open Online Courses (MOOCs) fundamentally serve as an asynchronous educational platform, utilizing pre-recorded lectures, resource videos, lecture notes, assignments, and quizzes for content delivery and self-assessment at regular intervals. The learning process involves a fixed time duration for course completion, leading to synchronous engagement where teachers and a substantial number of students participate simultaneously. This model resembles a traditional physical classroom setting but operates as an online course on a larger scale.

After several rounds of discussions with the NPTEL officials, they finally accepted to host the course on their platform. However, prior to hosting, the course modules were further reviewed by experts facilitated by ICMR-National Institute of Epidemiology, Chennai and NPTEL. The course modules were peer-reviewed by four domain experts from different Institutions and the revisions were made by re-organizing the order of topics, additions of the modules, modifications of specific topics, merging of common topics together, revising the time duration of lectures as per the content. It was decided that the course will be of 12 weeks and will have 6 modules in it covering different aspects

Table 1: Basic profile of learners under online certificate course on One Health

	Total (%)	Male (%)	Female (%)	Other (%)
Age by Category	**2058 (100)**	**986 (47.9)**	**1068 (51.9)**	**04 (0.2)**
13 – 20 Years	226 (11.0)	134 (13.6)	091 (8.5)	01 (25.0)
20 – 30 Years	849 (41.3)	358 (36.3)	490 (45.9)	01 (25.0)
30 – 40 Years	676 (32.8)	331 (33.6)	343 (32.1)	02 (50.0)
40 – 50 Years	233(11.3)	118 (12.0)	115 (10.8)	00
50 Years & Above	074 (3.6)	045 (4.6)	029 (2.7)	00
Country of Residence				
India	2027 (98.5)	967 (47.7)	1056 (52.1)	04 (0.2)
Outside India	0031 (1.5)	019 (61.3)	0012 (38.7)	00
Occupational Status				
Employed	383 (18.6)	216 (56.4)	166 (43.3)	01 (0.3)
Faculty	548 (26.6)	230 (42.0)	318 (58.0)	00
Students	912 (44.3)	439 (48.1)	472 (51.8)	01 (0.1)
Others	215 (10.4)	101 (47.0)	112 (52.1)	02 (0.9)

related to One Health. The course was divided into following six modules.

Units	Name of Modules	Durations
Unit I	Introduction to One Health	2 Weeks
Unit II	Emerging Infectious Diseases and Antimicrobial Resistance	4 Weeks
Unit III	One Health Application in Management of Zoonotic Diseases	2 Weeks
Unit IV	Applied Epidemiology & Public Health in One Health Research	2 Weeks
Unit V	One Health and Health Policy	1 Week
Unit VI	Media & Community engagement for One Health	1 Week

A total of eighteen professors were invited from across the world for delivering the lectures on the various modules of the course.

The introductory video of the Course which provided an overview of the course was recorded at our campus. The lectures were recorded through both virtual and in person mode. The in-person recording was at ICMR-RMRC Bhubaneswar, IIT Delhi and IIT Kharagpur. The entire recording was completed over a period of 52 days across the mentioned locations. Editing and proof reading was completed in 6 weeks by experts at NPTEL, Chennai.

The programme was launched on the 23rd of January 2023 in presence of the programme Office from Department. of Health Research, Ministry of Health and Family Welfare, Government of India, New Delhi, Principal investigator of the course and other resource persons. NPTEL conducted the course as a self-paced online course, spread across 12 weeks wherein the students had to spend about 3 hours per week. Assignments were designed after each topic to monitor the understanding and knowledge enhancement of the participants. The course was accessible to enrolled participants. Each week content was released based on the units assigned, post which students were given an assignment based on the lecture taught. Grievances and doubts were solved via a google group accessible to students and facilitated by NPTEL. A total of 60 grievances were addressed in this semester. Weekly feedback was obtained to understand the learning concept of the participants. After completion of the lectures and assignments, an online written test was conducted at multiple centre of the country on 30th April 2023. It was a computer-based examination wherein students had to undertake a three-hour examination at designated centres. A student had to secure minimum 40% marks (75% of Final exam and 25% from weekly assignments) to get the course completion certificate. Participations securing more than 90% will be awarded with the Achievement Award certificates.

A total of 2058 participants across the world enrolled within one month of course advertisement and undertook the course. Participants were post graduate students, research professionals, faculties, policy makers, development sector officials. About 2% of the total participants enrolled from different countries other than India, like Singapore, USA, UK, Nepal, Bangladesh, Sri Lanka, UAE, Canada, Nigeria etc. In India, the majority registrations were from Tamil Nadu, followed by Maharashtra. Majority of participants were aged between 20 to 40 years (74.1%) and about 52% of participants were female (Table 1). In view of its popularity and high enrollment, NPTEL has decided to re-run the course for the next 3 years during the January-April session. An advanced course on One Health that will provide emphasis on the components and further application of One Health in various industries and research institutes, is scheduled to be recorded and launched by 2024.

This present course is the first of its kind on One Health from India and launched online through NPTEL platform and represents a milestone in global health education, bridging the gap between human, animal, and environmental health.

In conclusion, the course will help give light to new directions for research work and studies in the area of One Health which is a growing phenomenon in the current world. Enhancing capacities and fostering One Health collaborations focused on prioritized diseases enables a country to not only address existing challenges posed by emerging diseases more effectively but also establishes robust systems to promptly detect and respond to new threats that may emerge, thus contributing to global health security.[4] As the world faces unprecedented health challenges and ecological threats, it is imperative that we equip professionals with the necessary tools and knowledge to collaborate across disciplines. By embarking on this transformative journey, participants will not only broaden their horizons but will also contribute to a sustainable and healthier future for all living beings on our planet.

Declarations

Ethics approval

Ethical clearance was obtained from the Institutional Human Ethics Committee of ICMR-Regional Medical Research Centre, Bhubaneswar.

Conflict of Interest

No conflict of interest.

Funding

The study received funding from the Dept. of Health Research, Ministry of Health & Family Welfare, Govt. of India,
[File No.R.12019/01/2020-HR dated 01.09.2020].

Acknowledgment

We thank Dept. of Health Research, Ministry of Health & Family Welfare, Govt. of India for providing the funding. We also thank all the resource persons who contributed with their valuable time for recording the informative lectures. We thank all officials of NPTEL for their continuous support and hosting the course in their platform., We are also grateful to Dr. Manickam P, Scientist F, ICMR-National Institute of Epidemiology for providing technical inputs for initiating this certificate course.

References

1. One Health Commission. What is One Health? Retrieved from https://www.onehealthcommission.org/en/why_one_health/what_is_one_health/

2. centres for Disease Control and Prevention (CDC). One Health Basics. Retrieved from https://www.cdc.gov/onehealth/basics/index.html

3. Zinsstag, J., Schelling, E., Waltner-Toews, D., Tanner, M. (eds.) (2015). One Health: The Theory and Practice of Integrated Health Approaches. CABI.

4. Salyer SJ, Silver R, Simone K, Barton Behravesh C. Prioritizing Zoonoses for Global Health Capacity Building-Themes from One Health Zoonotic Disease Workshops in 7 Countries, 2014-2016. Emerg Infect Dis. 2017 Dec;23(13): S55–64.

5. Woolhouse ME, Gowtage-Sequeria S. Host range and emerging and reemerging pathogens. Emerg Infect Dis. 2005; 11:1842–7.

6. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. Nature. 2008; 451:990–3.

7. Gebreyes WA, Dupouy-Camet J, Newport MJ, Oliveira CJ, Schlesinger LS, Saif YM, et al. The global One Health paradigm: challenges and opportunities for tackling infectious diseases at the human, animal, and environment interface in low-resource settings. PLoS Negl Trop Dis. 2014;8: e3257.

8. 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. Indian J Med Res. 2021;153(3):320-326.

One Health in Action: National One Health Programme for prevention and control of zoonoses - Need, Strategy, Progress and Challenges

Simmi Tiwari[1]*, Ajit Shewale[1], Aastha Singh[1], Tushar Nale[1], Dipti Mishra[1]

[1] National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr. Simmi Tiwari
Joint Director and Head, Centre For One Health
National Centre for Disease Control (NCDC)
Directorate General of Health Services
Ministry of Health and Family Welfare, Govt of India
drsimmi.tiwari11@gmail.com

Abstract

The concept of One Health has gained significant momentum to address the emerging risk at human- animal- environment interface. Recognizing that the health of these three interconnected domains is closely intertwined, the One Health approach offers a comprehensive perspective to tackle complex global health challenges. This article delves into the significance of One Health and its implications for promoting a healthier and sustainable future for all. The article takes a comprehensive review of ongoing efforts in these directions by various sector and describes the status and progress of the ongoing National One Health Programme for prevention and Control of Zoonoses. The article describes the strategies and Challenges faced by the programme to realize One Health Concept on ground.

Keywords: One Health, Zoonotic Diseases, National One Health programme for Prevention and Control of Zoonoses

Introduction

One Health has garnered notable recognition as a holistic strategy to comprehend and tackle emerging threats at the human-animal-environment interface. Acknowledging the interconnectedness of these three domains, the One Health approach provides a comprehensive viewpoint to address the global health challenges. This article explores the significance of One Health and its potential to foster a healthier and more sustainable future for everyone.

Understanding One Health

One Health can be defined as a collaborative and interdisciplinary approach that recognizes the interdependence of human, animal, and environmental health. It emphasizes the need for a systems-level understanding, acknowledging that diseases and health threats do not exist in isolation but are the result of intricate interactions between humans, animals, and their shared environment [(3)]. Historically, the human, animal, and environmental health sectors have often operated in isolation, leading to fragmented approaches in combating diseases and addressing health risks. One Health seeks to bridge this gap by promoting interdisciplinary collaboration, data sharing, and communication across various sectors, including human and veterinary medicine, public health, agriculture, ecology, and environmental conservation [(4)].

The health of humans, animals, and the environment is fundamentally interconnected. Many infectious diseases, known as zoonoses, can be transmitted between animals and humans. Approximately 75% of emerging infectious diseases affecting humans have an animal origin, with examples including Ebola, Zika, and COVID-19. By understanding the complex interactions between wildlife, livestock, and human populations, we can develop proactive strategies to prevent and control such diseases. Furthermore, environmental degradation and climate change have profound implications for health. Deforestation, habitat loss, and the encroachment of human settlements into previously untouched areas increase the risk of zoonotic disease transmission. Additionally, climate change influences the distribution of disease vectors, such as mosquitoes, impacting the spread of diseases like malaria and dengue fever. By considering these interconnections, the One Health approach provides a framework to mitigate these risks and safeguard human, animal, and environmental well-being [(7,10)].

Benefits of the One Health Approach

1. Disease Prevention and Control: By recognizing the shared nature of diseases, the One Health approach emphasizes early detection, surveillance, and rapid response to disease outbreaks. Collaborative efforts between human and veterinary health sectors enable better monitoring and control of zoonotic diseases, reducing the likelihood of pandemics and improving public health outcomes.

2. Antimicrobial Resistance: One Health recognizes the overuse and misuse of antibiotics in both human and veterinary medicine as a significant concern. By

fostering collaboration, One Health advocates for responsible antimicrobial stewardship, promoting the judicious use of antibiotics in both human and animal health settings, thus combating the growing threat of antimicrobial resistance.

3. Environmental Sustainability: The One Health approach underscores the importance of sustainable environmental practices. By addressing the root causes of environmental degradation, such as deforestation, pollution, and climate change, we can mitigate the emergence and spread of infectious diseases, preserve biodiversity, and ensure the long-term health of our planet.

4. Research and Innovation: One Health encourages interdisciplinary research collaborations, leading to new insights and innovations. By integrating knowledge from various fields, we can develop novel diagnostics, vaccines, and treatments for both human and animal health, improving health outcomes for all species.

One Health and Pandemic Preparedness

The COVID-19 pandemic has brought to the forefront the importance of adopting a One Health approach to global health emergencies. This novel coronavirus, like many other infectious diseases, demonstrates the intricate interplay between humans, animals, and the environment. Understanding the lessons learned from COVID-19 and embracing the principles of One Health can enhance our preparedness and response to future pandemics.

The One Health approach emphasizes proactive measures to identify and prevent cross species pathogens transfers and zoonotic spill over events. This involves addressing the underlying drivers of disease emergence, such as, deforestation, wildlife trade and habitat destruction. By implementing sustainable land-use practices, preserving biodiversity, and promoting responsible animal husbandry, we can reduce the likelihood of zoonotic diseases crossing into human populations. Furthermore, promoting public awareness and education about zoonotic diseases and their prevention can empower individuals to adopt safer practices and behaviours. Encouraging responsible pet ownership, advocating for the regulation of wildlife trade, and implementing strict food safety standards are crucial steps in preventing future zoonotic outbreaks.

The One Health approach encourages interdisciplinary research and innovation to tackle global health challenges. COVID-19 has highlighted the need for accelerated research efforts, including the development of diagnostics, therapeutics, and vaccines. By fostering collaboration between human health researchers, veterinarians, and environmental scientists, we can pool expertise and resources to expedite the discovery of solutions. Additionally, integrating animal health surveillance systems into existing human health surveillance networks can facilitate early detection of potential threats. This collaborative approach can also aid in the development of broad-spectrum antivirals and vaccines that protect against multiple coronaviruses, mitigating the impact of future outbreaks [5].

Pandemic preparedness is a global concept that requires strong international cooperation and governance. The One Health approach emphasizes the importance of collaborative partnerships, data sharing, and resource allocation among nations. International organizations, such as the World Health Organization (WHO), World Organisation for Animal Health (OIE), and the United Nations Environment Programme (UNEP), play a vital role in facilitating coordination, standardizing guidelines, and promoting best practices in One Health pandemic preparedness [6].

One Health in Indian Perspective

India, with its vast population, diverse ecosystems, significant livestock and wildlife populations, faces unique public health challenges. To effectively address these challenges, the integration of the One Health approach into the country's public health system is of paramount importance. This article explores the significance of incorporating One Health principles into India's public health framework and the potential benefits it can bring to the nation's well-being.

Integrating One Health into India's public health system would strengthen disease surveillance and response mechanisms. By establishing a collaborative framework involving human health, veterinary services, and environmental agencies, early detection and timely control of disease outbreaks can be achieved. This proactive approach enables rapid deployment of resources and interventions to prevent the spread of diseases from animals to humans and vice versa [2,11]. For instance, a One Health approach to combat diseases like avian influenza and Nipah virus would involve close coordination between veterinary departments, public health agencies, and wildlife authorities. This collaboration facilitates efficient monitoring of disease patterns in animals, early detection of potential threats to human health, and the implementation of preventive measures to minimize the impact of outbreaks [3,4,5,10,12].

Key Stakeholders for One health

Currently major stakeholders in India in One Health includes Ministries of Health, Agriculture, Animal Husbandry, Environment and Forest, Science and Biotechnology, Water and Sanitation Human Resource,

etc. and organizations such as NDMA, DCGI, FSSAI etc.

One Health initiatives in India

India also echoes the global voice acknowledging the importance of "One Health" and paid a particular heed to make One Health Approach as an inbuilt principle in its national programmes for e.g., There are several programmes and initiatives that are currently run by different ministries and stakeholders with One Health approach with well-defined subject specific objectives and strategies.

For zoonosis, ICMR and ICAR have developed collaboration for joint research priorities. Ministry of Science and Technology has proposed to have a One Health roadmap for India with the Ministries of Health, Agriculture and Environment, Forest and Climate Change.

National Disaster Management Authority (NDMA), NCDC, Emergency Medical Relief (EMR), IHR division had played important role in crisis situations especially outbreak response and managements e.g. outbreaks of Zika, Nipah and AMR related containment.

FSSAI have taken several initiatives under Swasth Bharat initiative for generating community awareness on eating habits of people. NDMA and Ministry of Health are working on preparation and implementation of action plans on climate change related events.

"National institute for One Health" in Nagpur is an upcoming key pillar for leading One Health Research under the aegis of ICMR.

National Programme for AMR containment was launched during 12th five-year plan (2012-2017) and currently strengthening state medical college labs in 26 States/UTs. The programme focusses to establish a laboratory-based AMR surveillance system in India and to strengthen infection control practices. Under the programme in April, 2017 an Inter-ministerial consensus was signed named as Delhi Declaration on AMR to adopt a holistic and collaborative approach for AMR containment in the country.

National Programme for Climate Change and Health was launched by MoHFW under National Health Mission in 2019 to create awareness among general population, health care providers and Policy makers about the impact of changing climate on human health and to strengthen healthcare system to reduce illness/diseases due to varying climate.

National Action Plan for Dog Mediated Rabies Elimination from India by 2030 launched jointly by Ministry of Health and Family Welfare and Ministry of Fisheries, Animal Husbandry and Dairying in 2021 is another endeavour to address the rabies menace in the country by adopting strategic One Health intervention both for human and animal health sector.

National One Health Mission was set up upon approval of The Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) to coordinate, support and integrate all the existing One Health activities in the country and fill any existing gaps. One Health Mission have several undergoing initiatives such as targeted research and development, database integration, streamlining of regulatory and approval processes and Integration of the efforts into existing programmes to prevent further siloes.

National One Health Programme for Prevention and Control of Zoonoses a hundred percent centrally funded programme was launched in 2013 by Ministry of health and family welfare with NCDC as its nodal agency to implement and coordinate the activities under the programmes. The key objective of the programme was to strengthen the intersectoral coordination between human, animal, and environmental sectors. Over the year the programmes has expanded its vision to institutionalize the structural mechanism for one health in the country at national, state district, block and up to village level with active community engagement. The programme has missioned to bring all stakeholders from policymakers makers till front -line workers with shared vision and common goal on strategic One Health Platform. The ultimate goal of the programme is protecting communities and minimizing socioeconomic losses due to emerging and re-emerging zoonotic threats.

The stated objective of the programmes is to operationalize "One Health" mechanisms for prevention and control of Zoonoses through strengthening Inter-sectoral Coordination among all stakeholders at the National, State, and District and below district level. The key strategies to achieve the objective is conceptual existing surveillance systems in all sectors, roping in veterinary and wild life institutes as regional coordinators joint capacity building

programmes, networking and mapping laboratory resources for cross sectoral efficient use of resources for zoonotic pathogens within the ambit of scientific protocols and preserving and protecting the sectoral priorities.
The programme has six broad components and many sub components as –

1. Institutionalize One Health mechanism at National, State and district level
2. Integrated Manpower development through Capacity Building programmes through Regional Coordinators network & partner institutions.
3. Establishing an Integrated Surveillance mechanism for one health by digital interlinkages of existing portal through APIs in different sectors and enhancing use of artificial intelligence and data modelling for predictive analytics for early warning signals. This component envisages establishing a network of sentinel surveillance sites on Zoonoses across the country.
4. Integrated Community Outreach programme activities interlinked with sentinel surveillance sites and regional coordinators
5. Advocacy and Risk Communication activities for target and at-risk population
6. Undertaking multidisciplinary operational research activities in collaboration with partners organization.

The programme is being implemented in all 36 States/UTs. At National level various committees have been formed to monitor the progress of these programme for e.g. standing committee on zoonosis and diseases specific national technical advisory group are constituted to advise the programme division on various technical aspects of the programme. The programmes have devised and formulated operational guidelines for its various components and has been able to sensitize the concerned stakeholders as evidenced by an active networking and partners ship with many institutes and universities both in health and veterinary sector. Constitution of State and district level zoonoses committees with representation of all concerned stakeholders has been able to draw the attention of state governments to address the zoonotic diseases with One Health approach.

The expanding network of sentinel surveillance sites for zoonoses with integrated community outreach activities, joint training of medical and veterinary professionals, state and district level rapid response teams on joint risk assessment and outbreak investigations has been able to improve intersectoral collaboration and hence bridging the knowledge gaps among various sectors. Operational and applied research activities for Zoonoses are consistently undertaken by regional coordinators and partners organizations The programme is attempting to create an integrated web/digital portal for zoonotic pathogens which would be a joint IT platform for data sharing on agreed parameters between concerned sectors such as health (IDSP), veterinary (NLM/NADRS) and Climate data (IMD). This will enable to develop a Real-time alert mechanism for zoonotic diseases and timely detection, effective prevention, and public health response for impending outbreaks.

Joint training is conceptualised to educate ASHAs, AWW, and Paravets and Field level Wildlife workers through joint training session and awareness programme on zoonoses and reverse zoonoses. Creating awareness on zoonoses among farmers and livestock handlers through Gram Sabha and Village committee through mass education and Inter-personal communication is a strategic intervention under the programme to foster the one health concept at grass root level.

Challenges

Implementing the One Health approach in India faces numerous challenges stemming from various factors. Firstly, the divergent priorities across different sectors pose a significant hurdle. Each sector, be it human health, animal health, or environmental sector, operates with its own set of priorities and objectives, often leading to fragmented efforts. Additionally, there is a lack of coordinated efforts among stakeholders and a deficiency of necessary policies to facilitate inter-sectoral collaboration. India's pursuit of comprehensive health practices, encompassing human, animal, and environmental health, faces significant challenges due to legislative barriers. There is a need to integrate and strengthen legislation for development of comprehensive One Health regulatory framework that integrates laws across human health, animal health, and environmental protection to enforce robust surveillance systems and timely reporting that is imperative for effective One Health practices.

Another critical issue is the minimal data sharing between sectors, hindering comprehensive and effective response to health challenges. Public awareness about the interconnectedness of human, animal, and environmental health remains low, further exacerbating the problem. Insufficient technical capabilities, especially in rural areas, and logistical constraints pose additional barriers. Furthermore, India's rich biodiversity and complex wildlife sector present unique challenges in

disease surveillance and management. Overcoming these challenges requires concerted efforts from policymakers, healthcare and veterinary professionals, researchers, and the public to foster a holistic approach towards health management.

Conclusion

Although One health is well conceptualized in the above national programme but realization of the concept seems impractical at times due to many challenges such as lack of policy framework, sectoral silos and disparate human and animal disease reporting and surveillance systems. There are significant gaps in the required infrastructure and human resources in all sectors particularly in veterinary and wild life sector. Inadequate resource allocation, lack of SOPs for systematic communication, inherent differences in disciplinary training, knowledge deficits and inter and Intra hierarchical coordination challenges further complicate the situation. However, with the lessons learnt with covid pandemic, there is global movement to incorporate the One Health Principle in all policies and programmes. The recent launch of Joint Plan of Action on One Health by UN quadripartite (WHO-OIE-FAO-UNEP) and systematic dialogue on One Health at G20 and UK G7 forum has resulted in significant sensitization the stakeholders to obtain the highest level formal mutual cooperation agreements on "One Health" activities. Triggered with the global momentum, the National One Health programme for Prevention and Control of Zoonoses, a policy driven initiative by Government entails a bright scope of realizing the concept of one health and has the potential to improve overall public health outcomes and promote sustainable development.

References

1. Guarner J. Introduction: One Health and emerging infectious diseases. Seminars in Diagnostic Pathology. 2019;36(3).

2. centres for Disease Control and Prevention (CDC).One Health basics. Available at: www.cdc.gov/onehealth/basics/index.html. 2018.

3. Dasgupta R, Tomley F, Alders R, Barbuddhe SB, Kotwani A. Adopting an intersectoral One Health approach in India: Time for One Health Committees. Indian J Med Res. 2021 Mar;153(3):281-286. doi: 10.4103/ijmr.IJMR_537_21.

4. Errecaborde KM, Macy KW, Pekol A, Perez S, O'Brien MK, Allen I, et al. Factors that enable effective One Health collaborations – A scoping review of the literature. PLoS ONE. 2019;14(12):e0224660.

5. Sinclair JR. Importance of a One Health approach in advancing global health security and the Sustainable Development Goals.
Rev Sci Tech. 2019 May;38(1):145-154. doi:10.20506/rst.38.1.2949. PMID: 31564744.

6. Machalaba CC, Salerno RH, et al.Institutionalizing One Health: from assessment to action.
Health Security. 2018;16(Suppl. 1):S37–S43. doi:10.1089/hs.2018.0064.

7. Frankson R, Hueston W, Christian K, Olson D, Lee M, Valeri L, et al. One Health Core Competency Domains. Front Public Health. 2016;4(September):192.

8. Amri M, Chatur A, O'Campo P. Intersectoral and multisectoral approaches to health policy: an umbrella review protocol. Health Res Policy Syst. 2022;20:21. https://doi.org/10.1186/s12961-022-00826-1.

9. Nair SR. Relevance of health economics to the Indian healthcare system: A perspective.
Perspect Clin Res. 2015 Oct-Dec;6(4):225-226. doi: 10.4103/2229-3485.167095.

10. Mackenzie JS, McKinnon M, Jeggo M. One Health: From Concept to Practice. In: Confronting Emerging Zoonoses. Tokyo: Springer Japan; 2014. p. 163–189.

11. Smith KM, Machalaba CC, Seifman R, Feferholtz Y, Karesh WB. Infectious disease and economics: The case for considering multi-sectoral impacts. One Health. 2019 Jan 9;7:100080.
doi: 10.1016/j.onehlt.2018.100080.

12. Chatterjee P, Kakkar M, Chaturvedi S. Integrating one health in national health policies of developing countries: India's lost opportunities. Infect Dis Poverty. 2016 Oct 3;5(1):87. doi: 10.1186/s40249-016-0181-2.

Animal Disease Surveillance: Perspectives and Issues

Abhijit Mitra[1], Aruna Sharma[1], Adhiraj Mishra[1]*, Abhijit Jha[1]

[1] Department of Animal Husbandry & Dairying, Ministry of Fisheries Animal Husbandry & Dairying

***Corresponding author**
Dr. Adhiraj Mishra
Assistant Commissioner
Department of Animal Husbandry & Dairying
Ministry of Fisheries Animal Husbandry & Dairying, Government of India
adhiraj.lolh@gov.in

Abstract

India, with over 536 million livestock, holds the world's highest livestock population, including 300 million cattle and buffaloes and 851 million poultry. This significant animal population supports millions of rural families' livelihoods. India ranks first in livestock population and milk production, third in egg production, and eighth in meat production, contributing substantially to global demands. Despite occupying only 2.4% of the world's land area, India maintains 10.71% of the global livestock. The global livestock demand is projected to reach $20 billion by 2026, presenting India with an opportunity to meet this demand. However, pandemics and zoonotic diseases pose significant threats, emphasizing the need for a comprehensive zoonotic disease surveillance system. Such a system would detect disease emergence early, minimizing transmission and spread. India's membership in the World Organization for Animal Health mandates disease surveillance and reporting, which is crucial for early detection and international trade. The Department of Animal Husbandry & Dairying has implemented surveillance programmes to detect disease events early, assess intervention measures, and determine disease-free areas, aiding national disease control and eradication efforts.

Keywords: Zoonotic disease, Surveillance, Animal health

Introduction

India is home to the world's highest livestock population, with around over 536 million livestock[1] including 300 million[2] cattle & buffaloes and 851 million poultry. This vast animal population is significant to the country, as it supports the livelihood of millions of rural families who depend on them for their daily needs. We rank 1st in livestock population[1], 1st in milk production[2], 3rd in egg production[3], 8th in meat production contributing 15%, 23%, 18% and 3%, respectively, towards global demands. Furthermore, with only 2.4% of the land area of the world, India is maintaining about 10.71% of the world's livestock[4]. As the global demand for livestock is estimated to reach $20 bn by 2026[5] (with livestock production anticipated to hit ~2 bn), it gives India an opportunity to fill the void in demand-supply.

Pandemics impact society, economy, and life both human and animal hence it must not be overlooked. India faced livestock diseases like LSD and ASF causing significant loss to farmers. Zoonotic diseases are a major concern, with 60% of human pathogens being zoonotic and 75% of emerging pathogens are also zoonotic[6]. Food-borne diseases and antimicrobial resistance burden the nation's health system and economy. Given recent experiences with rapidly spreading global outbreaks crossing borders and continents, it is crucial to establish a comprehensive and global zoonotic disease surveillance system. This system should be capable of detecting disease emergence in human or animal populations anywhere in the world as early as possible. A zoonotic disease surveillance system still offers significant benefits by providing critical data to inform evidence-based responses. This, in turn, minimizes the opportunities for zoonotic disease emergence, transmission, and spread in both human and animal populations (National Research Council, USA)

Importance of Animal Disease Surveillance & Reporting

Disease Surveillance and Reporting plays a major role in disease prevention and control. Further India being a member country of the World Organization for Animal Health (WOAH, formerly known as OIE) reporting of animal health situation becomes mandatory. Disease surveillance and reporting becomes utmost essential as it helps in early detection of diseases and facilitates international trade. To tackle these challenges, the Department of Animal Husbandry & Dairying (DAHD) has implemented livestock disease surveillance with specific objectives, including early detection of disease events, assessing intervention measures' effectiveness, and determining disease-free areas. The data obtained from such surveillance programmes helps in evaluating national disease control and eradication efforts.

Initiatives by the Department

To make the livestock sector more dynamic and vibrant, the Department has realigned/revised the schemes, viz., Rashtriya Gokul Mission, National Programme for Dairy Development, Livestock Health & Disease Control Programme, National Livestock Mission and

Livestock Census and Integrated Sample Survey to further boost the livestock sector growth and promote entrepreneurship thus making animal husbandry more remunerative to the crores of farmers engaged in this sector. The world's largest vaccination programme for livestock in form of National Animal Disease Control Programme (NADCP) for control of FMD and Brucellosis was initiated in 2019 with a budget allocation of ₹13343 crore[7]. The programme targeted for vaccination coverage of 300 million cattle and buffalo, 225 million sheep and goat and 10 million pigs including traceability with unique Pashu Aadhar. Further vaccination against PPR and CSF is also carried out with 100% support from Central Government.

To provide last mile doorstep veterinary service delivery, Mobile Veterinary Units have been supported by the Department with a dedicated vehicle with Call centre (@ 1962) for every 1 lakh livestock population[8]. Under this till date, 4340 Mobile Veterinary Units (MVUs) have been sanctioned to different States/UTs out of which 1805 have started providing doorstep service delivery to the farmers.

Additionally, disease diagnostic laboratories at the State and district levels, along with Central and Regional Disease Diagnostic Laboratories (CDDLs & RDDLs) for diagnostic services, are pivotal in the country's animal disease diagnosis and control activities. Furthermore, besides the government-run diagnostic laboratories, private animal disease diagnostic laboratories also operate across the country. Currently the diseases monitored on priority includes Foot and Mouth Disease, Peste des Petits Ruminants, African Swine Fever, Lumpy Skin Disease, Avian Influenza, Rabies, Brucellosis, Classical Swine Fever, and New Castle Disease.

The effective livestock surveillance measures and control programmes in India have led to attainment of WoAH disease-free status for several diseases Contagious Bovine Pleuro-pneumonia (CBPP), Bovine Spongiform Encephalopathy (BSE) and African Horse Sickness (AHS). Further, Rinderpest has been eradicated globally with continuous efforts through disease surveillance monitoring and vaccination. India has two WoAH reference laboratories, i.e ICAR-National Institute of High Security Animal Diseases (NIHSAD, Bhopal) for Avian Influenza and the Veterinary College, Bangalore, for Rabies which have been instrumental in keeping the two major diseases of global concern under the radar. Similarly, there are other National Reference Laboratories for specific diseases i.e ICAR-NIFMD in Bhubaneswar for Foot and Mouth Disease (FMD), ICAR-NRCE in Hisar for Equine diseases, and ICAR-NIVEDI in Bangalore specializing in surveillance and epidemiology, etc.

The Department is carrying out active surveillance for livestock diseases like Foot and Mouth Disease, Brucellosis, Peste des Petits Ruminants (PPR) and Highly Pathogenic Avian Influenza Virus (AIV). The surveillance plan has been designed based on multistage stratified/cluster random sampling. Active surveillance for avian influenza is conducted in at-risk populations based on detecting exposure to (antibody detection by serology) or the presence of (virus or antigen detection through swabs) the AIV. The veterinary authorities visit commercial poultry farms, backyard poultry, and live bird markets (LBMs) for clinical examinations and collection of samples etc. Surveillances are carried out with multistage stratified / cluster random sampling. The following sampling frame has been constructed with the assumption of a conserved prevalence rate of 2%; cluster level prevalence of 10% of 2% of animal prevalence; 90% test sensitivity; 50% Herd level sensitivity for detection of disease and 95% confidence interval. The active surveillance plan is detailed in the National Action Plan for Preparedness Control and Containment of Avian Influenza 2021.

Passive Surveillance is carried out to detect any unusual mortality for which the Animal Disease Surveillance Report is followed which included all notifiable diseases scheduled in the `The Prevention and Control of Infectious & Contagious Diseases in Animals Act 2009'. All States and UTs submit a monthly ADS report to the department which helps in the evaluation of the disease scenario in country and devise an effective control strategy.

Disease Reporting to WOAH

As a member country, India submits Animal Health Information to WOAH under the World Animal Health Information System (WAHIS) platform. In this, India summits the information related to the endemic diseases under the six-monthly report, whereas the emergent and exotic disease are reported under immediate notification. Under WAHIS there is also provision for reporting of diseases in wildlife.

National Animal Disease Referral Expert System (NADRES)

The ICAR- NIVEDI has developed an advanced software application called National Animal Disease Referral Expert System version (NADRES)[9]. This system serves as an early warning mechanism, providing livestock disease forewarning and climate-associated disease risk factors to stakeholders. It enables timely implementation of prevention and control measures, reducing disease incidence and minimizing morbidity and mortality. NADRES relies on nationwide disease surveillance, reporting, and epidemiological investigations, supported by a geographical information

system (GIS) for data integration and analysis. By combining animal health data with information like livestock population, land use, meteorological, and remote sensing data, dynamic and static livestock disease precipitating factors are identified. It utilizes climate and meteorological data, along with other risk parameters, to forecast disease outbreaks up to two months in advance at the district level. The unique forewarning methodology combines 24 parameters at the village level, aggregated to the district level for analysis. It has the potential to serve as a valuable tool for farmers, veterinarians, policymakers, and other visitors.

National Animal Disease Epidemiology Network (NADEN)

From April 2021, AICRP-ADMAS centres were renamed as the National Animal Disease Epidemiology Network (NADEN), which currently consists of thirty-one centres. NADEN aims to serve the following mandate:

a. Conducting sero-monitoring of animal diseases using a sample frame.
b. Investigating endemic, emerging, and re-emerging animal disease outbreaks with innovative technologies.
c. Strengthening the National Livestock Serum Repository.
d. Effectively updating NADRES with active disease data and climatic and non-climatic risk factors.
e. Conducting surveillance of diseases/pathogens in companion, laboratory, and wild animals.
f. Analyzing economic losses due to animal diseases and evaluating the effectiveness of control measures implemented for their management.

National Digital Livestock Mission (NDLM)

The National Digital Livestock Mission (NDLM) is an initiative by the Department aimed at transforming India's livestock sector into a farmer-centric, technology-driven ecosystem. The livestock sector plays a significant role in rural livelihoods but remains untapped. To achieve this, the NDLM has outlined several key objectives, including establishing a "farmer-centric system," building a mechanism for Direct Benefit Transfer programmes, encouraging greater participation of the private sector, implementing robust closed-loop breeding systems and disease surveillance/control programmes, and promoting better alignment and coordination among various national and state programmes.

The key building blocks of the NDLM are unique animal identification, enhanced mobile applications (e-Gopala), and well-designed backend IT systems. The NDLM emphasizes better analytics through high-quality data generation and utilization of Artificial Intelligence and Machine Learning (AI/ML) to enhance disease prediction, diagnostics, animal management, and product traceability. To ensure the sustainable management of the digital architecture, NDLM proposes the creation of a dedicated entity aligned with the Ministry's mission. This entity will serve as a technical resource and data analytics hub.

The basic digital applications like Information Network for Animal Productivity and Health (INAPH) have been implemented, gathering feedback for continuous improvement. Disease reporting systems, such as the National Animal Disease Reporting System (NADRS), have also been incorporated, refining reporting methods based on field input. The NDLM is a formidable undertaking, drawing inspiration from successful nation-scale programmes and seeking to capitalize on India's technological capabilities and resilience, aiming to unleash the full potential of the livestock sector. Recognizing the importance of controlling diseases that impact animals and humans, the mission aims to build robust disease surveillance and control programmes.

One-Health Initiatives

The urgency to address animal pandemics cannot be understated. Collaboration among Indian government institutions, private organizations, and states is crucial to ensure a comprehensive programme's success. Moreover, global community involvement is necessary due to the transboundary nature of infectious diseases. The Department of Animal Husbandry & Dairying (DAHD) is actively engaged in the proposed National One Health Mission, which aims to link databases and enhance disaster resilience. Meeting these global challenges demands collaborative efforts across sectors, borders, and disciplines. It is imperative that organizations and countries unite, sharing information and providing support, to foster a stronger and more resilient global community.

To prepare for future disease outbreaks, the Department of Animal Husbandry and Dairying (DAHD) has launched the Animal Pandemic Preparedness Initiative (APPI) on April 2023, the first of its kind worldwide. Under the APPI, several key activities are being undertaken. This includes the establishment of joint investigation and outbreak response teams (national and state), the development of an integrated disease surveillance system based on the National Digital Livestock Mission[10], strengthening the regulatory system (e.g. NANDI-NOC for approval of new drug and inoculation system online portal)[11], creating disease modeling algorithms and early warning systems, collaborating with the National Disaster Management Authority (NDMA) for disease mitigation strategies, initiating targeted research and development for priority diseases, and building genomic and surveillance

capacity for timely disease detection.
Recognizing the challenges posed by zoonotic diseases and exotic animal diseases of economic significance, Department of Animal Husbandry & Dairying (DAHD), Government of India took initiatives to address the emerging infections through One-Health approach wherein the focus of activities revolves around intersectoral coordination, capacity building, reporting, information sharing across sectors and outreach. One Health Support Unit (OHSU) was established by DAHD with funding support from BMGF and CII as implementing agency[12]. To pilot the proposed interventions, two states (Uttarakhand and Karnataka) were selected using various ranking indices, including operational and non-operational parameters. The interventions encompass the strengthening of field and diagnostic capacities, networking of laboratories, digital disease reporting and response, and strengthening of biosafety and biosecurity in farm settings towards achieving the "Predict-Prevent-Detect-Respond" doctrine.

The Department is initiating a programme for Animal Health System Support for Improved One Health (AHSSOH) with World Bank support wherein animal health infrastructure and capacities would be strengthened for effective implementation of One Health at the national level[13]. The project would target integrated disease surveillance for zoonotic diseases linking to human and wildlife systems, thereby creating a truly integrated system. The AHSSOH project will be piloted in five states, viz., Assam, Karnataka, Maharashtra, Madhya Pradesh, and Odisha. The primary goal of this project is to enhance the quality and accessibility of animal health services for livestock farmers and promote better coordination between animal and human health sectors in these focus states. The project would target integrated disease surveillance for zoonotic diseases linking to human and wildlife systems, thereby creating a truly integrated system. The project would cover 151 districts across the five participating states, with plans to upgrade 75 district/regional laboratories and strengthen 300 veterinary hospitals/dispensaries. Additionally, the project aims to train 9000 para-veterinarians/diagnostic professionals and 5500 veterinary professionals. It will also launch an awareness campaign on the prevention of zoonotic diseases and pandemic preparedness at the community level by reaching out to six lakh households.

Hence, the APPI, AHSSOH and One Health pilot initiatives aim to strengthen India's readiness to address future animal health emergencies. This ensures the well-being of livestock, farmers, and the overall economy.

Future plans

To enhance animal health management and disease control, a strong focus on strengthening Integrated Disease Surveillance and early warning systems is crucial. These systems play a critical role in timely detecting, monitoring, and responding to infectious and zoonotic animal diseases.

The approach involves various measures such as routine passive surveillance, environmental genomic surveillance, laboratory management information systems, and AI/ML-based data analytics to achieve comprehensive One Health surveillance. Strengthening disease surveillance systems helps authorities proactively identify disease outbreaks, assess their severity, and respond promptly, minimizing their impact on animal and public health and the economy.

Further focus on environmental genomic surveillance becomes essential to connect environmental data to early warning systems, detecting potential disease vectors or reservoirs to implement preventive measures.

Establishment of a laboratory management information system (LMIS) is the need of the hour to ensure efficient tracking of samples and results, aiding disease confirmation and guiding control strategies.

Acknowledgment

We acknowledge Department of Animal Husbandry & Dairying (DAHD), Government of India for constant support.

Conflicts of Interest

No conflict of interest.

References

1. 20th Livestock Census (2019).

2. Annual Report (2022-2023), Department of Animal Husbandry and Dairying (MoFAHD), Government of India.

3. PIB: 9 Years' Key achievements and initiatives of the Department of Animal Husbandry and Dairying. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=1935657.

4. Annual Report (2016-2017), Department of Animal Husbandry, Dairying and Fisheries, Government of India.

5. Global Livestock Trends, Report Linker. Available from: https://www.reportlinker.com/clp/global/8.

6. The Global Governance of Emerging Zoonotic Diseases, Council on Foreign Relations. Available from: https://www.cfr.org/report/global-governance-emerging-zoonotic-diseases#:~:text=Introduction%3A%20The%20Increasing%20Threat%20From%20Zoonotic%20Diseases&text=An%20estimated%2060%20percent%20of,2.7%20million%20human%20deaths%20worldwide.

7. National Library on Medicine. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5711306/.

8. Key Initiatives and Achievements for the Year 2021, Department of Animal Husbandry and Dairying (MoFAHD). Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=1786265#:~:text=National%20Animal%20Disease%20Control%20Programme,and%20was%20launched%20inSeptember%202019.

9. Inauguration of MVUs to provide veterinary services at the farmer's doorstep by Union Minister for Fisheries, Animal Husbandry and Dairying. Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1823690.

10. NADRES (NIVEDI). Available from: https://www.nivedi.res.in/Nadres_v2/.

11. National Digital Livestock Mission - Blueprint. Available from: https://dahd.nic.in/sites/default/filess/National%20Digital%20Livestock%20Mission-Blueprint-Draft%20%28002%29.pdf.

12. Launch of NANDI portal. Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1935455.

13. One Health Support Unit. Available from: https://www.ohsu.in/.

14. Launch of Animal Pandemic Preparedness Initiatives and World Bank-funded Animal Health System Support for One Health. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=1916531.

Unravelling the Secrets of Nature's Health - A Journey into Wild Animal Disease Surveillance and Disease Forecasting

Parag Nigam[1]*, Gowri Mallapur[2]

[1] Wildlife Institute of India, Dehradun, Uttarakhand
[2] Gaia Mitra Collective Foundation

***Corresponding author**
Dr. Parag Nigam
Scientist G & Head
Department. Of Wildlife Health Management, Wildlife Institute of India
Chandrabani, Dehradun, Uttarakhand
nigamp@wii.gov.in

Abstract

Monitoring and predicting diseases is essential to track and anticipate disease outbreaks in wild animal populations, impacting both animal and human health. Effective animal disease monitoring and control programmes, along with swift response systems, rely on robust surveillance systems. They can provide decision-makers with timely and reliable information about the state of animal diseases within a country. Conserving nature and preserving ecosystem services, including disease regulation, is crucial. The article summarizes the surveillance approaches from the animal health perspective.

Keywords: Health, Wild animal disease, Surveillance

Introduction

Monitoring and predicting diseases in wild animals are crucial elements of public health and wildlife management plans. These procedures seek to track and anticipate disease outbreaks in wild animal populations, which could have a big impact on both animal and human health. Effective animal disease monitoring and control programmes, along with swift response systems to emerging threats, rely on robust surveillance systems. They furnish decision-makers with timely and reliable information about the state of animal disease(s) within a country. Surveillance is the continuous scrutiny of the factors that determine the occurrence and distribution of disease and other conditions of ill health in a population.

Conserving nature and preserving ecosystem services, including disease regulation, is crucial for human well-being. Biodiversity acts as a buffer against the emergence and transmission of infectious diseases. Healthy ecosystems with diverse species populations can help regulate disease dynamics by limiting the transmission of pathogens between species or controlling the population of disease vectors. South Asia has been identified as a hot spot for the emergence of zoonotic infectious diseases, but limited capacity has kept wildlife departments in most countries from being active participants in preparedness and response efforts.[3]

The idea of "One Health" has changed over the past ten years as a result of the more frequent and serious risks to the health of people, animals, plants, and the environment.The interaction between domestic animals, wildlife, and humans has evolved as a result of the continuous globalization of society, human population development, and related landscape changes (Molyneux et al. 2011). A holistic and systems-based approach is required for one health, which acknowledges the interconnectedness between the wellbeing of people, animals, plants, and the environment. This integrative concept brings together various sectors to address the problems with productivity, conservation, and health.

With its extensive animal herds, rich fauna, and dense human population, India poses a higher risk for the inter-compartmental spread of illnesses.

Additionally, One Health approaches emphasize collaboration and cooperation among various sectors, including human health, veterinary science, environmental conservation, agriculture, aquaculture and wildlife management. By working together, sharing data, conducting joint research, and implementing coordinated strategies, we can enhance disease surveillance, early detection, and rapid response capabilities. Adopting holistic One Health approaches is crucial towards addressing the increasing threat of infectious diseases to wildlife conservation, public health,and overall ecosystem well-being. By conserving nature, preserving biodiversity, and understanding the drivers of disease emergence, we can better mitigate and manage the risks of emerging infectious diseases for the benefit of all species.

Wild Animal Disease Surveillance

Wild animal disease surveillance involves systematic monitoring and data collection to detect the presence and spread of diseases in wildlife populations. It is crucial for early detection and containment of infectious diseases that could potentially spill over to domestic animals or humans (zoonotic diseases). In the context of animal health, wildlife disease surveillance may provide information regarding domestic and wild animal morbidity and mortality, identify changes in patterns of disease occurrence over time, and assist in early detection of disease outbreaks, including those linked to emerging diseases. Since there are many species of wildlife, there are varied risks of bi-directional disease transmission in different regions or areas, which are dictated by the wildlife species and types of livestock interfaces present. Thus, setting up national wildlife disease surveillance programme is crucial for understanding local risks to animal health and potential zoonotic disease transmission.

Key elements of wild animal disease surveillance include

a. Data Collection: Wildlife biologists and veterinarians collect samples, such as blood, tissues, or faeces, from wild animals. These samples are then analysed in laboratories to identify pathogens and monitor disease prevalence.

b. Monitoring and Reporting: Surveillance programmes track disease patterns and incidents in specific animal populations and regions. This information is reported to relevant authorities for further analysis and response planning.

c. Disease Mapping: By recording disease occurrence geographically, surveillance efforts can create disease distribution maps, which help identify high-risk areas and potential sources of outbreaks.

d. Zoonotic Disease Monitoring: Surveillance focuses on zoonotic diseases to understand and mitigate their transmission risks. Many diseases can be transmitted from wild animals to humans. Health officials can identify potential zoonotic threats by monitoring wild animal populations and take preventive measures to minimize human exposure.

e. Population Health Assessment: Disease surveillance also plays a role in assessing the overall health and well-being of wildlife populations. Tracking disease prevalence can provide valuable data on the conservation status of species.

Distinctions from Domestic Animal Surveillance

Whereas farmers, animal handlers and veterinarians will commonly recognize illness in domestic animals, in most situations wild animals do not have this close observational vigilance and monitoring, which can limit detection and reporting of diseases in wildlife as well as access to data collected from other sources. In addition, some diagnostic tests may not be validated for wild species in terms of specificity and sensitivity. Furthermore, there are different stakeholders and participants; for example, wildlife biologists and ecologists should be engaged in the development, analysis, interpretation, and communication of results for a wildlife disease surveillance programme. Additionally, wildlife managers or rehabilitators, conservation managers and other stakeholders may be key collaborators in acquiring specimens.

Wild Animal Disease Forecasting

Wild animal disease forecasting employs various models and data analysis techniques to predict the likelihood of disease outbreaks in wild animal populations. The aim is to anticipate disease outbreaks and take proactive measures to prevent or control their spread. It helps wildlife managers prepare for potential outbreaks and take preventive measures.

Key components of wild animal disease forecasting include

a. Data Analysis: Surveillance data, environmental factors, and other relevant information are analyzed to identify patterns and trends related to disease occurrences. Environmental factors, such as temperature, humidity, and precipitation, can influence disease transmission and the behavior of wild animals. Forecasting models integrate this data to predict disease patterns. Understanding the movement patterns and behaviors of wildlife can help predict the potential pathways for disease transmission between different animal populations.

b. Mathematical Models: Disease models are used to simulate disease spread based on factors like population density, animal movement, environmental conditions, and transmission dynamics. Historical disease data can be analyzed to identify patterns and trends, helping to predict potential future outbreaks.

c. Risk Assessment: Forecasting enables the assessment of the risk of disease emergence and spread in specific regions or animal populations.

d. Early Warning Systems: Forecasting can trigger early warning systems to alert authorities and stakeholders about potential outbreaks, allowing them to implement appropriate measures promptly.

Benefits of Wild Animal Disease Surveillance and Forecasting

Early Detection: Surveillance allows for early detection of diseases, facilitating timely response measures and reducing the risk of widespread outbreaks. Forecasting helps implement preventive measures, reducing disease transmission and protecting both wildlife and human populations. By predicting disease outbreaks, resources can be allocated more efficiently to target high-risk areas and populations, optimizing disease control efforts.

Conservation: Disease surveillance helps protect endangered species by preventing disease-induced population declines.

Public Health: Monitoring zoonotic diseases in wildlife contributes to the prevention of human infections and pandemics.

Ecological Balance: Preventing disease outbreaks in wildlife maintains ecological balance and supports ecosystem health.

Avian Influenza as a specific case for integrated surveillance

Avian Influenza infection in poultry and other avian species is caused by the Influenza A viruses. Avian Influenza viruses have been classified into subtypes based on haemagglutinins (HA) and neuraminidase (NA) proteins. At least 16 types of HA and nine types of NA have been identified in Avian Influenza virus in birds. Diverse influenza A viruses are also found in aquatic waterfowl (Anseriformes and Charadriiformes), poultry, swine, horses, aquatic mammals, bats, and domestic pets such as cats and dogs. However, wild water birds (e.g., gulls) are the natural reservoirs. Because of antigenic shift and antigenic drift, the new Avian Influenza subtypes may emerge that could result in serious consequences. The first outbreak of Avian Influenza was reported in China in 1996, and it entered India in 2006. India has seen multiple outbreaks of Avian Influenza between 2006 and 2019 across 15 different states. A recent outbreak was reported in Kerala in December 2022. As per data from WHO, since 2003, more than 860 human infections of HPAI - H5N1 have been reported.

The Action Plan for Prevention, Control and Containment of Avian Influenza, 2021, has provided a surveillance plan for avian influenza with the aim of early warning, detection, and to take containment measures. The surveillance for avian influenza includes the screening of both domestic poultry and migratory birds. The samples collected during the surveillance process are screened at RDDLs, whereas ICAR – NIHSAD, Bhopal, acts as national referral laboratory for Avian Influenza.

Following the principles mentioned above, the following set of information is presented for designing the surveillance programme for Avian influenza:

1.Surveillance sites: Zoos, national parks, poultry farms, Slaughter houses, poultry markets, wet markets and other risk-based sites

2.Samples: Soil in deep litter system, droppings in battery caging system, carcass, air, water

3.Time and Frequency of Sampling: October to March; April to September

4.Epidemiological units: Poultry, migratory bird aggregation sites (e.g., lakes etc.), birds in zoos, birds in the wild.

5.Assays that can be used: Serological assays, Real-time PCR, sequencing

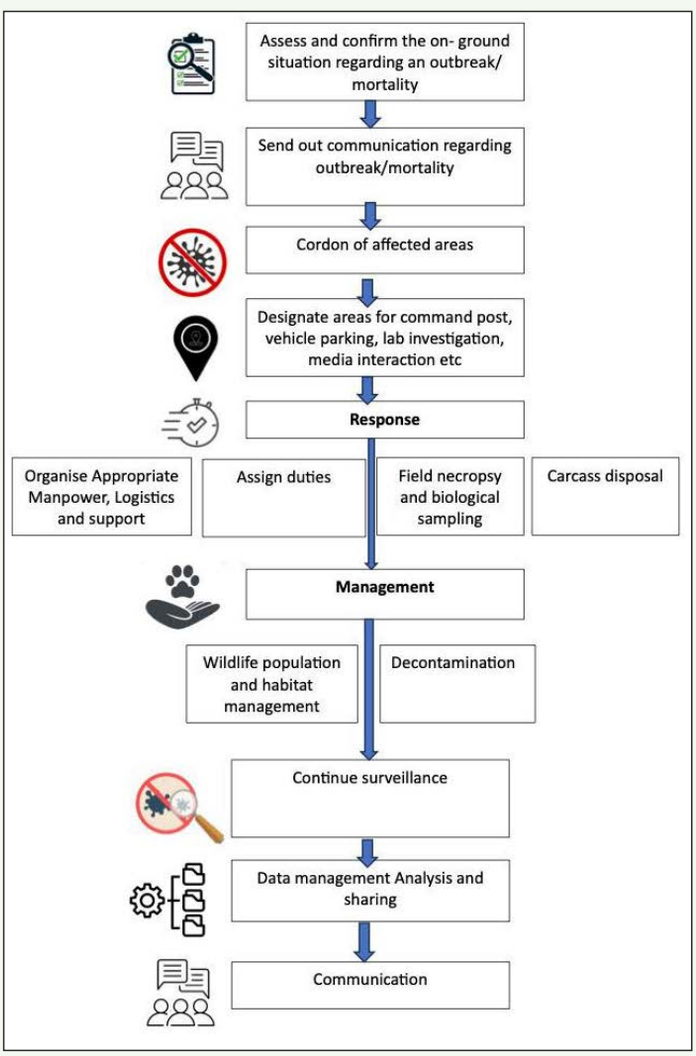


Figure 1: Integrated Surveillance for Avian Influenza

Conclusion

Overall, wildlife disease surveillance and forecasting are vital components of a comprehensive strategy to safeguard both wildlife and human health, conserve biodiversity, and sustain ecosystems. With increasing globalization and movement of people and goods and illicit wild animal trade, diseases can quickly spread across borders. Wildlife diseases can have significant

economic impacts on agriculture, aquaculture, and related industries. Surveillance and forecasting support biosecurity efforts by identifying potential sources of infection and guiding the implementation of preventive measures, such as quarantine protocols. Further, it helps minimize losses by enabling proactive measures to control outbreaks and make evidence-based decisions on disease control measures and resource allocation.

Acknowledgment

We acknowledge Ministry of Environment, Forest and Climate Change for constant support.

Financial support & Sponsorship

None.

Conflicts of Interest

No conflict of interest.

References

1.Chethan Kumar HB, Hiremath J, Yogisharadhya R, Balamurugan V, Jacob SS, Manjunatha Reddy GB, Suresh KP, Shome R, Nagalingam M, Sridevi R, Patil SS, Prajapati A, Govindaraj G, Sengupta PP, Hemadri D, Krishnamoorthy P, Misri J, Kumar A, Tripathi BN, Shome BR. Animal disease surveillance: Its importance & present status in India. Indian J Med Res. 2021 Mar;153(3):299-310. doi: 10.4103/ijmr.IJMR_740_21. PMID: 33906992; PMCID: PMC8204830.

2.Department of Animal Husbandry and Dairying (DAHD). Action Plan for Prevention, Control & Containment of Avian Influenza (Revised – 2021). New Delhi: Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India; 2021.

3. Laxminarayan R, Kakkar M, Horb P, Malavige GN, Basnyat B. 2017. Emerging and re-emerging infectious disease threats in South Asia: Status, vulnerability, preparedness, and outlook. BMJ. 357:j1447.

4.Molyneux D, Hallaj Z, Keusch GT, McManus DP, Ngowi H, Cleaveland S, Ramos-Jimenez P, Gotuzzo E, Kar K, Sanchez A, et al. 2011. Zoonoses and marginalized infectious diseases of poverty: Where do we stand? Parasit Vectors. 4:106.

5.World Organization for Animal Health. Avian influenza (infection with avian influenza viruses). Ch. 3.3.4. Paris France: OIE Terrestrial Manual; 2018.

6.World Organisation for Animal Health (OIE). Training manual on surveillance and international reporting of diseases in wild animals (Focal Point Manual). 2nd OIE Training Workshop for Focal Points on Wildlife. 2015.

7.World Organisation for Animal Health (OIE). Guidelines for Terrestrial Animal Health Surveillance (GTAHS). 2014.

8.World Health Organization. Avian influenza: Assessing the pandemic threat. Geneva, Switzerland: World Health Organization; 2005.

India Pioneers Initiative for Prevention and Control of Snakebite Envenoming: Syncing with the Global Goal

Ajit Dadaji Shewale[1]*, Tushar Nale[1], Simmi Tiwari[1] & Aastha Singh[1]

[1] National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr. Ajit Dadaji Shewale
Joint Director, centre for One Health
National Centre for Disease Control (NCDC)
ajitshewalencdc@gmail.com

Abstract

Snake bite envenoming is a significant public health problem globally and in southeast Asia. India is major contributor to global burden in terms of morbidity and mortality. Accordingly, it is envisaged by global organizations to reduce the deaths by half by 2030. Anti-Snake Venom (ASV) has been provided free of charge in government facilities and surveillance of snake bites is also undertaken by public health surveillance systems. To further strengthen these initiatives, recently National Centre for Disease (NCDC) Ministry of Health and Family Welfare (GoI) has included the activities on prevention and control of snake bites for capacity building of medical officers on management of Snake bites, community awareness, and coordination with relevant stakeholders. Further to achieve the global target of halving the death rate by 2030, the National Action Plan for Prevention and Control of Snakebite in India is drafted by the National Centre for Disease (NCDC) in consultation with relevant stakeholders. It provides guidance to states to prepare a comprehensive state action plan for reducing death due to snake bites among the human and livestock populations. This article highlights the summary of action undertaken and envisaged as part of NAPSE for information to stakeholders.

Keywords: Envenoming, Snake bite, Action plan, NCDC

Introduction

Worldwide, snakebite envenoming (SBE) kills between 81 000 and 138 000 people annually, putting over 5.8 billion people at risk. SBE is a major public health problem in the South-East Asia Region, which constitutes the world's most densely populated regions. It is an occupational, environmental, and domestic health hazard, particularly affecting farmers, fishermen and working children, and leads to thousands of deaths and permanent disabilities including blindness and amputation as well as post- traumatic stress disorder. [1,2]

Despite the global burden and impact, SBE has failed to attract requisite public health policy inclusion and investment for driving sustainable efforts to reduce the medical and societal burden. This is largely due to the demographics of the affected populations and their lack of political voice. Consequently, there is a paucity of health programmes addressing the issue of snakebite envenoming at national, regional and global level.The enormous impact of SBE can be substantially reduced with safe and effective therapeutics. However, a disproportionate number of young people and children in disadvantaged rural areas continue to die from snakebite envenoming due to a lack of awareness, knowledge, and access to appropriate antivenoms. [3]

In 2018, WHO listed SBE as a priority neglected tropical disease (NTD) after intense advocacy by concerned stakeholders, including the Global Snakebite Initiative, Health Action International and 20 member countries.[4] WHO global strategy for prevention and control of snakebite envenoming was launched in 2019, with the goal for all patients to have better overall care so that the numbers of deaths and cases of disability are reduced by 50% before 2030. Rather than perceiving SBE risk as a standalone issue, the SBE-WG considers that efforts to combat SBE need to be incorporated within national and regional health plans and aligned with global commitments to achieving universal health coverage and the Sustainable Development Goals (SDG). [5,6]

In this context, the Regional Action Plan for prevention and control of snakebite envenoming in South-East Asia 2022–2030 was developed through a consultative process with Member States, experts and partners. [7,8] The Regional Action Plan is intended to guide Member States, WHO, donors and partners to work together in a systematic and progressive manner to address issues and challenges and to strengthen health-system and programmatic components to accelerate prevention and control of snakebite envenoming in the South-East Asia Region.[9]

Snakebite Envenoming from Indian Perspective: The Journey so far

Within the South East Asia (SEA) region, Bangladesh, India, Nepal, Pakistan, and Sri Lanka together constitute nearly 70% of global snakebite mortality. It is estimated by independent studies that about 58,000 deaths occur of an estimated 3-4 million snakebites

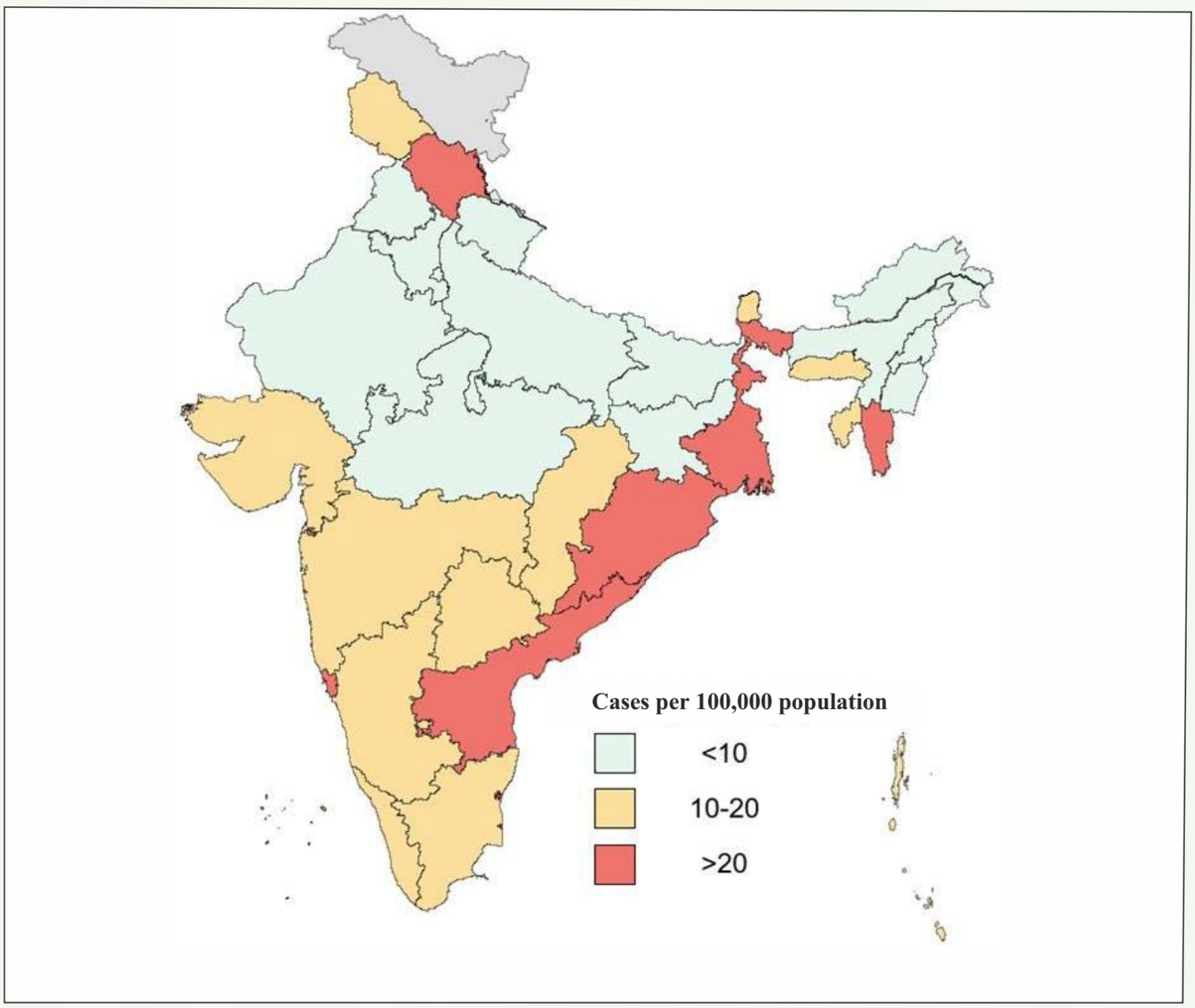


Figure 1: Average annual incidence rate of snakebites in India, 2016-2020.

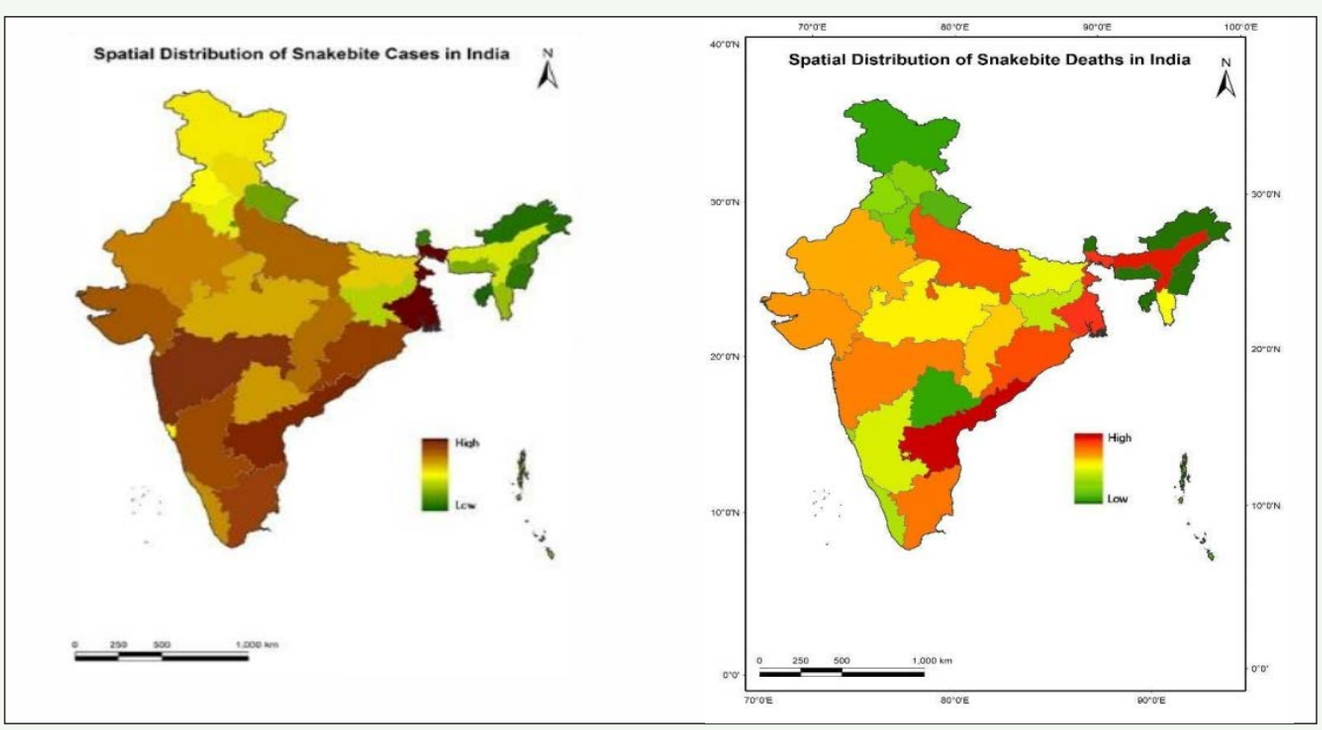


Figure 2: Snakebite cases and deaths as per CBHI data, 2016-2020.

annually in India which accounts for half of all snakebite deaths globally. Only a small proportion of snake bite victims across the country report to the clinics and hospitals and thus the actual burden of snake bite remains grossly underreported. [2]

People living in densely populated low altitude agricultural areas in the states of Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, Andhra Pradesh, Telangana, Rajasthan and Gujarat accounts for 70% of deaths particularly during the rainy season when encounters between snakes and humans are more frequent at home and outdoors areas.

Public Health Initiatives in India

Ministry of Health and Family Welfare (MoHFW), Government of India (GoI) published a National Snakebite Management Protocol in 2009 (updated in 2017) for clinicians for management of snakebite cases. Other interventions are also being taken by state health departments in medical sector such as capacity building by training of health professionals and paramedics on initial management, referral and life support skills.[10]

SBE is a medical emergency and earlier the treatment is available to the victim, higher are the chances of complete recovery. To ensure safe and effective treatment is available and affordable to all, States and UTs have been directed to include Anti Snake Venom Serum (ASVS) in the list of essential drugs and procurement of these drugs is supported under National Health Mission (NHM), also procurement is undertaken in a decentralized manner i.e. State/district/local purchase and majority of states are procuring it through State drug procurement department.

To comprehensively address the issues posed by any priority disease so as to initiate any policy-level interventions, it is important to know the accurate burden of the disease is available. To address this, Indian Council of Medical Research (ICMR) is undertaking Nationwide study to assess the accurate burden of snakebite envenoming and have also constituted a "National Task Force for Research on Snakebite in India". [11]

Recently, a national consultation was held for developing a dedicated National Action plan for Prevention and Control of Snakebite Envenoming (NAP-SE) in July 2022. This NAP-SE echoes the global voice of reducing the deaths due to snakebite envenoming by half and envisages all strategic components, roles and responsibilities of concerned stakeholders. [12]

Mission Steering Group (MSG) of NHM has approved the inclusion of activities for prevention and control of snake bites at district and state level under existing components of NHM. It includes activities i.e., training of medical officer/health workers, surveillance of snake bite cases & deaths, monitoring of health facilities for preparedness of Snake bite management, meetings for advocacy with various government and non-government stakeholders, raising community awareness on prevention of Snake bites and intersectoral coordination. The National Centre for Disease Control, MOHFW is the nodal agency for implementation of the above activities.

The major initiatives proposed to be undertaken as part of current action plan for mitigating the challenges of Snakebite envenoming in India are as under:

a) Strengthening of Surveillance of Snakebite through Integrated Health Information Platform (IHIP)
b) Capacity building of medical professionals
c) Development of Regional venom centres based on prevalent snake species to assure quality Anti Snake Venom across all regions
d) Addressing the legislative issues of anti-snake venom collection
e) Digital Mapping and Monitoring of facilities with availability of anti-snake venom for ensuring prompt and effective management of snakebite cases.
f) Community outreach activities to spread awareness about snakebite prevention and management.

As part of strengthening of surveillance for snakebite envenoming, efforts are underway through coordination with States under case bases reporting platform of IHIP. Line listed data of snake bite cases and deaths is expected to generate information on high-risk groups,

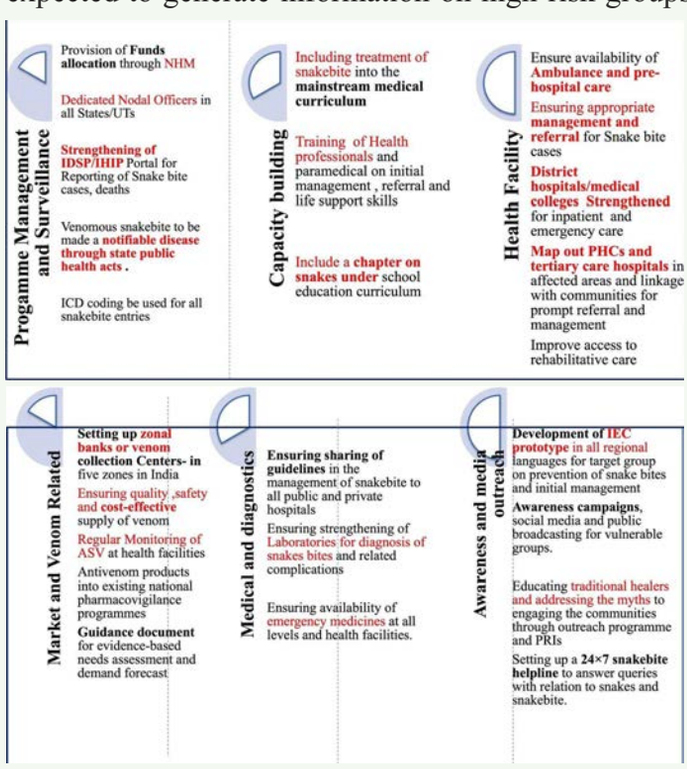


Figure 3: Major initiatives under NAP-SE

Table 1: Key Strategic Components included in National Action Plan for Prevention and Control of Snakebite Envenoming

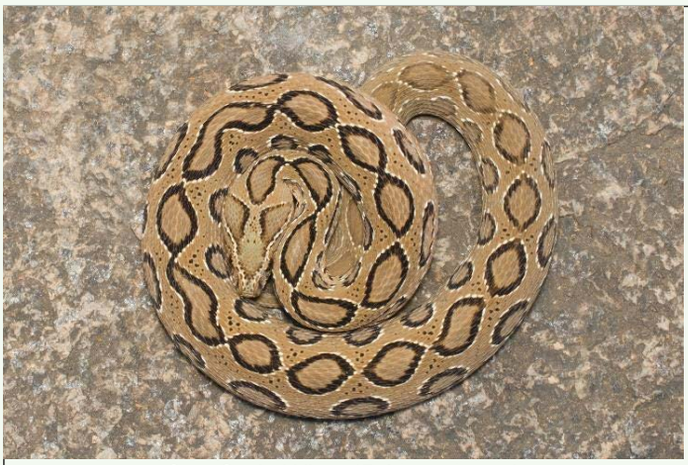
Human Health Sector	**Ensuring Provision of Anti Snake Venom at all Health facilities** • Financial assistance to states from Centre through earmarking funds for Anti Snake Venom procurement in National Free Drugs Initiative scheme • Trained manpower concerning appropriate snake bite management and inoculation of ASV. • Monitoring of ASV demand and supply positions to avoid stock out positions. • Provision of adequate cold chain facilities to store ASV stocks at appropriate levels. • Mechanism for recording and reporting of Adverse Event Following Immunization (AEFI) for Snake bite victims **Strengthening surveillance of Snake bite cases and deaths in Humans** • Notification of snake bite victims through Web portal • Strengthening the periodic reporting system about snakebites through IDSP and IHIP. • Resource mapping – mapping the facilities (State/ District wise) for management and treatment of Snake bite victims and mapping of laboratories for diagnosis of snake's bites and related complications **To strengthen the emergency care services at District Hospitals/ CHCs including services for Ambulance**. • Availability of ambulance services for snake bite cases • Availability of laboratory test required for diagnosis of Snake bite such as – 20 minutes Whole blood clotting test, peak flow meter, urine analysis, Prothrombin time, platelet count, clot retraction time, Liver and kidney function test, serum amylase etc. • Availability of beds with machine-supported ventilation unit • Availability of emergency medicines • Appropriate management and referral for Snake bite cases **Institutionalization of Regional Venom Centre's** • Region-specific venom centres to incorporate research on regional venoms of the Big 4 and other venomous species of that area/zone. • Facilities for biochemical, proteomic, genomic, taxonomic and toxicological studies of different snake species and venoms of India. **Public-Private Partnership** • Engagement with professional organizations such as IMA, IAP, Public professional bodies, NGOs for undertaking activities related to snake bite, research, organization of Continued Medical Education programmes and plenary sessions on scientific updates on Snake bites. **Inter-sectoral Coordination** • ·Active involvement of vaccine manufacturers, wildlife sector, tribal and rural population, KVKs, PRI and community engagements. Joint Training/Sensitization workshop of District level Medical/ Veterinary Department on snake bite and joint gap analysis for formulation of Action Plan for Prevention and Management of Snake bite.
Agriculture /Animal Health Sector	**Prevention of snake bites in livestock** • Identification of the risk areas near to domestic animal settlements/villages/grazing areas. Creation of some type of natural barriers to avoid direct contact between domestic animals and snakes. • Provision of polyvalent ASV at Veterinary Hospitals and Dispensaries with proper storage facility and training.

Wildlife Sector	**Education awareness** • Dedicated campaign in high risk areas near forests for generating community awareness on prevention of Snake bites. **Antivenom distribution** • Work in coordination with health sector at PHC/CHC level to ensure accessibility of antivenom to remote rural areas. • Training to provide the first aid during the snake bite where the primary health facility is negligible. **Strengthening of the key stakeholders** • The engagement of local communities to develop effective management strategies. • Community members can also be involved in reporting snake sightings, providing first aid, and helping to transport patients to medical facilities. **Systematic research and monitoring** • Research on the snakes to generate information that will eventually help to analyses the behavior pattern (e.g. radio telemetry) and habitat of particular snake species thereby minimizing the snakebite envenoming. **Snake venom collection and snake relocation** • Coordination and Collaboration with research and medical research institutes to collect snake venom. It will help reduce the risk of snake bite envenoming and maintain the production of sufficient antivenom in the country. The wildlife sector can also be involved in snake handling, relocation, and reporting snake sightings; due

Picture 1: Range restricted venomous snakes in India

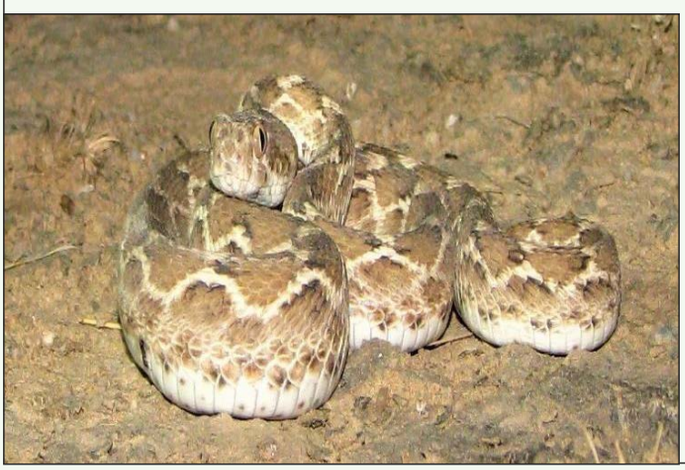
clustering of bites, health facility linkages for snake bite victims etc. For undertaking the activities of Snake bite prevention and control dedicated state/district nodal officers are being appointed.

For generating mass awareness on Snake bite prevention, IEC materials are being prepared at National and State level and through local /regional languages using various communication channel of



Saw-Scaled Viper (*Echis carinatus*)
(Photo credit: Dr. Gajendra Singh)

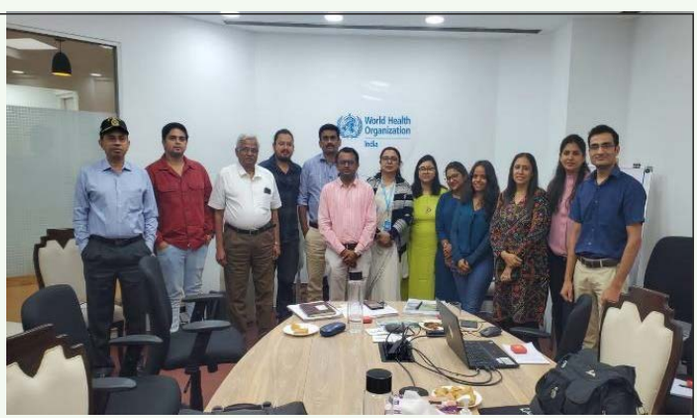
Common krait (*Bungarus caeruleus*)
(Photo credit: Gnaneswar Ch)



Russell's viper (*Daboia russelii*)
(Photo credit: Gnaneswar Ch)

Spectacled cobra (*Naja naja*)
(Photo credit: Gnaneswar Ch)

Picture 2: Big four venomous snake of India



Picture 3: Meeting with stakeholders of NGOs & Institutes for discussion on draft "National Action Plan for Snakebite Envenoming" India (NAPSE) on 22 March, 2023 at WHO India Office

Print and Audio/Video materials efforts are undertaken by respective governments for involvement of community on these issues especially in highly affected districts/States.

Recently, all states have been asked to prepare the state level action plan for prevention and control of Snakebite envenoming including mapping of referral facilities for timely management of snake bite cases, availability of Dialysis and ventilator for management of complicated cases. To ensure the availability of effective ASV against all venomous species in India, it is being envisaged under this action plan Regional Venom centres/banking centres may be established in suitable institutes iin respective regions.

Conclusion

It is evident that multisectoral collaboration and coordination will help in bringing together different stakeholders already working in field of snakebite control and management on one platform.

Further, Global organization working in the field of Snakebite envenoming are advocating for a dedicated National Programme in India to address the snakebite envenoming burden and to make snakebite envenoming a notifiable disease and efforts are underway for the same as part of the current action plan.

Measures like setting up of zonal banks or venom collection centres to cover regional differences in venom immunogenicity are envisaged. Further capacity building on breeding of snakes in captivity for venom collection to ensure venom supply at cost effective prices for ASV manufacturing and clinical research purposes will eventually improve the access to Anti-Snake Venom (ASV) at peripheral health facilities.

Current action Plan also envisages raising awareness among the community through media outreach programmes to the vulnerable groups. It also envisages setting up of a 24x7 toll free helpline to answer queries related to snakebite management are few of the key steps in mitigating the challenges of venomous snakebite in India.

In the view of above, it is expected that the recent interventions by MoHFW would definitely encourage the states and stakeholders to initiate concrete steps for effective actions against mortality and morbidity due to snakebite for reaching the global target of "halving the deaths from snakebite by 2030".

Acknowledgment

We acknowledge NCDC, MoHFW for constant support.

Financial support & Sponsorship

None

Conflicts of Interest

No conflicts of Interest.

References

1. Gutierrez JM, Calvete JJ, Habib AG, Harrison RA, Williams DJ, Warrell DA. Snakebite envenoming. Nat Rev Dis Primers. 2017;3:17063.

2. Suraweera W, Warrell D, Whitaker R, Menon G, Rodrigues R, Fu SH, et al. Trends in snakebite deaths in India from 2000 to 2019 in a nationally representative mortality study. Elife. 2020;9:e54076.

3. Alirol E, Sharma SK, Bawaskar HS, Kuch U, Chappuis F. Snake bite in South Asia: A review. PLoS Negl Trop Dis. 2010;4:e603.

4. Minghui R, Malecela MN, Cooke E, Abela-Ridder B. WHO's Snakebite Envenoming Strategy for prevention and control. Lancet Glob Health. 2019;7:e837-8.

5. World Health Organization. Expert Committee on Biological Standardization. WHO Guidelines for the Production, Control and Regulation of Snake Antivenom Immunoglobulins. Available from: https://www.who.int/publications/m/item/snake-antivenom-immunoglobulins-annex-5-trs-no-1004. Accessed on December 28, 2022.

6. World Health Organization. Snakebite envenoming: A strategy for prevention and control. Geneva: WHO; 2019. p. 70.

7. Williams DJ, Faiz MA, Abela-Ridder B, Ainsworth S, Bulfone TC, Nickerson AD, et al. Strategy for a globally coordinated response to a priority neglected tropical disease: Snakebite envenoming. PLoS Negl Trop Dis. 2019;13(2):e0007059.

8. Gutierrez JM, Warrell DA, Williams DJ, Jensen S, Brown N, et al. The Need for Full Integration of Snakebite Envenoming within a Global Strategy to Combat the Neglected Tropical Diseases: The Way Forward. PLoS Negl Trop Dis. 2013;7(6):e2162. doi:10.1371/journal.pntd.0002162.

9. Gutierrez JM, Williams D, Fan HW, Warrell DA. Snakebite envenoming from a global perspective: Towards an integrated approach. Toxicon. 2010 Dec 15;56(7):1223-35. doi: 10.1016/j.toxicon.2009.11.020. Epub 2009 Nov 29. PMID: 19951718.

10. Standard Treatment Guidelines on the Management of Snake Bites. Ministry of Health & Family Welfare, Government of India; 2017. Available from: https://nhm.gov.in/images/pdf/guidelines/nrhm-guidelines/stg/Snakebite_Full.pdf. Accessed on December 28, 2022.

11. Chakma JK, Menon JC, Dhaliwal RS, Indian Council of Medical Research. White paper on venomous snakebite in India. Indian J Med Res. 2020;152:568-74.

12. Dr. Mansukh Mandaviya Chairs 7th Meeting of Mission Steering Group for NHM. Press Information Bureau. New Delhi; 2022. Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1857490. Accessed on June 10, 2022.

ICMR research initiatives for prevention and control of snakebite envenomation in India

Rahul K Gajbhiye[1, 2]*, Joy Kumar Chakma[2]

[1] ICMR-National Institute for Research in Reproductive and Child Health, Mumbai, Maharashtra
[2] Model Rural Health Research Unit (MRHRU), Vani, District Nashik, Maharashtra, India 422215

***Corresponding author**
Dr. Rahul K Gajbhiye
Scientist E & Head
DBT Wellcome Trust India Alliance Clinical and Public Health Intermediate Fellow
Department of Clinical Research Laboratory
ICMR-National Institute for Research in Reproductive and Child Health, Mumbai, India
Nodal Officer, MRHRU, Vani, District Nashik, Maharashtra
Email: gajbhiyer@nirrch.res.in

Abstract

Snakebite envenoming (SBE) is one of the major public health issues in India. SBE is an acute life-threatening emergency affecting mainly rural and tribal population. There is a paucity of data on incidence, mortality and morbidity of SBE in different geographical regions in India. The studies funded by Tribal Health Research Forum and National Task Force of Indian Council of Medical Research, demonstrated reduction in case fatality rate due to SBE. The efforts of ICMR also focused on community empowerment and capacity building of healthcare system in alignment with WHO strategy. With the strong commitment and coordination of various stakeholders, the WHO goals of 2030 are achievable.

Keywords: Snakebite, Envenomation, Prevention

Introduction

Snakebite burden in India

Snakebite envenoming (SBE) is an important health issue causing 81000 to 137000 deaths from 1.8 - 2.7 million cases globally.[1] Apart from mortality, SBE causes permanent physical or psychological disabilities in nearly 400,000 people every year.[2] Mainly, the farmers, agricultural labours, migratory population, tribes, hunters, and often earning members of their families are affected. This is compounded by non-scientific first aid, delayed health access, and suboptimal treatment contributing to poor outcomes.[3] India alone contributes to half of the global burden of snakebites with ~ 58,000 deaths per year. [4] Since snakebite is not a notifiable disease in India, the burden of snakebite is likely to be an underestimated. A study from West Bengal reporting that only 7.2% of snakebite deaths were officially reported suggesting the discrepancy between SBE deaths reported by population based survey and hospital data .[5]

The National mortality survey (2001-2003), reported mortality between 45,000 to 50,000 every year in India.[4] This study also reported higher annual age-standardized mortality rates per 100,000 populations due to snakebite in 13 states: Andhra Pradesh (6.2), Madhya Pradesh (5.9), Odisha (5.6), Jharkhand (4.9), Bihar (4.9), Tamil Nadu (4.7), Uttar Pradesh (4.6), Chhattisgarh (4.4), Karnataka (4.2), West Bengal (3.5), Gujarat (3.5), Rajasthan (3.3), and Maharashtra (3.0).[4] Jharkhand and Odisha had higher deaths reported in the age group of 5–14 years. However, states like Andhra Pradesh, Bihar, Madhya Pradesh, and Uttar Pradesh reported SBE deaths higher in older age groups. It was observed that deaths due to SBE were higher in females in states like Bihar, Madhya Pradesh, Maharashtra, and Uttar Pradesh.[4] Another study reported the highest absolute number of SBE deaths in 2019 at 51,100 deaths (95% UI 29,600–64,100).[6] The study reported a decline in the age-standardized rate of death due to SBE from 7.3 per 100,000 (4.1–8.8) in 1990 to 4.0 per 100,000 (2.3–5.0) in 2019. The age-standardized death rates in Chhattisgarh, Uttar Pradesh, and Rajasthan were 6.5 deaths (3.5–8.4), 6.0 deaths (2.6–8.0), and 5.8 deaths (3.5–7.4) per 100,000, respectively. Among all the Indian states, the highest number of deaths were reported in Uttar Pradesh in 2019 [12,000 deaths (5230–16,100)][6].During 2001–2014, the mean age-standardized SBE death rate in the Indian population was 4.8 per 100,000 population.[7]

Out of the total 300 species of snakes that are found in India; nearly 60 species are categorised as venomous. Daboia russelii (Russell's viper), Najanaja (common Indian Cobra), Bungarus caeruleus (common krait) and Echis carinatus (saw-scaled viper) are distributed throughout the country and are responsible for most cases of envenoming, morbidity and mortality.[8] The

only scientifically proven treatment for venomous snakebite is Anti-snake venom (ASV) which is produced by raising antibodies against snake venom in horses.

ICMR-NIRRCH research on snakebite

The genesis of the snakebite research in ICMR-NIRRCH was learnings from Model Rural Health Research Unit (MRHRU) Dahanu, Maharashtra. While establishing Maharashtra's first MRHRU in Dahanu, District Palghar, the burden of SBE and key knowledge gaps in snakebite research were identified in 2013. Snakebite envenomation was reported as a major public health problem in the tribal block of Dahanu with the case fatality rate as high as 4.5%.[9]

The National Snakebite Management Protocol was released in 2009. [10] However, there was no awareness of the national protocol, and medical officers did not receive any formal training for snakebite management as per Snakebite Management Protocol.[9] Therefore, medical officers did not follow the national protocol for the management of snakebites. ASV intradermal skin test was practiced by the medical officers and ASV was given in cases of non-venomous snakebites leading wastage of precious ASV.[11] To address these gaps, an implementation research project was conducted in Dahanu block of Palghar, Maharashtra. The study focused improving the community awareness and capacity building of healthcare system. The study was funded by the Tribal Health Research Forum of ICMR and received mentoring support from Dr. Vishwa Mohan Katoch, former Secretary, Department of Health Research and former Director General, ICMR. Dr. Himmatrao Bawaskar, a national expert and internationally recognized researcher on snakebite prevention, diagnosis, and management provided support for the capacity building of healthcare system in Dahanu block, Maharashtra. In early 2016, ICMR co-the facilitated development of an Indian guideline on the management of snakebite. These guidelines covered critical issues in clinical diagnosis and management of snakebite including symptoms and signs of envenomation, first aid, transport and referral criteria, dose of ASV, anaphylactic reactions and complications. The guidelines also covered snakebite management in at PHC, CHC and also at tertiary health care facility. These guidelines were developed with an aim of covering management of SBE in all populations and age groups including pregnant women and children. These standard treatment guidelines were then released by Ministry of Health and Family Welfare in 2017. [12]

In Dahanu, we conducted a facility assessment to understand ASVs distribution and utilization. Interviews of frontline healthworkers (ANMs, MPWs) and doctors were conducted for documenting their knowledge of SBE. [3] Focus group discussions were conducted for the communities and the traditional healers to understand their perspective in developing awareness materials. [3] As a part of the study, we developed the educational materials, including the posters, training manuals in regional language (Marathi). IECs were distributed in all healthcare facilities [sub centre, PHCs, Rural Hospital (RH), Sub District Hospital (SDH)], Anganwadi, Community centres, schools including tribal residential schools, Gram Panchayats etc. Copies of Snakebite Treatment Guidelines (STG), 2017 and Training manuals were provided to all PHCs, RH and SDH in Dahanu block. Community awareness programmes on prevention, first aid and treatment of SBE were conducted with the help of local politicians, religious leaders and state health workers. Intense training of medical officers was conducted as per STG 2017 in Dahanu block by Dr. Himmatrao Bawaskar, one of the leading experts who developed national snakebite treatment protocol (STG, 2017). Training was provided to Sarpamitra (snake rescuers), ANMs, ASHA, MPWs and Tantrics in Dahanu block. These interventions led to drop in mortality rate from 4.5% to 0.4%. [3]

WHO included SBE in the list of neglected tropical diseases in 2017. [14] In 2019, WHO gave a roadmap for achieving the reduction of 50 % mortality and morbidity by the year 2030. [15] The WHO strategy is focused on prevention; availability of safe and effective treatment; empowering the health systems; and improved linkages, coordination, and resources. One of the important components of WHO strategy is the empowerment of the community through awareness and education. The development of anti-venom, availability and affordability of anti-venoms are also incorporated in the WHO strategy. [15,16]

Much before the World Health Assembly (WHA) resolution (2017) and WHO strategy (2019) to combat snakebite, Department of Health Research and ICMR-Tribal Health Research Forum funded an implementation research study on SBE in tribal block of Dahanu, Maharashtra. From 2013 onwards, ICMR initiated research programmes for a) generating evidence on the burden of snakebite and strengthening surveillance, prevention, treatment programme; b) training of healthcare workers on the prevention, diagnosis and treatment of SBE as per national snakebite protocol; c) supporting research on snakebite envenoming, particularly implementation research and d) promoting community awareness of snakebite envenoming, through culturally appropriate IECs and encouraging community participation in increasing awareness and prevention efforts in India.

ICMR National Task Force on snakebite research

ICMR had set up a Task Force on Venom Research in 2014 and which accomplished six projects under the Division of Basic Medical sciences (BMS). This Task Force was reconstituted as "ICMR-National Task Force for Research on Snake Bite in India" in August 2019 to look into the following focus areas for research:

1. Prevalence study including mapping of hotspots of Snake Bite in India, type of snake involved, outcomes, and risk factors.

2. Prevention of Snake Bite and its mortality and morbidity

3. Provision of Anti-venom, essential drugs and facilities at PHCs

4. Health system strengthening through training of doctors and paramedics of PHCs and CHCs on Standard Treatment Guidelines for the Management of Snake Bite, MoHFW (2016) and National Snakebite Management Protocol (India), 2009.

5. Basic and translational research on Snake Venom

6. Development of diagnostics and therapeutics of snakebite

The ICMR National Task Force (NTF) recommended two national projects on snakebite. These snakebite research projects were included in the priority research areas under Honorable Prime Ministers vision 2022 and thereafter.

1. Nationwide Study to estimate incidence, mortality, morbidity and economic burden due to snakebite in India.

This project is being conducted covering 14 states, 39 districts, and 372 blocks covering nearly 7% of Indian population. This study is expected to generate comprehensive epidemiological data and evidence on the actual burden on health and socio-economic fallout due to snakebites and also gaps in the health system in the timely referral and management of venomous snakebites. It is also expected to generate information on hotspot of venomous snakebites and bites by different species. [17]

2. ICMR National Snakebite Project (INSP) on capacity building of health system on prevention and management of snakebite envenomation including its complications

The ICMR National Snakebite Project (INSP) was carried out in Shahapur block of Thane district in Maharashtra, Aheri block of Gadchiroli district in Maharashtra, Khordha block of the Khordha district in Odisha and Kasipur block of the Rayagada district in Odisha. The study will be useful for providing inputs for National Snakebite Management Protocol relevant to public health system taking into consideration regional differences in India. The two-year implementation research involves collection of retrospective data collection, community focus group discussions, facility check survey, training of doctors, interviews of frontline healthcare workers, development of comprehensive culturally appropriate IEC material in local languages, capacity building of public health care system.[1] The outcome of the study will be reduction in case fatality rate due to SBE in study areas. The study will empower the community and health system for prevention and improved management of snakebites in selected regions in India. The results of the study will be crucial for establishing centres of excellence for snakebite management.

IEC materials & technical support to state governments

SBE often affects people living in rural and tribal areas mainly engaged in hunting, farming and other agricultural activities. [15] Majority of the snakebite victims visit the traditional faith healers, tantrics. Therefore, providing education to the community is very important so that there is a change in health seeking behaviour of the community. Most of these deaths are preventable and therefore conducting community awareness programmes on prevention and first aid and treatment of snakebite is extremely important. Simple, cost effective preventive measures can prevent a snakebite. We developed the culturally appropriate educational and awareness materials in regional languages through the INSP project, and these educational and awareness materials will be useful for the states having high burden of snakebites in India. Flow chart on the management of snakebite at PHC and CHC was developed by the expert group of ICMR NTF study. Snakebite information brochures for community are developed. IEC posters on knowledge, prevention, and first aid of snakebite are developed. Training manuals covering information on venomous and non-venomous snakes, prevention, first aid, treatment of SBE etc. are developed for ASHAs, ANMs, MPWs and other healthcare workers. The training booklet of health care workers, MO flow chart, snake identification chart, snakebite awareness posters and snakebite brochures are available online.

ICMR-NIRRCH is providing technical support on snakebite management training for Maharashtra and Odisha states through the ICMR National task force study. Training of ASHAs on prevention and, first aid of SBE was conducted nationwide through the ICMR NTF

study. Majority of the medical officers in PHCs and CHCs do not have confidence and experience of ASVs administration as a result, the snakebite patients are not managed at PHC and CHCs and are referred to higher centres leading to delay in ASV administration and death of snakebite patients during transportation. The community empowerment through culturally appropriate IECs, capacity building of health system and implementation of Standard Treatment Guidelines (STG, 2017) for snakebite treatment will help in improving the outcomes with reduction in deaths due to snakebite in India.

Snakebite research to Policy and National programme

The results of the MRHRU Dahanu study were published in national and international journals. Based on the publications, a policy brief was prepared to highlight the policy issues that need urgent attention by the state, central government and ASV manufactures. This policy brief was released by Dr Harsh Vardhan, the then Honourable Union Health Minister, Government of India on 20thFebruary 2020 at Mumbai. An Earlier study conducted through MRHRU Dahanu revealed the unnecessary practice of ASV intradermal test being carried out by Medical Officers[9,11] and also that the ASV manufacturers recommended this practice in their ASV vial inserts. [13] This issue was brought to light of the Public Health Department, Government of Maharashtra and Managing Director Haffkine Biopharma, Mumbai. The copy of the policy brief was sent to the ASV manufacturers and other relevant stakeholders. An article was published to discuss issues responsible for high mortality and morbidity due to SBE and the article also provided policy recommendations for improving quality of venom and anti-snake venom, prevention of SBE etc. [8]

To further develop strategies to counter the rising burden of snakebites in India, authors (RG and JC) along with other experts were invited for a policy talk by the NITI Aayog on 19th May 2022. We outlined the need to develop a national programme for snakebite management in India that should not only encompass all the proved components of snakebite prevention and management but also take in to account all the regional variations across the high burden states and most affected populations in India. To deal with the underreporting of cases at health facilities, we advocated for notification of snakebite cases and deaths in India and strengthening of the Standard Treatment Guidelines (STG, 2017) for snakebite management issued by the Government of India.

The national consultation meeting of all stakeholders was organized at New Delhi, India in August 2022. During the meeting, it was decided to launch a national programme for prevention and control of snakebite envenomation. [18] Based on our experience, we provided a detailed guidance on components of national programme for prevention and control of snakebite envenomation in India. [19] The National Consultation meeting was organised by National centre for Disease Control (NCDC) in July 2022 for drafting a National Action plan for Prevention and Control of Snakebite Envenoming (NAP-SE). Subsequently, a National conclave was organised in October 2023 for endorsement of NAP-SE by various stakeholders. For effective implementation of the NAP-SE, a strong commitment and coordination is required at different levels specifically NCDC, Ministry of Health and Family Welfare, Government of India, Department of Health Research, Indian Council of Medical Research, NITI Aayog, and State Health Authorities all over India. Through the combined efforts of various stakeholders including ICMR, NCDC, MOHFW, WHO, the mortality and morbidity due to SBE can be reduced as per the WHO goal of 2030.

Acknowledgment

Dr V M Katoch, Dr Balram Bhargava, Dr Soumya Swaminathan, Dr Rajiv Bahl, Dr R S Dhaliwal, Dr Smita Mahale, Dr Geetanjali Sachdeva, Dr Himmatrao Bawaskar, Dr Hrishikesh Munshi and members of ICMR National Task Force on snakebite are sincerely acknowledged.

Conflicts of Interest

No conflicts to declare.

References

1. Gajbhiye RK, Chaaithanya IK, Munshi H, Prusty RK, Mahapatra A, Palo SK, et al. National snakebite project on capacity building of health system on prevention and management of snakebite envenoming including its complications in selected districts of Maharashtra and Odisha in India: A study protocol. PLoS ONE 2023; 18: e0281809.

2. Gutiérrez JM, Calvete JJ, Habib AG, Harrison RA, Williams DJ, Warrell DA. Snakebite envenoming. Nat Rev Dis Primers 2017; 3: 17063.

3. Chaaithanya IK, Abnave D, Bawaskar H, Pachalkar U, Tarukar S, Salvi N, et al. Perceptions, awareness on snakebite envenoming among the tribal community and health care providers of Dahanu block, Palghar District in Maharashtra, India. PLoS One 2021; 16: e0255657.

4. Mohapatra B, Warrell DA, Suraweera W, Bhatia P, Dhingra N, Jotkar RM, et al. Snakebite Mortality in India: A Nationally Representative Mortality Survey. PLOS Neglected Tropical Diseases 2011; 5: e1018.

5. Majumder D, Sinha A, Bhattacharya SK, Ram R, Dasgupta U, Ram A. Epidemiological profile of snake bite in south 24 Parganas district of West Bengal with focus on underreporting of snake bite deaths. Indian J Public Health 2014; 58: 17–21.

6. Roberts NLS, Johnson EK, Zeng SM, Hamilton EB, Abdoli A, Alahdab F, et al. Global mortality of snakebite envenoming between 1990 and 2019. Nature Communications 2022; 13: 6160. [Available from: https://doi.org/10.1038/s41467-022-33627-9].

7. Suraweera W, Warrell D, Whitaker R, Menon G, Rodrigues R, Fu SH, et al. Trends in snakebite deaths in India from 2000 to 2019 in a nationally representative mortality study. Elife 2020; 9: e54076.

8. Chakma JK, Menon JC, Dhaliwal RS, Indian Council of Medical Research#. White paper on venomous snakebite in India. Indian J Med Res 2020; 152: 568–74.

9. Gajbhiye R, Khan S, Kokate P, Mashal I, Kharat S, Bodade S, et al. Incidence & management practices of snakebite: A retrospective study at Sub-District Hospital, Dahanu, Maharashtra, India. Indian J Med Res 2019; 150: 412–6.

10. National snakebite management protocol. India: Directorate General of Health Services, Ministry of Health & Family Welfare, Government of India. 2009. [Available from http://statehealthsocietybihar.org/nationalsnakebitemanagementprotocol.pdf, accessed on July 16, 2023].

11. Chaaithanya IK, Salvi N, Bhoye P, Bhorekar S, Yadav A, Mahale S, et al. Anti-snake Venom (ASV) Intradermal Skin Test, a Common Clinical Practice in the Primary Health Care Setting in Tribal Block of Dahanu, Maharashtra, India. J Assoc Physicians India 2020; 68: 87–

12. Standard Treatment Guidelines. Management of Snakebite. National Health Systems Resource centre; 2017. [Available from: https://nhsrcindia.org/sites/default/files/2021-05/Management%20of%20Snake%20Bite.pdf, accessed on July 16, 2023].

13. Gajbhiye R, HimmatraoBawaskar, Yadav A, Mahale S. A Model for addressing burden of Snakebites in rural areas through Health System Capacity building. Policy brief, 2020. [Availablefrom:https://nirrh.res.in/wp-content/uploads/2021/08/Snakebite-Dr-R-Gajbhiye.pdf, accessed on July 16, 2023].

14. Burki T. Resolution on snakebite envenoming adopted at the WHA. Lancet 2018; 391: 2311.

15. Lancet T. Snakebite—emerging from the shadows of neglect. The Lancet 2019; 393: 2175.

16. Minghui R, Malecela MN, Cooke E, Abela-Ridder B. WHO's Snakebite Envenoming Strategy for prevention and control. The Lancet Global Health 2019; 7: e837–8.

17. Menon JC, Bharti OK, Dhaliwal RS, John D, Menon GR, Grover A, et al. ICMR task force project-survey of the incidence, mortality, morbidity and socio-economic burden of snakebite in India: A study protocol. Soto-Blanco B, editor. PLoS ONE 2022; 17: e0270735.

18. Dr Mansukh Mandaviya chairs 7th meeting of Mission Steering Group for NHM. Press Information Bureau. New Delhi; 2022. [Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1857490, accessed on July 16, 2023].

19. Gajbhiye R, Munshi H, Bawaskar H. National programme for prevention & control of snakebite in India: Key challenges & recommendations. Indian J Med Res 2023; 0: 0.

Prevention & Control of Leptospirosis in India: Human Health Initiatives

Dipti Mishra[1], Aastha Singh[1], Ajit Dadaji Shewale[1], Simmi Tiwari[1]* & Tushar Nale[1]

[1] National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr. Simmi Tiwari
Joint Director & Head, Centre For One Health
National Centre for Disease Control (NCDC)
simmi.phs14@gmail.com

Abstract

Leptospirosis is a zoonotic bacterial infection caused by Leptospira, with 10 pathogenic species and 250 serovars. It is prevalent in tropical and sub-tropical regions, especially in areas with heavy rainfall or poor sanitation. Transmission occurs through contact with urine of infected animals like rodents, dogs, and livestock. Symptoms range from mild (headaches, muscle pain, fever) to severe (lung bleeding, meningitis). Environmental factors and occupational risks increase susceptibility. Annually, leptospirosis affects over 1 million people globally, causing around 60,000 deaths. In India, it is under-reported, with significant outbreaks in coastal regions. National Leptospirosis Control Programme has been established to strengthen surveillance and laboratory support.

Keywords: Leptospirosis, Prevention, Zoonotic

Background

Leptospirosis is an important zoonotic bacterial infection caused by the bacteria spirochete of the genus Leptospira. There are 10 pathogenic species with approximately 250 pathogenic serovars.(1) The disease occurs worldwide and the majority of the cases are reported from tropical and sub-tropical weather conditions. Usually, the outbreaks of leptospirosis are inclined to occur in endemic areas where there is a heavy rainfall or areas with flooding, especially affecting the zones with substandard housing and poor sanitation conditions.(2) The spread of leptospirosis infection is through animal urine or soil and water contaminated by animal urine. The disease can spread through direct contact with urine or tissue of infected animals (through skin abrasions, intact mucous membrane etc), indirect contact (broken skin with infected soil, water, or vegetation ingestion of contaminated food and water), and droplet infection (inhalation of a droplet of infected urine). The agents responsible for spreading this disease are rodents, dogs, wild animals and domestic animals. Signs and symptoms can range from none to mild (headaches, muscle pains, and fevers) to severe (bleeding in the lungs or meningitis).(3)

Environmental factors such as heavy rainfall, pH of soil and occupational risks to farmers working in agriculture lands, sanitary workers and animal health care workers, handlers, and veterinarians are at higher risk of being affected by Leptospirosis.(4)

Burden of Disease

A. Globally: It is estimated annually more than 10 lakh cases are being reported with almost 60,000 deaths per year.(5) The annual incidence for leptospirosis in South East Asia region is estimated to be approximately 2.7 Lakhs with 14,000 deaths. The incidence of leptospirosis in developing countries is 10-100/1,00,000 cases per year.(6) According to the study, roughly 290 million disability adjusted life years are lost globally each year (UIs 125–454 million) from approximately 103 million cases recorded in a year. The study also estimated that the highest burden for leptospirosis was found in tropical regions such as South and South east Asia, Western Pacific, Central and South America, and Africa.(6)

B.In India: India has one of the most important coastal, agro-ecosystems in the world, with an 8,129-kilometre coastline and abundant natural resources. India has one of the highest humans and domestic animal population with close interaction between them which is responsible for emergence of Zoonotic diseases.(7) Many new zoonotic diseases have emerged as a result of rapid ecological changes in the area over the last decade, resulting in epidemics that have caused considerable morbidity and mortality in humans. One of them is leptospirosis.

The distribution and occurrence rate of leptospirosis have changed in direct relation to changes in the eco-system. Wasteland reclamation, afforestation, irrigation, crop reforms, and agricultural technology have all played a role. The areas that would have stayed free of the infection have become potentially endemic zones as a result of man-

made or natural changes.[8] As per the estimate, India is expected to report 0.1-1.0 million cases per year [5], but less than 10,000 cases are reported.[9] Only four states i.e., Kerala, Gujarat, Tamil Nadu and Maharashtra report more than 500 cases per year as per IDSP Disease Alert. Andaman, Andhra Pradesh, Assam, Goa, Delhi, Karnataka, Odisha, Puducherry and Uttar Pradesh also report cases. Due to a lack of awareness of the disease and a lack of suitable laboratory diagnostic capabilities in most regions of the country, leptospirosis has been under-reported and under-diagnosed in India.[10]

Current Scenario

A. Leptospirosis Cases in India: Currently the leptospirosis cases are reported through IDSP programme as suspected case (By health centre), probable case (Medical Officers) and confirmed case (laboratory) during 12th Five Year Plan. To address the rising burden of the disease government of India launched the Programme for Prevention and Control of Leptospirosis (PPCL) as Central Sector Scheme under the Umbrella of NHM. Lately the confirmed cases are reported in 22 out of 36 states and UTs. Leptospirosis outbreaks were reported only in Coastal areas. However, with advancement of laboratory facilities cases are being reported from other areas too. The outbreaks of leptospirosis have been reported from coastal districts of Gujarat, Maharashtra, Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Andamans& Nicobar, Dadar & Nagar Haveli, Daman & Diu & Puducherry from time to time. In addition, the cases have been reported from Goa and Odisha. The high burden of disease has been reported from Andaman & Nicobar, Gujarat (4 districts affected) Kerala (14 districts affected), Maharashtra (4 districts and Mumbai city affected), Karnataka (9 districts affected) and Tamil Nadu (2 districts and Chennai city affected).[11]

Leptospirosis is also being reported from non-endemic states wherever facility for diagnosis of such cases exists. During last 5-year (2015-20) total 21046 laboratory confirmed cases and 291 deaths reported from affected states along with 57 outbreaks till 2020 with Case Fatality Rate in endemic states ranges from 0% to 7% over the years. Total of 114 Districts (10 States) are affected in India since 2017. On an average 4753 cases are reported every year for leptospirosis and with average of 83 deaths.

Heavy rains and floods in India have resulted in massive outbreaks. According to a study done in Kerala, the increase in leptospirosis infections coincides with the rainy season. The study reported that leptospirosis has a seasonal trend and with high incidence from June to October and correlates with the meteorological changes like rainfall, temperature, humidity etc in the region.[12] In tropical, subtropical, and temperate climates, leptospirosis can be present in both urban and rural areas. Massive outbreaks are caused by heavy rains and floods. Leptospirosis cases are directly proportional to rainfall, rendering it a seasonal disease in temperate climates and a year-round disease in tropical climates.[13,14] There is an increase in cases during summer and monsoon and rainy season (June to September).[15] This relationship has been also found in the study conducted in Philippines[16], Maharashtra,[13] Kerala .[17]

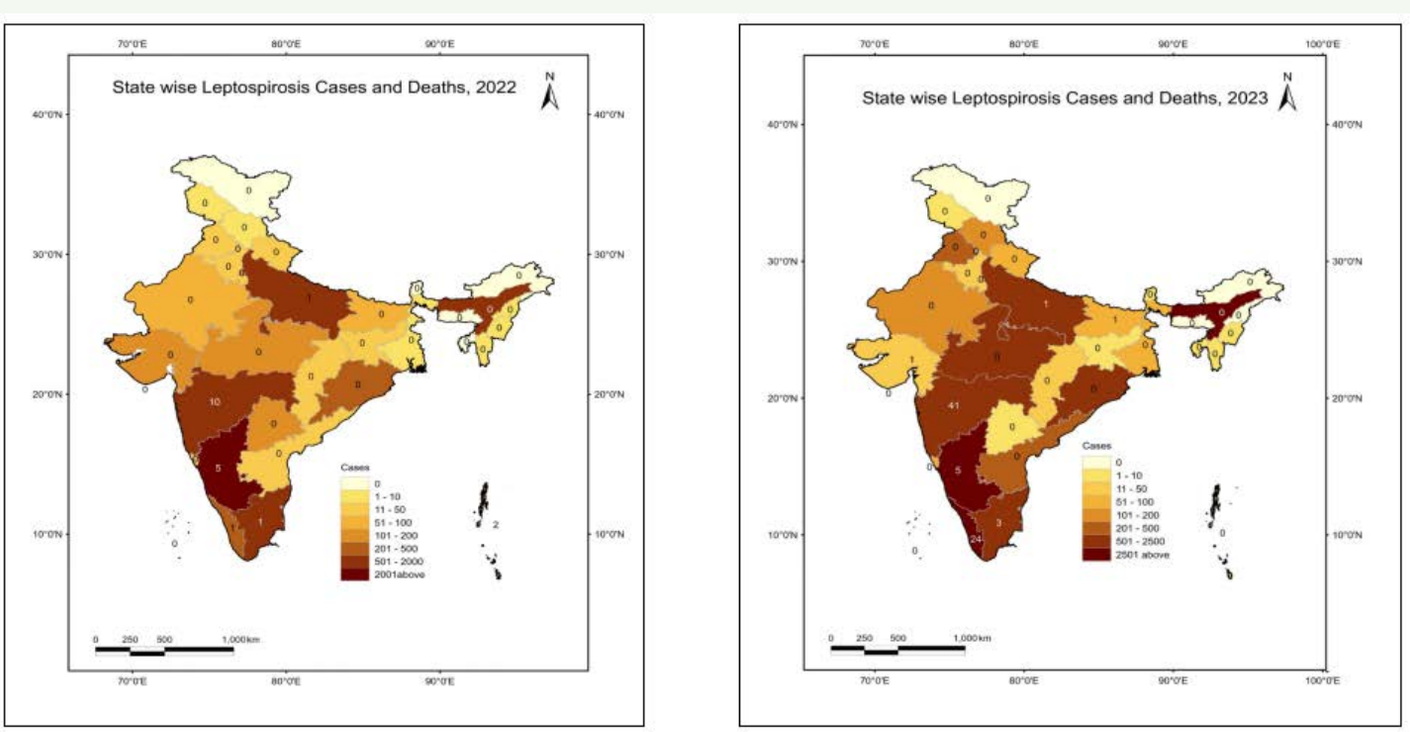


Figure 1: State wise Leptospirosis cases and deaths in 2022 and 2023

The prevalence of human leptospirosis has been documented in numerous states and UTs, intermittently or as epidemics, particularly during the rainy season in India. As a result, a public health programme for its prevention and control was required as part of the development of a comprehensive strategy for the control of all major infectious zoonotic diseases.

Programme for Prevention and Control of Leptospirosis

The objective to establish this Programme was to strengthen the disease surveillance and laboratory support so that the burden of disease must be monitored before and after intervention for control. National Centre for Disease Control has been designated as the Nodal agency for the implementation of the programme. Programme was implemented in the endemic states viz. Gujarat, Kerala, Tamil Nadu, Maharashtra, Karnataka and UT of Andaman &Nicobar Islands. Based on epidemiological analysis of IDSP data it was evident that cases are being regularly reported from States such as Uttar Pradesh, Assam, Goa and UTs of Dadra Nagar Haveli, Daman & Diu other than Programme states which were identified during 12th Five-Year Plan. Hence, Programme was expanded to include other 3 States and 1 UT. Currently the Programme is being implemented in 14 States/UTs (12 States and 2 UTs) in total 181 district.

Institutional Mechanism for programme implementation:
At Centre: The nodal ministry for the programme will be the Ministry of Health and Family Welfare. It is proposed to use the current NHM's mechanism of MSG & EPC for policy decisions. An existing National Technical Advisory Committee under the chairpersonship of DGHS to advise on all technical aspects of the programme.

The role of NCDC is to act as Coordinating Agency for implementation of Programme in the endemic states, release of funds to the programme states, training of core trainers – medical, paramedical and laboratory personnel, development of prototype IEC material, strengthening of diagnostic components, establishing inter laboratory quality control, monitoring and evaluation and periodic meetings to review the programme.

At State & district: The programme shall be implemented through the State Health Society. District Health Society will be the overall implementing agency for the implementation of the programme at the district level.

Following are the key strategies under the Programme:

A. Capacity Building - Trainings of health care professionals on case management, diagnosis, prevention, and control of Leptospirosis.

B. Strengthening of Surveillance activities for Leptospirosis-Leptospirosis surveillance is the key strategy for early detection and management of leptospirosis cases. It involves the collection of essential data to determine the leptospirosis situation, to monitor and evaluate the progress and impact of the intervention, to manage potential human exposures adequately, to calculate the cost-effectiveness of control efforts and to demonstrate absence and freedom of disease in a given area. The standard case definitions for leptospirosis surveillance through IDSP have been formulated.

C. Laboratory Strengthening for diagnosis of Leptospirosis in Humans- Diagnosis of Leptospirosis is vital for initiating prompt and appropriate infection control and public health measures. Early diagnosis can obviate the need for unnecessary treatment, medical tests. The programme provides financial support for the procurement of equipment and consumables to institutes which serve as Regional Reference Centre for Leptospirosis. Government Medical College Surat is being strengthened as Regional Leptospirosis Diagnostic Laboratory. The programme has also been successful in the creating diagnostics facilities/labs for confirmation of disease for rational treatment in endemic districts.

D. Advocacy for strengthening of patient management facilities- National Guidelines for Diagnosis, Case Management Prevention and Control of Leptospirosis (Year 2015) have been published under the programme and disseminated to States. In addition, detailed operational guidelines for ensuring implementation of prevention and control of leptospirosis also been circulated to States. Advisory has been issued from NCDC to States from time to time to undertake preventive measures, especially during monsoon season and flood events. States have also been provided guidelines on measures to be taken for chemoprophylaxis during outbreaks. States/UTs are also advocated through regular review meetings, field visits and through monitoring of programme to strengthen the patient management facilities especially for complicated cases of Leptospirosis as ICU facilities with ventilator support, dialysis etc.

E. Strengthening inter-sectoral coordination at State and district level for outbreak detection, prevention, and control of Leptospirosis-States are being advocated to undertake rodent control measures though State/municipal rodent control departments in endemic areas during each year before onset of monsoon in coordination with health department. Rodent control is part of intersectoral coordination and strategies for its

implementation lies with concerned stakeholders as mentioned in the guidelines. As on date approximately all states and UTs have formulated a state level zoonotic committee which has a member from Ministry of agriculture, veterinary institutes like IVRI, ICMR, CRI Kasauli, Wildlife Institute of India, etc. These state level zoonosis committees are entrusted to identify areas of collaboration with stakeholder's relation to zoonotic diseases, to oversee and monitor activities of joint technical working group and district level zoonoses committee, to issue guidelines and/or notifications as necessary on prevention and control strategies for zoonotic diseases etc.

F. IEC activities- To create awareness in general community for timely detection and appropriate treatment of patients it is proposed to create IEC prototypes (Audio & Video spots, pamphlet, poster etc.) and disseminate it through print and electronic media for wider dissemination. The IEC can be accessed on this link: https://ncdc.mohfw.gov.in/iec-material-on-zoonotic-disease/

Achievements under the Programme

The programme has made significant qualitative achievements such as:

A. Reporting of suspected and laboratory confirmed cases have increased over the years due to improved reporting mechanism, sensitization of officials and improved diagnostic capacity while case fatality rate has shown declining trend in the programme States and is under 15 % as per accepted standard (currently ranging from,0-7%).

B. State officials have now been sensitized to allocate the budget for Leptospirosis.

C. Health departments at state and district level have been advocated to collaborate with veterinary and agriculture department for rodent control and animal vaccination.

D. Technical support to states in terms of Guidelines for diagnosis case management prevention and control of Leptospirosis and Operational Guidelines, Prototype IEC material has been provided. Advisory is issued to States with heavy rain or flood affected areas and review meeting for sensitization and training of master trainers are carried out.

E. Prototype IEC material & Audio spots developed and disseminated to States.

F. Reporting formats finalized and aligned with the IHIP portal for improving real-time surveillance of Leptospirosis and Network of trained laboratory professionals has been created.

G. The programme states are given financial support through NHM PIP mechanism for activities like training, monitoring and surveillance, procurement of consumables and kits for diagnostic activities. The programme also supports financially in procurement of medicines as prophylaxis to control the infection.

H. As on date, all programme state has adequate stock of Doxycycline medicine.

Challenges Under the Programme

The programme had identified challenges such as large variety of serovars are circulating in animals, lack of trained manpower for diagnosis, inadequate coordination between the animal health and human health sectors, fragmented approach for leptospirosis control. Capacity Building- Training to laboratory staff, health workers, doctors need to be further strengthened in high endemic states. Intersectoral coordination between Animal Husbandry Department/Veterinary Department with the health department need to be strengthened. A central guideline for such collaboration needs to be evolved.

Conclusion

Leptospirosis is a disease with a high case fatality rate to the extent of 10 to 70% if left untreated. However, the mortality is preventable if detected and treated early with judicious use of chemoprophylaxis. There is an under reporting in the cases of leptospirosis in India and efforts are being undertaken to reduce this gap. As funds are being provided to the states from the financial year 2019-20, reporting is expected to improve over the next 2-3 years. Joint initiative of medical and veterinary department for outbreak prevention, risk mitigation, demarcation of high-risk spots is planned to further strengthening the Programme. The Programme is planning to conduct Reassessment of Endemicity of the states with respect to Leptospirosis and restructuring of the Programme by reprioritization of states based on endemicity of the states. It was also recommended by the NTAC- Meeting that Leptospirosis programme must be expanded in other States & UTs which are regularly reporting the Leptospirosis cases and these States and UTs will be supported through NHM. Intensive IEC and training of health care professionals needs to impart in all States. Emphasis needs to be given for early diagnosis, standard case management in Programme States.

In conclusion, Preventive efforts should be strengthened by using a multidisciplinary strategy that considers environmental factors as well as animal and human populations in order to limit the number of cases of

leptospirosis. Protective clothing and knowledge of climate-related drivers (floods, rainfalls) may help to limit the number of human cases. All precautions should be taken to protect individuals who are at risk. Early detection and treatment may help to lessen the severity of the condition as well as the number of hospitalizations and expenditures connected with them.

Acknowledgment

We would like to acknowledge NCDC for constant support.

Financial support & Sponsorship

None

Conflicts of Interest

No conflict of interest.

References

1. CDC. Resources | Leptospirosis | CDC [Internet]. 2018 [cited 2021 May 11].Available from: https://www.cdc.gov/leptospirosis/resources/index.html.

2. Pereira MM, Schneider MC, Munoz-Zanzi C, Costa F, Benschop J, Hartskeerl R, et al. A road map for leptospirosis research and health policies based on country needs in Latin America. Rev Panam Salud Pública [Internet]. 2017 Oct 24 [cited 2021 May 11];41. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6645167/.

3. Haake DA, Levett PN. Leptospirosis in Humans. Curr Top Microbiol Immunol [Internet]. 2015 [cited 2021 Jun 15];387:65–97. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4442676/.

4. Lane AB, Dore MM. Leptospirosis: A clinical review of evidence-based diagnosis, treatment, and prevention. World J Clin Infect Dis [Internet]. 2016 Nov 25 [cited 2021 May 11];6(4):61–6. Available from https://www.wjgnet.com/2220-3176/full/v6/i4/61.html.

5. Costa F, Hagan JE, Calcagno J, Kane M, Torgerson P, Martinez-Silveira MS, et al. Global Morbidity and Mortality of Leptospirosis: A Systematic Review. Small PLC, editor. PLoS Negl Trop Dis [Internet]. 2015 Sep 17 [cited 2021 May 11];9(9):e0003898. Available from: https://dx.plos.org/10.1371/journal.pntd.0003898.

6. Torgerson PR, Hagan JE, Costa F, Calcagno J, Kane M, Martinez-Silveira MS, et al. Global Burden of Leptospirosis: Estimated in Terms of Disability Adjusted Life Years. Small PLC, editor. PLoS Negl Trop Dis [Internet]. 2015 Oct 2 [cited 2021 May 11];9(10):e0004122. Available from: https://dx.plos.org/10.1371/journal.pntd.0004122.

7. Origin NRC (US) C on ASGC for S and R to ED of Z, Keusch GT, Pappaioanou M, Gonzalez MC, Scott KA, Tsai P. Drivers of Zoonotic Diseases [Internet]. Sustaining Global Surveillance and Response to Emerging Zoonotic Diseases. National Academies Press (US); 2009 [cited 2021 Jun 15]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK215318/.

8. NCDC. National Guidelines Diagnosis, Case Management Prevention and Control of Leptospirosis [Internet]. National Centre for Disease Control, Delhi; 2015 [cited 2021 May 25]. Available from: https://ncdc.gov.in/WriteReadData/l892s/File558.pdf.

9. Disease Alert:: Integrated Disease Surveillance Programme(IDSP) [Internet]. [cited 2021 May 25]. Available from: https://idsp.nic.in/index4.php?lang=1&level=0&linkid=427&lid=3780.

10. Holla R, Darshan B, Pandey L, Unnikrishnan B, Kumar N, Thapar R, et al. Leptospirosis in Coastal South India: A Facility-Based Study. BioMed Res Int [Internet]. 2018 May 15 [cited 2021 Jun 15];2018:e1759125. Available from: https://www.hindawi.com/journals/bmri/2018/1759125/.

11. NCDC. Programme for Prevention and Control of Leptospirosis:: National Centre for Disease Control (NCDC) [Internet]. [cited 2021 May 25]. Available from: https://www.ncdc.gov.in/index1.php?lang=1&level=1&sublinkid=147&lid=151.

12. Premdas AK, Areekal B, Sukumaran ST, Raj Kunnumel Kandi A. Trend of leptospirosis and its association with meteorological factors in Thrissur district, Kerala. Int J Community Med Public Health [Internet]. 2019 Oct 24 [cited 2021 Jun 15];6(11):4857. Available from: https://www.ijcmph.com/index.php/ijcmph/article/view/5405.

13. Pawar S, Kore M, Athalye A, Thombre P. Seasonality of leptospirosis and its association with rainfall and humidity in Ratnagiri, Maharashtra. Int J Health Allied Sci [Internet]. 2018 [cited 2021 Jun 10];7(1):37. Available from:

http://www.ijhas.in/text.asp?2018/7/1/37/226260.
14. Banukumar S. Study on Incidence of Leptospirosis by Serodiagnosis in Rural Population in the District of Kanchipuram, Tamilnadu, India. 2016;8(3):4.

15. Disease Alert 2020 :: Integrated Disease Surveillance Programme(IDSP) [Internet]. [cited 2021 Jun 10]. Available from: https://idsp.nic.in/index1.php?lang=1&level=1&sublinkid=7042&lid=5013.

16. Matsushita N, Ng CFS, Kim Y, Suzuki M, Saito N, Ariyoshi K, et al. The non-linear and lagged short-term relationship between rainfall and leptospirosis and the intermediate role of floods in the Philippines. PLoS Negl Trop Dis [Internet]. 2018 Apr 16 [cited 2021 Jun 15];12(4). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5919665/.

17. Pappachan M, Sheela M, Aravindan K. Relation of rainfall pattern and epidemic leptospirosis in the Indian state of Kerala. J Epidemiol Community Health [Internet]. 2004 Dec [cited 2021 Jun 15];58(12):1054. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1732650/.

Plan for FEP Training in One Health

Dr Meera Dhuria[1]*, Dr Priyanka Kundra, Dr Shaileja Yadav, Dr Bhavesh, Dr Anamika Sahu, Dr Dhanalaxmi

[1] National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr. Meera Dhuria
Joint Director and Head, Public Health Preparedness & NCD
National Centre for Disease Control (NCDC)
E-mail IDs: meera.dhuria@gov.in, headncd@gmail.com

Abstract

The National Centre for Disease Control (NCDC) is launching "Sector Connect," a training programme to address health challenges from human-animal-ecosystem interactions. With increasing zoonotic diseases, antimicrobial resistance, and vector-borne diseases, the One Health Approach, emphasizing multidisciplinary collaboration, is crucial. NCDC aims to build a resilient public health workforce through in-service capacity-building programmes for professionals in public health, animal health, and related sectors. The programme includes the FEP-OH Short Course and FEP-OH Fellowship, focusing on practical learning and mentorship. Sector Connect aims to enhance inter-sectoral coordination, epidemiological skills, and evidence-based decision-making.

Keywords: FEP Training, One Health, Sector Connect

Introduction

The National Centre for Disease Control (NCDC) is launching a new training programme called "Sector Connect" to address the complex health challenges arising from the interactions between humans, animals, and ecosystems. With rapidly evolving human habitation and production systems, the spillover of pathogens from animals to humans has increased, leading to a rise in zoonotic diseases and along with emerging infections. Additionally, challenges like antimicrobial resistance, vector-borne diseases, and chemical exposures are also on the rise, impacting health of humans and animals.

The concept of the One Health Approach, which emphasizes on multidisciplinary collaboration, data sharing, and coordination among various stakeholders, has gained significant importance in addressing these health challenges. To build a resilient public health workforce, it is crucial to adopt the One Health approach, involving health agencies, veterinarians, environmental scientists, policymakers, and community representatives, to assess, prevent, and respond to health threats in a coordinated manner.

Building on the lessons learnt from the 3x3 Frontline Field Epidemiology training, NCDC plans to implement the concept of one health training at the field level by initiating in-service capacity- building programme for professionals working in the area of public health, animal health, wildlife, forest, agriculture, food safety and others at state, and district level. The 3x3 Frontline FEP Training model has demonstrated a high level of acceptability of a mentored field activity-based training programme both among the participants and the leadership at the state level. We believe that such training programme also provide and an opportunity to connect with colleagues from other sectors, allowing a better exchange of information with other stakeholders when required. NCDC plans to launch the following trainings under the Sector Connect training progamme -

a. FEP - OH Short Course: This three-month on-the-job field epidemiology training in One Health is targeted for mid-career district and state-level officers working as epidemiologists, veterinarians, microbiologists, wildlife experts, environmental experts and those working in the agriculture sector.

b. FEP - OH Fellowship: This 12-month fellowship course in One Health Field Epidemiology is an advanced programme for professionals seeking a deeper understanding of One Health principles and competencies.

Sector Connect Training Programmes

Goal

The goal of Sector Connect training is to build a network and capacity of professionals across the human, animal, agriculture and environmental health sectors, enabling an integrated response at the field level.

Objectives

The training programme aims to achieve the following objectives:

- Strengthen the system's capacity to respond to public health threats through a multi-sectoral collaborative approach.
- Enhance inter-sectoral coordination and cross-learning.
- Improve epidemiological skills for joint risk assessment and outbreak investigation among officers at the state and district level.

- Enable sharing of information across sectors for early identification and response to health threats.
- Enhance skills for evidence-based decision-making, effective communication, and transformational leadership.
- Build a sustainable network of trained professionals across sectors for continued collaborative efforts to address public health issues.

Mentorship

Mentorship is a key component of the training programme. The trainees will be mentored by experienced professionals from medical and veterinary colleges. The mentors will guide the field assignments and presentations, providing support, clarifying concepts, and ensuring completion of weekly targets.

Sector Connect FEP - OH Short Course

The FEP - OH Short Course, total of 12 weeks duration, is predominantly based on practical learning with up to 90% of the time allotted for field assignments and 10% for classroom teaching during contact sessions. The schedule includes contact sessions and field assignments as follows:

SectorConnect FEP OH – Curriculum Development

The development of the SectorConnect FEP OH curriculum was a collaborative and iterative process, tailored to the Indian context through extensive

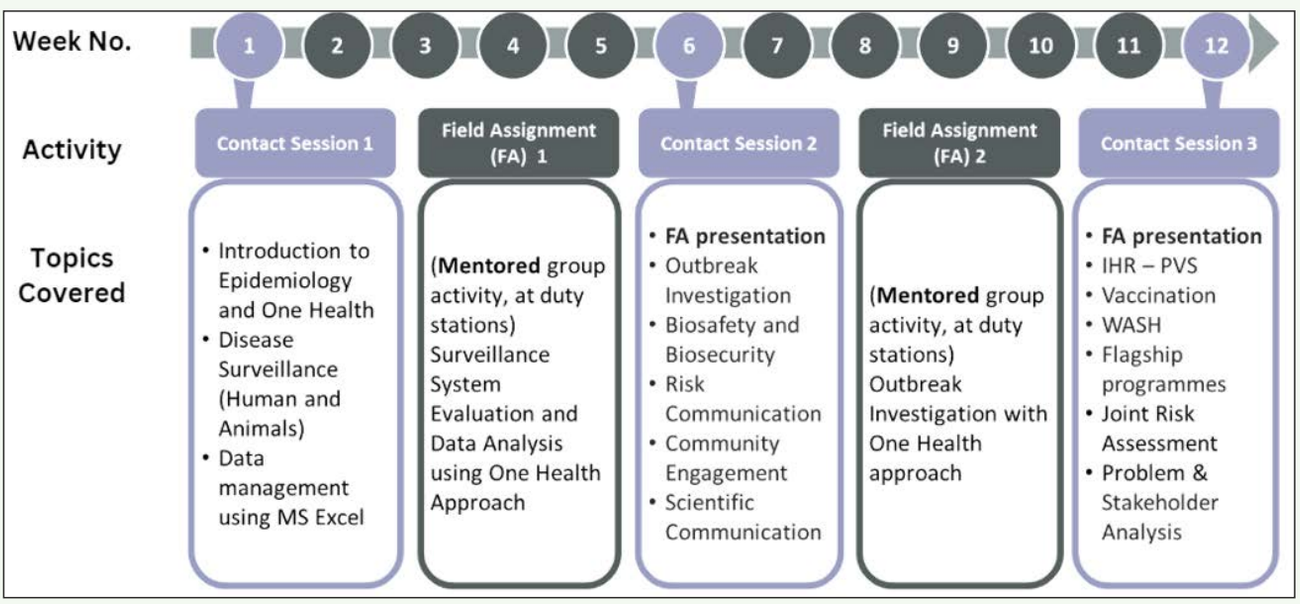


Figure 1: Sector Connect FEP OH overview

stakeholder engagement and strategic partnerships. Recognizing the need for a multi-sectoral perspective, the initiative brought together representatives from national and state institutions across public health, veterinary science, food safety, and international health. Key milestones included alignment with national job roles and international standards like the COHFE framework, coordination between DAHD and NCDC to avoid duplication, and leveraging existing resources through partnerships with CDC India and Quadripartite agencies. Challenges such as identifying appropriate participants and harmonizing diverse sectoral needs were addressed through structured engagement with experts from field, research, and academic backgrounds. Detailed reports of this journey are available on NCDC's website - https://ncdc.mohfw.gov.in/teaching-training/?tab=2

Targeted Learners and Eligibility

The Sector Connect programme is targeted at officers working at the state and district levels in public health, animal husbandry & dairying, FSSAI, wildlife, airport & seaport authority, veterinary & medical universities, water & sanitation, and other related departments.

Looking Ahead: SectorConnect Fellowship in One Health

The SectorConnect Fellowship in One Health is envisaged to be a one-year immersive fellowship for state-level officers. For the Fellowship, two national-level stakeholder consultations have been conducted for finalisation of the target audience, training material and curriculum. Currently, the modules for the training are under development.

Acknowledgment

We acknowledge NCDC for constant support.

Financial support & Sponsorship

None

Conflicts of Interest

No conflict of interest.

Marching towards Rabies free India: Challenges and way forward

Tushar Nanasaheb Nale[1]*, Dipti Mishra[1], Simmi Tiwari[1], Ajit Dadaji Shewale[1], Sowntappan Balasubramanian[1]

[1] National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr Tushar Nanasaheb Nale
Deputy Director, Centre For One Health
National Centre For Disease Control (NCDC)
drtusharphs@gmail.com

Abstract

Rabies presents a significant challenge as a zoonotic disease that transfers from animals to humans. In India, the country faces a heavy burden of human deaths resulting from rabies, with dog bites being responsible for more than 99% of fatalities. The region, particularly India, experiences a high number of deaths related to rabies and incurs a considerable economic toll. Numerous obstacles hinder effective rabies control in India, including limited availability of vaccines and immunoglobulin, insufficient epidemiological and laboratory surveillance, low community awareness, inadequate capacity building for healthcare professionals, and a lack of coordination across sectors.

To address these challenges and prevent human deaths caused by rabies, the National Rabies Control Programme (NRCP) was established. Initially piloted in five cities between 2008 and 2012, the programme demonstrated success, leading to its nationwide implementation. The programme's objectives encompass providing human rabies vaccines and immunoglobulins, enhancing surveillance of animal bites and human rabies cases, improving laboratory diagnosis, establishing model anti-rabies clinics, conducting awareness campaigns, and fostering intersectoral coordination. Adhering to a One Health approach, the NRCP aligns with the National Action Plan for Rabies Elimination (NAPRE), launched in September 2021.

The NAPRE encourages states to develop comprehensive action plans encompassing both human and animal health aspects. Funding for interventions related to human health is obtained through the National Health Mission, while animal health components explore various funding options. Implementation of the NAPRE aims to reduce the risk of rabies through mass dog vaccinations, pre and post-exposure prophylaxis, and public education, with the ultimate goal of achieving "Rabies-Zero by 2030." Effective execution of the NRCP and NAPRE is crucial to successfully combat rabies and safeguard public health in India.

Keywords: National Rabies Control Programme (NRCP), National Action Plan for Rabies Elimination (NAPRE), World Health Organization (WHO)

Background

Rabies, a zoonotic disease transmitted from animals to humans, has been recognized for centuries and presents a significant challenge in the context of One Health. The majority of human deaths caused by rabies are attributed to dog bites, accounting for over 99% of fatalities [(1)]. Annually, approximately 59,000 human deaths and a loss of 3.7 million DALYs (disability-adjusted life years) are associated with dog-mediated rabies, with Asia and Africa bearing the highest burden [(1)]. In Asia, India alone accounts for 59.9% of rabies deaths and 35% of global deaths, resulting in a substantial economic cost estimated at $8.6 billion. [(1)]

Rabies is endemic throughout India, except for the Andaman & Nicobar and Lakshadweep Islands, and human cases are reported nationwide throughout the year. According to WHO estimates, India contributes to 36% of global rabies deaths and 65% of human rabies deaths in the South East Asia region [(1)]. Dog bites are responsible for about 96% of the mortality and morbidity associated with rabies in India, with children being the most vulnerable group, constituting 40% of individuals exposed to dog bites in rabies-endemic areas.[(1)] Studies provide varying figures on the incidence of animal bites and deaths due to rabies in humans. The WHO-APCRI 2004 study estimated 17.4 million animal bites and 20,000 deaths per year in India [(2)], while the Million Deaths Study in 2012 reported an estimated 12,700 deaths due to furious rabies. [(3)]

Current Scenario

Incidence of Human Rabies Cases in India

Various reports and studies [(2)(3)(4)(5)] provide estimates of human rabies deaths in India. (Figure 1)

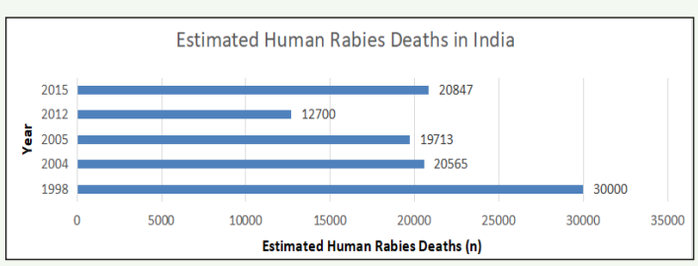


Figure 1: Trend of Estimated Human Rabies cases in India

The Central Bureau of Health Intelligence [(6)] has been monitoring human rabies cases, and the trend of reported deaths is illustrated in Figure 2 [(6)]

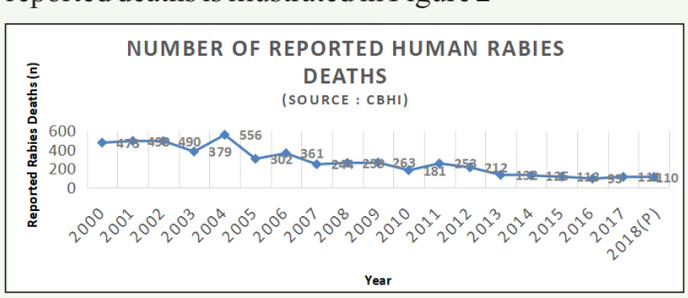


Figure 2: Human Rabies Deaths reported in India (Source: CBHI)

Mortality due to Human Rabies (Information from the National Rabies Control Programme)
The number of human deaths caused by rabies in India is tracked under the National Rabies Control Programme. Figure 3 shows the reported suspected human rabies cases for period 2018 to 2022.

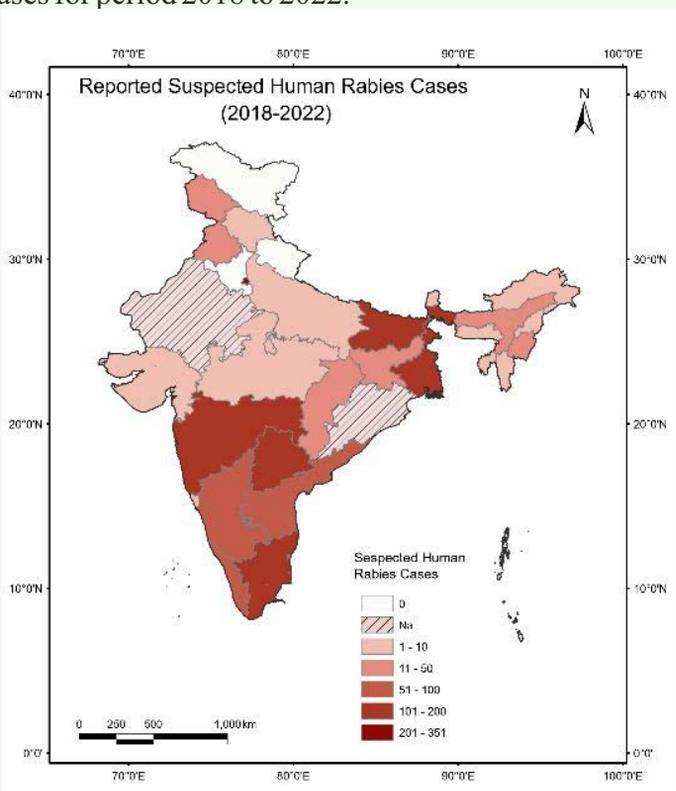


Figure 3 : Human Rabies Cases Reported under NRCP (Source: Programme Data)

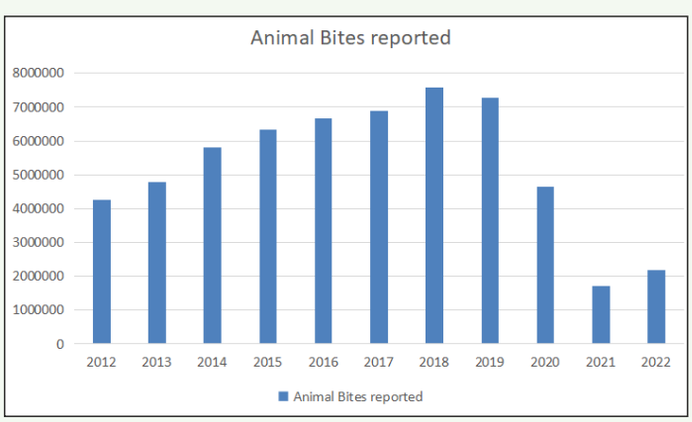


Figure 4 : Reported Animal Bite Incidents in India (Source: IDSP)

Under the Integrated Disease Surveillance Programme (IDSP), the number of reported animal bites has increased from 4.2 million in 2012 to 7.2 million in 2019 (Fig 4). These include bites from dogs, cats, monkeys, and other animals that require rabies post-exposure prophylaxis.

In 2023, a nationwide population-based assessment of burden of human rabies and animal bites was undertaken by National Institute of Epidemiology (NIE), Indian Council of Medical Research, Chennai. It estimated annual human rabies deaths using a decision-tree probability model with parameters from the community survey and laboratory data on rabies positivity among suspected rabid dogs.

1. Challenges in Rabies Control in India: Availability of Rabies Vaccine & Rabies Immunoglobulin: Ensuring the timely availability of rabies vaccine and immunoglobulin is crucial in preventing human rabies cases. However, the procurement, distribution, and availability of these biologicals vary significantly between states, as it is the responsibility of individual states. [8] Studies have indicated inadequate facilities for wound washing and a preference for the more expensive intramuscular route of vaccination instead of the cost-effective intradermal route. Stock-outs of vaccines and immunoglobulin have also been reported. Recently two rabies monoclonal antibodies have been produced in the private sector and available in the country and are under post-marketing surveillance (PMS).

2. Epidemiological Surveillance: There is a considerable gap between the actual number of human rabies cases and the estimated and reported cases in India. Due to the lack of effective medical treatment for clinical rabies and the severity of the disease, most rabies victims die at home rather than receiving hospital treatment. This underestimation of the health and economic impact of rabies hinders effective public health policymaking. Strengthening surveillance systems would provide a better understanding of the scale of the problem and the distribution of animal and human cases across different states in the country [9].

3. Laboratory Surveillance: Timely and accurate laboratory diagnosis of human and canine rabies is essential for reliable surveillance data and decision-making regarding post-exposure prophylaxis (PEP). However, the infrastructure and utilization of laboratory services for rabies diagnosis are grossly inadequate [9].

4. Awareness: Awareness Generation Rabies is a disease that affects both rural and urban areas. However, many rabies patients do not seek proper PEP from healthcare facilities and may instead visit traditional healers. Community participation plays a vital role in any disease control programme for rabies [9].

5. Capacity Building: Continuous education and training of medical and health professionals regarding PEP are necessary to ensure the provision of quality medical services to individuals bitten by dogs.

6. Intersectoral Coordination: In many countries, including India, the responsibility for rabies control falls under multiple ministries. However, there is often a lack of coordination and collaboration among these line agencies, leading to inadequate technical and financial resources for effective rabies control measures.

Evolution of the National Rabies Control Programme

The National Centre for Disease Control (NCDC) in Delhi has played a crucial role in the implementation of Rabies Control activities in India. In 2002, NCDC organized a consultation to establish national guidelines for rabies prophylaxis, aiming to standardize post-exposure prophylaxis practices [10]. These guidelines were revised in 2007 and 2013, recommending the use of modern cell culture vaccines (CCVs) for post-exposure prophylaxis after the discontinuation of Nervous Tissue Vaccine production in 2004. However, the high cost associated with the intramuscular administration of CCVs limited its widespread use. To address this, the Drugs Controller General of India (DCGI) approved the safe, effective, and cost-effective intra-dermal (ID) route of CCV inoculation in February 2006, following WHO recommendations and a feasibility study conducted by National Institute of Epidemiology, Chennai, in 2005. The national guidelines for rabies prophylaxis have been further revised and updated in 2019[10].

In the 11th Five-Year Plan (2007-2012), the Ministry of Health and Family Welfare initiated efforts to control human rabies through pilot projects, allocating funds for this purpose. For the first time, the plan also included animal welfare components such as rabies control in animals, animal birth control, and vaccination of stray dogs, to be managed by the Animal Welfare Board of India (AWBI).

The pilot project, known as the "National Rabies Control Programme: Initiative," was implemented by NCDC in five cities from 2008 to 2012. Its objectives included preventing human deaths from rabies, raising community awareness, training healthcare professionals, strengthening diagnostic facilities, and improving surveillance. The successful implementation of the pilot project demonstrated the feasibility and reproducibility of the strategy, leading to the approval of the National Rabies Control Programme (NRCP) for nationwide implementation during the 12th Five-Year Plan. The NRCP was fully funded by the central government, and funds were disbursed to states and stakeholders through the Ministry of Health & Family Welfare [11].

Currently, the Ministry of Health and Family Welfare is responsible for implementing the human health component of the NRCP programme in all states and union territories. State-level activities are carried out through the National Health Mission, following approval from the 8th Empowered Programme Committee (EPC) meeting[11]. Funds are allocated for various activities related to the NRCP at different administrative levels, following the National Health Missions Programme Implementation Plan mechanism. The objective of the programme is to prevent and control deaths due to rabies in humans, with the ultimate aim of achieving the global target of "Rabies-Zero by 2030," starting from the fiscal year 2021-22.

Institutional Mechanism for programme implementation

At Centre: The nodal ministry for the programme is the Ministry of Health and Family Welfare. It is proposed to use the current NHM's mechanism of Mission Steering Group (MSG) & Empowered Programme Committee (EPC) for policy decisions. National Technical Advisory Committee chaired by DGHS to advise on all technical aspects of the programme.

At State & district: The programme is implemented through the State Health Society At state level and District Health Society at district level.

To achieve these objectives, the programme has adopted key Strategies as under:

(A) Provision of Human Rabies Vaccine & Human Rabies Immunoglobulins (ARV & ARS): Rabies is preventable if timely and appropriate administration of post-exposure prophylaxis is given. The programme division has revised National Guidelines for rabies prophylaxis based on WHO Expert Consultation on Rabies[12]. The direct cost of PEP including ARV & RIG ranges Rs. 3,104 (1,180-3,662). The objective of this component is to facilitate and ensure the regular availability of Anti Rabies Vaccines and RIG for prompt and appropriate management of human-animal bite victims free of cost in all districts. As envisaged under the programme the objective is to promote ID use of Anti Rabies Vaccine (ARV) and Rabies immunoglobulin (RIG) to the animal bite victims as per national guidelines. ARV & RIG are already included in the National Essential Drug List. The procurement to be done by states/UTs out of funds allocated under National Free Drug Initiatives or State Revenue.

To ensure availability of ARV & RIG as per NHM's Essential Drug list Rabies vaccine should be available at all PHC & above health facilities while RIG should be available at CHC & above health facilities. The programme division recommends use of cost-effective intradermal route of Rabies vaccination to animal bite victims.

(B) Capacity Building by Training of Health care Professionals: Training and capacity buildings of health care professionals at all levels on, appropriate animal Bite management, ID route of rabies vaccine administration, RIG infiltration and other technical

aspects will be held periodically. The training may be conducted for Medical & Paramedical personnel including students, private practitioners and others.

(C)Strengthening Surveillance of Animal Bites and Rabies Cases in Human: Rabies surveillance is the key index for the success of any intervention programme. It involves the collection of essential data to determine the rabies situation, to monitor and evaluate the progress and impact of the intervention, to manage potential human exposures adequately, to calculate the cost-effectiveness of control efforts and to demonstrate absence and freedom of disease in a given area. The Standard case definitions for rabies surveillance through IDSP have been formulated. Animal bites are reported in the P form on the IDSP portal. Standardized recording and reporting formats finalized for streamlining reporting. As a part to strengthen Human Rabies surveillance, Secretary (Health), MoHFW has advocated the states to declare Human Rabies as a notifiable Disease. So far, 20 states have declared Human Rabies as a Notifiable Disease (Fig 5).

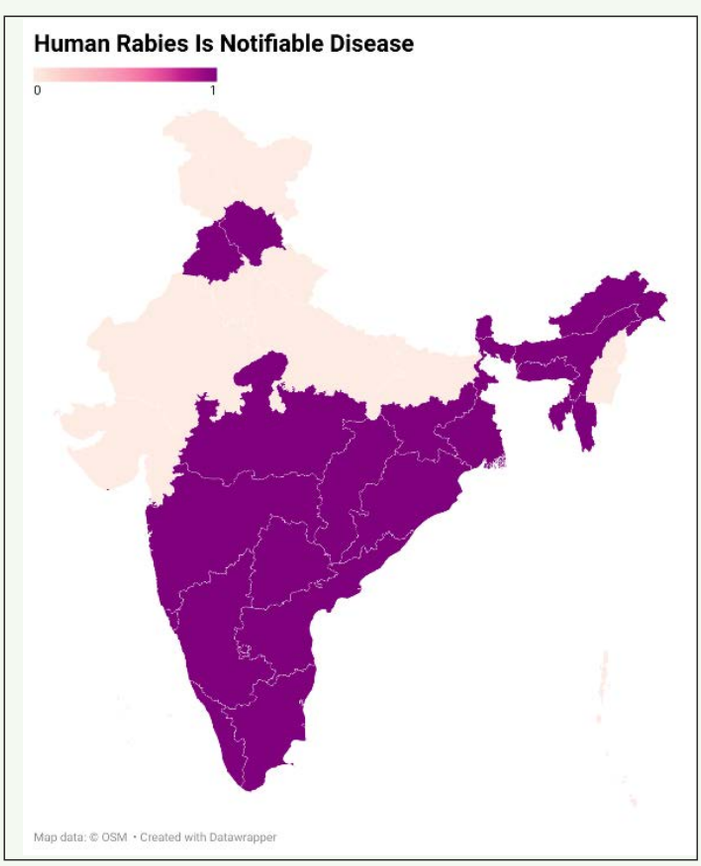


Figure 5 : Status of Declaration of Human Rabies Notification

(D) Strengthening Laboratory Diagnosis of Human Rabies: The vision of programme is to Elimination of Dog Mediated Human Rabies. For this each and every case of Human Rabies needs laboratory confirmation. Laboratories have the following role in Rabies Elimination:

(I) Confirmation of clinical diagnosis-especially in paralytic/atypical cases
(II) Patient Management/Barrier Nursing/Disinfection of ICU facilities
(III) Prophylactic vaccination to relatives, clinical & nursing staff
(IV) Characterization of causative agent/molecular epidemiology
(V) Surveillance and estimation of disease burden
(VI) Confirmation/Monitoring of disease-free status

In view of this, the programme division has envisaged to develop a network of Rabies Diagnostic Laboratories. Programme division is strengthening identified institutes as Rabies Diagnostic Facility. NCDC, Delhi and Virology laboratory of NIMHANS, Bangalore have been identified and have been working as National Reference Laboratories. So far, nine institutes all over the country are being strengthened as Rabies Diagnostic facilities.

(E) Model Anti-Rabies Clinic: The existing resources of district hospitals will be strengthened as Model Animal Anti Rabies Clinics as per proposed IPHS standards. These centres will provide comprehensive Animal Bite Management facilities which include animal bite wound washing facility, Availability of Rabies post-exposure prophylaxis- Anti-rabies vaccine and RIG, counseling of Animal Bite victims, and referral services for suspected Rabies patients, Surveillance activities and Intersectoral Coordination with other stakeholders. These sites will act as sentinel sites for animal bite surveillance in the initial period. A trained staff nurse, under the guidance of the Medical officer in charge, will manage these centres. Their objective is to deliver quality animal bite management services over time. Till the NRCP surveillance mechanism gets streamlined, these centres will act as sentinel surveillance site for PEP coverage.

(F) IEC Activities: Rabies is a practically hundred per cent fatal disease. Once bitten by a rabid dog, the deaths of the victim are sure if treatment is not instituted timely. Misconceptions about managing animal bite wounds are prevalent in the community. Raising awareness among at-risk populations is crucial for rabies prevention [12]. It is essential to educate the general public about the appropriate actions to take in the event of an animal or dog bite to prevent rabies-related deaths. Therefore, the

programme aims to conduct Information, Education, and Communication (IEC) activities to increase awareness of the disease and emphasize the importance of seeking timely and suitable treatment for animal bites. These IEC activities include developing materials for dissemination to states, creating audio and video content for professionals and the community, conducting mass media campaigns through electronic channels, organizing public lectures, scientific symposiums, and communication workshops on rabies.

(G) Intersectoral Coordination: Rabies represents a prime example of the One Health approach, requiring collaboration among various sectors such as animal welfare, public health, veterinary medicine, and civil administration. Dogs, as primary source of rabies transmission, play a crucial role in its prevention and control. The active involvement of veterinary sectors, municipal corporations, and community engagement is necessary for effective rabies control. Strengthening inter-sectoral coordination and adopting a One Health approach at the national, state, district, and block levels are key strategies for the programme. Advocacy workshops, joint training, and Information, Education, and Communication (IEC) activities will be conducted to support these efforts. Establishing state and district-level joint steering committees will facilitate programme monitoring and review of rabies elimination activities.

In September 2021, the Ministry of Health and Family Welfare (MoHFW) and the Ministry of Fisheries, Animal Husbandry, and Dairying (MoFAHD) jointly launched the National Action Plan for Rabies Elimination (NAPRE). This action plan was developed with the involvement of various ministries, stakeholders, and experts to systematically reduce rabies risk through mass dog vaccinations, pre- and post-exposure prophylaxis for humans, and public education until the country becomes free of dog-mediated human rabies. The NAPRE identifies key stakeholders, supporting stakeholders, and partner institutes based on their mandates and responsibilities.

(H) Plan of Implementation of the National Action Plan for Rabies Elimination: Based on the strategic components, it is envisaged that States will prepare a comprehensive action plan for both human and animal health components. The implementation of the NAPRE will involve comprehensive action plans prepared by each state, covering both human and animal health components. Funding for the human health component will continue to be sourced from the National Health Mission (NHM), while animal health components will explore funding options through existing schemes or revenue available with municipal corporations or state veterinary departments. Delivery of animal health services will utilize existing veterinary infrastructure, including the Animal Husbandry Department, urban/rural governing bodies, NGOs, and municipal cooperation. However, implementation of NAPRE is a resource intensive activity. Hence, in January, 2023 Government of India as an initiative of "Rabies Free Cities" has recommended to the states to prioritize densely populated Tier 1 & Tier 2 cities and then gradually progress to cover the remaining areas of the states. A list of Tier 1(Number of Cities7) and Tier 2 (Number of Cities :103) cities have been provided to the states.

Since the human health component under the National Rabies Control Programme is already in progress, designated state and district nodal officers will continue implementing its activities. For the animal health component, states will identify and nominate state and district nodal officers who will coordinate with their counterparts in the human health component to implement the activities effectively.

Acknowledgment
We acknowledge NCDC for constant support .

Financial support & sponsorship
None.

Conflicts of Interest
None.

References

1. World Health Organization, editor. WHO Expert Consultation on Rabies: third report. Geneva, Switzerland: World Health Organization; 2018. 183 p. (WHO Technical Report Series).

2. Sudarshan MK, Madhusudana SN, Mahendra BJ, Rao NSN, Ashwath Narayana DH, Abdul Rahman S, et al. Assessing the burden of human rabies in India: results of a national multi-centre epidemiological survey. International Journal of Infectious Diseases [Internet]. 2007 Jan [cited 2021 Mar 3];11(1):29–35. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1201971206000117

3. Suraweera W, Morris SK, Kumar R, Warrell DA, Warrell MJ, Jha P, et al. Deaths from Symptomatically Identifiable Furious Rabies in India: A Nationally Representative Mortality Survey. Zinsstag J, editor. PLoS Negl Trop Dis [Internet]. 2012 Oct 4 [cited 2021 Mar 3];6(10):e1847. Available from: https://dx.plos.org/10.1371/journal.pntd.0001847

4. Knobel DL, Cleaveland S, Coleman PG, Fèvre EM, Meltzer MI, Miranda MEG, et al. Re-evaluating the burden of rabies in Africa and Asia. Bulletin of the World Health Organization. 2005;11.

5. WHO. WHO | Rabies surveillance and control - The world survey of rabies [Internet]. WHO. World Health Organization; [cited 2021 Mar 4].Available from: https://www.who.int/rabies/resources/wsr1998/en/

6. CBHI I. National Health Profile :: Central Bureau of Health Intelligence [Internet]. [cited 2021 Mar 4]. Available from: https://www.cbhidghs.nic.in/index1.php?Lang=1&level=1&sublinkid=75&lid=1135

7. OIE-WAHIS [Internet]. [cited 2021 Mar 31]. Available from: https://wahis.oie.int/#/dashboards/qd-dashboard

8. Hanumanthaiah AND, Haradanhalli RS. Assessment of Procurement, Distribution, Availability, and Utilization of Rabies Biologicals for Postexposure Prophylaxis in Seven States of India. Indian Journal of Public Health. 2019;63:7.

9. Asia WHORO for S-E. Strategic framework for elimination of human rabies transmitted by dogs in the South-East Asia Region [Internet]. WHO Regional Office for South-East Asia; 2012 [cited 2021 Mar 31]. Available from: https://apps.who.int/iris/handle/10665/205920

10. MoHFW. National Guidelines for Rabies Prophylaxis, National rabies Control Programme [Internet]. Division of Zoonotic Disease Programme, National centre for Disease Control; 2019. Available from: https://ncdc.gov.in/WriteReadData/linkimages/GuidelinesforRabiesProphylaxis.pdf

11. Haradanhalli RS, Hanumanthaiah AND, Varadappa ST. Cost of Rabies Post Exposure Prophylaxis in Different Healthcare Settings in Six States of India. Indian Journal of Public Health. 2019;63:5

12. WHO | Rabies vaccines: WHO position paper – April 2018 [Internet]. WHO. World Health Organization; [cited 2021 Mar 31]. Available from: http://www.who.int/rabies/resources/who_wer9316/en/

One Health Approach for Understanding and Managing Animal Leptospirosis in India

Kirubakaran Vinod Kumar[1] Prajakta Prashant Bokade[1] Archana Pal1 Swathi M.[1] Chethan Kumar H. B.[1] Baldev Raj Gulati[1] Vinayagamurthy Balamurugan[1]*

[1]Indian Council of Agricultural Research -National Institute of Veterinary Epidemiology and Disease Informatics (ICAR-NIVEDI), Yelahanka, Bengaluru 560 064, Karnataka, India

***Corresponding author**
Dr. Vinayagamurthy Balamurugan
Principal Scientist, Veterinary Microbiologist
ICAR-National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), Yelahanka, Bengaluru
E-mail: b.vinayagamurthy@icar.gov.in; balavirol@gmail.com

Abstract

Leptospirosis is a zoonotic disease of significant public health concern globally and in India, where a diverse range of animal hosts contribute to its perpetuation and spread. This paper reviews the epidemiology of leptospirosis in various animal species in India and underscores the importance of the One Health approach in overcoming complacency towards its management. The interconnectedness of human, animal, and environmental health is central to understanding the disease's dynamics. This approach exposes the shortcomings of isolated efforts and the necessity for comprehensive strategies that foster intersectoral collaboration, supported by appropriate policies, educational initiatives, and technological advancements. This review highlights the critical roles of various stakeholders, from government and policymakers to health professionals and the general public in implementing and promoting One Health initiatives. Despite the challenges, the review illustrates the significant potential of the One Health approach in mitigating the impact of leptospirosis in India, with insights valuable for other zoonotic diseases. This review concludes by outlining future directions and recommendations, focusing on advancements in leptospirosis prevention and control and identifying areas necessitating further research. By addressing complacency and promoting proactive, integrated actions, we can effectively manage leptospirosis, thereby protecting both animal health and public health in India.

Keywords: Leptospirosis, One Health, India, Epidemiology, Livestock, Wildlife, Disease control

Introduction

Leptospirosis: An Invasive Zoonotic Threat

Leptospirosis, a zoonotic disease caused by the pathogenic bacteria of the Leptospira genus, thrives with alarming pervasiveness across the globe.[1, 2] Leptospirosis afflicts an extensive array of mammalian species, encompassing humans, livestock, and a diverse array of wildlife. [3] With an unusual ability to occupy diverse mammalian hosts, the organism has a complex life cycle. The life cycle involves a maintenance host harboring a chronic renal infection, contrasting the incidental host susceptible to acute disease episodes with potential severe outcomes including Weil's disease or pulmonary hemorrhagic syndrome.[4] Leptospirosis has a protean clinical presentation, ranging from mild, flu-like conditions to potentially fatal complications including jaundice, renal failure, and hemorrhage.[5] The broad spectrum of manifestations and symptomatic overlaps with other febrile illnesses pose significant diagnostic challenges, often culminating in underreporting and misdiagnoses.[4] Transmission of this disease to humans and other animals is primarily via direct or indirect contact with urine from infected animals, entering the body through skin cuts or mucous membranes of the mouth, nose, and eyes. Flooded regions and water bodies contaminated with the urine of infected animals serve as hotspots for leptospirosis transmission.[6] Global incidence estimation is a complex task, rendered challenging due to variations in surveillance and reporting across countries. Nevertheless, the yearly worldwide tally of severe leptospirosis in humans is estimated to surpass a million cases, with a death toll approximated at 58,900 cases.[1] Resource-limited, tropical countries bear the highest burden, due to their conducive conditions for survival and propagation of Leptospira.

The One Health paradigm recognizes the intricate relationship between human health, animal health, and the environment health, with the objective of optimizing health outcomes.[7, 8] This concept is critically relevant to leptospirosis, a zoonotic disease hosted in animal reservoirs.[9] This review addresses the application of One health concept for understanding the epidemiology and control of leptospirosis in India, emphasizing the importance of a One Health approach for effective disease management. The One Health strategy has proven effective in managing leptospirosis through veterinary health measures, such as screening and vaccinating domestic animals in high-risk areas, and environmental health initiatives that improve sanitation and water quality.[10] These measures reduce human infection risk and environmental burden of Leptospira. The approach fosters multi-sectoral data sharing, enabling early detection of leptospirosis outbreaks and swift intervention to limit disease spread.[11] Nonetheless, there is a prevailing complacency in implementing the One Health approach to leptospirosis.[3, 12] This complacency can delay diagnosis and treatment, inhibit effective prevention strategies, and obfuscate disease patterns (Table I).[13,14]
The root causes of this complacency include

coordination gaps due to institutional and professional barriers, lack of awareness of the One Health approach, and resource constraints in both human and veterinary health sectors. Limited availability of diagnostic tools and surveillance systems compounds the problem, reducing capacity to detect and monitor leptospirosis in human and animal populations.[15] Overcoming this complacency is imperative to enhance leptospirosis management and reduce its impact on human and animal health. The review further explores the ethical dimensions of the One Health approach (Fig.1), underscoring principles like harm minimization, duty of care, solidarity, healthcare equity, and research ethics. By fostering interdisciplinary collaboration and a holistic understanding of leptospirosis, the One Health approach can significantly contribute to strategies to reduce the disease's impact on human, animal, and environmental health in India.

Table 1: Types of Complacency in Leptospirosis Research and Management in India

Type of Complacency	Description
Geographic Complacency	Focus on Gujarat, Maharashtra, and Kerala, neglecting other endemic regions.
High-Risk Group Complacency	Underrepresentation of certain high-risk groups, ignoring their specific risks
Intervention Research Complacency	Absence of studies on diverse interventions like dialysis, human vaccines, and personal
Community-Level	Limited focus on systemic
System and Policy-Level Complacency	Lack of research on governance and health system readiness.
Seasonal Risk Complacency	Inconsistent consideration of seasonal risks like monsoons and flooding
Disease Course Complacency	Few studies explored alternative therapeutic measures for leptospirosis.
Animal Transmission Complacency	Limited focus on animal vaccines or birth control programmes to control disease spread.
Health System Response Complacency	Inadequate studies evaluating health system readiness.
Innovative Approach Complacency	Limited use of multicomponent interventions in studies
Non-Endemic Areas Complacency	Minimal focus on non-endemic regions in leptospirosis management studies.
Lesser-Known Intervention Complacency	Absence of studies on novel interventions like dialysis or vaccines.
Health System Infrastructure Complacency	Limited research into healthcare infrastructure.

2. Leptospirosis

2.1. An Overview

Leptospirosis is caused by spirochete bacteria from the Leptospira genus, falls within the phylum Spirochaetes and comprises over 64 species based on molecular classification, differentiated through a variety of genetic techniques such as DNA-DNA hybridization and 16S rRNA phylogeny.[16] However, for practical epidemiological and diagnostic purposes, the serological classification, which identifies over 300 serovars based on surface-exposed lipopolysaccharides (LPS), is frequently used.[17] The Leptospira genome is unique among bacteria for its two circular chromosomes and the presence of lateral gene transfers and multiple pathogenicity islands, indicating its genomic plasticity and evolutionary adaptation to diverse environments.[18]

Morphologically, Leptospira bacteria are slender, helically coiled, and possess internal flagella or endoflagella that are located in the periplasmic space. The coordinated rotation of these endoflagella provides Leptospira with their distinctive translational motility, which is not only important for their survival in aqueous environments but is also aid in host tissue invasion during infection (Fig. 2).[19] The Leptospira bacteria thrive in warm and humid conditions and can survive for months in damp soil and stagnant water bodies, especially those rich in organic matter and with slightly alkaline pH. This remarkable environmental resilience helps to maintain the transmission cycle in nature, particularly in areas with frequent flooding or swamps. [6, 20]

2.2 Transmission Dynamics

Leptospira, a bacterium with a broad host range, primarily persists in the environment due to the widespread distribution, high population density, and chronic infection nature of rodents.[9] Humans, incidental hosts, usually contract the disease through direct or indirect exposure to the bacteria found in the urine of infected animals, water, or soil.[21] Upon entering a host, Leptospira spreads, affecting various organs, notably the liver and kidneys.

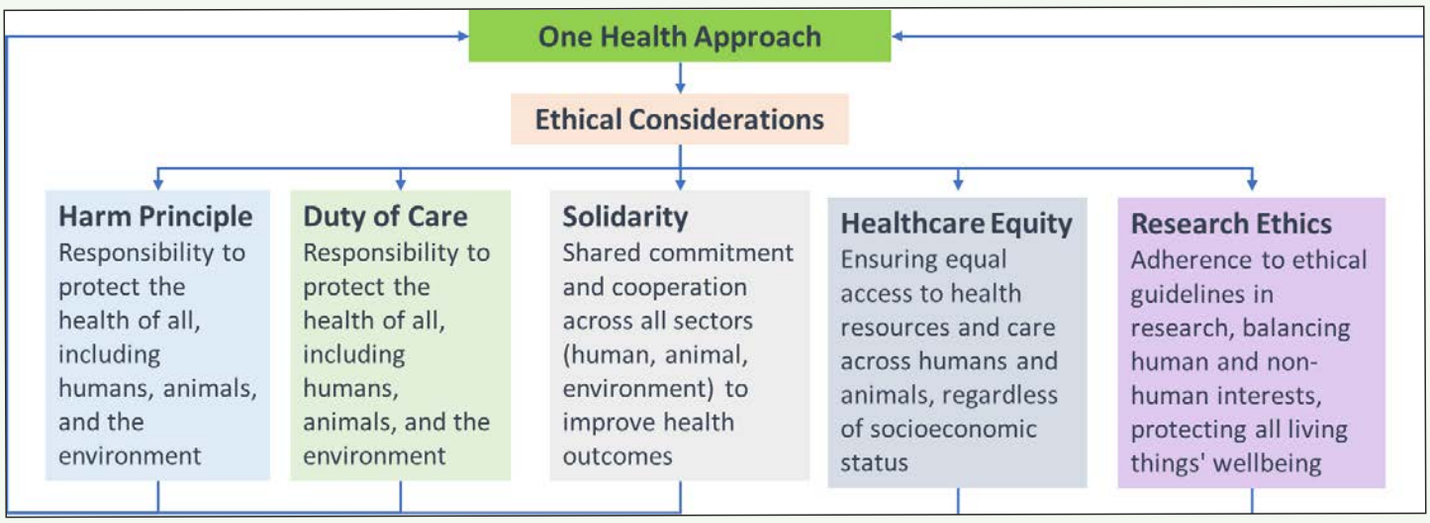


Figure 1: The Ethical Principles Guiding the One Health Approach

Figure 2: The Ethical Principles Guiding the One Health Approach

This targeting induces jaundice and renal impairment - classic severe leptospirosis symptoms. Moreover, the bacteria can colonize renal tubules, promoting urinary shedding and further spread of the disease.[6, 22] The complex transmission dynamics incorporate multiple hosts and environmental factors. Rats, primary Leptospira reservoirs, harbor the bacteria in their renal tubules and excrete it in their urine, often asymptotically.[9] This shedding, especially prevalent in urban areas with dense rodent and human populations, is instrumental in spread of leptospirosis Here, humans frequently contract the infection through exposure to rodent urine-contaminated water or soil, especially in sanitation-poor areas.[4]

Livestock, such as cattle, pigs, and horses, heavily influence epidemiology of leptospirosis in rural and agricultural settings. These animals, infected similarly to humans, often suffer from reproductive disorders and milk drop syndrome, causing economic losses.[9] They can become chronic Leptospira shedders, contaminating the environment and contributing to reinfection cycles in livestock and potential transmission to other animals and humans.[9] Wildlife also plays a key role in leptospirosis transmission dynamics. Wild rodents, marsupials, and carnivores can harbor and shed Leptospira, potentially contaminating natural water sources, soil, and vegetation.[23] This contamination poses risks to humans engaged in recreational activities and domestic animals in these areas. Humans contract the infection through occupational or recreational exposure to Leptospira-contaminated environments (Fig. 3)[4]. Farming, mining, abattoir work, veterinary practice, and certain water-related recreational activities notably heighten Leptospira exposure risk. The intricate interplay of these hosts and environments sustains the lifecycle of Leptospira, underscoring the need for a multi-sectoral and transdisciplinary approach, epitomized by the One Health Concept, in leptospirosis control and prevention (Fig. 4).[2]

2.3. Human leptospirosis, its Impact on Human Health, Livestock Productivity and Economy

Estimates suggest that leptospirosis affects more than one million people annually, leading to 58,900 deaths worldwide.[1] Livelihoods, particularly in resource-limited settings, are also severely affected by leptospirosis. The disease frequently affects vulnerable populations such as farmers, slaughterhouse workers, and others exposed to infected animals or contaminated water or soil.[4] Among the Asian countries, it has been estimated that China has the second largest burden estimate (301,688 DALYs, 95% UI: 119,388–525,491 or 22.05 DALYs per 100,000 population, 95 UI: 8.82–38.81) after India (684,369 DALYs, 95% UI: 290,213–1,217,287 or 56.35 DALY per 100,000 population, 95% UI: 23.90–100.23).[25] A country-level evidence gap map in India highlighted limited data and research gaps on the epidemiology of leptospirosis, indicating the need for more comprehensive studies to understand the disease burden and risk factors better.[26]

Despite these valuable studies, a country-level evidence gap map highlighted limited data and research gaps on the epidemiology of leptospirosis in India, signaling the need for more comprehensive studies to better understand the disease burden and risk factors.[26] A few of seroprevalence studies in India have provided valuable insights into the prevalence and distribution of leptospirosis in different regions. For instance, a study

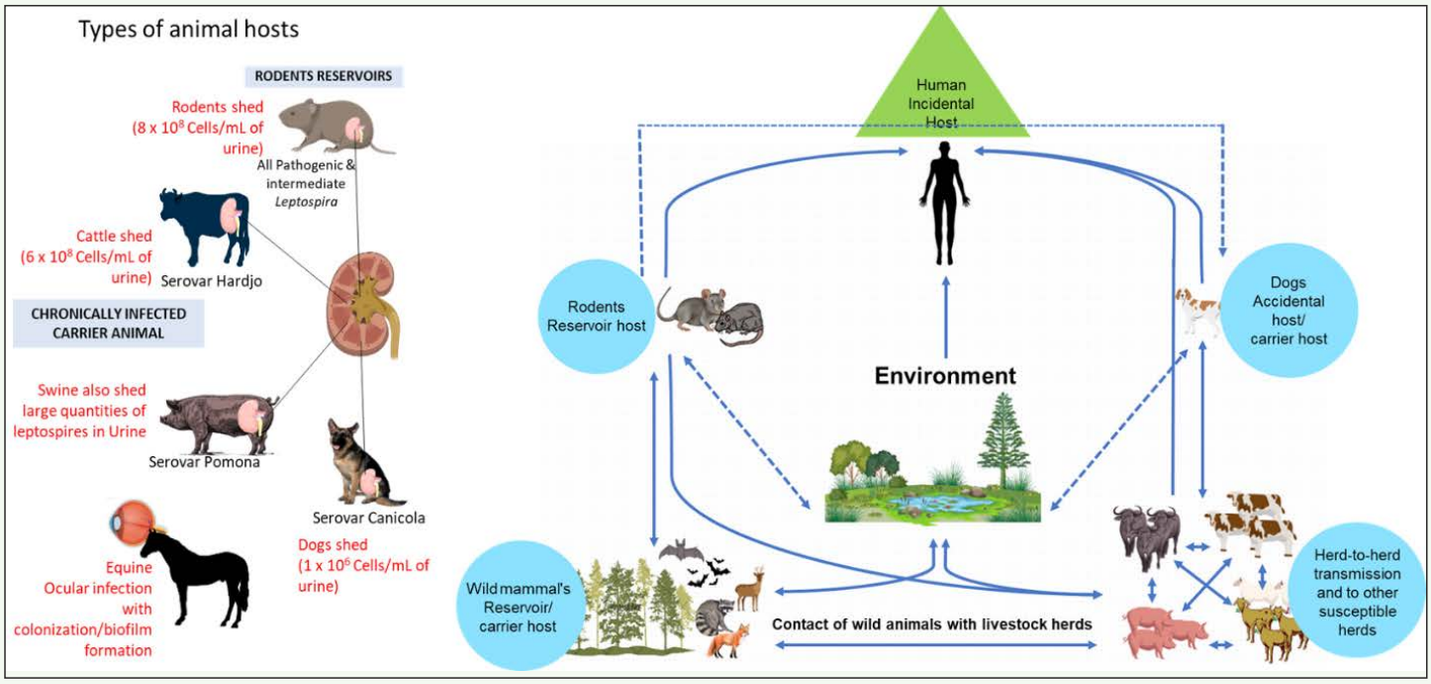


Figure 3: Leptospirosis Transmission Cycle: A diagram showingthe zoonotic transmission cycle of leptospirosis, including the roles of different animal reservoirs, the environment, and human.

conducted in the South Andaman Island found an overall seroprevalence of 10.9%, with higher rates in rural subjects compared to urban subjects. The most common infecting serogroup was Icterohaemorrhagiae, followed by Grippotyphosa, and the study suggested a shift in infecting serogroups possibly linked to changing trends in the animal population.[27] Another population-based case-control study in the Kodagu district of southern India identified environmental and occupational factors associated with leptospirosis risk, including flooding or water collection near houses, proximity to open sewers, direct contact with mud or water during work, animal farming, and the presence of rodents in houses.[28]

In Lucknow, Uttar Pradesh, a study focused on pediatric patients with acute febrile illness and found a seropositivity rate of 10% through IgM ELISA. Contact with infected animals and contaminated environments were highly associated with seropositivity, and common clinical symptoms included fever, chills, myalgia, headache, abdominal pain, and cough.[29] An outbreak investigation in Keerakadu village, Tamil Nadu, traced leptospirosis to contaminated water from an unprotected well. The outbreak was controlled through patient isolation and treatment, prophylactic antibiotics for the community, and recommendations for regular water chlorination and well protection.[30]

Studies have also explored the clinical profile, management strategies, and outcomes of patients with leptospirosis in different regions of India. In North India, an increase in leptospirosis incidence was observed over the years, with severe complications such as renal failure, respiratory failure, neuroleptospirosis, and disseminated intravascular coagulation (DIC). Early diagnosis and treatment were emphasized to reduce mortality. [31] In South India, a study investigated the co-infection of dengue and leptospirosis, revealing significant associations between clinical features like rashes and bleeding gums and co-infection. Laboratory parameters like thrombocytopenia were also linked to co-infection.[32] During the Coronavirus disease-2019 outbreak, one study described the clinical profile and outcome of leptospirosis patients and stressed the need to consider leptospirosis as a differential diagnosis for acute febrile illnesses, especially in tropical regions with specific risk factors.[33]

Southern India recorded a notable positivity rate of 25.6%, followed by 8.3%, 3.5%, 3.1%, and 3.3% in the north, west, east, and central regions, respectively. Rapid urbanization, climate change, poor sanitation, and improper waste management have contributed to an increase in leptospirosis outbreaks in recent years. [34]

The economic repercussions are due to various factors, such as reduced milk yield, weight loss, infertility, abortion, and even death in severe cases, which directly reduce the productivity of livestock.[9, 35] In cattle, leptospirosis is often associated with reproductive disorders, including abortion, stillbirths, and infertility.

Besides, the illness may also lead to decreased milk production and anorexia, which directly influence the dairy industry's profitability. Furthermore, the need for veterinary care and treatments for infected animals adds to the cost burden.[36]

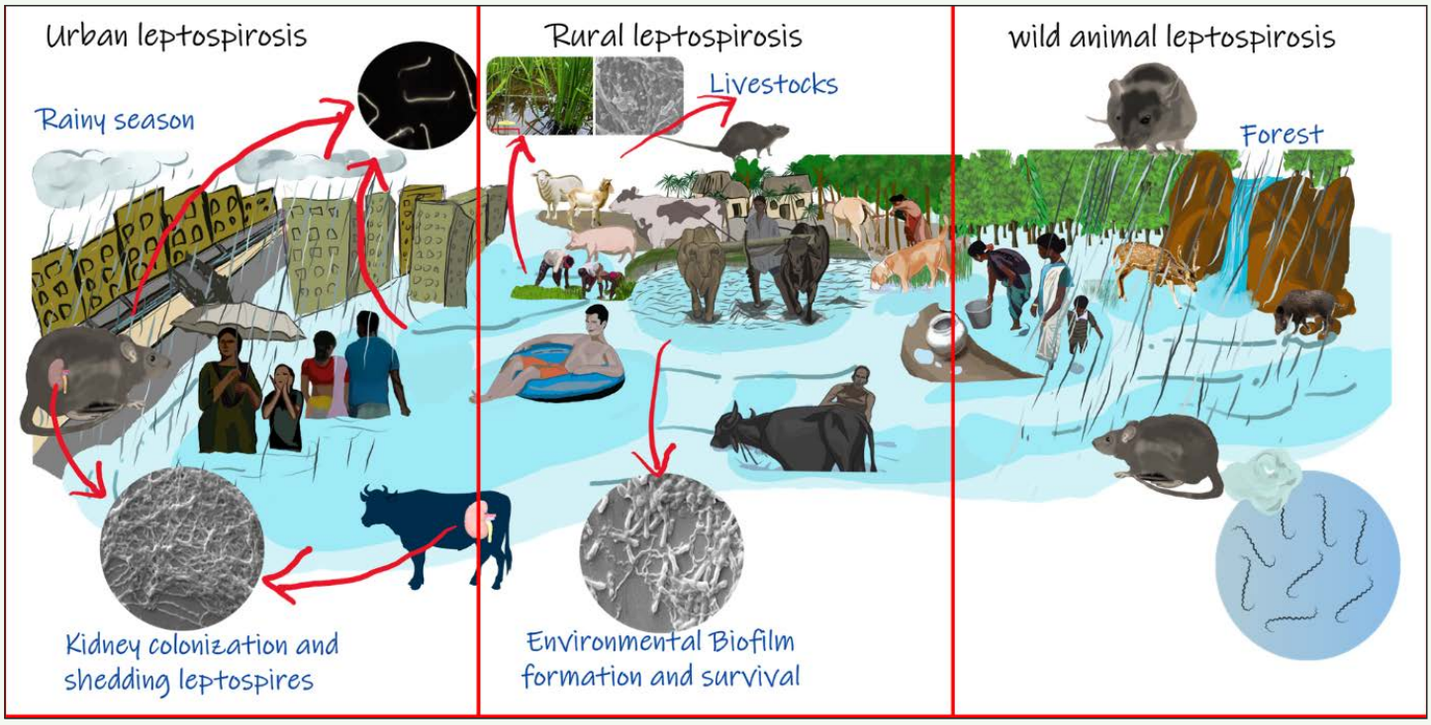


Figure 4: Illustration showing overall risk group, hosts and environmental risk factors for Urban, rural and wild leptospirosis.

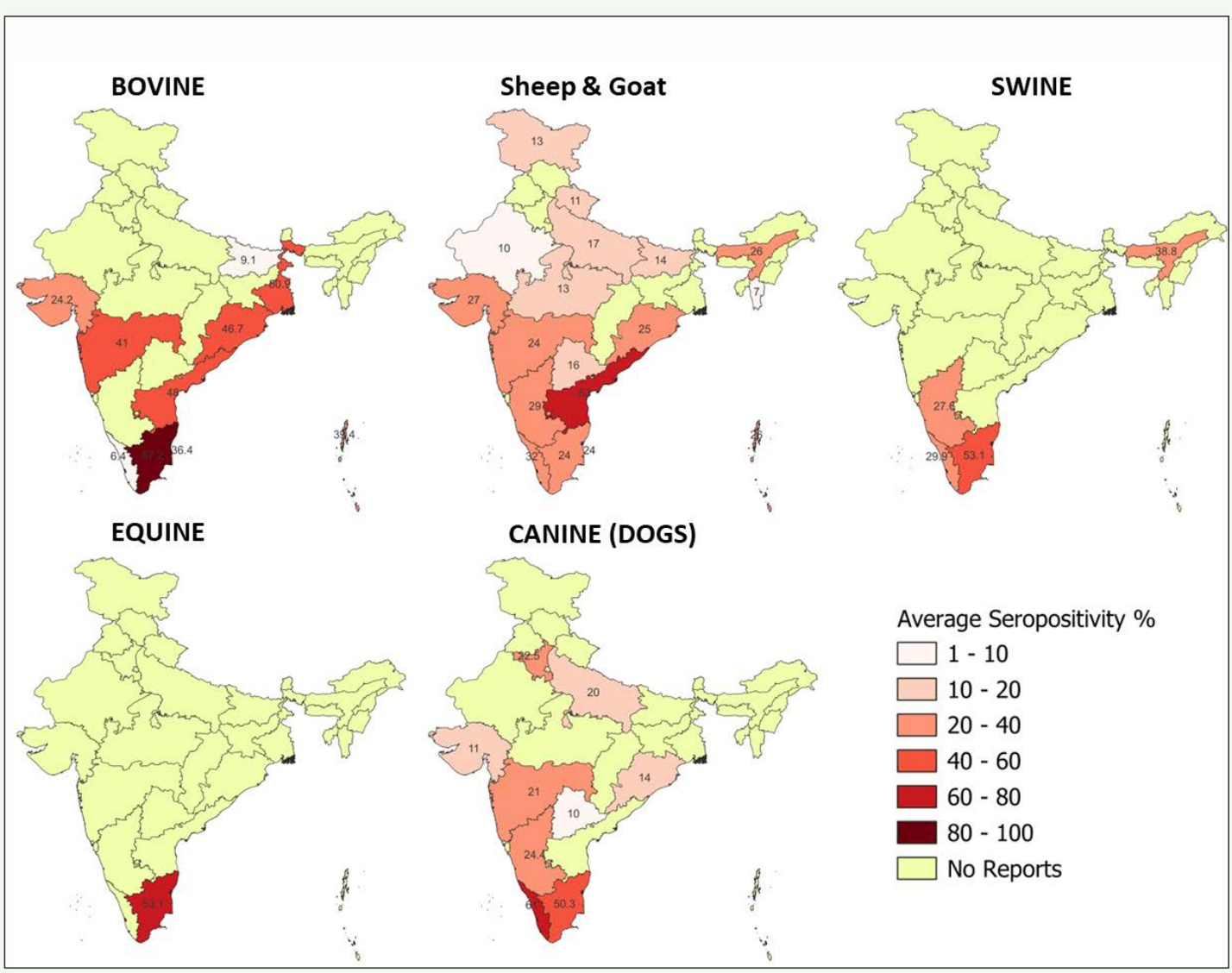


Figure 5: Prevalence of Animal leptospirosis depicted in India map (published data for year 2000 to 2021)

Table 2: Preventive Measures: This table outlines the main preventive measures for leptospirosis, the rationale behind them, and their expected impact on disease control.

Strategy	Stakeholders	Expected Outcome
Joint Surveillance programmes	Public health officials, veterinarians, environmental health specialists	Early detection and prevention of outbreaks
Coordinated Vaccination programmes	Veterinarians, livestock owners, public health officials	Reduced disease prevalence in animal reservoirs, reduced transmission to humans.
Environmental Risk Management	Environmental health professionals, urban planners, community leaders	Reduced environmental exposure to Leptospira, reduced transmission
Public Health Education	Stakeholders: Public health officials, community health workers, educators	Increased awareness and adoption of preventive measures, reduced exposure to the disease.
Livelihood Support programmes	Government agencies, NGOs, community leaders	Reduced dependence on high-risk activities, and decreased exposure to the disease.

Table 3: Preventive Measures: This table outlines the main preventive measures for leptospirosis, the rationale behind them, and their expected impact on disease control.

Stakeholders	Roles
Government Health Agencies	Development and implementation of policies, surveillance programmes, funding research and control initiatives, public health education
Non-Governmental Organizations (NGOs)	Disease awareness campaigns, support in executing control measures, conducting research, providing resources and aid
Veterinary Professionals	Disease diagnosis and control in animals, public education on zoonotic diseases, reporting cases to health agenciesinterventions like dialysis, human vaccines, and personal protective equipment.
Medical Professionals	Diagnosis and treatment of human cases, health education, reporting casesand WASH interventions.
Academia and Research Institutions	Conducting research on disease pathogenesis, diagnostic methods, treatments, and prevention strategies; training future professionals
Communities/General Public	Adherence to prevention measures, reporting suspected cases, participation in awareness programmes
Agricultural Sector	Implementing animal health practices to prevent disease, reporting suspected cases in livestock therapeutic measures for leptospirosis.
Pharmaceutical Companies	Development of effective treatments and vaccines, research and developmentvaccines or birth control programmes to control disease spread.
Technology Companies	Development of health technologies for disease surveillance, diagnostics, data sharing

Similarly, in pigs and small ruminants such as sheep and goats, leptospirosis has been linked to reproductive problems and failure to thrive in newborns, leading to significant productivity losses. Anorexia, weight loss, and other clinical symptoms can also affect the growth rate and market weight of pigs, sheep and goats. [9, 37] The impact of leptospirosis on the equine industry is also considerable. Horses infected with Leptospira can develop recurrent uveitis, potentially leading to blindness, and suffer from kidney disease and abortion, affecting their health and performance.[38]

Moreover, the disease has implications for wildlife and the associated tourism industry. Rodents and other wildlife species often serve as asymptomatic carriers, contributing to the spread of disease.[39] Overall, the economic burden of leptospirosis on livestock productivity is vast and extends to various sectors, including dairy, meat, wool, and hide production, as well as the associated industries such as tourism.

2.3. Animal Leptospirosis in India

Animal leptospirosis in India exhibits marked regional variability due to different climatic conditions, farming practices, and the diversity of potential animal reservoirs.[26] Prevalence rates and implicated serovars differ from region to region, with studies reporting evidence of the disease in animals such as dogs, swine, horses, rodents, and even captive wild animals (Fig. 5). Understanding this geographical and host variability is crucial for developing targeted control strategies to mitigate the impact of leptospirosis in India.[26]

In the case of bovine leptospirosis, India faces a matter of particular concern, given the considerable variation in prevalence rates and serovar distributions across its diverse regions. [26] Studies conducted in various states have reported a complex epidemiological landscape. For example, in Andhra Pradesh, [40,41] it was found leptospirosis prevalence rates of 56.23% and 19.65%, respectively, with multiple serovars identified, including Hebdomadis, Pomona, Sejroe, Ballum, Australis, Grippotyphosa, Autumnalis, Javanica, and Canicola. Similarly, in Gujarat, prevalence ranged from 5.77% to 38.55%, with several serovars detected, such as Sejroe, Hebdomadis, Ballum, Australis, Pomona, Canicola, Icterohaemorrhagiae, Autumnalis, and Tarassovi.[42, 43] Such variations underscore the necessity for region-specific surveillance and targeted control measures.[26]

Leptospirosis in sheep and goats also presents a unique epidemiological landscape in India. The prevalence rates vary across regions, with states reporting rates from 7% to 63%. [44, 45] In the northern region,[45] prevalence rates of 13% in Jammu and Kashmir, 10% in Rajasthan, and a slightly higher rate of 11% in Uttarakhand were reported. The western state of Gujarat demonstrated a notably high prevalence ranging from 12% to 52%, with a wide array of serovars identified.[45-48] In the southern states of Karnataka and Kerala, prevalence rates of 29% and 28% to 36% were reported, respectively, with Pomona, Australis, and Grippotyphosa being the most common serovars.[45, 49] Such variations emphasize the need for tailored surveillance and control measures to address this public health concern.[26]

Canine leptospirosis, a significant zoonotic disease in India, presents diverse epidemiological profiles across different regions. Studies have reported prevalence rates ranging from 10.98% to 77.7 %.[50, 51] The regional prevalence and serovar distribution underscore the need for sustained surveillance and region-specific control measures.[26]For instance, in northern India, Uttarakhand reported a prevalence of 20%, with prominent serovars including Autumnalis, Icterohaemorrhagiae, Grippotyphosa, and Canicola.[50, 51] In contrast, Kerala reported an alarming prevalence of 71.12% with a wide array of serovars identified.[52]

Swine leptospirosis poses an emerging public health challenge in India, with varying seroprevalence rates across different regions. For example, a study in Assam reported a seroprevalence of 38.8%, predominantly identifying Ballum as the leading serogroup in swine. [53] In contrast, Kerala reported a seroprevalence of 35.92%, with a variety of serogroups identified. [54]

Leptospirosis poses a significant health risk to the equine population in India. A study in Chennai reported a distressing seroprevalence rate of 76.05% in horses, with predominant causative serovars being Leptospira Pomona and Leptospira Grippotyphosa.[55] The high prevalence in urban centres like Chennai requires stricter surveillance measures, particularly due to the significant public health risk posed by asymptomatic carriers.[56]

Leptospirosis extends beyond rodents to various animal species in India. Captive sloth bears have shown seropositivity, with Pyrogenes being the most common serovar.[57] Wild animals like Sambhar, Cheetal, Tiger, and Elephant also showed seropositivity, indicative of the disease's broad host range.[58] Additionally, captive elephant handlers have demonstrated antibodies against multiple Leptospira serovars, highlighting the disease's risk for individuals in proximity with potential animal reservoirs.[59] Zoological parks and animal rescue centres often house leptospirosis, with significant seropositivity reported among various animal species and staff.[60, 61] Continued research and collaboration across disciplines are essential to address this public health challenge effectively.

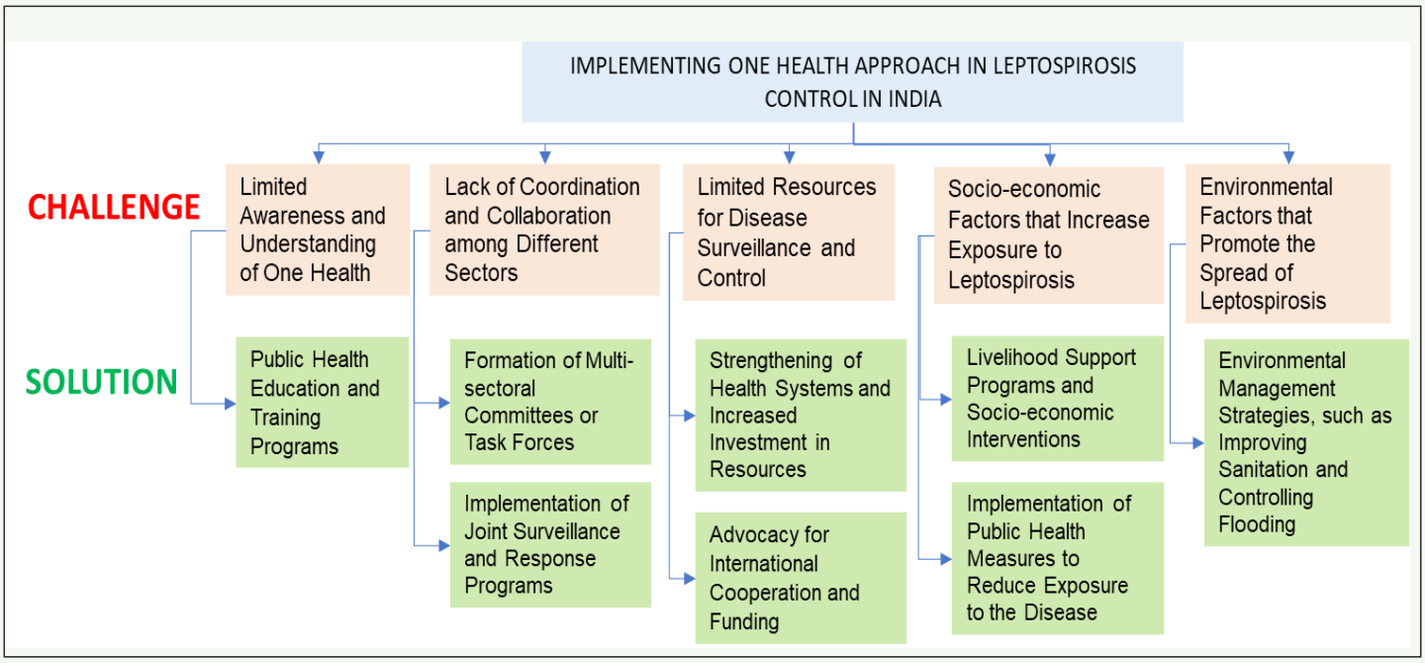


Figure 6: Challenges and Barriers to implementing the One Health approach in leptospirosis control in India and their potential solutions

3. Recommendations for future research, policy, and practice

Addressing the spread and impact of leptospirosis in India necessitates a multifaceted, interdisciplinary approach. This strategy encompasses numerous spheres, from research to diagnostics, policy integration, surveillance systems, public awareness, and increased funding.

a. Enhanced Interdisciplinary Research: This is a pivotal aspect of managing the complexities of leptospirosis. A collaborative effort between various stakeholders such as public health and veterinary professionals, policymakers, researchers, and the private sector can lead to better disease management.[62] The interdisciplinary approach combines human and veterinary medicine, epidemiology, environmental science, and social science. Research should focus on the epidemiology and ecology of leptospirosis, the role of various animal reservoirs, environmental factors contributing to Leptospira survival and transmission, and socioeconomic and cultural factors influencing disease exposure and health-seeking behaviours (Table I & II).[63]

b. Improved Diagnostics and Technological Innovations: The limitations of current diagnostic methods necessitate investment in research and development of rapid, accurate, and affordable diagnostic tests.[35,46,64] Novel technologies such as point-of-care diagnostics, advanced vaccines, and digital health platforms can greatly enhance disease detection, prevention, and management. In addition, AI can aid in predictive modelling and risk mapping, enhancing surveillance capabilities.[65]

c. Effective Vaccines: For both humans and animals, the creation of cross-protective vaccines that can provide immunity against a broad range of Leptospira serovars is vital.[66]

d. Integrated Surveillance Systems and Standardization: Surveillance systems need to amalgamate data from human, animal, and environmental health to track disease trends and detect outbreaks early. This integration necessitates digital technologies for real-time data reporting, visualization, and analysis. Standardization of diagnostic and reporting protocols, along with centralized data management platforms, will enhance the surveillance system.[67]

e. Policy Integration: Policies should address leptospirosis across different sectors, including strategies for rodent control, waste management, water and sanitation, land-use planning, and livestock management. Inclusion of leptospirosis in the national list of notifiable diseases at least in the endemic areas can enhance disease reporting and response.[68]

f. Community Engagement, Education, and Public Awareness: Efforts need to be made to increase community knowledge about leptospirosis, especially among high-risk groups. Education programmes and public advocacy campaigns can inform about personal protective measures, safe water and sanitation practices, and responsible pet and livestock management.

g. Capacity Building and Funding: Investing in training programmes for health professionals, veterinarians, laboratory staff, and field workers is crucial. A well-trained workforce is key to effectively

diagnosing, preventing, and controlling leptospirosis. Additionally, advocating for more resources to support research, control programmes, and capacity-building initiatives related to animal leptospirosis is essential.

h. Climate Change Adaptation: With climate change potentially influencing the transmission dynamics of leptospirosis, research into its impacts and the development of climate-adaptive control strategies are required.[69]

With these strategies in place, India can make substantial strides toward a more integrated, effective, and sustainable approach to controlling animal leptospirosis, ultimately benefiting the health of humans, animals, and the environment (Fig. 6).[62]

4. Conclusion

It is evident that leptospirosis remains a significant public health challenge in India, especially in regions where there is close interaction between humans, animals, and the environment. This zoonotic disease not only poses a significant threat to human and animal health but also reflects the broader systemic and environmental issues at play, such as sanitation, waste management, and land use.

A One Health approach – emphasizing the interconnectivity between human, animal, and environmental health – offers a promising strategy for managing leptospirosis. This strategy recognizes the need for collaboration among various stakeholders, including veterinary and public health professionals, policymakers, researchers, and the private sector. Yet, the effective implementation of One Health approach in India faces challenges due to complacency, resource constraints, and lack of public awareness.

The review emphasized the need for interdisciplinary research, improved diagnostics, effective vaccines, integrated surveillance systems, policy integration, community engagement, capacity building, climate change adaptation, and the importance of technological innovations such as Artificial Intelligence in managing leptospirosis. Investments in these areas can facilitate the early detection and rapid response necessary to control the spread of leptospirosis and limit its impacts on public health. It's also imperative to advocate for increase funding and resources to support research, control programmes, and capacity-building initiatives related to leptospirosis. These efforts must be complemented with community engagement and public awareness campaigns about the risks and preventive measures associated with leptospirosis.

Author Contributions

KVK conducted the literature search, performed data analysis and wrote the rough draft of the manuscript. PPB, SM, and AP extracted and interpreted the data as well as edited the draft. CHB handled language, copy editing and rewriting the manuscript. VB provided guidance and support for the research, designed and conceptualized the idea, interpreted the data and edited the manuscript. BRG offered support. All authors reviewed and approved the final edited manuscript.

Acknowledgment

The authors wish to thank the Indian Council of Agricultural Research (ICAR), New Delhi, India, and the ICAR-NIVEDI staff for their constant encouragement and support always. The authors thank NCDC, Delhi for the support and all the researchers who contributed to the understanding of leptospirosis.

Financial support & Sponsorship

None

Conflicts of Interest

No conflicts to declare

References

1. Costa F, Hagan JE, Calcagno J, Kane M, Torgerson P, Martinez-Silveira MS, et al. Global Morbidity and Mortality of Leptospirosis: A Systematic Review. PLoS Negl Trop Dis 2015;9:e0003898.

2. Torgerson PR, Hagan JE, Costa F, Calcagno J, Kane M, Martinez-Silveira MS, et al. Global burden of leptospirosis: estimated in terms of Disability Adjusted Life Years. PLoS Negl Trop Dis 2015;9:e0004122.

3. Bharti AR, Nally JE, Ricaldi JN, Matthias MA, Diaz MM, Lovett MA, et al. Leptospirosis: a zoonotic disease of global importance. Lancet Infect Dis 2003;3:757-71.

4. Haake DA, Levett PN. Leptospirosis in humans. Curr Top Microbiol Immunol 2015;387:65-97.

5. Hartskeerl RA, Collares-Pereira M, Ellis WA. Emergence, control and re-emerging leptospirosis: dynamics of infection in the changing world. Clin Microbiol Infect 2011;17:494-501.

6. Barragan VA, Mejia ME, Trávez A, Zapata S, Hartskeerl RA, Haake DA, et al. Interactions of Leptospira with Environmental Bacteria from Surface Water. Curr Microbiol 2017;74:80–88.

7. CDC. One Health Basics: centres for Disease Control and Prevention, National centre for Emerging and Zoonotic Infectious Diseases (NCEZID), 2022.

8. OHHLE. One Health: A new definition for a sustainable and healthy future. PLoS Pathog 2022;18:e1010537.

9. Ellis WA. Animal leptospirosis. Curr Top Microbiol Immunol 2015;387:99-137.

10.Goldstein RE. Canine leptospirosis. Vet Clin North Am Small Anim Pract 2010;40:1091-101.

11.Rist CL, Arriola CS, Rubin C. Prioritizing zoonoses: a proposed one health tool for collaborative decision-making. PLoS One 2014;9:e109986.

12. Adler B, de la Peña Moctezuma A. Leptospira and leptospirosis. Vet Microbiol 2010;140:287-96.

13. Galaz V, Leach M, Scoones I, Stein C. The political economy of One Health research and policy. STEPS Working Paper 81. Brighton: STEPS Centre, 2015.

14. Rüegg SR, McMahon BJ, Häsler B, Esposito R, Nielsen LR, Ifejika
Speranza C, et al. A blueprint to evaluate One Health. Front Public Health 2017;5:20.

15. Gibbs EPJ. The evolution of One Health: a decade of progress and challenges for the future. Vet Record 2014;174:85-91.

16. Vincent AT, Schiettekatte O, Goarant C, Neela VK, Bernet E, Thibeaux R, et al. Revisiting the taxonomy and evolution of pathogenicity of the genus Leptospira through the prism of genomics. PLoS Negl Trop Dis 2019;13:e0007270.

17. Cerqueira GM, Picardeau M. A century of Leptospira strain typing. Infect Genet Evol 2009;9:760-68.

18. Picardeau M. Genomics, proteomics, and genetics of Leptospira. Curr Top Microbiol Immunol 2015;387:43-63.

19. Nakamura S. Motility of the zoonotic spirochete Leptospira: Insight into association with pathogenicity. Int J Mol Sci 2022;23.

20. Bierque E, Thibeaux R, Girault D, Soupé-Gilbert ME, Goarant C. A systematic review of Leptospira in water and soil environments. PLoS One 2020;15:e0227055.

21. Levett PN. Leptospirosis. Clin Microbiol Rev 2001;14:296-326.

22. Yamaguchi T, Higa N, Okura N, Matsumoto A, Hermawan I, Yamashiro T, et al. Characterizing interactions of Leptospira interrogans with proximal renal tubule epithelial cells. BMC Microbiol 2018;18:64.

23. Mwachui MA, Crump L, Hartskeerl R, Zinsstag J, Hattendorf J. Environmental and behavioural determinants of leptospirosis transmission: A systematic review. PLoS Negl Trop Dis 2015;9:e0003843.

24. Zinsstag J, Schelling E, Waltner-Toews D, Tanner M. From "one medicine" to "one health" and systemic approaches to health and well-being. Prev Vet Med 2011;101:148-56.

25. Dhewantara PW. Spatial epidemiological approaches to monitor and measure the risk of human leptospirosis. School of Veterinary Science. Volume Ph.D. Australia: University of Queensland, 2019:1-330.

26. Moola S, Beri D, Salam A, Jagnoor J, Teja A, Bhaumik S. Leptospirosis prevalence and risk factors in India: Evidence gap maps. Trop Doctor 2021;51:415-421.

27. Vimal Raj R, Vinod Kumar K, Lall C, Vedhagiri K, Sugunan AP, Sunish IP, et al. Changing trend in the seroprevalence and risk factors of human leptospirosis in the South Andaman Island, India. Zoonoses Public Health 2018;65:683-689.

28. Udayar SE, Chengalarayappa NB, Madeshan A, Shivanna M, Marella K. Clinico epidemiological study of human leptospirosis in hilly area of south India-A population based case control study. Indian J Community Med 2023;48:316-320.

29. Jahan A, Bhargava P, Kalyan RK, Verma SK, Gupta KK, Inbaraj S, et al. Serological and molecular study of Leptospira in pediatric patients at a tertiary care centre of northern India. Indian J Med Microbiol 2021;39:245-248.

30. Mohankumar SK, Govindarajan RK, Chokkalingam M. Leptospirosis outbreak in a hill due to water from anunprotected well, Keerakadu village, Kollihills, Namakkal, Tamilnadu, India. Infect Control Hosp Epidemiol 2020;41:s310-s310.

31. Sethi S, Sharma N, Kakkar N, Taneja J, Chatterjee SS, Banga SS, et al. Increasing trends of leptospirosis in northern India: a clinico-epidemiological study. PLoS Negl Trop Dis 2010;4:e579.

32. Sachu A, Madhavan A, Vasudevan A, Vasudevapanicker J. Prevalence of dengue and leptospirosis co-infection in a tertiary care hospital in

south India. Iran J Microbiol 2018;10:227-232.

33. Gupta N, Wilson W, Ravindra P, Joylin S, Bhat R, Saravu K. Clinical profile, management and outcome of patients with leptospirosis during the times of COVID-19 pandemic: A prospective study from a tertiary care centre in South India. Infez Med 2021;29:393-401.

34. Chaudhary A. Leptospirosis in India: a forgotten tropical disease. London: Royal Society of Tropical Medicine and Hygiene, 2021.

35. Picardeau M. Virulence of the zoonotic agent of leptospirosis: still terra incognita? Nat Rev Microbiol 2017;15:297-307.

36. Guernier V, Goarant C, Benschop J, Lau CL. A systematic review of human and animal leptospirosis in the Pacific Islands reveals pathogen and reservoir diversity. PLoS Negl Trop Dis 2018;12:e0006503.

37. Arent Z, Frizzell C, Gilmore C, Allen A, Ellis WA. Leptospira interrogans serovars Bratislava and Muenchen animal infections: Implications for epidemiology and control. Vet Microbiol 2016;190:19-26.

38. Di Azevedo MIN, Lilenbaum W. Equine genital leptospirosis: Evidence of an important silent chronic reproductive syndrome. Theriogenology 2022;192:81-88.

39. Cilia G, Bertelloni F, Fratini F. Leptospira Infections in domestic and wild animals. Pathogens 2020;9.

40. Balakrishnan G, Roy P, Govindarajan R, Ramaswamy V, Murali Manohar B. Bovine leptospirosis in Andhra Pradesh Indian Vet. J. 2011;88:140-141.

41. Prameela RD, Sreenivasulu D, Vijayachari P, NatarajSeenivasan K. Seroepidemiology of leptospirosis in Andhra Pradesh. Arch. Clin. Microbiol. 2013;4:1-10.

42. Patel JM, Prasad MC, Vihol PD, Kalyani IH, Prajapati MG. Seroprevalence of Leptospira hardjo in Cattle of Gujarat, India. Int. J. Curr. Microbiol. Appl. Sci. 2017;6:1304-1310.

43. Balakrishnan G, Roy P, Govindarajan R, Ramaswamy V, Murali Manohar B. Seroepidemiological studies on leptospirosis among bovines in an organized farm. Int. j. agro vet. med. sci. 2011;10:87-88.

44. Balamurugan V, Alamuri A, Kumar KV, Varghese B, Govindaraj G, Hemadri D, et al. Prevalence of anti-leptospiral antibodies and frequency distribution of Leptospira serovars in small ruminants in enzootic South Peninsular India. Vet World 2021;14:2023-2030.

45. Sabarinath T, Behera SK, Deneke Y, Atif Ali S, Kaur G, Kumar A, et al. Serological evidence of anti-Leptospira antibodies in goats in various agro climatic zones of India. Small Rumin Res 2018;169:74-80.

46. Alamuri A, Kumar KV, SowjanyaKumari S, Linshamol L, Sridevi R, Nagalingam M, et al. Expression of Recombinant Leptospiral Surface Lipoprotein-Lsa27 in E. coli and Its Evaluation for Serodiagnosis of Bovine Leptospirosis by Latex Agglutination Test. Mol Biotechnol 2020;62:598-610.

47. Vihol PD, Patel JH, Patel JM, Raval JK, Kalyani IH, Varia RD. Serological investigation on leptospirosis in clinically ailing goats. Int J Curr Microbiol Appl Sci 2017;6:845-850.

48. Vihol PD, Patel JM, Patel JH, Prasad MC, Kalyani IH, Raval JK. Serological and clinicopathological studies on leptospirosis among sheep. J Anim Res 2016;6:571-571.

49. Krishna S, Joseph S, Ambily R, Mini M, Jadhav A, Radhika G. Caprine leptospirosis-a seroprevalence study. J Vet Anim Sci 2012;43:27-29.

50. Bojiraj M, Kannan P, Laskhmanapathy G, Sundaram SK. Evaluation of outer membrane protein based in house I-ELISA for screening of leptospirosis in dogs and cattle. Progressive Research – An International Journal 2016;11:4115-4119.

51. Tufani N, Singh JL, Kumar M. Microscopic Agglutination Test (MAT) for leptospirosis in association with acute renal failure in dogs. J Anim Res 2019;9:581-584.

52. Ambily R, Mini M, Joseph S, Krishna SV, Abhinay G. Canine leptospirosis – a seroprevalence study from Kerala, India. Vet World 2013;6:42-44.

53. Saranya P, Goswami C, Sumathi K, Balasundareshwaran AH, Bothammal P, Dutta LJ, et al. Prevalence of leptospirosis among animal herds of north eastern provinces of India. Comp Immunol Microbiol Infect Dis 2021;79:101698.

54. Reshma P, Joseph S, Mini M, Ramachandran A, Usha A, Reji R, et al. Seroprevalence of leptospirosis among swine in Kerala, India. Pharm Innov J

2018;7:101-103.
55. Naseema U, Vairamuthu S, Balachandran C, Ravikumar G. Seroprevalence of leptospirosis in horses in chennai. Indian Vet J 2017;94:44-46.

56. Kumar VH, Arunaman C. S., Brahma J. Diagnosis and therapeutic management of leptospirosis in horses. INTAS POLIVET 2019;20:399-400.

57. Mathesh K, Thankappan S, Deneke Y, Vamadevan B, Siddappa CM, Sharma AK, et al. A multipronged approach for the detection of leptospirosis in captive sloth bears (Melursus ursinus) in Agra and Bannerghatta sloth bear rescue centres in India. J Vet Med Sci 2021;83:1059-1067.

58. Srivastava SK, Kumar AA. Seroprevalence of leptospirosis in animals and human beings in various regions of the country. Indian J Comp Microbiol Immunol Infect Dis 2003;24:155-159.

59. Vengadabady N, Govindan B, Ravikumar G, Govindarajan R. Seroprevalence of leptospirosis among mavooths residing at Mudhumalai and Anamalai Wildlife Sanctuary. Adv Appl Res 2014;6:12.

60. Deneke Y, Deb R, Kabir SML. Comparative evaluation of recombinant LigB based latex agglutination test with microscopic agglutination test for the diagnosis of wildlife leptospirosis. Asian J Med Biol Res 2020;6:440-448.
61. Rajesh NV, Veeraselvam M, Sridhar R, Senthikumar TMA, Thangaraj MG. Seroprevalence of leptospirosis in captive sloth bears (Melursus ursinus). Indian Vet J 2013;90:113-114.

62. Johnson I, Hansen A, Bi P. The challenges of implementing an integrated One Health surveillance system in Australia. Zoonoses Public Health 2018;65:e229-e236.
63. Queenan K, Garnier J, Nielsen L, Buttigieg S, Meneghi Dd, Holmberg M, et al. Roadmap to a One Health agenda 2030: CABI International, 2017.

64. Senthilkumar K, Ravikumar G. Lateral flow assay for rapid serodiagnosis of bovine leptospirosis. Iran J Vet Res 2022;23:7-11.

65. Durski KN, Jancloes M, Chowdhary T, Bertherat E. A global, multi-disciplinary, multi-sectorial initiative to combat leptospirosis: Global Leptospirosis Environmental Action Network (GLEAN). Int J Environ Res Public Health 2014;11:6000-8.

66. Adler B. Vaccines against leptospirosis. Curr Top Microbiol Immunol 2015;387:251-72.

67. Drewe JA, Hoinville LJ, Cook AJC, Floyd T, Stärk KDC. Evaluation of animal and public health surveillance systems: a systematic review. Epidemiol Infect 2012;140:575-590.

68. Pereira MM, Schneider MC, Munoz-Zanzi C, Costa F, Benschop J, Hartskeerl R, et al. A road map for leptospirosis research and health policies based on country needs in Latin America. Rev Panam Salud Publica 2018;41:e131.

69. Lau CL, Smythe LD, Craig SB, Weinstein P. Climate change, flooding, urbanisation and leptospirosis: fuelling the fire? Trans R Soc Trop Med Hyg 2010;104:631-8.

Epidemiological Trends of Zoonotic Diseases in India: A Focus on Crimean-Congo Hemorrhagic Fever, Kyasanur Forest Disease, and Nipah Virus Disease

Deepak Y. Patil[1], Anita M. Shete[1], Rima R. Sahay[1], Sreelekshmy Mohandas[1], Pragya D. Yadav*

[1]Maximum Containment Laboratory, Microbial Containment Complex, ICMR-National Institute of Virology, Sus-Pashan Road, Pune, Maharashtra, Pin 411021, India

***Corresponding author**
Dr. Pragya D. Yadav
Scientist 'F' & Group Leader
Maximum Containment Laboratory, Microbial Containment Complex
ICMR-National Institute of Virology
E mail ID: hellopragya@gmail.com

Abstract

In recent decades, numerous emerging and re-emerging diseases have extended their reach to diverse global regions, collectively contributing to around 25% of annual global mortality. Over the past decade, highly contagious viruses such as Crimean-Congo Hemorrhagic Fever, Nipah Virus, and Kyasanur Forest Disease have emerged, causing severe outbreaks in various regions of India. However, it is evident that these viruses have now re-emerged in newer areas, resulting in significant morbidity and mortality among the human population. Given the changing epidemiological landscape, there is a good chance that these viruses will continue to appear in new places in the future. In light of this context, we present a comprehensive account of the incidence, prevalence, and the growing trend of these viruses appearing in various geographical locations throughout India.

Keywords: Crimean Congo Hemorrhagic Fever, Kyasanur forest disease, Nipah, India

Introduction

Being one of the world's most densely populated nations, India grapples with a multitude of infectious diseases, creating significant public health challenges. Among the prevalent infectious diseases reported in India are Malaria, Cholera, Hepatitis, Tuberculosis, Rabies, Dengue, Plague, Chikungunya, Japanese Encephalitis, Typhoid, HIV, Influenza, and Diarrhoeal illnesses.[1] However, the last two decades has been truly a menace to the public health of India. During this period, India has witnessed many outbreaks of deadly viral disease viz., Avian Influenza H5N1 (2006)[2]; Chikungunya (2006-2023)[3]; pandemic influenza (2009)[4]; Crimean Congo hemorrhagic fever (CCHF) (2011-2023)[5-17], Kyasanur Forest disease (KFD) (2014, 2016, 2017-2023)[19-32]; Nipah virus (2001, 2007 & 2018, 2019, 2021, 2023)[37-51]; Zika virus (2016, 2017, 2018, 2021, 2022, 2023)[52-56]; and SARS-CoV-2 (2020-2023)[57].

Among these, CCHF, KFD, and Nipah viruses stand out as the most significant and highly contagious emerging viral infections in India during the 21st century.[5-51] They have triggered periodic outbreaks in various parts of the country, despite originally being endemic to specific regions. In this report, we shed light on the occurrence, prevalence, and emergence/re-emergence of these viruses in various parts of India.

Crimean Congo hemorrhagic fever (CCHF)

CCHF is a zoonotic illness caused by ticks that affects humans and animals. A nairovirus, which is a member of the Nairoviridae family, is the causal agent. Human infection can occurs via direct contact with the blood of infected people or cattle or by the bite of an infected Hyalomma tick. There have been reports of human to human transmission, especially when the virus is in its acute viremic phase and involves close interactions. According to international classification, the CCHF virus is considered highly infectious due to its high pathogenicity, established human to human transmission, and high case fatality rate. This deadly disease has been documented in Africa, Asia, Middle East, southern and eastern Europe,[7,9,17] and has significantly impacted human and animal health in India.[5-17]

The initial identification of CCHF in India was made in 2011 after a nosocomial outbreak in Ahmedabad, Gujarat State, by the ICMR-National Institute of Virology (NIV) in Pune. The development of novel molecular and serological assays for the diagnosis of CCHF was made possible by the establishment of a state-of-the-art Biosafety Level (BSL)-4 Laboratory at ICMR-NIV, Pune. These tools were essential for the rapid diagnosis of suspected CCHF cases as well as for

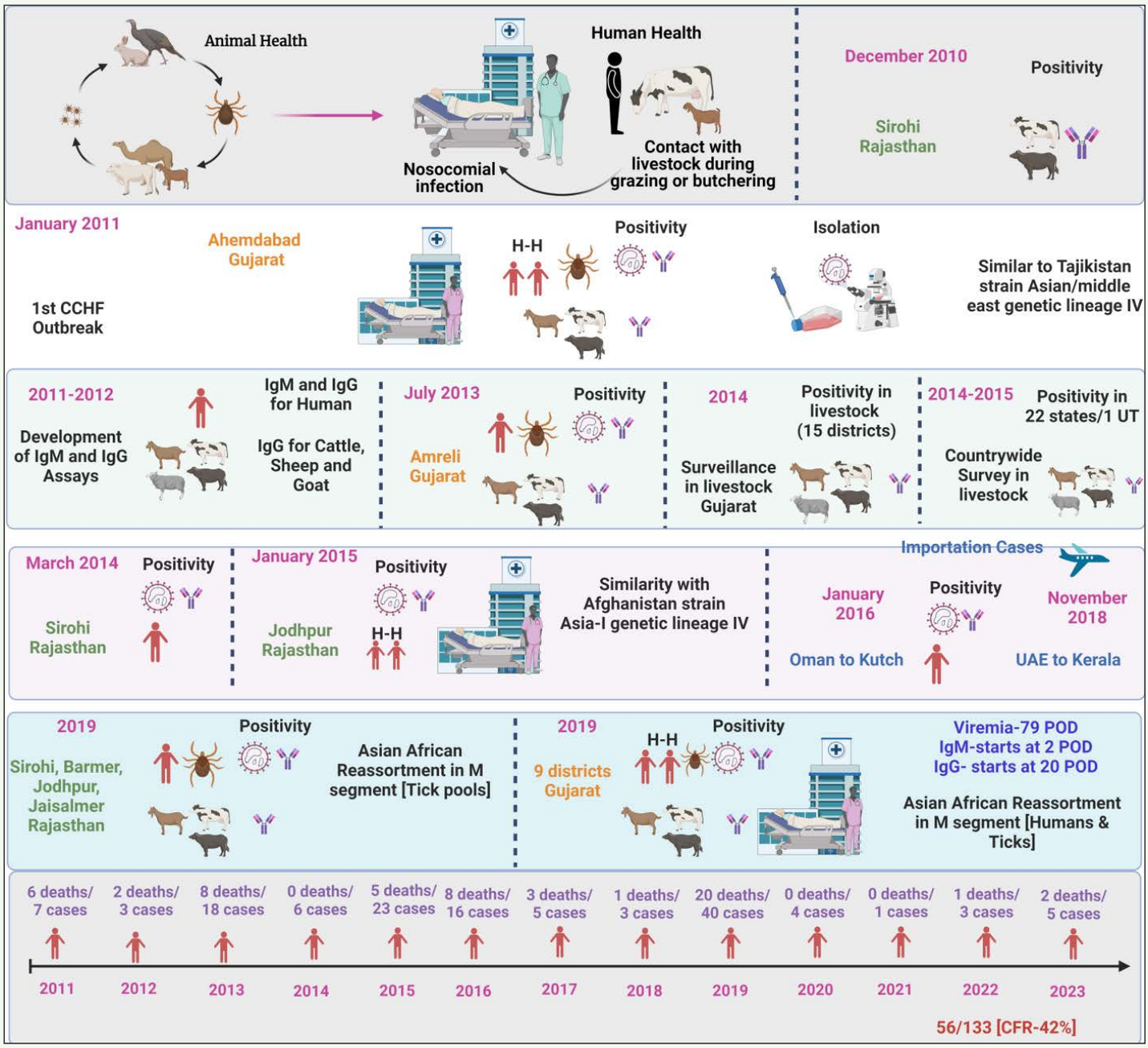


Figure 1: CCHF outbreaks in India – Outbreak investigations, surveillance, and R&D

monitoring populations of ticks, cattle, and humans. Numerous nosocomial and sporadic CCHF outbreaks were investigated and confirmed in fifteen districts of Gujarat State between 2011 and 2023.[5-17] Although anti-CCHF IgG antibodies were found in livestock in Rajasthan State in 2010,[5] the first human case of CCHF was reported in the Sirohi area of Rajasthan in 2014.[10] Subsequently, a nosocomial outbreak of CCHF was identified among healthcare workers in a private hospital in Jodhpur, Rajasthan, in 2015.[12] A nationwide serosurvey conducted by NIV, Pune revealed widespread seroprevalence of CCHF among sheep, goats, and cattle in 23 states and one union territory in India.[11] In recent years, two imported cases of CCHF were identified in individuals traveling from Oman13 and the UAE, and they were successfully managed in Gujarat and Kerala states in 2016 and 2018, respectively.

From 2011 to 2023, 138 cases of CCHF were confirmed, with 57 fatalities, accounting for a Case Fatality Rate (CFR) of 41.3%.[5-17] These CCHF cases were documented in 15 districts within Gujarat state, including Ahmedabad, Kutch, Patan, Surendranagar, Morbi, Jamnagar, Amreli, Aravali, Anand, Gandhinagar, Rajkot, Bhavnagar, Botad, Kheda, and Sabarkantha.

Additionally, CCHF cases were reported in 4 districts of Rajasthan state: Jodhpur, Jaisalmer, Barmer, and Sirohi. Since 2019, over 900 close contacts of CCHF cases have been monitored, and a very low sub-clinical infection rate of less than 0.3% was observed.

Many guidelines were developed for recognizing cases, diagnosing, putting isolation measures in place, and tracing contacts due to the high risk of CCHF in India as well as the possibility of the virus spreading through

animal trade and international travelers. The responsibility for managing sporadic CCHF outbreaks in India was shared among the Indian Council of Medical Research (ICMR), the Integrated Disease Surveillance programme (IDSP), and the National Centre for Vector Borne Diseases Control (NCVBDC). This collaborative effort enabled the timely detection, diagnosis, and efficient containment of CCHF outbreaks.

Following the larger outbreak of CCHF in 2019, a laboratory network equipped with BSL-3 facilities was established and staffs were trained across India for CCHF diagnosis, supported by an ICMR-funded project. Currently, seven active laboratories have the capacity to test for CCHF, including SMSMC, Jaipur; KGMU, Lucknow; ICMR-RMRC, Port Blair; AIIMS, Jodhpur; ICMR-NICED, Kolkata; ICMR-RMRC, Dibrugarh; and ICMR-NIRTH Jabalpur.

There are currently no licensed vaccines or approved treatments for CCHF, hence the primary strategy to treatment is supportive care. Although Ribavirin has displayed some efficacy in laboratory settings and has been employed during outbreaks, there is limited and uncertain evidence supporting its effectiveness.[18] In July 2023, Turkey initiated the first Phase-1 clinical trial for intravenous Ribavirin and Favipiravir as potential treatments.[19] Additionally, there is a pressing need for the development of monoclonal

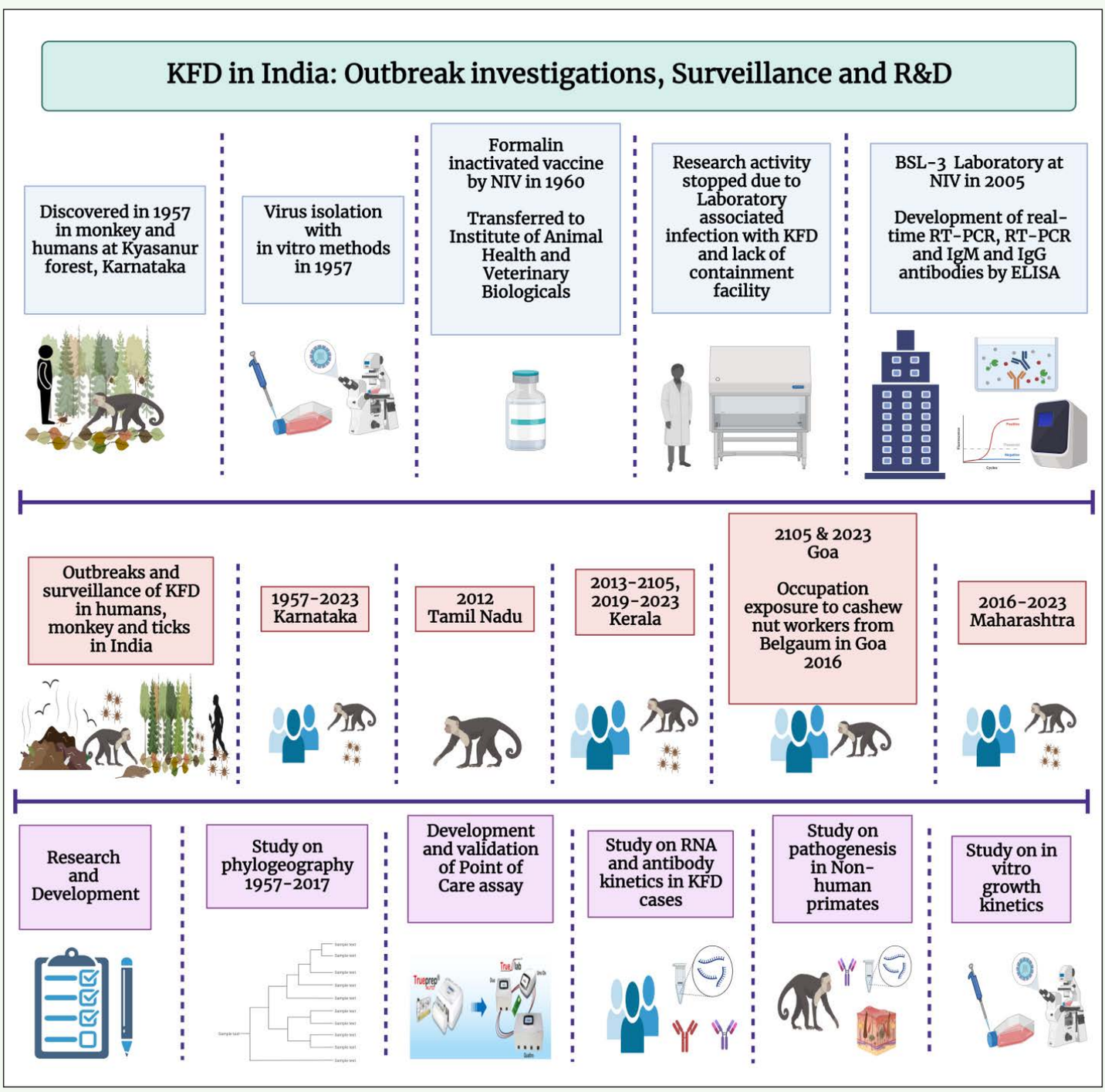


Figure 2: KFD outbreaks in India: Outbreak investigations, surveillance, and R&D

antibody therapies to address CCHF cases and individuals at high risk of infection.

A significant challenge in the quest for CCHF vaccines and therapeutics has been the absence of suitable and standardized animal models. The emergence of new animal models that are susceptible to CCHFV infection, such as IFNAR-/-mice, STAT-1 mice, and cynomolgus macaques, has enhanced the screening and validation of potential vaccines in preclinical studies.[19] Nonetheless, these models must be refined and standardized further, including the selection of appropriate viral strains, reagents, and challenge methods. This will better replicate clinical characteristics observed in humans, while bridging data on animal and human immunogenicity and facilitate the selection of vaccine candidates for human evaluation.

Kyasanur forest disease (KFD)

Kyasanur Forest Disease (KFD) was first discovered in 1957 following a study into a large number of monkey deaths in Karnataka's Shimoga district. The KFD virus, a member of the Flaviviridae family, causes the disease. Humans and monkeys are the main hosts that the virus primarily affects in its natural cycle, which is maintained in Haemaphysalis ticks, mammals, and birds. KFDV is transmitted to humans via tick nymph bites or contact with carcasses of deceased monkeys.[9,17]

Ever since its discovery, Kartaka State has had a number of outbreaks and occasional instances of KFD, mostly in five districts: Shimoga, Chikmagalur, Uttara Kannada, Dakshina Kannada, and Udupi. These areas have experienced an average of around 400 to 500 cases per year.[9,17]

Apparently from around 2012, KFD has been reported in new areas, involving either monkey deaths or human cases. These regions include the districts of Chamarajanagar in Karnataka State (2012), the Mudumalai Tiger Reserve in Tamil Nadu State (2012), the districts of Wayanad and Malappuram in Kerala State (2013–14, 2018), the state of Goa (2015–2023), and the state of Maharashtra (2016-2023).[20-32]

The mortality rate associated with KFDV infection is reported to range from 2% to 10%. Higher fatality rates have been observed in non-endemic areas, primarily due to a lack of awareness about the disease and lower levels of herd immunity to the virus. In Karnataka's KFD-endemic areas, a formalin-inactivated chick embryo tissue culture vaccination has been used since 1990. However, studies have indicated low vaccination coverage in the population and reduced vaccine effectiveness compared to initial reports.[33]
As a result, the use of the KFD vaccine has been discontinued, and ongoing efforts are focused on developing a new vaccine. Currently, supportive care is the main method of managing infected cases of KFD as there is no particular treatment for the disease.

Time-sensitive and affordable molecular and serological tests, such as nested RT-PCR and real-time RT-PCR, as well as KFD IgM and IgG ELISA, were developed for KFDV identification after a BSL-3 laboratory was established at ICMR-NIV in Pune.[21] These advances have greatly improved the screening for KFDV among human, monkey, and tick populations in various geographic locations across India. ICMR-NIV, Pune has taken significant steps in ecological, entomological, and virological research on KFD, shedding light on this enigmatic "monkey fever."

A number of variables, including deforestation, monkey migration, changes to agricultural land use methods, and changes in people's socioeconomic behavior, may have contributed to the disease's spread into new regions. Infected monkeys and rodents, along with ticks, contribute to the disease's expansion into new regions. Therefore, the KFD virus continues to spread through wildlife-tick-human interactions, and the Western Ghats' extensive densely forested areas provide the perfect environment for tick cycles to complete. While KFD is endemic to India,[9,17] it has the potential to spread to neighboring countries through animal transportation or the diverse migratory bird population.

Studies on the genome and phylogeography have shed light on the evolution of the virus and the areas connected to KFDV transmission dynamics. Recent KFDV isolates (from 2006-2017) displayed approximately a 3% difference compared to early strains from Karnataka.[34] Laboratory mice and Bonnet macaques have been extensively studied as animal models to understand KFD disease pathogenesis and progression. Rodent models exhibit neurological disease, while Bonnet macaques experience prolonged disease with relatively few fatalities. Studies on viremia, virus shedding in different secretions, antibody responses, and viral RNA loads in different organs have all benefited from the use of these animal models.[35-36]

In conclusion, KFD is a serious threat to public health, especially in India's Western Ghats. To manage and prevent future outbreaks and, ultimately, protect the health and well-being of at-risk communities, vigilance, research, and cooperative efforts are essential. This tick-borne viral disease, caused by KFDV, has demonstrated its potential to trigger periodic outbreaks of varying severity.

Nipah virus disease

Nipah virus (NiV), belonging to the paramyxovirus family, is a recently identified zoonotic virus capable of causing severe and fatal infections in humans. The first known case of NiV infection in humans was discovered in 1998–1999 during a major encephalitis outbreak in Malaysia.[58] The Nipah virus has been known to spread from animal to human and from human to human during a number of outbreaks. NiV can cause an extremely deadly respiratory and encephalitic disease in humans. From 1998 to 2023, cases of the disease were documented in a number of countries, including Singapore, Malaysia, Bangladesh, the Philippines, and India.[59]

During January and February of 2001, the Siliguri area of West Bengal in India experienced the first Nipah virus outbreak, which resulted in [45] deaths out of 66 cases (CFR 68%). The majority of the afflicted people had symptoms such as fever, headache, myalgia, vomiting, altered sensorium, acute respiratory distress, and convulsions. During that period, India was devoid of the diagnostic tests required to identify the Nipah outbreak and the containment facilities required to manage high-risk viruses.[37] In April 2007, the Nadia district of West Bengal had the second Nipah virus outbreak. This was an intra-familial outbreak, affecting all five family members, who unfortunately succumbed to the infection (CFR 100%).[38] In 2015, ICMR-NIV, Pune conducted a multi-site virological survey that established the presence of NiV in Pteropus giganteus bats in the Cooch Bihar district of West Bengal and the Dhubri district of Assam.[41]

During May 2018, the third Nipah virus outbreak occurred, resulting in 16 fatalities out of [18] confirmed cases (CFR 89%). The first Nipah outbreak in southern India was recorded in the Kerala state's Kozhikode district. This outbreak occurred far from the two earlier outbreaks in 2001 and 2007 in West Bengal, which is located in eastern India. Patients primarily presented with symptoms such as fever, cough, altered sensorium, acute respiratory distress syndrome, vomiting, headache, and signs of myocarditis.[40] During this outbreak, therapeutic monoclonal antibodies (m102.4), developed by the University of Queensland, Australia, were provided to India, and emergency use authorization was granted by the Drug Controller General of India in June 2018. Guidelines for the use of m102.4 monoclonal antibodies on Nipah cases were developed through global research collaboration in 2019.

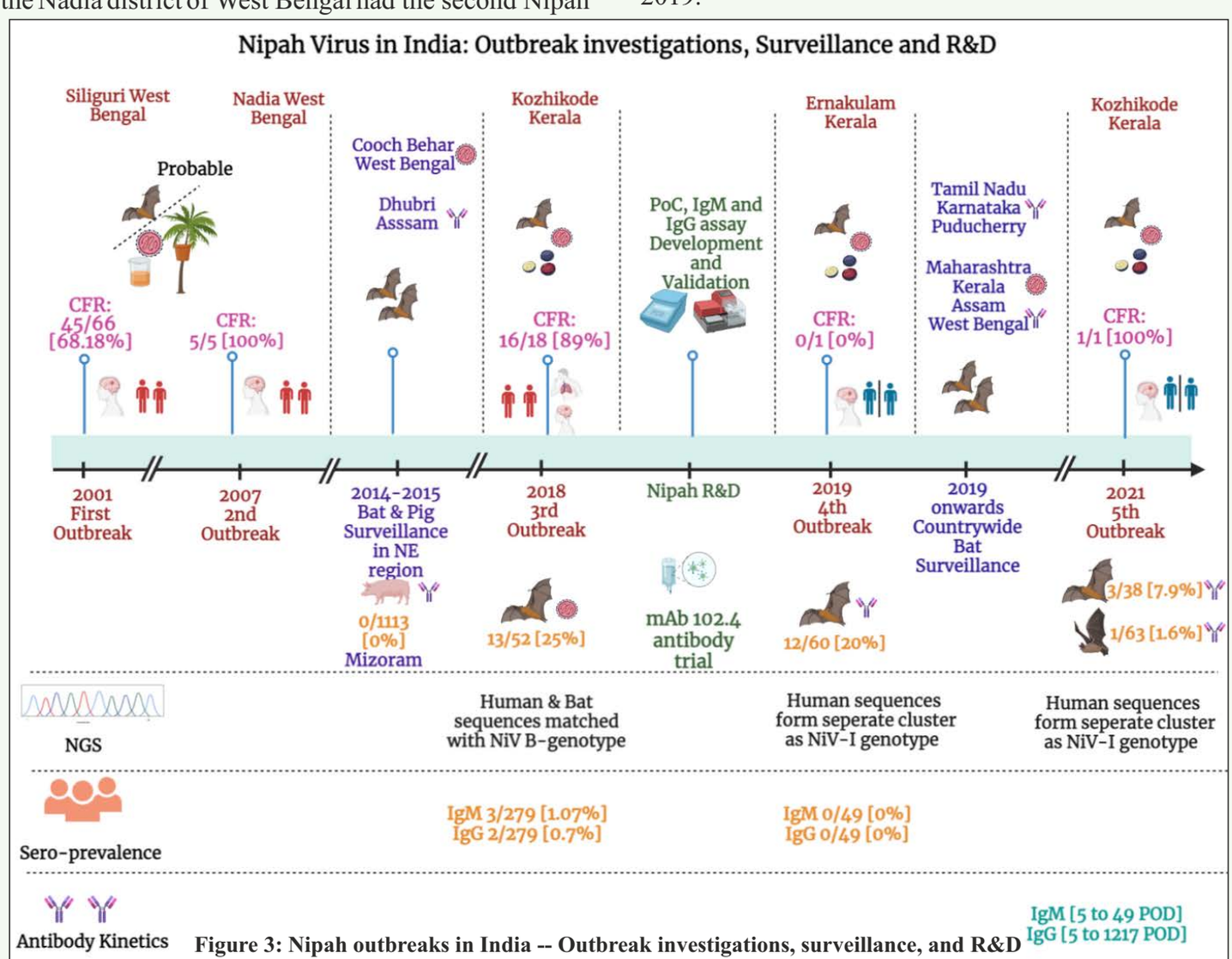


Figure 3: Nipah outbreaks in India -- Outbreak investigations, surveillance, and R&D

One significant development following the outbreak was the creation of a point of care (PoC) assay for NiV diagnosis. This PoC assay was standardized and employed in the field for Nipah diagnosis during the outbreaks in 2019 and 2021. NiV surveillance was made possible by the development of human IgM and IgG tests as well as an IgG screening assay for pigs and bats following the isolation of the virus. Only 3 out of 239 contacts (1.2%) tested positive for IgM and IgG during the 2018 outbreak, indicating an extremely low seroprevalence among close contacts.[40]

Only one case—who showed signs of fever and encephalitis-like symptoms—tested positive for the Nipah virus disease during the fourth outbreak that occurred in the Ernakulam district of Kerala in June 2019. During this outbreak, none of the patient's close contacts showed signs of seropositivity, and the patient survived with supportive treatment.46 Amidst the COVID-19 epidemic, the Kerala district of Kozhikode recorded the fifth Nipah outbreak in August-September 2021, which claimed one life (CFR 100%). Affected individual presented with fever and late-onset encephalitis.[51]

In all three of the outbreaks in 2018, 2019, and 2021, Pteropus medius bats were found to be the likely source of infection and transmission in the vicinity of the index case, based on positive results from real-time RT-PCR or IgG ELISA tests. The NiV sequences from the 2018 outbreak belonged to the B genotype, while sequences from the 2019 and 2021 outbreaks were identified as I (Indian) genotype. All of these human sequences were consistent with the bat sequences.[44,45,48]
The Pteropus species of fruit bats, also referred to as flying foxes, are identified as the Nipah virus's known reservoirs. Previous ICMR-NIV investigations in Nipah outbreak-affected areas have detected the virus in fruit bats from a number of locations, including Dubri in Assam, Myanaguri and Cooch Behar in West Bengal in 2015, Maharashtra in 2020, and Kozhikode, Kerala in 2018.[41,44,45] The paucity of information on the virus's presence among Pteropus bat species in the other parts of the country motivated the ICMR-NIV to initiate a nationwide survey. This survey has so far been carried out in fourteen states and two union territories, namely Kerala, Tamil Nadu, Karnataka, Telangana, Goa, Maharashtra, West Bengal, Gujarat, Punjab, Himachal Pradesh, Odisha, Bihar, Assam, Meghalaya, Chandigarh, and Puducherry. The presence of Nipah viral antibodies was detected in bats from seven states and one union territory,[52] suggesting evidence of virus circulation within the bat population. This study aims to identify areas at risk of spill-over and, as a result, facilitate the implementation of necessary precautionary measures and control strategies to prevent future outbreaks in the country.

In the most recent Nipah virus outbreak, the sixth occurrence, which was declared on September 13, 2023, in Kozhikode, Kerala, three out of five suspected cases were diagnosed as NiV positive by ICMR-NIV, Pune. Nipah virus was confirmed in six cases, resulting in two fatalities (CFR 33.33%). All close contacts and other suspected cases not epidemiologically linked were found to be negative for Nipah virus infection.[62] Further investigations are essential to delve into the underlying factors contributing to recurring spillover events in Kerala State. While bats in this region have tested positive for NiV RNA, the precise mode of transmission to the initial cases remains to be determined.

As of the now, there is no approved vaccine or therapies for Nipah virus infections. Since 2018, the Coalition for Epidemic Preparedness Innovations (CEPI) has supported the NiV vaccine development and continues to provide significant funding to scientific endeavors such as the creation of International Standards for NiV antibodies, assay development, and epidemiological research.[63] Numerous Nipah virus vaccine candidates are undergoing preclinical trials and clinical trials.[64,65]

Nipah virus is an extremely contagious and lethal virus. Because there is no specific treatment for Nipah virus infection, supportive care may enhance the patient's prognosis. Taking preventive measures is of paramount importance to prevent Nipah virus infection. This entails refraining from contact with bats and their excrement, consuming only well-cooked fruits and vegetables, and maintaining regular hand hygiene by washing hands with soap and water.

Current interventions and prospects

At present, there are no vaccines or antiviral drugs that are useful in treating Nipah virus disease and Crimean-Congo hemorrhagic fever (CCHF). Supportive care is the main strategy used to manage these diseases, and the main focus of current preventative efforts is increasing awareness in the affected areas. It is noteworthy that the WHO R&D Blueprint list of pandemic threats requiring immediate R&D initiatives includes both the CCHF and the Nipah virus. Recently KFD immunization campaigns have been discontinued due to a paucity of information regarding the immunogenicity of the currently available vaccine.[33] Cases of KFD are treated with supportive care because of the absence of antiviral treatment.

Reducing the chain of transmission, treating infectious diseases appropriately, and eventually saving lives all depend on accurate diagnosis. Given extensive scale of the outbreaks caused by these viruses, a more comprehensive examination of their areas of origin is necessary. Timely and affordable molecular and serological tests for the identification of CCHF, KFD,

and Nipah viruses have been established with the development of containment laboratories (BSL-3 & BSL-4 laboratories) at ICMR-NIV in Pune, India.

The implementation of these technologies has facilitated the identification of these diseases in various geographical locations across India, subsequently aiding in the application of effective control measures.

Furthermore, various training programmes have been organized for laboratories, healthcare officials, hospitals, and medical colleges, with a specific focus on biosafety, bio-risk mitigation, the transportation of infectious samples, and laboratory diagnosis of emerging and re-emerging viruses. This proactive approach has contributed to the development of emergency preparedness strategies to address significant public health challenges in India.

Acknowledgment
We acknowledge NIV for constant support.

Financial support & sponsorship
None.

Conflicts of Interest
None.

References

1. Kambrath SV, Deshmukh M. The burden of infectious diseases in India-An overview. International Journal of Current Research in Life Sciences. 2018; 7(06):2237-40.

2. Tosh C, Murugkar HV, Nagarajan S, Bhatia S, Pateriya AK, Behera P, et al. Outbreak of avian influenza virus H5N1 in India. The Veterinary Record. 2007; 161(8):279.

3. Translational Research Consortia (TRC) for Chikungunya Virus in India. Current status of chikungunya in India. Frontiers in Microbiology. 2021; 12:695173.

4. Khanna M, Kumar B, Gupta A, Kumar P. Pandemic influenza A H1N1 (2009) virus: lessons from the past and implications for the future. Indian Journal of Virology. 2012; 23:12-7.

5. Mourya DT, Yadav PD, Shete AM, Gurav YK, Raut CG, Jadi RS, et al. Detection, isolation and confirmation of Crimean-Congo hemorrhagic fever virus in human, ticks and animals in Ahmadabad, India, 2010–2011. PLoS Negl Trop Dis. 2012; 6:e1653.

6. Yadav PD, Raut CG, Mourya DT. Re-occurrence of Crimean-Congo haemorrhagic fever in Ahmedabad, Gujarat, India (2012): a fatal case report. The Indian journal of medical research. 2013; 138(6):1027.

7. Yadav PD, Raut CG, Patil DY, Majumdar T, Mourya DT. Crimean-Congo hemorrhagic fever: current scenario in India. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences. 2014; 84:9-18.

8. Yadav PD, Gurav YK, Mistry M, Shete AM, Sarkale P, Deoshatwar AR, et al. Emergence of Crimean-Congo hemorrhagic fever in Amreli district of Gujarat state, India, June to July 2013. International Journal of Infectious Diseases. 2014; 18:97-100.

9. Mourya DT, Yadav PD, Patil DY. Highly infectious tick is borne viral diseases: Kyasanur forest disease and Crimean-Congo hemorrhagic fever in India. WHO South-East Asia J Public Health 2014; 3(1):8-21.

10. Makwana D, Yadav PD, Kelaiya A, Mourya DT. First confirmed case of Crimean-Congo hemorrhagic fever from Sirohi district in Rajasthan State, India. Indian J Med Res. 2015; 142:489–91.

11. Mourya DT, Yadav PD, Shete AM, Sathe PS, Sarkale PC, Pattnaik B, et al. Cross-sectional serosurvey of Crimean-Congo hemorrhagic fever virus IgG in livestock, India, 2013–2014. Emerg Infect Dis. 2015; 21:1837–9.

12. Yadav PD, Patil DY, Shete AM, Kokate P, Goyal P, Jadhav S, et al. Nosocomial infection of CCHF among health care workers in Rajasthan, India. BMC Infect Dis. 2016; 16:624.

13. Yadav PD, Thacker S, Patil DY, Jain R, Mourya DT. Crimean-Congo Hemorrhagic Fever in Migrant Worker Returning from Oman to India, 2016. Emerging infectious diseases. 2017; 23 (6), 1005.

14. Mourya DT, Yadav PD, Gurav YK, Pardeshi PG, Shete AM, Jain R, et al. Crimean Congo hemorrhagic fever serosurvey in humans for identifying high-risk populations and high-risk areas in the endemic state of Gujarat, India. BMC infectious diseases. 2019; 19(1):1-8.

15. Sahay RR, Dhandore S, Yadav PD, Chauhan A, Bhatt L, Garg V, et al. Detection of African genotype in Hyalomma tick pools during Crimean Congo hemorrhagic fever outbreak, Rajasthan, India, 2019. Virus research. 2020; 286:198046.

16. Tripathi S, Bhati R, Gopalakrishnan M, Bohra GK, Tiwari S, Panda S, et al. Clinical profile and outcome of patients with Crimean Congo haemorrhagic fever: a hospital based observational study from Rajasthan, India. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2020; 114(9):650-6.

17. Mourya DT, Yadav PD, Patil DY, Sahay RR. Experiences of Indian Council of Medical Research with tick-borne zoonotic infections; Kyasanur Forest disease and Crimean Congo hemorrhagic fever in India with one health focus. Indian J Med Res. 2021; 153(3):339.

18. Hawman DW, Feldmann H. Crimean–Congo haemorrhagic fever virus. Nature Reviews Microbiology. 2023 Mar 14:1-5.

19. ClinicalTrials.gov. UMIT-1 Trial Favipiravir & Ribavirin for the Treatment of CCHF (UMIT-1). Available from: https://classic.clinicaltrials.gov/ct2/show/NCT05940545. Accessed on October 16, 2023

20. Mehla R, Kumar SR, Yadav PD, Barde PV, Yergolkar PN, Erickson BR, et al. Recent ancestry of Kyasanur Forest disease virus. Emerg Infect Dis. 2009; 15(9):1431-7.

21. Mourya DT, Yadav PD, Mehla R, Barde PV, Yergolkar PN, Kumar SR, et al. Diagnosis of Kyasanur forest disease by nested RT-PCR, real-time RT-PCR and IgM capture ELISA. J Virol Methods. 2012; 186(1-2):49-54.

22. Mourya DT, Yadav PD, Sandhya VK, Reddy S. Spread of Kyasanur Forest disease, Bandipur Tiger Reserve, India, 2012-2013. Emerg Infect Dis. 2013; 19(9):1540-1.

23. Kasabi GS, Murhekar MV, Yadav PD, Raghunandan R, Kiran SK, Sandhya VK, et al. Kyasanur Forest disease, India, 2011-2012. Emerg Infect Dis. 2013; 19(2):278-81.

24. Yadav PD, Shete AM, Patil DY, Sandhya VK, Prakash KS, Surgihalli R, et al. Outbreak of Kyasanur Forest disease in Thirthahalli, Karnataka, India, 2014. Int J Infect Dis. 2014; 26:132-4.

25. Murhekar MV, Kasabi GS, Mehendale SM, Mourya DT, Yadav PD, Tandale BV. On the transmission pattern of Kyasanur Forest disease (KFD) in India. Infect Dis Poverty. 2015; 4:37.

26. Tandale BV, Balakrishnan A, Yadav PD, Marja N, Mourya DT. New focus of Kyasanur Forest disease virus activity in a tribal area in Kerala, India, 2014. Infect Dis Poverty. 2015; 4:12.

27. Awate P, Yadav PD, Patil DY, Shete AM, Kumar V, Kore P, et al. Outbreak of Kyasanur Forest disease (monkey fever) in Sindhudurg, Maharashtra State, India, 2016. J Infect. 2016; 72(6):759-761.

28. Patil DY, Yadav PD, Shete AM, Nuchina J, Meti R, Bhattad D, et al. Occupational exposure of cashew nut workers to Kyasanur Forest disease in Goa, India. Int J Infect Dis. 2017; 61:67-69.

29. Sadanandane C, Gokhale MD, Elango A, Yadav PD, Mourya DT, Jambulingam P. Prevalence and spatial distribution of Ixodid tick populations in the forest fringes of Western Ghats reported with human cases of Kyasanur forest disease and monkey deaths in South India. Exp Appl Acarol. 2018; 75(1):135-142.

30. Munivenkatappa A, Sahay RR, Yadav PD, Viswanathan R, Mourya DT. Clinical & epidemiological significance of Kyasanur forest disease. Indian J Med Res. 2018; 148(2):145-150.

31. Yadav PD, Sahay RR, Mourya DT. Detection of Kyasanur forest disease in newer areas of Sindhudurg district of Maharashtra State. Indian J Med Res. 2018; 148(4):453-455.

32. Gurav YK, Yadav PD, Gokhale MD, Chiplunkar TR, Vishwanathan R, Patil DY, et al. Kyasanur Forest Disease Prevalence in Western Ghats Proven and Confirmed by Recent Outbreak in Maharashtra, India, 2016. Vector Borne Zoonotic Dis. 2018; 18(3):164-172.

33. Kasabi GS, Murhekar MV, Sandhya VK, Raghunandan R, Kiran SK, Channabasappa GH, et al. Coverage and effectiveness of Kyasanur forest disease (KFD) vaccine in Karnataka, South India, 2005–10. PLoS neglected tropical diseases. 2013; 7(1):e2025.

34. Yadav PD, Patil S, Jadhav SM, Nyayanit DA, Kumar V, Jain S, et al. Phylogeography of Kyasanur Forest Disease virus in India (1957–2017) reveals evolution and spread in the Western Ghats region. Scientific reports. 2020; 10(1):1966.

35. Sawatsky B, McAuley AJ, Holbrook MR, Bente DA. Comparative pathogenesis of Alkhumra hemorrhagic fever and Kyasanur forest disease viruses in a mouse model. PLoS neglected tropical diseases. 2014; 8(6):e2934.

36. Patil DR, Yadav PD, Shete A, Chaubal G, Mohandas S, Sahay RR, et al. Study of Kyasanur forest disease viremia, antibody kinetics, and virus infection in target organs of Macaca radiata. Sci Rep. 2020; 10(1):12561.

37. Chadha MS, Comer JA, Lowe L, Rota PA, Rollin PE, Bellini WJ, et al. Nipah-virus associated encephalitis outbreak, Siliguri, India. Emerg Infect Dis. 2006; 12(2):235–240.

38. Arankalle VA, Bandyopadhyay BT, Ramdasi AY, Jadi R, Patil DR, Rahman M, et al. Genomic characterization of Nipah virus, West Bengal, India. Emerg Infect. Dis. 2011; 17(5):907–909.

39. Yadav PD, Raut CG, Shete AM, Mishra AC, Towner JS, Nichol ST, et al. Detection of Nipah virus RNA in fruit bat (Pteropus giganteus) from India. Am J Trop Med Hyg. 2012; 87(3):576-8.

40. Arunkumar G, Chandni R, Mourya DT, Singh SK, Sadanandan R, Sudan P, et al. Outbreak Investigation of Nipah Virus Disease in Kerala, India, 2018. J Infect Dis. 2019; 219(12):1867-1878.

41. Yadav PD, Sudeep A, Gokhale M, Pawar S, Shete A, Patil DY, et al. Circulation of Nipah virus in Pteropus giganteus bats in northeast region of India, 2015. Indian J Med Res. 2018; 147(3):318-320.

42. Kumar CPG, Sugunan AP, Yadav PD, Kurup KK, Aarathee R, Murhekar MV et al. Infections among Contacts of Patients with Nipah Virus, India. Emerg Infect Dis. 2019; 25(5):1007-1010.

43. Mourya D, Yadav PD, Rout M, Pattnaik B, Shete A, Patil DY. Absence of Nipah virus antibodies in pigs in Mizoram State, North East India. Indian J Med Res. 2019; 149(5):677-679.

44. Yadav PD, Shete AM, Kumar GA, Sarkale P, Sahay RR, Radhakrishnan C, et al. Nipah Virus Sequences from Humans and Bats during Nipah Outbreak, Kerala, India, 2018. Emerg Infect Dis. 2019; 25(5):1003-1006.

45. Mourya DT, Yadav PD, Sudeep AB, Gokhale MD, Gupta N, Gangakhedkar RR, et al. Spatial Association Between a Nipah Virus Outbreak in India and Nipah Virus Infection in Pteropus Bats. Clin Infect Dis. 2019; 69(2):378-379.

46. Sahay RR, Yadav PD, Gupta N, Shete AM, Radhakrishnan C, Mohan G, et al. Experimental learnings from the Nipah virus outbreaks in Kerala towards containment of infectious public health emergencies in India. Epidemiol Infect. 2020; 148:e90.

47. Gokhale MD, Sreelekshmy M, Sudeep AB, Shete A, Jain R, Yadav PD. Detection of possible Nipah virus infection in Rousettus leschenaultii and Pipistrellus bats in Maharashtra, India. Journal of Infection and Public Health. 2021; 14(8): 1010-1012.

48. Sudeep AB, Yadav PD, Gokhale MD, Balasubramanian R, Gupta N, Shete A, et al. Detection of Nipah virus in Pteropus medius in 2019 outbreak from Ernakulam district, Kerala, India. BMC Infect Dis. 2021; 21(1):162.

49. Shete AM, Radhakrishnan C, Pardeshi PG, Yadav PD, Jain R, Sahay RR, et al. Antibody response in symptomatic & asymptomatic Nipah virus cases from Kerala, India. Indian Journal of Medical Research. 2021; 154(3):533-5.

50. Yadav PD, Majumdar T, Gupta N, Kumar MA, Shete A, Pardeshi P, et al. Standardization & validation of Truenat™ point-of-care test for rapid diagnosis of Nipah. The Indian Journal of Medical Research. 2021; 154(4):645.

51. Yadav PD, Sahay RR, Balakrishnan A, Mohandas S, Radhakrishnan C, Gokhale MD, et al. Nipah virus outbreak in Kerala State, India amidst of COVID-19 pandemic. Frontiers in Public Health. 2022; 10:14.

52. Gokhale M, Sudeep AB, Mathapati B, Balasubramanian R, Ullas PT, Mohandas S, et al. Serosurvey for Nipah virus in bat population of southern part of India. Comparative Immunology, Microbiology and Infectious Diseases. 2022; 85:101800.

53. Shete AM, Jain R, Mohandas S, Pardeshi P, Yadav PD, Gupta N, et al. Development of Nipah virus-specific IgM & IgG ELISA for screening human serum samples. The Indian Journal of Medical Research. 2022; 156(3):429.

54. Gupta N, Potdar V, Yadav PD, Patil DY, Sapkal GN. Preparedness of public health-care system for Zika virus outbreak: An Indian perspective. J Infect Public Health. 2020: 13(7): 949-955.

55. Malhotra B, Gupta V, Sharma P, Singh R, Sharma H, Vyas M, et al. Clinico-epidemiological and genomic profile of first Zika Virus outbreak in India at Jaipur city of Rajasthan state. J Infect Public Health. 2020; 13(2020) 1920-1926.

56. Yadav PD, Niyas VK, Arjun R, Sahay RR, Shete AM, Sapkal GN, et al. Detection of Zika virus disease in Thiruvananthapuram, Kerala, India 2021 during the second wave of COVID-19 pandemic. Journal of Medical Virology. 2022; 94(6):2346.

57. Gurav YK, Alagarasu K, Yadav PD, Sapkal G, Gokhale M, Parashar D, et al. First case of Zika virus infection during an outbreak of chikungunya in a rural region of Maharashtra state, India. Transactions of The Royal Society of Tropical Medicine and Hygiene. 2022; 116(10):974-7.

58. Yadav PD, Kaur H, Gupta N, Sahay RR, Sapkal GN, Shete AM, et al. Zika a vector borne disease detected in newer states of India amidst the COVID-19 pandemic. Frontiers in Microbiology. 2022:1852.

59. Markov PV, Ghafari M, Beer M, Lythgoe K, Simmonds P, Stilianakis NI, et al. The evolution of SARS-CoV-2. Nature Reviews Microbiology. 2023; 21(6):361-79.

60. Chua KB, Goh KJ, Wong KT, Kamarulzaman A, Tan PS, Ksiazek TG, et al. Fatal encephalitis due to Nipah virus among pig-farmers in Malaysia. Lancet. 1999; 354(9186):1257–1259.

61. Gavi. Seven things you need to know about Nipah virus. Available from: https://www.gavi.org/vaccineswork/seven-things-you-need-know-about-nipah-virus. Accessed on October 16, 2023.

62. World Health Organization. Nipah Virus Infection – India. Available from: https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON490#:~:text=Between%2012%20and%2015%20September,the%20Kozhikode%20district%20of%20Kerala. Accessed on October 16, 2023.

63. CEPI. Targeting diseases with epidemic and pandemic potential. Available from: https://cepi.net/research_dev/priority-diseases/. Accessed on October 16, 2023.

64. Johnson K, Vu M, Freiberg AN. Recent advances in combating Nipah virus. Faculty Reviews. 2021;10.

65. de Wit E, Feldmann F, Cronin J, Goldin K, Mercado-Hernandez R, Williamson BN, Meade-White K, Okumura A, Callison J, Weatherman S, Rosenke R. Distinct VSV-based Nipah virus vaccines expressing either glycoprotein G or fusion protein F provide homologous and heterologous protection in a nonhuman primate model. EBioMedicine. 2023 Jan 1;87.

Strengthening diagnostic capacities for Zoonotic Diseases in India

Vishesh Sood[1], Monil Singhai[1] *

[1]National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr. Monil Singhai
Joint Director & Section Incharge
Centre for Arboviral and Zoonotic Diseases
National Centre for Disease Control (NCDC)
drmonil@gmail.com

Abstract

Preventing and controlling zoonotic diseases requires coordination among various national, regional, state, and local stakeholders in the health, veterinary, and wildlife departments. These stakeholders rely on each other for laboratory diagnosis and timely response. Unfortunately, there is a lack of standardized procedures and approved kits for diagnosing these diseases, which limits laboratory capacity for diagnosis. Additionally, limited technical expertise and the absence of internationally recognized EQAS agencies further complicate the diagnostic process. Therefore, it is crucial to prioritize zoonotic diseases that require a laboratory network and integrate them at the veterinary and human levels based on focus areas outlined in this manuscript. This article offers a roadmap for developing policies for each prioritized zoonotic disease using the 4C model (Communication, Coordination, Collaboration, and Capacity building) of One Health.

Keywords: Zoonoses, One Health, capacity building

Introduction

Classical infectious diseases like rabies and plague, well known for centuries, are zoonotic infectious diseases that have not been eradicated despite significant efforts from human and veterinary health sectors. The zoonotic diseases of major public health importance in India are Dengue/CHK, Japanese encephalitis, leptospirosis, plague, rabies, anthrax, Kala-azar, Kyasanur Forest Disease, Rickettsial diseases, cysticercosis, hydatid disease, trypanosomiasis and toxoplasmosis, some of which cause outbreaks at a great frequency.

Recently, new zoonotic entities with pandemic/ outbreak potential in humans such as Monkeypox (2022) and SARS-COV-2 (2019 onwards), Crimean Congo Hemorrhagic fever (2011 onwards), Nipah virus infection (2001 onwards), Ebola virus (2014 onwards), Avian Influenza (2006 onwards) & H1N1 Influenza (2009 onwards) have stirred the public health machinery. Apart from these, the country is threatened by the import of exotic zoonotic infections like Yellow Fever, Hantavirus infection, Rift Valley fever, etc. The infections/diseases, as evident, can travel across the world and result in not only loss of human and animal lives but also devastating effects on economies. As the disease transcends beyond more than one species, the approach to protecting lives from these infections also is multidimensional, involving many Stakeholders.

One Health is an integrative approach that aims to achieve active participation from all the stakeholders. One Health requires all the stakeholders from human, veterinary, and environmental health to come together and address the health challenges and issues. One Health High-Level Expert Panel (OHHLEP) was established under a quadripartite collaboration between Food and Agriculture Organization (FAO), World Health Organization (WHO), World Organization for Animal Health (WOAH), and United Nations Environment Programme (UNEP) has defined one health as follows [1]:

"One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes that the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent. The approach mobilizes multiple sectors, disciplines, and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems while addressing the collective need for healthy food, water, energy, and air, taking action on climate change and contributing to sustainable development."

The definition emphasizes a 4C model based on Communication, Coordination, Collaboration, and Capacity building to transform OH from a concept to reality. Defining OH in this way is a milestone as it identifies equity, parity, equilibrium, stewardship, and trans-disciplinarity as critical underlying principles for OH. The present manuscript aims at identifying focus areas for strengthening diagnostic capacity for zoonotic infections and employ the 4C model for developing a policy framework for implementation.

As a policy framework, the present text does not include sections on policy analysis, including budgetary provisions, as it is outside the purview of this manuscript. The policy framework for focus areas for diagnostic capacity strengthening are outlined in Figure-2.

Challenges posed and proposed solutions based on one health approach for each focus area will be discussed in the subsequent sections of this manuscript. As different zoonotic infections will have specific requirements in terms of diagnosis, this framework will need to be used for developing policies for each zoonotic infection on a case-by-case basis based on expert consultation.

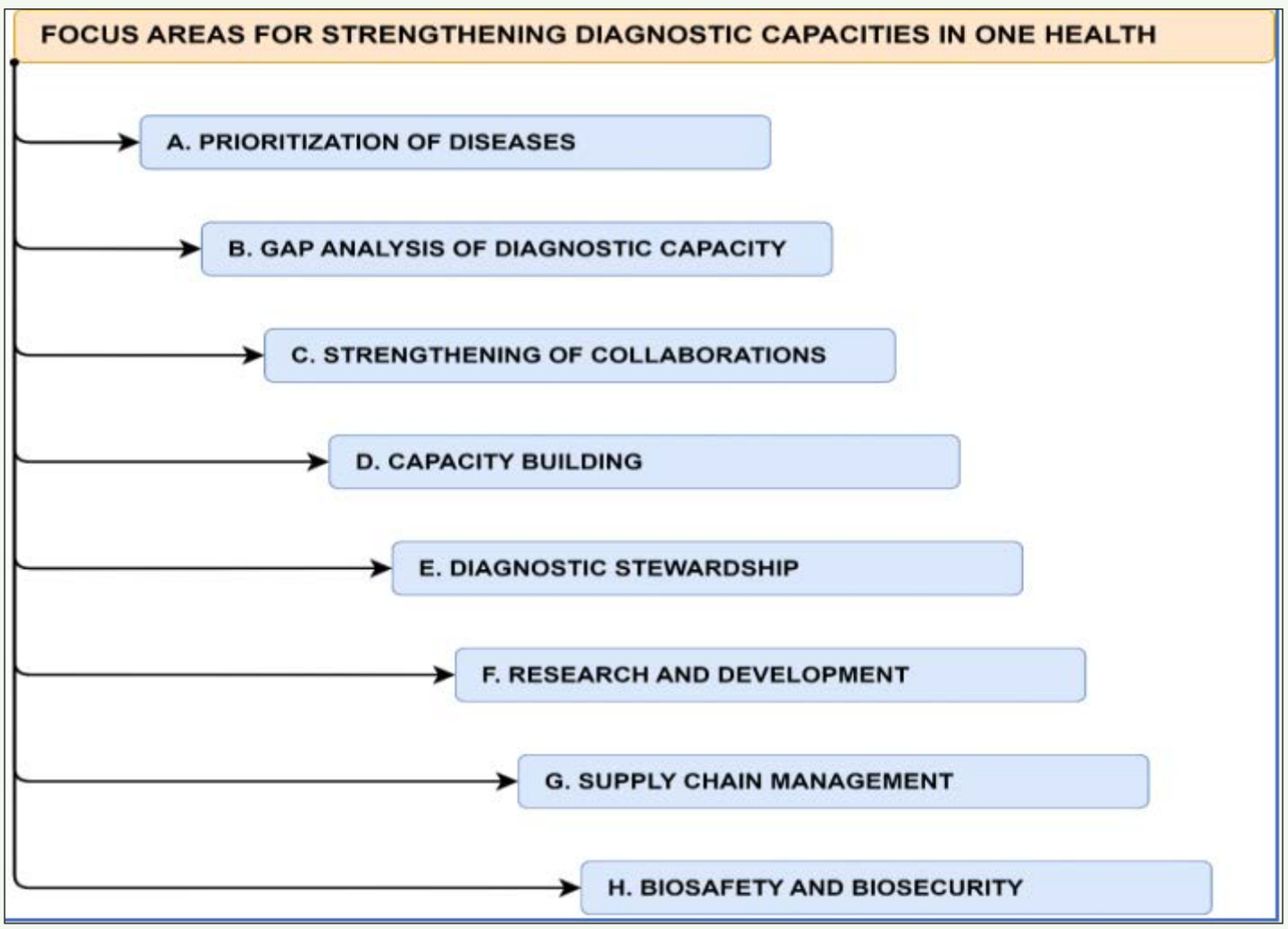


Figure 1: Focus areas for strengthening diagnostic capacities in one health

Strengthening Diagnostic Capacity in One Health

A. Prioritization of diseases:

The foremost issue to be resolved for initiating any OH-based approach is prioritizing the diseases. As a concept, OH should encompass all the diseases that humans and animals share. In practice, however, the system must be systematically strengthened to ensure the OH approach's success. The prioritization is a collaborative task and requires a multi-sectoral consensus-building effort of experts from various stakeholders. The criteria for prioritization of diseases can be defined based on the following factors with expert consultation [2].

1. The severity of human disease
2. Role of animals in human diseases
3. Availability of therapeutic intervention
4. The burden of animal disease (endemicity)
5. Any existing intersectoral collaboration

B. Gap analysis of diagnostic capacity:

The immediate step after prioritization of disease is to understand the diagnostic capacity of India for each disease. Gap analysis, again, is a multi-sectoral exercise and involves identifying diagnostic gaps in the country across the sectors. Two broad areas considered for gap analysis are:

1. Diagnostic capacity mapping – the diagnostic capacity can be mapped to identify laboratories performing diagnostic tests in human and veterinary sectors, availability of equipment and infrastructure, list of available diagnostic methods (preferably with

their diagnostic performance characteristics), and workforce competency.

2. Diagnostic quality mapping – the diagnostic quality can be mapped regarding quality control and quality assurance protocols followed by the laboratories, including participation in any External Quality Assurance (EQA) programmes or inter-laboratory comparison (ILC) programmes.

C. Strengthening of collaborations:

OH, as a concept, relies on collaborative efforts from various sectors. The strength of collaboration can be defined as the relative ease with which different sectors can work together to achieve a common goal. In the case of diagnostic capacities, the primary goal will be to provide services for surveillance, preparedness, and response for prioritized diseases. The gap analysis will provide information about areas where strengthening is required.

Collaborative efforts must engage all stakeholders to build up a successful collaboration. The nature of collaborative effort can have a significant effect on its success. Collaboration can be classified into four levels based on the extent of involvement between the sectors [3]. These levels are outlined in Figure 2 and are as follows:

1.Sectoral contributions:

Various stakeholders are working in their respective fields. There is no issue-based consensus or defined common goals between the sectors. Sectoral contributions from the baseline of response to any public health concern in the community.

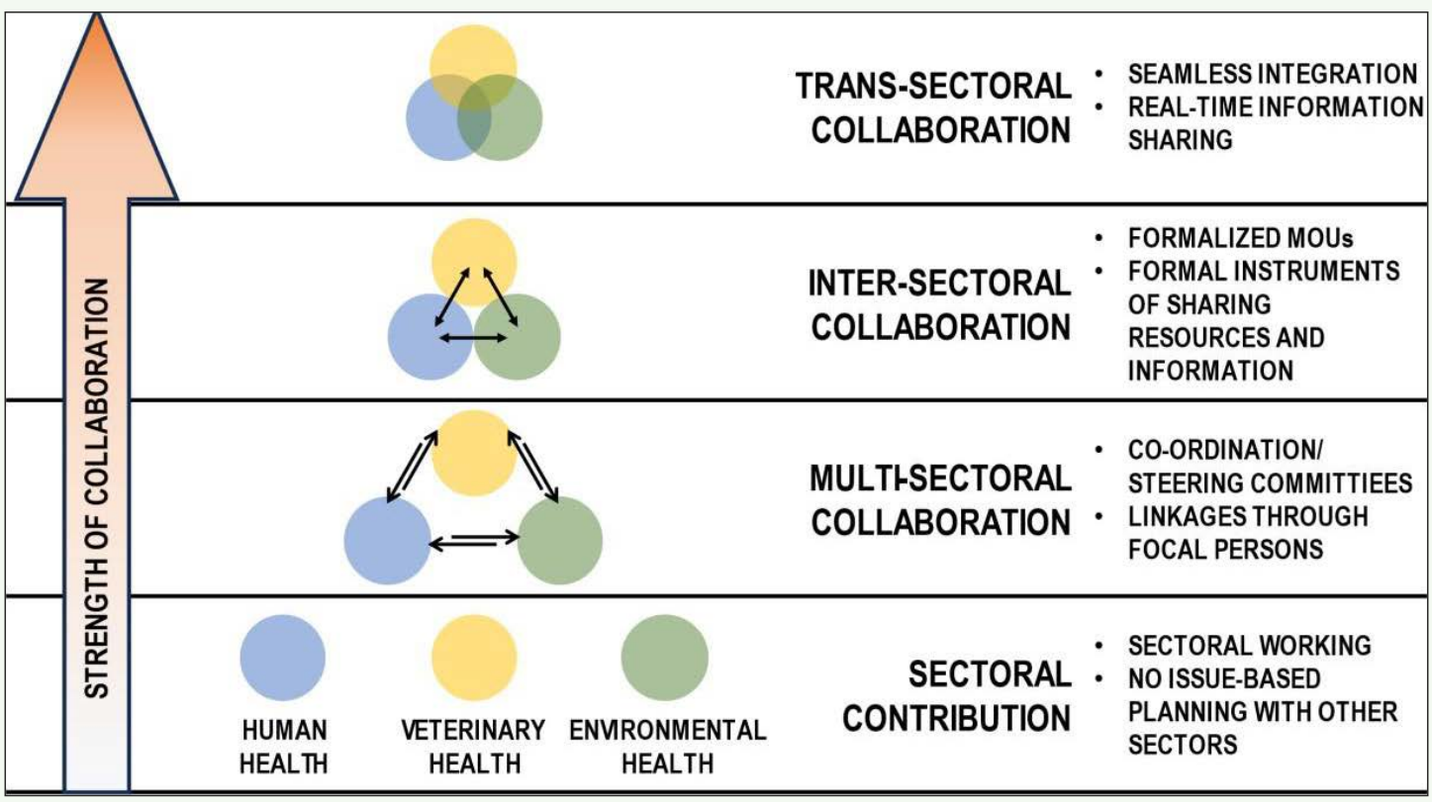


Figure 2: Concept of strengthening of collaboration in One Health [3]

2.Multi-sectoral collaboration:

Various stakeholders are working through coordination and steering committees, which are mandated to identify common goals and establish linkages between sectors by identifying focal points. Achieving this level is crucial for developing communication channels between the sectors.

3.Inter-sectoral collaboration:

Various stakeholders have agreed on common goals, have formalized the collaboration through memorandums of understanding (MOUs) between the sectors, and have developed resource and information-sharing instruments. Achieving this level is essential for capacity building.

4. Trans-sectoral collaboration:

Seamless integration between sectors to achieve a common goal and real-time information sharing. This level is essential for coordinating rapid response during a public health emergency.

Further, various factors may contribute to the success of a collaboration. These determinants of successful collaboration can be classified under three broad categories: individual attributes, environmental attributes, and procedural attributes [4]. In case of strengthening of diagnostic capacity, the determinants of collaborative success can be outlined as follows:

i.Personal attributes: Personal attributes ensuring successful collaboration include the expertise of the focal person or collaboration contact points in the organization, the relevance of their experience to the goals of collaboration, their ability to carry forward collaboration in a productive manner, and their motivation to be a part of the collaboration.

ii.Environmental attributes: Environmental attributes of collaborative success include institutional support regarding the infrastructure required and financial support in running the programme. These attributes are also enabling and may help provide motivation and collaborative skills in the persons involved.

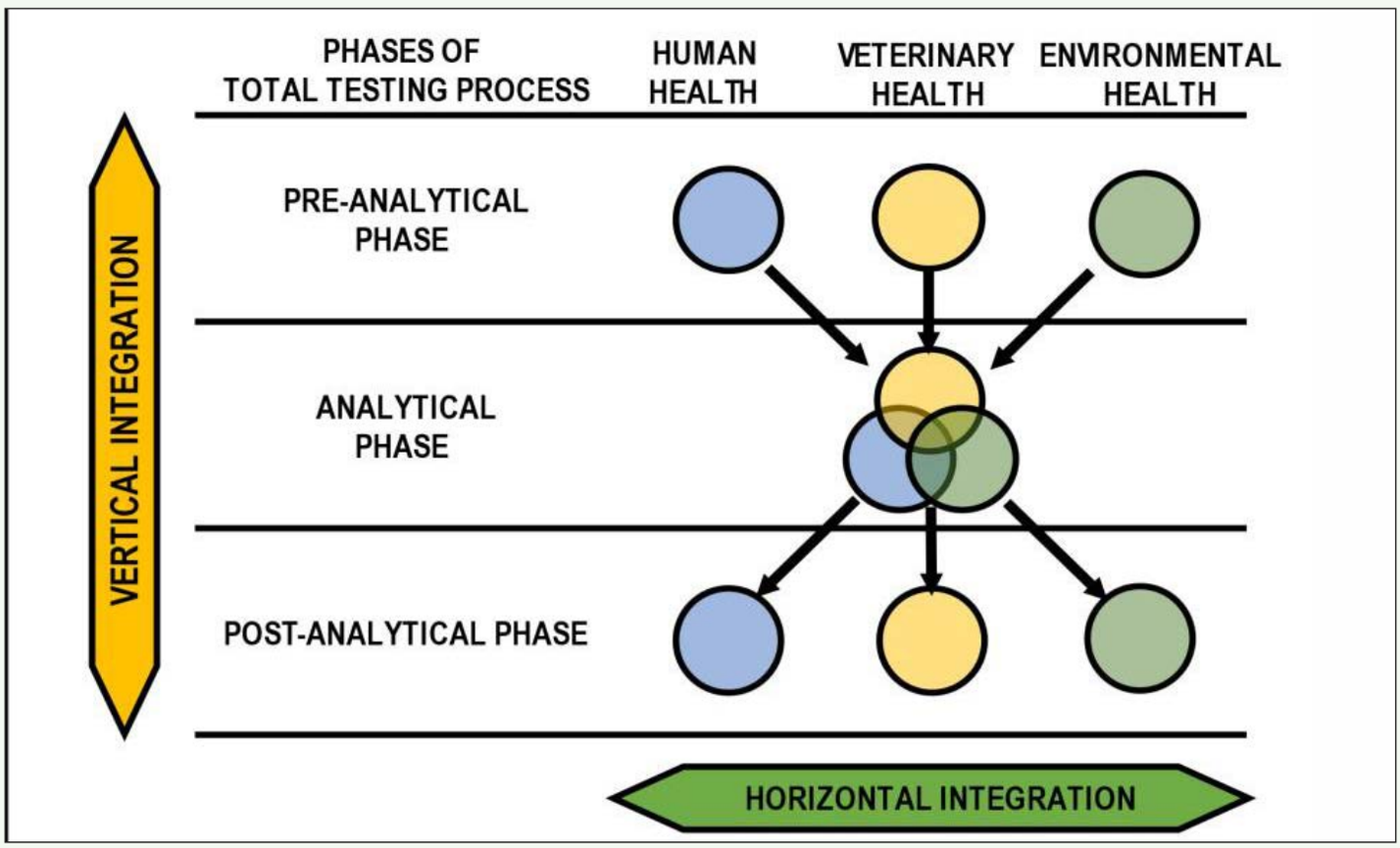


Figure 3: Capacity building measures for strengthening the diagnostic capacity in One Health.

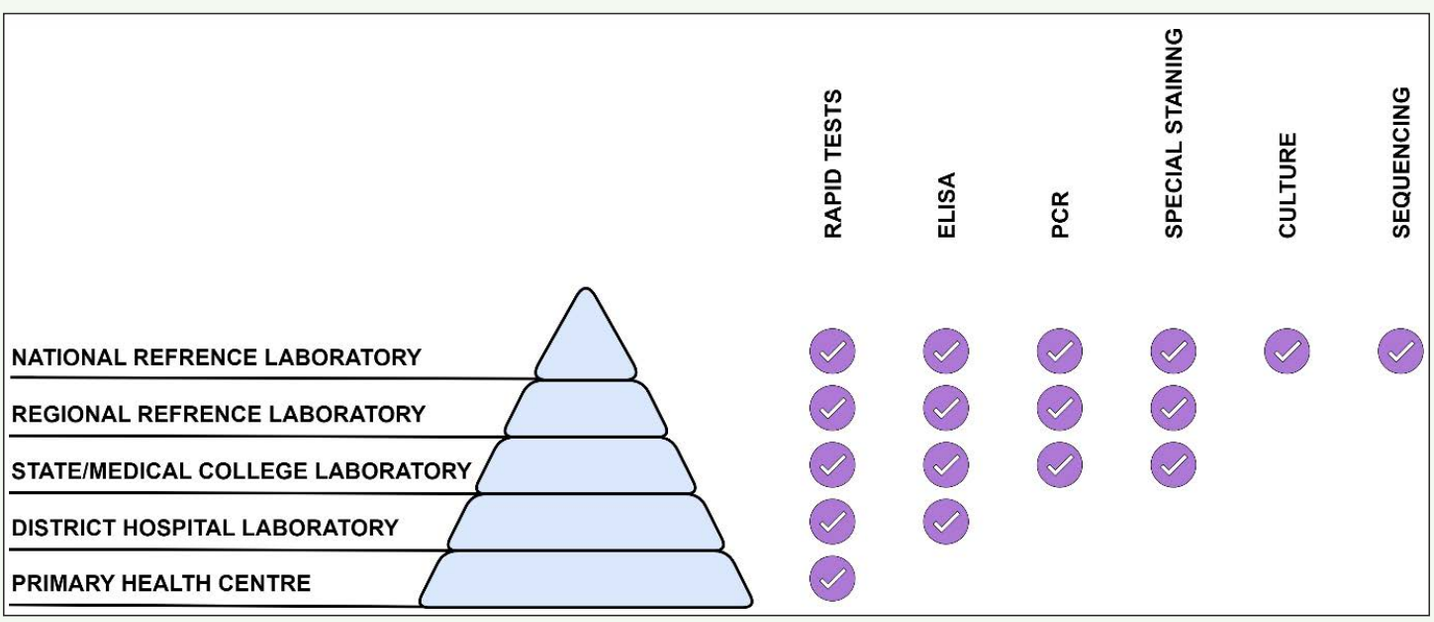


Figure 4: Tiered laboratory network mapped to available tests and competency of the staff at each level. (Example-Laboratory network of Rabies)

iii.Procedural attributes: Procedural attributes may include formalizing the collaboration through signing MOUs, developing a common goal such as strengthening laboratories for diagnosing a particular disease, regular communication with all stakeholders regarding the common goal and progress made, and establishing conflict resolution mechanisms through formal instruments like MOUs. Formalization of the collaborative process results in developing a shared responsibility and providing a conflict resolution framework while preparing academic manuscripts or sharing the credit among the stakeholders.

D. Capacity building:

The capacity building exercise aims to develop the overall ability of the system to detect, diagnose, and characterize pathogens causing diseases in a particular geographical area. The capacity building exercise requires understanding of various steps in the total testing process (TTP). TTP includes pre-analytical, analytical, and post-analytical aspects of a diagnostic test. It is essential to understand that errors in diagnostic tests span the entire TTP and are not limited to a single step [5]. By an estimate, the analytical phase had only 15% of errors during reporting, while the pre- analytical phase had 61.9% errors [6]. Therefore, it is essential to put a concerted effort to identify the human resource responsible for the successful completion of each step and put efforts to minimize the error by using appropriate capacity-building measures. Briefly, the following capacity-building instruments can be utilized to strengthen the diagnostic capacity in OH:

1.Advocacy workshops: Aim to inform clinicians about the appropriate test based on the patient's clinical symptoms, the optimum sample based on the disease stage, and available clinical management guidelines.

2.Guidelines: Guidelines about sample collection, storage, and transport need to be developed for each diagnostic assay and should be prepared in a language that is easy to understand.

3.Hands-on training workshops: Hands-on training workshops should aim to increase the proficiency of laboratory personnel in sample processing and testing.

In the context of capacity-building measures for strengthen diagnostic capacity may adopt vertical or horizontal integration approaches (Figure 3).

1. Vertical-integration model: Laboratories already engaged in analytical methods for other diseases can be targeted for vertical integration of new assays. The capacity-building measures should target all phases of TTP irrespective of laboratory experience.

2. Horizontal integration model: Horizontal integration involves sharing of resources across sectors. In the case of OH, laboratories from the animal and human sectors may be tasked to perform the analytical phase of the diagnostic assay. However, as the requirements for pre-analytical and post- analytical phases will vary for different sectors, these phases should not be integrated horizontally. For example, a veterinarian should not prescribe the test to a human

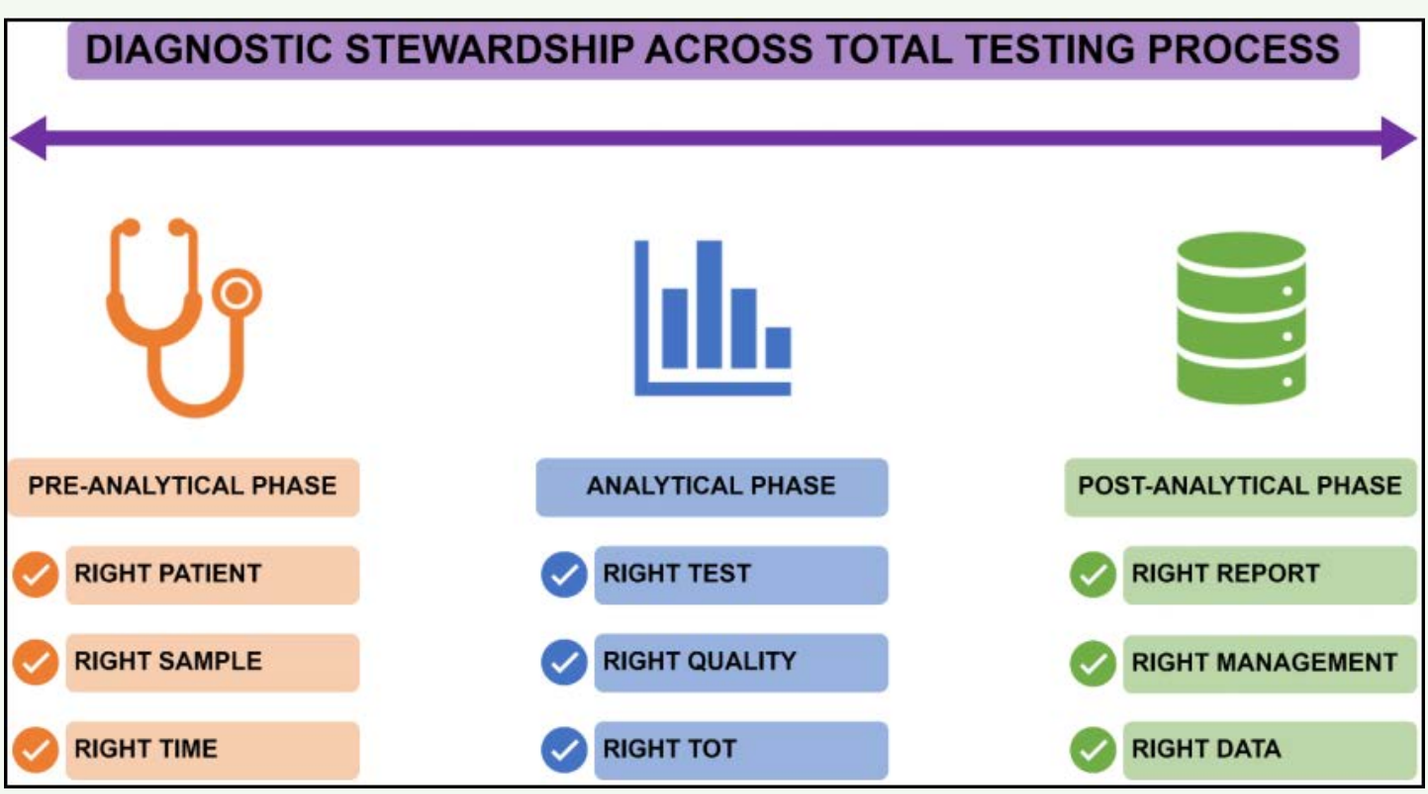


Figure 5: Diagnostic stewardship applied across the total testing process. Areas of focus has been identified for pre-analytical, analytical, and post-analytical phases.

sample, but a veterinary laboratory can perform the assay and report the results through established channels to clinicians for further action. Further, capacity building should focus on developing a tiered laboratory network while considering the staff competency available at each tier. A tiered laboratory network (example laboratory network of Rabies) is mapped to the diagnostic methods and competency of staff available is given in Figure 4.

E. Diagnostic stewardship in strengthening the diagnostic capacity in one health

Stewardship is a concept applied to improve diagnosis in healthcare based on the principal of minimizing diagnostic errors [7]. In a broader sense, diagnostic stewardship can be used to minimize errors across the total testing process. Championing diagnostic stewardship could provide appropriate clinical management and help control systemic issues in healthcare, such as antimicrobial resistance. In the context of strengthening diagnostic capacity in one health, diagnostic stewardship across the Total Testing Process (TTP) is shown in Figure 5.

Briefly, the focus areas during the entire TTP are as follows:

1. Pre-analytical phase: The focus of diagnostic stewardship in the pre-analytical phase should be on informing clinicians and sample collectors about the laboratory tests available and the requirements of laboratories to ensure that quality sample reaches for the testing [8]. In addition to sample requirements, the pre-analytical phase should also focus on packaging, transportation, and sample identification in the laboratory [9].

2. Analytical phase: The focus of diagnostic stewardship in the analytical phase should be on diagnostic laboratories. It is essential to understand what sample should be collected and when. Understanding the prioritized disease's pathophysiology and the kinetics of various diagnostic markers will help address this issue. For example, in dengue, understanding the dynamics of the appearance of viremia, antigenemia, anti-dengue IgM antibodies, and anti-dengue IgG antibodies can help select appropriate test [10]. The focus should also be on the analysis of the results as errors in analysis can result in inferior quality of reporting. Providing quality diagnostic assays is the mainstay of laboratory strengthening efforts.

ISO 15189 outlines the requirements of the quality management system in a diagnostic laboratory. NABL is the authority in India that accredits laboratories after verifying their compliance with these requirements (Document number NABL112). The ISO 15189 standard also requires establishing quality assurance in the medical laboratory. Laboratories can employ internal quality control (IQC) and external quality assurance (EQA) as the main tools to ensure and improve the quality of analytical methods through constant monitoring, evaluation, and improvement [11].

3. Postanalytical phase: The focus of diagnostic stewardship in the post-analytical phase is on developing guidelines on reporting results, undertaking advocacy workshops to inform clinicians about how to interpret the results, and ensuring that the data is being used to generate evidence for future improvement in control and management of the prioritized disease.

F. Research and Development

Focused research is required to establish diagnostic protocols for prioritized diseases, and effort should be put into developing these protocols as commercial kits through Public Private Partnerships (PPP). Developing disease-specific Target Product Profiles (TPP) remains the best instrument to persuade stakeholders to do focused research and development. TPP ensures the assays are developed to fit the intended purpose [12]. TPP requires extensive consultation to determine the scope of TPP, including any unmet clinical needs, drafting of TPP to include end user-specific requirements and consultation among stakeholders to reach a consensus [13]. TPP can be used as guiding document by public and private partners to develop required assays. Further, assay developed by academic institutions can be used as emergency diagnostic assays after proper analytical validation. However, using a commercial kit as an invitro diagnostic kit will require regulatory approvals.

G. Management of supply chain

Supply chain management remains a significant bottleneck for the diagnosis of zoonotic infections. Non-availability of commercial kits and unregulated pricing make managing supply chains unpredictable. Logistics management requires focusing on the following areas[14] :

1. Product selection: Product selection will depend on the type of assay required for prioritized diseases.

2. Forecasting: Quantification depends on the forecasting of the number of assays required to be performed in the coming year. Previous year baseline data, if available, can help in forecasting the number of tests that the laboratory will perform during next year. A proportional increase may also be estimated if yearly data for the last five years is available with the laboratory.

3. Procurement: The procurement process should consider the government procurement rules and availability of good quality commercial kits for the prioritized diseases in local and international market.

There may be a need to reverify the manufacturer's claims to ensure that the kits perform their intended function.

4. Inventory management: Inventory management of procured items, their distribution, and collecting consumption records may help minimize resource misutilization.

H. Biosafety and Biosecurity

Most pathogens causing zoonotic infections are also a biosafety and biosecurity concern. The biosafety measures must include the following attributes:

1. Monitoring and warning. A comprehensive monitoring system may be established employing both active and passive surveillance for prioritized diseases. Additionally, real-time information sharing mechanisms among all the stakeholders must be established enabling prompt response to an adverse incident.

2. Detection and traceability. Detection of pathogens and establishing their traceability through molecular methods may help identify the source of the breach in the system, thereby facilitating necessary improvements to prevent future incidents.

3. Prevention and control. It is essential to establish guidelines to inform laboratory personnel about the prevention and control strategies for prioritized pathogens which should be employed to ensure containment of any adverse event in the laboratory itself.

4. Diagnosis and treatment. Comprehensive guidelines should be provided regarding clinical symptoms, diagnosis, and available treatment of prioritized diseases. Such information may be pivotal in effective management of laboratory infections caused by prioritized disease.

5. Training and competency. Laboratory personals should be trained regularly in biorisk management, biosafety and biosecurity in public health laboratories to enhance their competency.

Competent staff will ensure prompt identification and containment of any adverse incident.

Acknowledgment

We acknowledge NCDC for their constant support.

Financial support & sponsorship

None.

Conflicts of Interest

None.

References

1. One Health High-Level Expert Panel, et al. One Health: A new definition for a sustainable and healthy future. PLOS Pathogens. 2022;18(6):e1010537.

2. Pieracci EG, et al. Prioritizing zoonotic diseases in Ethiopia using a one health approach. One Health. 2016;2:131-135.

3. Abbas SS, Shorten T, Rushton J. Meanings and mechanisms of One Health partnerships: insights from a critical review of literature on cross-government collaborations. Health Policy and Planning. 2021;37(3):385-399.

4. Amabile TM, et al. Academic-Practitioner Collaboration in Management Research: A Case of Cross-Profession Collaboration. Academy of Management Journal. 2001;44(2):418-431.

5. Plebani M. The detection and prevention of errors in laboratory medicine. Annals of Clinical Biochemistry. 2010;47(2):101-110.

6. Carraro P, Plebani M. Errors in a Stat Laboratory: Types and Frequencies 10 Years Later. Clinical Chemistry. 2007;53(7):1338-1342.

7. Miller BT, Balogh EP, Ball JR, eds. Improving Diagnosis in Health Care. National Academies Press; 2016.

8. Morjaria S, Chapin KC. Who to Test, When, and for What: Why Diagnostic Stewardship in Infectious Diseases Matters. The Journal of Molecular Diagnostics. 2020;22(9):1109-1113.

9. Shahangian S, Snyder SR. Laboratory Medicine Quality Indicators: A Review of the Literature. American Journal of Clinical Pathology. 2009;131(3):418-431.

10. Muller DA, Depelsenaire ACI, Young PR. Clinical and Laboratory Diagnosis of Dengue Virus Infection. The Journal of Infectious Diseases. 2017;215(suppl_2):S89-S95.

11. Plebani M. Internal quality control and external quality assurance: a great past opens the way to a bright future. Advances in Laboratory Medicine / Avances en Medicina de Laboratorio. 2022;3(3):215-217.

12. Ebels KB, et al. Incorporating user needs into product development for improved infection detection for malaria elimination programmes. IEEE Global Humanitarian Technology Conference (GHTC 2014); 2014.

13. Cocco P, et al. Target Product Profiles for medical tests: a systematic review of current methods. BMC Medicine. 2020;18(1):119.

14. USAID, DELIVER PROJECT, Task Order 1. The Logistics Handbook: A Practical Guide for the Supply Chain Management of Health Commodities. 2011.

Research Priorities in One Health

Mala Chhabra[1]*, Ruchita Chhabra[2], Nandini Duggal[1*]

[1]Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Manohar Lohia Hospital, New Delhi,
[2]Institute of Liver & Biliary Sciences, New Delhi

***Corresponding author**
Dr. Mala Chhabra, M.D.
Department of Microbiology, Atal Bihari Vajpayee Institute of Medical Sciences & Dr. Ram Manohar Lohia Hospital, New Delhi
malachhabra@yahoo.co.in

Abstract

One Health is an interdisciplinary approach that recognizes the interconnections between human health, animal health, plant health and environment. It emphasizes collaboration and coordination among multiple sectors to address complex health challenges at the human- animal-environment interface. This article explores various research priorities within the One Health framework, including zoonotic disease surveillance and control, antimicrobial resistance (AMR), food safety, environmental impact on health, and One Health policy and governance. By integrating research outputs from various disciplines, leveraging technology, and fostering collaboration, researchers and policymakers can contribute to better health outcomes for humans, animals, plants and environment. The prime focus is to highlight the significance of the areas of research in advancing One Health research and addressing national and global health challenges.

Keywords: One Health Research, Research Priority, Multidisciplinary Approach, Global Health, Surveillance, Health Outcome

Introduction

The One Health approach has emerged as a powerful framework for addressing complex health challenges by recognizing the interconnectedness of human health, animal health, plant health and environment. By understanding and addressing these interconnections, better health outcomes can be achieved for all. The One Health framework aligns closely with the Sustainable Development Goals (SDGs) set forth by the United Nations, as they share a common objective of promoting health, well-being, and sustainability for all. Out of the 17 SDGs, eight (2,3,6,10, 13,14,15 & 17) are directly related to One Health, highlighting the broad relevance and impact of this approach. (Fig 1). Additionally, SDG 16 and 1 are indirectly related to One Health by focusing on providing environmental justice and overarching goal of "No Poverty". Collectively, these SDGs encompass a wide range of interconnected issues, fostering a comprehensive framework to achieve global health and sustainable development.[1,2,3]

In the face of emerging infectious diseases, antimicrobial resistance, and environmental degradation, it is imperative to identify and prioritize key research areas within the One Health paradigm which involve multiple disciplines. These research priorities aim to enhance our understanding, preparedness, and response to global health threats, while fostering collaboration between diverse disciplines. The priority research areas within One Health are (but not limited to,) (i) Zoonotic disease surveillance and control (ii) Combating antimicrobial resistance (AMR) (iii) Food safety (iv) Environmental impact on health.[4]

The aim of this article is to delve into these research priorities, providing specific examples and references to highlight the significance of these areas of focus in advancing One Health research and addressing national and global health challenges.

Zoonotic Diseases: Emerging and Re-emerging infections

Zoonotic diseases, which originate in animals and can be transmitted to humans, have the potential to cause widespread illness, economic disruptions, and even pandemics. Effective surveillance and control of zoonotic diseases are paramount to prevent and mitigate their impact on human and animal health. Thus, robust research efforts focused on zoonotic disease surveillance and control are critical within the One Health framework.

Surveillance

Surveillance systems play a crucial role in detecting, monitoring and setting up early warning signals for emerging and remerging zoonotic diseases. By actively monitoring animal populations, including wildlife, livestock, and companion animals, the potential reservoirs of zoonotic pathogens can be identified and their transmission dynamics can be tracked. Surveillance data provides valuable insights into the geographical distribution, prevalence, and risk factors associated with zoonotic diseases.

Research in this area aims to enhance surveillance

Figure 1: One Health Approach priorities to improve health outcomes -- Alignment with Sustainable Development Goals

strategies by integrating multiple data sources and developing innovative approaches using IT tools. For example, advancements in remote sensing technologies can contribute to zoonotic disease surveillance by monitoring environmental factors linked to disease transmission, such as vegetation indices, temperature, and water bodies. These data can aid in identifying high-risk areas and predicting outbreaks, enabling targeted surveillance and intervention efforts. In addition, mapping and layering, using Geographic Information System (GIS), data on distribution of human, animal, vector and environmental indices along with the epidemiology of diseases may aid in detection of "hotspots" and generating early warning signals for prevention of disease outbreaks.[5,6]

Moreover, research efforts focus on understanding the drivers of zoonotic disease emergence and transmission. Factors such as land-use changes, climate change, wildlife trade, and human behaviour can significantly impact disease dynamics. Investigating these drivers can provide valuable insights into risk factors and inform preventive measures. For instance, studies have shown that deforestation and habitat fragmentation can increase interactions between humans, wildlife, and domestic animals, thereby elevating the risk of zoonotic disease spill over.[7]

Table 1: Research Priorities for Zoonotic Diseases, Vector Borne Diseases and Plant, Animal & Human Health

Zoonotic Diseases[12]	1. Burden of disease • Measures of mortality, morbidity and health associated life years. • Measure health-adjusted life years (HALYs) for capturing associated duration, suffering and subsequent disability due to disease. The two most common HALYs are quality-adjusted life years (QALYs) and disability-adjusted life years (DALYs). • Measures of mortality and morbidity in animals • Economic (monetary) burden of zoonotic disease 2. Intervention-oriented research issues • Community-led or community-directed interventions • Community-led Total Sanitation 3. Research at the human-animal interface for spill over and disease transmission 4. Chemotherapy and immunization • Mass chemotherapy (mass-targeted, humans-animals) 5. Vector and intermediate host control 6. Vaccination a control option for zoonoses -vaccination coverage, impact and drivers • Animal-targeted immunization • Human-targeted vaccines

Zoonotic Diseases[12]	7. Targeting animal reservoirs to control zoonotic diseases 8. Health education and health literacy 9. Cost–effectiveness analysis 10. Disease-specific research priorities • Studies of disease burden in both humans and animals in both urban and rural settings in a manner that brings the human and veterinary health communities together; • Determination of the economic cost of these diseases for both the human and animal populations involved; • Studies of the efficacy of integrated interventions that address more than one disease and/or agent at the same time; • Determination of the cost-effectiveness of these interventions; • Studies on promotion of health literacy and social mobilization to ensure maximal engagement of the affected populations in the selected interventions.
Vector-Borne Diseases	1. Vector Biology and Ecology: Investigate the biology, behavior, and ecology of vectors for understanding their distribution, abundance, and capacity to transmit diseases. Identify factors influencing vector population dynamics, such as breeding sites, climate change impacts, and vector control strategies. 2. Disease Surveillance: Develop robust surveillance systems to integrate human, animal, environmental and vector surveillance data for setting up early warning signals and rapid response to vector-borne diseases.Methods to enhance the accuracy, timeliness, and spatial resolution of surveillance systems to effectively monitor disease transmission patterns and identify hot spots and high-risk areas. 3. Integrated Vector Management: Develop and evaluate the effectiveness, feasibility, and sustainability of integrated vector management strategies that combine multiple approaches to control vectors such as insecticide-treated bed nets, indoor residual spraying, larval source reduction, biological control, and community engagement. 4. Vector Control Tools and Technologies: Develop novel vector control tools and technologies that are environmentally friendly, cost-effective, and sustainable such as, evaluation of vector trapping systems, new insecticides, vector control products, and genetic control methods (sterile insect technique, gene drive technologies etc). 5. Climate Change and Vector-Borne Diseases: Investigate the impact of climate change on vector-borne diseases such as, how climate variability and environmental factors influence vector distribution, vectorial capacity, and disease transmission dynamics. 6. One Health Approaches in Vector Control: Understand the role of animal reservoirs and wildlife in disease transmission, assessing the impact of vector control interventions on non-target organisms, and evaluating the effectiveness of community-based interventions involving multiple stakeholders. 7. Vector-Borne Disease Vaccines: Research focuses on vaccine development, efficacy, safety, and the impact of vaccination on disease transmission dynamics of vector borne disease such as dengue, malaria, zika and tick-borne diseases 8. Health Education and Behavioral Interventions: Research on studying human behavior, social determinants of health, and community perceptions to design effective interventions that improve vector control practices, use of protective measures, and compliance with treatment and preventive measures.
Plant, Animal and Human Health[18]	• Surveillance, early warning and control systems capable of analysing disease emergence by developing participatory health approaches and collective control; • Biocontrol and antimicrobial resistance; • Phytobiomes, microbiomes, holobiomes and interactions between communities of microorganisms; • Genome editing (resistance, vaccines, vectors, etc); • Big data, particularly text and environmental data and metagenomics; • Modelling, including spatial modelling, studies of human and animal mobility, landscape analysis; • Health economics and public-private sector partnerships; • Analyses of the socioeconomic and cultural factors that determine the behaviour of at-risk social players; • Support of territorial players adopting an integrated health management approach (including farmers, consumers, decision makers, etc); • Contributing to drafting and analyzing health policy.

Prevention and control

This includes evaluation of diagnostic tools, development of vaccines, and assessment of interventions aimed at reducing disease transmission. Research can focus on understanding the effectiveness of vaccination campaigns, investigating the impact of vector control measures, and identifying strategies for promoting responsible pet ownership and animal hygiene practices.[8]

One noteworthy example of research in zoonotic disease surveillance and control is the surveillance of zoonotic viruses in wildlife populations. By studying wildlife species known to harbour zoonotic viruses, such as bats and primates, researchers can detect potential reservoirs and assess the risk of viral spill over to humans. This approach was exemplified during the Ebola and Nipah Virus outbreaks, where surveillance efforts in bat populations helped identify potential sources of the virus.[9,10,11]

The Global Virome Project (GVP) is also an exemplary collaborative scientific initiative to discover zoonotic viral threats. It is aimed to identify unknown viruses and fill the knowledge gap, including their host(s), ecology and drivers and learn where the greatest threats for spillover exist. It will provide new strategies for prevention and development of vaccines and countermeasures.[12]

WHO's Disease Reference Group on Zoonoses and Marginalized Infectious Diseases of Poverty (DRG6), published a report that highlights common research priorities for all zoonoses and disease specific research priorities which will help policy-making decisions for improved surveillance, interaction between the health, livestock, agriculture, natural resources and wildlife sectors in tackling zoonotic diseases, and true assessment of the burden of zoonoses (Table 1). [13]

Vaccine Development

Vaccine development is a crucial research priority for addressing zoonotic diseases and emerging pathogens, protecting both human and animal populations. This can enhance preparedness and response efforts against emerging Zoonotic infections like Ebola, Middle East Respiratory Syndrome (MERS), and emerging coronaviruses like SARS-CoV-2 and ultimately reducing the impact of outbreaks and preventing future pandemics.

Research in vaccine development aims to achieve several key objectives. First, it involves identifying target antigens that can elicit a robust immune response against specific pathogens. This involves studying the characteristics of the pathogen, such as its surface proteins or genetic components, to identify suitable vaccine candidates. Researchers also explore various vaccine platforms and delivery systems to optimize the immune response generated by the vaccine, vaccine safety and efficacy through extensive pre-clinical and clinical trials.

In the context of One Health, vaccine development research often involves collaborations across disciplines. For example, human and veterinary scientists collaborate to understand the transmission dynamics of zoonotic pathogens and identify potential reservoirs in animal populations. This collaboration helps in identifying suitable vaccine targets and evaluating the impact of vaccination on reducing transmission and preventing spill over events.

One notable example of vaccine development research within the One Health framework is the development of vaccines against the H5N1 avian influenza virus. Avian influenza represents a zoonotic threat, with the potential for human-to-human transmission and severe disease outcomes. By understanding the genetic diversity of the virus, conducting surveillance in poultry populations, and assessing vaccine candidates, significant progress has been made in developing effective vaccines to protect both human and animal populations.[14]

Moreover, the ongoing COVID-19 pandemic has highlighted the importance of vaccine development in addressing emerging pathogens.15 The rapid development and deployment of vaccines against SARS-CoV-2 have demonstrated the power of global collaboration and accelerated research efforts. Vaccine development research has not only focused on achieving high efficacy but also on ensuring equitable access, vaccine distribution, and overcoming vaccine hesitancy to control the spread of the virus.

Antimicrobial Resistance (AMR)

Antimicrobial resistance (AMR) is a global health crisis that occurs when microorganisms develop the ability to survive and grow in the presence of antimicrobial drugs, rendering these medications ineffective. AMR poses significant threat to human, animal, plant and environmental health, leading to increased mortality, prolonged illnesses, and higher healthcare costs (use of expensive drugs, greater use of diagnostics etc). The emergence and spread of resistant pathogens have profound implications for public health, food security, and the effectiveness of medical interventions worldwide.[16]

Addressing AMR requires a multi-faceted approach, and research efforts focus on several key priorities within the One Health framework. The policies in this regard are, by and large, in place. The important research

priority is the implementation and responsible use of policies. This involves promoting appropriate prescribing practices in human medicine, reducing unnecessary antimicrobial use in animal and agriculture, and implementing surveillance systems to monitor antimicrobial consumption and resistance patterns. Additionally, research aims to develop strategies to educate healthcare providers, veterinarians, and the general public about the prudent use of antimicrobials and the importance of infection prevention and control measures, biosafety, biosecurity and environmental contamination.

Another research priority is the exploration of alternative antimicrobial strategies. This includes the development of new classes of antimicrobial agents, repurposing of existing drugs, and investigation of novel therapeutic approaches such as bacteriophage therapy or immunotherapies. By diversifying antimicrobial arsenal, resistance mechanisms employed by pathogens can be overcome to ensure effective treatment options.[17]

Infection prevention and control plays a vital role in combating AMR. Research in this area focuses on identifying effective interventions to reduce the transmission of resistant pathogens. This includes improving and monitoring hygiene practices, optimizing sterilization techniques, and implementing surveillance systems to detect outbreaks and monitor healthcare-associated infections. By preventing the spread of infections, the selective pressure on microbes can be reduced, thereby limiting the emergence and dissemination of resistance.

WHO has prioritized 40 research topics for evidence generation to inform the AMR policy. The research findings will be critical in guiding policy-makers, researchers, funders, implementing partners, industry and civil society in generating new evidence to inform antimicrobial resistance policies and interventions as part of collective efforts to address antimicrobial resistance. These research priorities have been categorized under five heads- AMR prevention, diagnostics, treatment and care and cross cutting issues and drug-resistant TB.[18]

FAO-ICAR experts identified about 20 research priority projects in animals and fisheries reflecting antimicrobial usage in India, antimicrobial resistances, links between Antimicrobial use and AMR, direction of transmission of antimicrobial resistance, rate of development of antimicrobial resistance, surveillance and monitoring of counterfeit and fake usage of antibiotics, rapid diagnostic development, alternatives to antibiotics usage and other preventive methods of vaccines and probiotics.[19]

Within the One Health framework, numerous research initiatives have addressed AMR and demonstrated the effectiveness of interdisciplinary collaboration. For instance, studies have investigated the transmission dynamics of resistant bacteria between animals and humans, highlighting the interconnectedness of human and animal health. This knowledge informs strategies to control the spread of AMR and emphasizes the importance of coordinated efforts between healthcare sectors, veterinary medicine, and environmental agencies.

Food Safety

Foodborne zoonoses are diseases that can be transmitted to humans through the consumption of contaminated food of animal origin. These diseases pose significant public health risks and highlight the interconnections between human health, animal health, and the environment. Causative agents of foodborne zoonotic diseases include Salmonella sp, Campylobacter sp, Escherichia coli, Toxoplasma sp, Hepatitis E, Listeria monocytogenes and others. These diseases can be transmitted through direct contact with infected animals, consumption of undercooked or raw meat, eggs, dairy products, contaminated water, or fruits and vegetables contaminated with animal feces.

One of the major issues in food safety has been the lack of cross-sectoral collaboration across the food production chain. Major food safety events have been significantly affected by the lack of collaboration between animal health, food control, and human health sector. The One Health approach emphasizes the need for coordinated actions to prevent, detect, and control foodborne zoonoses. This includes collaboration between human health agencies, veterinary authorities, agriculture departments, food safety agencies, and environmental agencies. By working together, these sectors can implement strategies to ensure the safety of the food from "Farm to Fork" by addressing issues in food production chain, supply chain, protect animal health, and safeguard public health. This includes implementing good agricultural practices on farms to minimize the risk of contamination, ensuring proper animal health and hygiene measures, conducting regular monitoring and surveillance of food products, and promoting safe food handling practices during processing, distribution, and preparation.[19]

One Health research plays a crucial role in understanding the transmission dynamics, risk factors, and control strategies of foodborne zoonoses. Researchers investigate the sources of contamination, the impact of agricultural practices on disease prevalence, and the effectiveness of interventions such as vaccination, improved sanitation, and hygiene practices. This knowledge informs the development of

evidence-based guidelines and policies to mitigate the risk of foodborne zoonoses.

Furthermore, surveillance systems are vital for early detection and response to foodborne zoonotic outbreaks. These systems involve monitoring and analyzing data on human cases, animal diseases, and environmental factors. By integrating data from multiple sources, public health authorities can identify patterns, trace the source of contamination, and implement appropriate control measures to prevent further spread. [20]

The integration of the One Health approach into food safety regulations and policies is crucial. This involves developing and implementing regulations that encompass the entire food production chain, including primary production, processing, transportation, and retail. It also requires collaboration between agencies responsible for human health, animal health, and food safety to ensure effective coordination and enforcement of regulations.

Environmental Impact on Health

Probably the oldest written document about on environmental impact on health is 'On Airs, Waters, and Places', written by Hippocrates which describes how human health is influenced by its interaction with the environment. [21]

Research on the environmental impact on health focuses on studying the effects of various factors, such as climate change, pollution, habitat loss, and biodiversity decline, on disease transmission and overall health outcomes. These factors can directly or indirectly influence the emergence and spread of zoonotic diseases and pose risks to both human and animal populations.

One significant environmental factor of concern is climate change. Rising temperatures, changing precipitation patterns, and extreme weather events associated with climate change have direct and indirect effects on health. For instance, shifts in temperature and rainfall can influence the distribution and abundance of vectors (such as mosquitoes and ticks) and alter the geographical range of infectious diseases. Research in this area aims to understand the specific impacts of climate change on disease transmission and develop strategies to mitigate these risks.

Pollution, both air and water, is another critical environmental factor affecting health. Exposure to pollutants, such as particulate matter, toxic chemicals, and heavy metals, can lead to respiratory diseases and other non-communicable diseases such as cardiovascular problems, and other adverse health outcomes. Research efforts focus on assessing the health impacts of pollution, identifying sources of contamination, and implementing measures to reduce pollution levels and protect human, animal and plant health. [22]

Habitat loss and biodiversity decline are also areas of concern within the One Health framework. Destruction of natural habitats and loss of biodiversity can disrupt ecological balance and increase the risk of disease transmission. Deforestation can lead to increased contact between humans, vectors, wildlife, and domestic animals, facilitating the spillover of zoonotic pathogens. For example, scrub typhus, a disease which was primarily reported from foothills of Himalayas is now being reported from atleast 2/3rds of the country. This may be due to deforestation, urbanization leading to removal of scrub vegetation exposing mite islands and decrease of human-vector interface. Research in this area explores the complex relationships between biodiversity, ecosystem health, and disease dynamics to inform conservation efforts and mitigate disease risks.

Additionally, the impact of environmental degradation on water and food security is a crucial research area within the One Health approach. Contamination of water sources and foodborne illnesses can have severe health consequences. Understanding the sources of contamination, developing effective monitoring systems, and implementing appropriate interventions are vital to ensuring access to safe water and food for both human and animal populations.

One example of research on the environmental impact on health is the study of vector-borne diseases, such as malaria, dengue, Lyme disease, CCHF, KFD etc. Researchers investigate how environmental factors, such as temperature, precipitation, and land use, influence the distribution and abundance of disease-carrying vectors. By understanding these relationships, interventions can be designed to minimize vector populations and reduce disease transmission risks. (Table 1).The integration of environmental considerations in health policies and interventions is essential for fostering resilient and sustainable health systems in the face of global challenges.

The European consortium has identified six overarching research agenda covering 30 specific research priorities under the Health and Environment Research Agenda (HERA) project for the environment, climate & health, 2021–2030. [23]

French Agricultural Research Centre for International Development (CIRAD) works with its partners to build knowledge and solutions and invent resilient farming systems for a more sustainable, inclusive world. In the field of plant, animal and ecosystem health, CIRAD's

research fits into a systemic, integrated approach that addresses the links between agriculture and health. It acts as a leading contact for ministries in charge of health management, international organizations and the French Ministry of Agriculture, on various topics such as epidemiological surveillance and global health monitoring. It is involved in the integrated One Health approach covering a range of disciplines (from biology to the social sciences), sectors (environment, agriculture, public health, etc), and players (political, institutional, research, private, and beneficiaries such as producers and livestock farmers). The One Health research includes several fields that are vital for implementing integrated approaches: entomology, microbiome studies, knowledge of disease-resistant local varieties and races, ecology on every level, epidemiology and modelling, risk analysis and improvement of surveillance systems.[23] (Table 1)

Xenotransplantation and One Health

Xenotransplantation refers to the transplantation of organs, tissues, or cells from one species to another, usually from animals to humans. This emerging field of medical science holds promise for addressing the critical shortage of human organs available for transplantation.

However, xenotransplantation also raises important considerations related to human health, animal welfare, potential zoonotic disease transmission, use of Genetically Engineered Animals, ethical considerations, and ecological implications of using animals as organ donors for humans.[24]

By adopting One Health approach, researchers, clinicians, policymakers, and stakeholders in xenotransplantation can ensure that human health advances are pursued while minimizing risks to animal welfare, environmental sustainability, and zoonotic disease transmission.

Collaborative research, multidisciplinary engagement, and ethical considerations are critical for advancing the field of xenotransplantation.

One Health policy and Governance

One Health policy and governance research is crucial to effectively implement the One Health approach. Evaluating the impact of current policies, identifying gaps and barriers to collaboration within various disciplines, strengthening collaborative national and international networks, developing effective intersectoral and multidisciplinary/transdisciplinary training programmes for capacity building and developing strategies for integrating One Health into national and international health systems are vital for successfully addressing global health challenges within this framework.

The latest definition of One Health by the CDC has expanded the approach from multidisciplinary to transdisciplinary. In a multidisciplinary approach, different disciplines contribute their knowledge and expertise to address a common problem, but they typically remain within their disciplinary boundaries. On the other hand, a transdisciplinary approach involves researchers from various disciplines working together to create new ideas, theories, methodologies, and practical applications that go beyond the limitations of individual disciplines[4,25]

By prioritizing research in these areas, the One Health approach can generate evidence-based strategies and interventions to mitigate the risks of emerging diseases, improve public health outcomes, and promote sustainable and resilient health systems.

Financial support & sponsorship

None.

Conflicts of Interest

None.

References

1. World Health Organization (WHOne Health. [Online] Available at: https://www.who.int/europe/initiatives/one-health

2. Dasgupta R, Tomley F, Alders R, Barbuddhe SB, Kotwani A. Adopting an intersectoral One Health approach in India: Time for One Health Committees. Indian J Med Res. 2021 Mar;153(3):281-286. doi: 10.4103/ijmr.IJMR_537_21. PMID: 33906990; PMCID: PMC8204840.

3. Bhatia R. National framework for one health. Food & Agriculture Organization of the United Nations (FAO), ISBN: 9789251341926, Aug 2021.

4. Miao L, Li H, Ding W, Lu S, Pan S, Guo X, Zhou X, Wang D. Research Priorities on One Health: A Bibliometric Analysis. Front Public Health. 2022 May 31;10:889854. doi: 10.3389/fpubh.2022.889854. PMID: 35712284; PMCID: PMC9194370.

5. Tran A, Kassié D, Herbreteau V. Applications of Remote Sensing to the Epidemiology of Infectious Diseases: Some Examples, Editor(s): Nicolas Baghdadi, Mehrez Zribi, Land Surface Remote Sensing, Elsevier, 2016, 295-315, ISBN 9781785481055, https://doi.org/10.1016/B978-1-78548-105-5.50009-8.

6. Gong P, Xu B, Liang S. Remote sensing and geographic information systems in the spatial-temporal dynamics modeling of infectious diseases. Science in China. Series C, Life sciences / Chinese Academy of Sciences. 2007;49:573-582. doi:10.1007/s11427-006-2015-0.

7. Barbier EB. Habitat loss and the risk of disease outbreak. J Environ Econ Manage. 2021 Jul;108:102451. doi: 10.1016/j.jeem.2021.102451. Epub 2021 Apr 13. PMID: 33867599; PMCID: PMC8041730.

8. Wallace RM, Undurraga EA, Gibson A, Boone J, Pieracci EG, Gamble L, Blanton JD. Estimating the effectiveness of vaccine programmes in dog populations. Epidemiol Infect. 2019 Jan;147:e247. doi: 10.1017/S0950268819001158. PMID: 31364582; PMCID: PMC6805755.

9. Calisher CH, Childs JE, Field HE, Holmes KV, Schountz T. Bats: important reservoir hosts of emerging viruses. Clin Microbiol Rev. 2006 Jul;19(3):531-545. doi: 10.1128/CMR.00017-06. PMID: 16847084; PMCID: PMC1539106.

10. Mahmoud M. Naguib, Ruiyun Li, Jiaxin Ling, Delia Grace, Hung Nguyen-Viet, Johanna F. Lindahl. Live and Wet Markets: Food Access versus the Risk of Disease Emergence. Trends in Microbiology, July 2021, Vol. 29, No.7. https://doi.org/10.1016/j.tim.2021.02.007.Gokhale M, Sudeep AB, Mathapati B, Balasubramanian R, Ullas PT, Mohandas S, Patil DR, Shete AM, Gopale S, Sawant P, Jain R, Holeppanavar M, Suryawanshi AT, Chopade G, Dhaigude S, Patil DY, Mourya DT, Yadav PD. Serosurvey for Nipah virus in bat population of southern part of India. Comp Immunol Microbiol Infect Dis. 2022 Jun;85:101800. doi: 10.1016/j.cimid.2022.101800. Epub 2022 Mar 26. PMID: 35390635; PMCID: PMC9754148.

11. Carroll D, Daszak P, Wolfe ND, et al. The Global Virome Project- Expanded viral discovery can improve mitigation. Science. 3 Feb 2018. Vol 359, Issue 6378, 872-874. DOI:10.1126/science.aap7463.

12. Research Priorities for Zoonoses and Marginalized Infections Report of the TDR Disease Reference Group. WHO TRS No 971, 2012.

13. Clegg CH, Rininger JA, Baldwin SL. Clinical vaccine development for H5N1 influenza. Expert Rev Vaccines. 2013 Jul;12(7):767-77. doi: 10.1586/14760584.2013.811178. PMID: 23885822; PMCID: PMC6101019.

14. Sapkal GN, Yadav PD, Ella R, Deshpande GR, Sahay RR, Gupta N, Vadrevu KM, Abraham P, Panda S, Bhargava B. Inactivated COVID-19 vaccine BBV152/COVAXIN effectively neutralizes recently emerged B.1.1.7 variant of SARS-CoV-2. J Travel Med. 2021 Jun 1;28(4):taab051. doi: 10.1093/jtm/taab051. PMID: 33772577; PMCID: PMC8083765.

15. Bhatia R. Global Initiatives to Combat Antimicrobial Resistance. Indian J. Comp. Microbiol. Immunol. Infect. Dis. Vol. 42 (Special Issue) November, 2021: 1-6.

16. Hess KL, Jewell CM. Phage display as a tool for vaccine and immunotherapy development. Bioeng Transl Med. 2019 Sep 18;5(1):e10142. doi: 10.1002/btm2.10142. PMID: 31989033; PMCID: PMC6971447.

17. WHO, Global research agenda for antimicrobial resistance in human health, Policy brief, June 2023. [Online] Available at: https://cdn.who.int/media/docs/default-source/antimicrobial-resistance/amr-spc-npm/who-global-research-agenda-for-amr-in-human-health---policy brief.pdf?sfvrsn=f86aa073_4&download=true.

18. Wielinga PR, Schlundt J. One Health and Food Safety. Confronting Emerging Zoonoses. 2014 Jul 19:213–32. doi: 10.1007/978-4-431-55120-1_10. PMCID: PMC7121645.

19. Foodborne Disease Outbreak Surveillance System (FDOSS), Centre for Disease Control and Prevention, USA. [Online] Available at: https://www.cdc.gov/fdoss/index.html.

20. Drakvik E Kogevinas, M Bergman, Å et al. Priorities for research on environment, climate, and health, a European perspective. Environ Health 21, 37 (2022). https://doi.org/10.1186/s12940-022-00848-w.

21. Manisalidis I, Stavropoulou E, Stavropoulos A, Bezirtzoglou E. Environmental and Health Impacts of Air Pollution: A Review. Front Public Health. 2020 Feb 20;8:14. doi: 10.3389/fpubh.2020.00014. PMID: 32154200; PMCID: PMC7044178.

22. CIRAD, One Health, Research Topics. [Online] Available at: https://www.cirad.fr/en/our-activities-**our-impact/priority-research-topics/one-health/research-topics.**

23. Denner J. Xenotransplantation - A special case of One Health. One Health. 2017 Feb 9;3:17-22. doi: 10.1016/j.onehlt.2017.02.002. PMID: 28616498; PMCID: PMC5454160.

24. CDC. One Health: Centres for Disease Control and Prevention (2017).[Online] Available at: **https://www.cdc.gov/onehealth/basics/history/index.html.**

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

Manju Rahi[1]* and Sam Joy[1]*

[1] Indian Council of Medical Research, New Delhi, India

***Corresponding author**
Dr. Manju Rahi
Director, ICMR-Vector Control Research Centre (VCRC), Puducherry
drmanjurahi@gmail.com

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 particularly 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 factor and is augmented by various factors which includes 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 globalsurge 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 thevarious 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 successfully 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 lnfrastructure 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-remerging 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.

Financial support & sponsorship

None.

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. Spernovasilis 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%98one-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_realease_files/Press_Release_ICMR_15_September.pdf. Accessed 20th Sep 2023.

Uniting for One Health – The Importance of Community Engagement in One Health

Saumya Deol[1], Harmanmeet Kaur[1], Anoop Velayudhan[1]*

[1]Division of Communicable Diseases, Indian Council of Medical Research, New Delhi, India

***Corresponding author**
Dr. Anoop Velayudhan
Scientist E, Division of Communicable Diseases
Indian Council of Medical Research (ICMR)
New Delhi, India
anoop.vel@icmr.gov.in

Abstract

The One Health approach emphasizes the interconnectedness of human, animal, plant, and environmental health. It mobilizes various sectors and communities to address health threats and promote well-being. In India, zoonotic diseases pose significant risks, particularly to livestock-rearing communities. Human brucellosis, scrub typhus, and anthrax are prevalent, with specific risk factors identified. Vector-borne diseases like malaria and dengue also threaten communities. Community engagement is crucial for implementing sustainable One Health interventions, integrating local knowledge, building capacity, and promoting risk communication. Despite challenges, such as resource intensity, community engagement fosters inclusivity, participatory decision-making, and improved health outcomes.

Keywords: One Health, Community engagement

Introduction

The One Health approach recognizes the interdependence of the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) and seeks to mobilize multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems. Communities form an integral part within the one health framework as they can be vulnerable to one health threats such as zoonotic transmission of diseases and also play a key role in the implementation of sustainable one health interventions. Risks reported for India are several.

Pastoralist or livestock rearing communities are often at risk of acquiring zoonotic infections. Many zoonotic diseases are prevalent in livestock and are occupational zoonosis in the livestock farmers in India. Lack of knowledge on the disease transmission, prevention and control measures are potential risk factors in livestock rearing communities. Human brucellosisis common in rural India. Close contact with goats and sheep, and raw milk ingestion are the major risk factors.

Villagers of Gorakhpur are at risk of infection with scrub typhus, which might lead to Acute Encephalitis Syndrome (AES). Some of the risk factors identified for occurrence of scrub typhus has been storing of firewood in houses and children playing in bushes infested with mites. Another example is the anthrax outbreaks that affect communities in Orissa every year. The soil in the forest is highly organic with good moisture and supports anthrax spores. Due to scanty agriculture, tribals mainly depend on forest for livelihood. Risk of infection increases due to anthrax spores in the wild. Outbreaks of anthrax in these indigenous populations occur as food poisoning following consumption of contaminated cattle meat.

Communities also face the threat of vector borne diseases due to common close environment. Important vector-borne diseases for India include malaria, dengue, Japanese encephalitis, kala-azar, lymphatic filariasis and chikungunya. Community awareness and participation is key to successful implementation of vector control measures for mosquitoes.

Community engagement is a pillar in the implementation of a sustainable one health framework. which ensures active participation and regular communication with the community to achieve positive health impact and outcomes. It has many facets in the domain of One Health, including knowledge integration. All communities are endowed with local knowledge and perspectives regarding their own health, of their livestock and also their environment. Understanding and utilizing this knowledge in risk factor ascertainment can help recognize inter-linkages and plan integrated health delivery strategies for humans and animals that are locally relevant and sustainable.

Capacity building is another facet of community engagement. It is possible to involve the community in

surveillance and active reporting mechanisms for zoonotic diseases and spillover threats and also increase their knowledge and promote safe practices. ,

Risk communication is another sphere that can facilitate desirable behavioral changes and health promotion activities. Community members can be sensitized on various zoonotic diseases that are prevalent regionally and their modes of transmission. Such workshop scan aid in improving awareness, especially in the context of information about the complex inter-relationship between human, animal and environmental health , as well as building solutions against spillover mechanism . For instance, in settings where the human and animal population lives together such as livestock rearing communities, integrated one health camps can be organized for detection of diseases in the human population and animals, the assessment of the risk factors in the community, the prevalent knowledge, attitudes and practices, the nutritional status of the community, tick surveillance in animals, etc. The Indian Council of Medical Research (ICMR) had the opportunity to join in the excellent initiative of One Health Support Unit (OHSU), Department of Animal Husbandry & Dairying, to participate in such One Health Camps.

IInclusivity is an important feature of community engagement . It gives the local level stake-holders an opportunity to participate in the decision making process, which promotes social equityin the process of addressing one health concerns. The interventions designed through participatory processes find greater acceptance amongst the community members and create a sense of ownership in the health interventions and health outcomes of the community.

There are also some limitations. Community engagement as an approach can be resource intensive as the needs of various communities are different and individual programmes need to be tailor-made. Such interventions may lack reproducibility and care must be taken to use local perspectives in conjunction with scientific research methods .

Summarily, community engagement can be a tool for knowledge integration, risk-communication, capacity building, surveillance for zoonotic diseases, behavioral change, participatory decision making, inclusivity and empowerment of the community to optimize its health outcomes. It strengthens the health system in a holistic manner through bringing last-mile connectivity by reaching out to the community through bottom-up approach.

Financial support & sponsorship

None.

Conflicts of Interest

None.

References

1. One Health Joint Plan of Action, 2022–2026. FAO; UNEP; WHO; World Organisation for Animal Health (WOAH) (founded as OIE); 2022. doi:10.4060/cc2289en

2. Singh BB, Kaur R, Gill GS, Gill JPS, Soni RK, Aulakh RS. Knowledge, attitude and practices relating to zoonotic diseases among livestock farmers in Punjab, India. Acta Tropica. 2019;189:15-21. doi:10.1016/j.actatropica.2018.09.021

3. Mangalgi SS, Sajjan AG, Mohite ST, Kakade SV. Serological, Clinical, and Epidemiological Profile of Human Brucellosis in Rural India. Indian J Community Med. 2015;40(3):163-167. doi:10.4103/0970-0218.158847

4. Encephalitis-Gorakhpur-report-NGT-June-2022.pdf. Accessed February 12, 2024. http://www.indiaenvironmentportal.org.in/files/file/Encephalitis-Gorakhpur-report-NGT-June-2022.pdf

5. Patil RR. Anthrax: Public Health Risk in India and Socio-Environmental Determinants. Indian J Community Med. 2010;35(1):189-190. doi:10.4103/0970-0218.62573

6. vbd-fact-sheets.pdf. Accessed February 12, 2024. https://www.who.int/docs/default-source/searo/india/health-topic-pdf/vbd-fact-sheets.pdf?sfvrsn=c1908b04_2

7. One health joint plan of action (2022-2026): working together for the health of humans, animals, plants and the environment. Accessed January 5, 2024. https://www.who.int/publications-detail-redirect/9789240059139

8. Community engagement: a health promotion guide for universal health coverage in the hands of the people. Accessed January 4, 2024. https://www.who.int/publications-detail-redirect/9789240010529

9. Halton K, Sarna M, Barnett A, Leonardo L, Graves N. A systematic review of community-based interventions for emerging zoonotic infectious diseases in Southeast Asia. JBI Database System Rev Implement Rep. 2013;11(2):1-235. doi:10.11124/jbisrir-2013-801

10. Risk communication and community engagement joins forces with One Health in the Kingdom of Saudi Arabia. Accessed January 5, 2024. https://www.who.int/news/item/13-12-2023-risk-communication-and-community-engagement-joins-forces-with-one-health-in-the-kingdom-of-saudi-arabia

11. What is Community Engagement? Department of Agricultural Economics, Sociology, and Education. Accessed January 5, 2024. https://aese.psu.edu/research/centres/cecd/engagement-toolbox/engagement/what-is-community-engagement

Preventing Pandemics: Shifting from Reactive to Proactive One Health approaches

Ritu Chauhan[1]*, Prejit [1]

[1]WHO Country Office for India, New Delhi

***Corresponding author**
Dr. Ritu Chauhan
National Professional Officer- IHR
WHO's Health Emergencies Department
WHO Country Office for India, New Delhi
Chauhanr@who.int

Abstract

Recent public health events like SARS, Avian Influenza, Ebola, Monkeypox, and COVID-19 have highlighted the need to understand emerging risks at the animal-human interface. Pandemics cause significant morbidity, mortality, and economic consequences, emphasizing the importance of pandemic prevention through a One Health strategy. Zoonotic pathogens often originate from the wild but can spill over to humans via domestic animals. Major drivers of zoonotic spillover include deforestation, wildlife trade, livestock farming, urbanization, and habitat fragmentation. Implementing the One Health approach helps understand disease risk factors and develop proactive strategies for preventing future pandemics.

Keywords: Zoonosis, One Health, pandemics

Introduction

Recent public health events such as SARS, Avian Influenza, Ebola viral disease, and Monkeypox – as well as the unprecedented health, economic, and societal impact of the COVID-19 pandemic – have refocused attention on the need to comprehensively understand emerging risks at the animal-human interface. As a result, countries are nearly unanimous on one point: The world cannot afford another pandemic[1].

Pandemics can lead to considerable morbidity and mortality, particularly in vulnerable populations such as children, the elderly, and immunocompromised individuals[2]. They can also have severe economic consequences, including healthcare costs, disruptions to businesses and supply chains, and long-term socioeconomic impacts. This highlights the significance of investing in pandemic prevention through a One Health strategy and adopting proactive measures to forestall pandemics rather than waiting for them to arise.

Zoonotic pathogens typically originate from the wild but can spill over to humans from domestic animals because of their close interaction with wild animals3. In a recently issued white paper by the One Health High-Level Expert Panel (OHHLEP) on zoonotic spill-over prevention, the document states, "It's clear that pandemic prevention at the source cannot continue as an afterthought – a much larger commitment is overdue and sorely needed to prevent future pandemics"[4].

Understanding the Risk Drivers

In the 21st century, zoonoses has relentlessly and consistently threatened public health and produced devastating pandemics[5]. Around 80% of pathogens infecting animals are "multi-host," meaning that they move among different animal hosts, including occasionally infecting humans. Domestic animals and peri-domestic wildlife also act as bridges for the emergence of human diseases[6].

Tropical deforestation, wildlife trade, intensification of livestock

Farming, unplanned urbanization, and habitat fragmentation are throwing ecosystems out of balance and are considered to be major drivers of zoonotic disease spillover. Close encounters between people and wild animals are relatively uncommon compared to those with domestic animals, but the recent emergence of diseases like Ebola, SARS, and Nipah, highlights the danger that wildlife pathogens pose to global health security[7]. For example- in Bangladesh, bats harboring Nipah virus — which can kill 40–75% of infected people — now roost in areas of high human population density because their forest habitat has been almost entirely cleared.

To understand the rising frequency of spillover events more comprehensively, the OHHLEP is suggesting investigating the following upstream drivers using a systematic review: hunting of wild animals, captive wild animals, live wild animal trade, trade in wild animal products, agricultural expansion for farming livestock,

intensification of livestock farming, extensive livestock farming, climate change, urbanization, and habitat fragmentation[8].

By implementing the One Health approach we can gain a deeper understanding of the complex web of factors contributing to disease risk and develop proactive strategies to prevent and mitigate potential outbreaks. This requires transdisciplinary approaches, with a systemic focus on the health of animals, humans, and ecosystems, and it will be only through a collaborative risk-based approach that prevention and preparedness for future health emergencies can be ensured.

Risk reduction Measures

Strategies to address upstream determinants for risk reduction at the animal side include (but are not limited to): Improved biosecurity measures at livestock farms and wet markets, better veterinary care, strengthened surveillance, and increasing awareness for hot spot areas for pathogen spillover and related risk reduction measures, reporting for animal diseases and instituting early quarantines to limit pathogen spread.

In addition, investing in conservation initiatives would have the potential to safeguard biodiversity and global health security. Wildlife conservation efforts should aim at reducing human-wildlife interactions in the wildlife trade by protecting wildlife habitats and providing local communities with alternative protein sources.

Conducting joint risk assessments to evaluate the potential impact of a pathogen and developing strategies to reduce the associated risk is a proactive approach9. This includes assessing the pathogen's transmissibility, severity, and potential for spillover from animals to humans. Continuous monitoring of high-risk areas, such as wildlife markets and areas experiencing ecological disruptions, can help identify and mitigate potential threats.

How can the sectors work together?

"Just as health emergencies have impacts across many sectors, so must our preparedness and response efforts span sectors, disciplines, and pathogens. It is critical, too, that community engagement and equity are the centre of our efforts, especially for those populations that are marginalized and most at risk."- Tedros Adhanom Ghebreyesus, WHO Director-General speaking at the launch of PRET (Preparedness and resilience for emerging threats), 26 April 202312.

While One Health may need no further advocacy[10], given the clarion calls after the COVID-19 pandemic, the real test of its adoption will lie in the field implementation at both national and sub-national levels. The quadripartite (WHO, FAO, OIE, and UNEP) have revisited the entirety of the definition of 'One health' which is defined as an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent.[11]

In most cases, the sectors do come together briefly for the reactive response phase, only to be dismantled once the acute public health event is over. The siloed approaches of thinking and working and short-term address of the acute issues at hand, will not be able to generate the vision needed for protecting the health of the animals, people, and the planet.

For countries where one health needs greater traction at the national/ field level, periodically looking at the country profile of emerging zoonoses threats (for a large country- this to include subnational/local epidemiology as well) and jointly addressing risk assessments, risk profiling and planning for targeted strategies, recognizing specific local vulnerabilities and concurrent health threats/disasters opens considerable room for multi-sectoral dialogue across the one health landscape.

Moreover, addressing public health events through a One Health approach has significant subsequent economic co-benefits; for example, reducing deforestation is estimated to create $4 billion per year in social benefits from reduced greenhouse gas emissions[13]. Recurrent episodes of Nipah virus outbreaks in Kerala for instance require an understanding complex relationship between the ecological niche within which the spillover events occur, including addressing the risk drivers, habitat loss, role of sentinel animals, and the potential for further zoonotic disease transmission.

Rethinking health emergency preparedness- Moving towards an ecosystem approach

The latest document from WHO on health emergency preparedness and response (HEPR) calls for a strategic shift towards an ecosystem approach with a focus on strengthening core health emergency components: collaborative surveillance; community protection; safe and scalable care; access to countermeasures; and emergency coordination. Furthermore, with the formation of a Quadripartite following the formal inclusion of the UN Environmental Programme (UNEP) into the Tripartite (FAO-WOAH-WHO) in 2022[14], and with the subsequent launch of the global One Health Joint Plan of Action (OH JPA) (2022-26)[15], the commitment towards ecosystem approach has further strengthened.

Strong integrated disease surveillance, efficient

laboratory capacity and diagnostics for pathogen and genomic surveillance, and collaborative approaches for event detection, risk assessment, and response monitoring are all necessary to strengthen collaborative surveillance.

While efforts are being made to achieve a truly equitable and globally accessible genomic surveillance network, it remains a challenge that requires sustained investment, collaboration, and support from the international community. Evidence has shown that low-income countries continue to have limited genomic surveillance capabilities[16]. Following the pandemic, the need for a robust genomic surveillance capability has become even more pressing[17].

The pandemic brought many opportunities- for coordination beyond the health sector, and these lessons need to be institutionalized and well-documented. Sustaining whole of society- whole of government approaches should be possible for preparedness and readiness activities but requires clear leadership and strong governance models.

A system thinking approach for readiness and community resilience needs to be at the heart of the health security agenda, including addressing contextual vulnerabilities. The complexity and connectivity of multi-source surveillance need to be addressed while recognizing the benefit of sharing intelligence, early information sharing, and data sharing best practices. This may necessitate formal administrative arrangements (such as a Memorandum of Understandings/legal/administrative framework) to provide an agreed institutional framework for sectors to converge.

A silent pandemic of antimicrobial resistance (AMR)

The silent pandemic of antimicrobial resistance (AMR) also continues to take a toll on patients and their families, leading to prolonged infections, extended and costly hospital stays, and preventable deaths. Sub-optimal infection control practices, agricultural contaminants in the environment, improper management, and consumption of antimicrobials both in animals and humans, together with the migration of animals/people infected with drug-resistant pathogens continue to facilitate the spread of resistance. If treatment is not administered in accordance with a stringent AMR policy and without adhering to prescription guidelines during a health emergency, it may aggravate AMR and treatment results.

Effective management of antimicrobial resistance (AMR) necessitates stringent and effective regulation of antimicrobial types and dosages used in medical and veterinary practices, in addition to tracking and controlling the spread of resistant bacteria into the environment by implementing the One Health strategy outlined in the AMR national action plan.[18]

What gets measured gets done

WHO has provided several tools for monitoring and evaluating core capacities under the IHR (2005) and the legal instrument itself is being reviewed globally to incorporate some of the recommendations being made by the Member States. However, its full application and implementation would be possible through continuous improvements for pandemic preparedness made through regular exercises (tabletop/ drills/simulation scenarios), using after-action reviews to improve National Action Plans for Health security, and assessing/elevating public health workforce capacity with an all-hazard approach. Capacities at Points of Entry (Ports, airports, and ground crossings) can be assessed using available tools for PoE, and contingency plans need to be tested regularly based on periodic risk assessments and functional exercises.

Exercises planned well can encourage multi-sectoral involvement and cooperation. There is a need for greater advocacy for multisectoral participation in the conduct of e SPAR and the use of other tools such as Joint External evaluation (including at the sub-national level)

Along similar lines, the World Organization of Animal Health (WOAH) (an intergovernmental organization responsible for developing standards for animal health) has developed the Performance of Veterinary Services (PVS) Pathway, which is composed of a range of tools to assist countries to objectively assess and address the main weaknesses of their Veterinary Services. To analyze and improve the collaboration between the two sectors in the prevention, detection, and response to Pandemics arising from zoonotic diseases, the two organization recommends conducting a WHO-WOAH IHR-PVS National Bridging Workshops (NBWs) to identify bridging opportunities between the two sectors, as well as next steps and activities needed to strengthen national capacities relevant to the animal-human interface[19].

The OH Joint Plan of Action provides comprehensive technical guidance to countries for collective and coordinated action to mainstream the One Health approach.[15] Build around six interdependent action tracks, the OH-JPA provides a clear roadmap to countries to collectively contribute to achieving sustainable health and food systems, reduced global health threats and improved ecosystem management.

Conclusion

Preventing pandemics necessitates a shift from a reactive to a proactive (multi-pronged- One Health) approach thereby recognizing and resolving possible pandemic risks before they become global crises. By considering the broader impacts of pandemics, we must involve multiple sectors and disciplines in a way that protects not only individual health but also the stability and well-being of communities, societies, animals, and ecosystems. Preparedness efforts should not be limited to specific pathogens but rather focus on building systems that can respond to a wide array of infectious agents. By taking such proactive measures with a strong focus on the ecosystem approach, we can prevent future pandemics from emerging at the animal-human interface.

Disclaimer

The article represents the personal opinion of the authors and not that of the organization for whom they work.

Financial support & sponsorship

None.

Conflicts of Interest

None.

Reference

1. World Health Organization. WHO Reforms for a Post-Pandemic Future. Available from: ORF (orfonline.org),accessed on July 3, 2023

2. Noguera LP, Charypkhan D, Hartnack S, Torgerson PR, Rüegg SR. The dual burden of animal and human zoonoses: A systematic review. PLoS Negl Trop Dis 2022; 16(10): e0010540. https://doi.org/10.1371/journal.pntd.0010540

3. Moreno-Madriñan MJ, Kontowicz E. Stocking Density and Homogeneity, Considerations on Pandemic Potential. Zoonotic Diseases. 2023; 3(2):85-92. https://doi.org/10.3390/zoonoticdis3020008

4. World Health Organization: Prevention of zoonotic spillover. Available from: Prevention of zoonotic spillover (who.int) ,accessed on July 3, 2023

5. Choi, Y.K. Emerging and re-emerging fatal viral diseases. Exp Mol Med 53, 711–712 (2021). https://doi.org/10.1038/s12276-021-00608-9

6.World Organization of Animal Health. Available from: Improving wildlife surveillance.pdf (woah.org) ,accessed on July 1, 2023

7. Morens, D. M. & Fauci, A. S. Emerging infectious diseases: threats to human health and global stability. PLoS Pathog. 9, e1003467–e1003467 (2013).

8.World Health Organization. Available from: One Health High-Level Expert Panel Annual Report 2022 (who.int) ,accessed on July 3, 2023.

9.World Health Organization. Joint Risk Assessment Operational Tool (JRA OT) (who.int). Available from: JRA OT (who.int) ,accessed on July 3, 2023.

10.World Health Organization. Quadripartite call to action for One Health for a safer world - WOAH - World Organisation for Animal Health. Available from: Quadripartite call to action , accessed on June 29, 2023.

11.World Health Organization. One Health High-Level Expert Panel. Available from: OHHLEP (who.int) ,accessed on July 3, 2023.

12.World Health Organization. Pandemic preparedness. Available from: WHO launches new initiative to improve pandemic preparedness

13.Dobson AP, Pimm SL, Hannah L, Kaufman L, Ahumada JA, Ando AW, et al. Ecology and economics for pandemic prevention. Science. 2020;369(6502):379-81

14.World Health Organization. Quadripartite Memorandum of Understanding (MoU) signed for a new era of One Health collaboration (who.int) Available from: who.int ,accessed on July 1, 2023

15.World Health Organization. One health joint plan of action (2022-2026): working together for the health of humans, animals, plants and the environment (who.int). Available from: One health joint plan of action (2022-2026) (who.int) ,accessed on July 3, 2023

16. Goel V, Mathew S, Gudi N, Jacob A, John O. A scoping review on laboratory surveillance in the WHO Southeast Asia Region: Past, present and the future. J Glob Health. 2023; 13:04028. doi: 10.7189/jogh.13.04028. PMID: 37083001.

17. Inzaule SC, Tessema SK, Kebede Y, Ouma AEO, Nkengasong JN. Genomic-informed pathogen surveillance in Africa: opportunities and challenges. Lancet Infect Dis. 2021;21:e281-e289. 10.1016/S1473-3099(20)30939-7

18. World Health Organization. India: National action plan on antimicrobial resistance (NAP-AMR) 2017 – 2021. Available from: India: National action plan on

antimicrobial resistance (NAP-AMR) 2017 – 2021 (who.int), accessed on July 5, 2023.

19. World Organization for Animal Health. IHR-PVS National Bridging workshops (NBW) - WOAH – Europe. Available from: IHR-PVS National Bridging workshops, accessed on July 3, 2023

20. Directorate of Health Service, Kerala. Nipah Virus Update. Available from: Nipah Virus – dhs (kerala.gov.in) , accessed on September 30, 2023

National Conclave on Uniting for One Health - Summary Report & Recommendations

Simmi Tiwari[1]*, Ajit Dadaji Shewale, Tushar Nale, Vineet Srivastava, Preetishirin Katapur, Dipti Mishra, Aastha Singh

[1]National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr. Simmi Tiwari
Joint Director and Head, Centre For One Health
National Centre for Disease Control (NCDC)
drsimmi.tiwari11@gmail.com

Executive Summary

The interconnected world creates a pathway for devastating pandemics to emerge. Ecological circumstances provide opportunities for spillover events, which evolution capitalizes on, transforming them into global health crises. The Influenza pandemic of 1918-1920 and the emergence of SARS CoV-19 virus in December 2019 illustrate the severe consequences of such crises. Factors such as rapid population growth, urbanization, increased human-wildlife interactions, deforestation, and global travel have all facilitated the transmission of once- isolated viruses to larger human populations. With a global burden of 2.5 billion cases of infection and 2.7 million human deaths worldwide each year, zoonotic diseases (originating in animals and jumping to humans) constitute 60 percent of known infectious diseases and up to 75 percent of new infectious diseases; hence, significantly burden global health.

The National One Health Programme-Prevention and Control of Zoonoses (NOHP- PCZ), National Centre for Disease Control, Ministry of Health and Family Welfare, Government of India decided to plug the gaps that the COVID-19 revealed; the inadequacy of the Indian health system in providing an integrated One Health response. The health system already burdened

with various health challenges needed a prioritized and competent multisectoral platform for One Health. As a next step, NOHP-PCZ, NCDC held a National Conclave on "Uniting for One Health on 6th-7th July, 2023, in Delhi.

The conclave witnessed unprecedented convergence with the engagement of high-level delegates from multiple ministries and representatives from various departments like public health, animal health, environment, agriculture, forestry, climate change, and wildlife and development partners, including USAID, WHO, CDC, and PATH. It was a first-of-its-kind convergence experience with scope for future collaboration that will remain a landmark event within the realm of public health.

The objectives of the conclave were

- To enhance intersectoral surveillance for zoonoses to consolidate and merge diverse data reporting platforms, facilitating data integration.
- Prototype Development for Multi-Sectoral Zoonoses Data Reporting in relevant sectors to record and report zoonotic data from multiple sectors, fostering collaboration and coordinated efforts.
- Emphasize Data Integration in Zoonoses Surveillance to promote a cohesive approach in data collection, analysis, and reporting by prioritizing data integration, foster multi-sectoral and inter-departmental collaboration, facilitating joint risk assessment.
- Expand the surveillance network for critical zoonotic diseases. Integrate data from various sources using advanced analytics and AI.

The conclave witnessed participation from over 160 distinguished guests from 28 states. The participants convened at the Conclave signed the `Pledge Wall", accompanied by a message advocating for the unification of efforts and affirming their commitment to work cohesively for One Health. The objectives of the conclave were primarily met, and the outcomes were achieved. Much was learned from the deliberations and the discussions on implementation and collaboration issues and how to proceed.

As a next step, overcoming the challenges will be crucial in safeguarding the health and well-being of humans, animals, and the environment in India. By consolidating efforts, expanding knowledge, integrating data, embracing technology, prioritizing collaboration among sectors, and engaging communities, the spread of infectious and emerging threats of zoonotic diseases can be mitigated.

However, addressing the challenges and implementing the recommendations will require collective action and commitment from all sectors involved. The National Conclave is an essential step towards achieving this shared vision and assuring the well-being of humans, animals, and the environment.

Recommendations

1. Strengthen Collaboration & Information Sharing: In light of the interconnected nature of human, animal, and environmental health, it is essential for countries and international organizations to collaborate and share information on disease surveillance, outbreaks, and response measures. This will facilitate early detection and rapid response to potential health threats, enabling a proactive approach to preventing and controlling zoonotic diseases.

2. Foster Multisectoral Collaboration: To effectively address zoonotic disease outbreaks, collaboration and coordination among various sectors, such as health, agriculture, environment, and wildlife, must be promoted. Breaking down silos and facilitating information sharing will enable joint risk assessment and response planning, leading to comprehensive strategies for disease control.

3. Invest in Robust Surveillance and Early Warning Systems: Allocation of resources and funding is necessary to establish and enhance surveillance networks for zoonotic diseases with animal origins. Early warning systems will provide timely alerts, enabling swift and targeted interventions to contain outbreaks at their source. Investing in prevention now is far more cost- effective than dealing with the consequences of large-scale pandemics later.

4. Prioritize Comprehensive Disease Surveillance: The programme should prioritize establishing comprehensive disease surveillance systems for zoonotic diseases, focusing on priority diseases like Food and Mouth Diseases, Avian Influenza, Rabies, etc. This will help streamline resources and efforts, enabling timely detection, monitoring, and response to potential outbreaks.

National Conclave on "Augmented Zoonotic Diseases Surveillance at Human Wildlife Interface"

Simmi Tiwari[1]*, Ajit Dadaji Shewale, Tushar Nale, Nidhi Khandelwal, Gajendra Singh, Priyanka Khuda

[1]National Centre for Disease Control (NCDC), Delhi

***Corresponding author**
Dr. Simmi Tiwari
Joint Director and Head, Centre For One Health
National Centre for Disease Control (NCDC)
drsimmi.tiwari11@gmail.com

Background

The National Conclave on "Augmented Zoonotic Diseases Surveillance at Human-Wildlife Interface" commenced on October 17, 2023, at the Nalanda Hall, Dr Ambedkar International Centre, New Delhi. The event was facilitated by the Centre for One Health, National Centre for Diseases Control, under the Chairmanship of Shri. Sudhansh Pant, Secretary, MoHFW, Government of India. The objective of the national conclave was to understand the outbreaks of zoonotic disease events, strengthening of wildlife pathogen surveillance for early detection of emerging zoonotic disease events, address human-wildlife conflict and inter-sectoral collaborations.

Following the welcome address, a symbolic lamp lighting ceremony took place, graced by all dignitaries present. **Ms. Payden**, Deputy WR to India, **Dr. Ashok Kumar**, Addl. DG-ICAR, **Prof.(Dr.) Atul Goel**, DGHS, MoHFW GoI, **Shri Abhijit Mitra**, Commissioner Animal Husbandry, and **Mrs R. Jaya**, Additional Secretary, MoTA delivered impactful addresses, highlighting the significance of the initiatives being undertaken. During the Inaugural event a rabies helpline number 120-602-5400 and following technical documents were launched by all dignitaries' present:

- The Inter-Ministerial One Health Support Statement on NAPSE
- Technical Guidance on Zoonotic Diseases Prevention, Preparedness, and Response
- Comprehensive guide on Medically Important Snakes in India.

The session concluded with a vote of thanks by **Dr. Ajit Shewale**, Deputy Director, COH, NCDC, expressing gratitude to all participants and stakeholders for their contributions and commitment to the cause.

The conclave witnessed participation from over 160 distinguished guests from 28 states/UTs. The participants convened at the Conclave signed the "Pledge Wall", accompanied by a message advocating for the unification of efforts and affirming their commitment to work cohesively for One Health. The objectives of the conclave were primarily met, and the outcomes were achieved. Much was learned from the deliberations and the discussions on implementation and collaboration issues and how to proceed.

Recommendations

As a next step, overcoming the challenges will be crucial in safeguarding the health and well-being of humans, animals, and the environment in India. By consolidating efforts, expanding knowledge, integrating data, embracing technology, prioritizing collaboration among sectors, and engaging communities, the spread of infectious and emerging threats of zoonotic diseases can be mitigated. However, addressing the challenges and implementing the recommendations will require collective action and commitment from all sectors involved. The National Conclave is an essential step towards achieving this shared vision and assuring the well-being of humans, animals, and the environment.

The following recommendation has been given in both session

1. **Dr. Gyanendra Gongal**, Senior Public Health Officer (Food safety, Zoonoses and One Health) WHO SEARO gave comprehensive presentation on zoonotic diseases, covering their types, and providing insights into the global and Indian scenarios.

2. **Dr Ritu Chauhan**, NPO, IHR, WHO India Office presented a comprehensive overview of the COVID-19 pandemic. She elucidated the primary drivers of biodiversity loss and introduced initiatives aimed at fortifying health emergency preparedness and response. Stressing the imperative for collaborative efforts in the realm of One Health, she articulated the need for multisectoral involvement in risk assessment. She underscored the inadequacy of single surveillance systems and proposed Quadripartite approach for One Health framework. Dr Chauhan emphasized the importance of a strengthened global architecture for health emergency preparedness and response.

3. **Dr. Lesa Thompson**, Regional Project Officer, WOAH then discussed factors contributing to spillovers events, emphasizing the importance of understanding and managing the associated risks. She highlighted the crucial role of wildlife disease surveillance, the need for wildlife disease reporting requirements, and the significance of risk analysis in evaluating disease risks.During the Q&A session, stakeholders sought suggestions for establishing a Human-Wildlife interface. Dr Thompson stressed the importance of input from stakeholders, the prioritization of zoonotic diseases, and the need for strategies related to dog birth control.

4. **Dr. Vineeta Shrivastava**, Health Advisor Ministry of Tribal Affairs, GoI provided a behavioral perspective, underscoring the necessity for tribal affairs to be actively involved. She highlighted the challenges faced by rural areas, including financial burdens, poor awareness, language differences, and a lack of health facilities. Dr Vineeta proposed strategies to mitigate the risk of emergency zoonoses, including recognizing community perceptions, mapping stakeholders, conducting training programmes, fostering shared learning, and collaborating with community partners to instill a sense of ownership. To address existing gaps, Dr Vineeta recommended advocacy for prioritizing zoonoses, mapping health facilities, estimating the burden of zoonoses, and effective communication through mass media. The importance of convergence was emphasized. Some initiatives of the Ministry of Tribal Affairs (MoTA) were presented, including dedicated health cells, the development of the Swasthya portal, massive

awareness campaigns, tribal Tuberculosis initiatives, the launch of tribal health collaboration and the early childhood development initiatives etc.

5. **Dr. HV Girisha**, Additional Director at the Wildlife Crime Control Bureau (MoEFCC), then presented a global perspective on wildlife trade, animal movement and its associated risks of zoonotic diseases. He defined wildlife broadly to include animals, aquatic life, and land vegetation, describing it as a transnational organized activity. The global magnitude of wildlife trade was outlined, with an overview of species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Spillover risk factors linked to wildlife trade, such as hunting, transport, and unhygienic practices, were discussed, along with challenges like the lack of SOPs for human, veterinary and wildlife for handling of seized animals and medical research, etc. Institutional arrangements to prevent spillover were presented, encompassing risk understanding, assessment, and reduction strategies to enhance ecosystem, human, and animal health.

The pivotal takeaways highlighted the critical need for collaboration, a clear institutional framework, financial support, and a culture of trust to address the complex challenges posed by health emergencies and wildlife trade.

- The post lunch technical session, chaired by **Dr Anil Kumar**, Principal Advisor, NCDC MoHFW, GOI, commenced with a focus on biodiversity hotspots by **Dr. J. Soundrapandi**, Project Officer- UNDP, National Biodiversity Authority. The discussion highlighted the National Mission on Biodiversity and Human well-being, emphasizing habitat destruction and wildlife trade as significant drivers of zoonotic diseases.

- During the Q &A session, the absence of quantitative indicators for tracking species progress or extinction was addressed. The challenge lies in the lack of a surveillance system to assess population or species status. Population variability assessment, a tool to gauge the extinction of fauna and flora, was mentioned.

6. **Dr. Sanket**, Joint Director, IDSP provided an update on zoonotic outbreaks, detailing two surveillance systems: event-based surveillance and routine/indicator-based surveillance. He highlighted the Integrated Disease Surveillance Programme (IDSP) objectives, incorporating early signals, rapid response teams, and a decrease in mortality and morbidity. Challenges in the Nipah outbreak in Kerala, particularly the inability to identify the index case, were discussed. During the Q&A session, the integration of health and zoo surveillance systems and the regular sharing of information were addressed. The need for a technical person to share user credentials for seamless integration was emphasized. The technical team session focused on the ongoing establishment of the National Referral for Wildlife and solicited ideas and suggestions from experts to enhance effectiveness

Panel Discussion 1: Understanding Prevailing gaps to detect and Address the zoonoses emergence at Human-Wildlife interface

During the panel discussion, the eminent panelist engaged in a thoughtful discourse on the crucial topic of "Understanding prevailing gaps to detect and address the zoonoses emergence at Human- Wildlife interface". **Dr. Simmi Tiwari**, the Joint Director and Head of the Centre for One Health at NCDC, expertly moderated the session. The panel included **Dr. Gyanendra Gongal** from WHO SEARO, **Dr. Ritu Chauhan** from the WHO India Office, **Shri Sunil Sharma**, Joint Director (WL) at MoEFCC, **Dr Manoj Kumar**, Senior Scientist at NIHSAD, Bhopal, **Dr Abhijit Pawde**, Senior Scientist at IVRI, Izzatnagar, Bareilly, **Dr. Ranjana Devi**, Professor and Head, Regional Institute of Medical Science, Imphal, Manipur.

This panel discussion unfolded with valuable insights and recommendations from distinguished experts:

Q) Which are the countries who have any such surveillance mechanism in existence?

Dr. Gyanendra Gongal, WHO SEARO, advocated the need for indicator based and event-based surveillance in every country to achieve the goal of surveillance. He emphasized that sustained community driven surveillance should be in place; Anganwadi, self-help groups, and other community-centric channels should be used, as they are the main contact point to community; stressing the necessity for funding and resources to establish surveillance.

Q) What are gaps and challenges WHO and Quadripartite identified globally in this area? What is the way forward for member countries as per JPA-One Health?

Dr. Ritu Chauhan, NPO, WHO India, highlighted the significance of conducting gap analysis, stimulation exercise; joint external evaluation for comprehensive action plans in National Health Security and foster coordination. She emphasized the need to advocate One Health at all levels and importance of involving local community champions and media; setting up laboratories; bridging workshops; risk assessment; coordination and communication is the key.

Q) What is the current scenario of wildlife disease surveillance in India both in free ranging and captive animals? What gaps do you realize in the present scenario? What are the challenges and way forward to surmount these?

Shri Sunil Sharma, Joint Director (WL), MoEFCC stated that there is an established disease monitoring system for captive animals (Zoo) however no such system is available for free ranging animals currently. The existing surveillance system for wildlife disease is event based. He proposed measures such as capacity building for the veterinarian, sponsoring advance course for wildlife management; training of forest officials; vaccination of animals within 5 km of protected areas; technical partnership with veterinary, wildlife and health departments.

Q) What is your understanding regarding prevailing gaps in laboratory diagnostics for zoonotic pathogens (both endemic and emerging, and novel pathogens) in your sector (Human, Veterinary, and Wildlife): wider country perspective

Dr. Manoj Kumar, Senior Scientist, NIHSAD stated that NIHSAD mainly deals with diagnosis of Avian Influenza and CCHF Genomic detection.

Dr. Abhijit Pawde, Senior Scientist, IVRI, Izzatnagar, Bareilly stressed the need for a comprehensive data base.

Dr. Mala Chhabra, Sr. Consultant, Dr. RML Hospital and ABVIMS urged the use of GIS/remote sensing for hotspot identification and the need for joint training for clinicians and community. She emphasized that for diagnosis of zoonotic disease clinical suspicion is very important and there is an urgent need of own validated diagnostic kits. A major challenge towards the diagnosis of zoonotic disease is slow preparedness of the laboratories and hence the laboratories should be strengthened.

Dr. Ranjana Devi, Professor and Head, Regional Institute of Medical Science, Imphal, Manipur recommended that since there is no gap in the existing laboratory facilities infrastructure following COVID-19 pandemic, there is a need for a protocol for everyone to follow. She informed that it is mandatory that every medical college should have BSL2 and hence our country has a well-equipped laboratory infrastructure for human disease diagnosis.

The meeting concluded with **Dr Ajit Shewale**, Deputy Director, COH, NCDC facilitated the panelists with memento, and **Dr Simmi Tiwari**, Joint Director and Head Centre for One Health, NCDC expressing gratitude in her vote of thanks, highlighting the collective commitment to addressing the gaps and challenges in zoonotic diseases and management.

Addressing Emerging Zoonoses Risk at Human Animal Interface- Status of Ongoing Effort

On the second day of the conference, October 18,2023, the technical session was chaired by **Dr Sunil Gupta**, Principal Consultant at the National Centre for Disease Control (NCDC), with **Dr. Runa Gokhale**, Associate Director for Science and programmes, CDC, India and **Dr C. Sreekumar**, Professor & Head of Madras Veterinary College, serving as co-chairs. The day commenced with a recap of the discussion and key insights from the previous day, ensuring that participants were aligned with the outcomes and conclusion drawn.

D**r Pragya Yadav**, Scientist "F" NIV Pune provided a comprehensive update on ICMR's surveillance of emerging zoonotic diseases of wildlife origin, emphasizing the lab aspects. She covered key topics as the overview of zoonotic diseases, the history of pandemics, and the impact of urbanization on infectious diseases. Dr Yadav highlighted the importance of anticipating, preventing, preparing, detecting, and responding to outbreak. She pointed out the challenges faced, including the shortage of medical workforce and diagnostic labs. She recommended to strengthen the existing infrastructure, capacity building, and coordination, early detection of biothreats through surveillance, data should be at one place, developing strategies to prevent and detect biothreats, training of biosafety workers, pro-active surveillance for wildlife, mapping of animals, do molecular testing. The Q&A session addressed safety measures for research personnel in forest, which included risk assessment before field work, use of antibiotics and rabies vaccine.

Dr. Lallianpuri Kawlni, Scientist "D" Wildlife Institute of India presented on Wildlife health management and disease surveillance in relation to zoonotic diseases – Ongoing projects, and discussed about field training courses, endangered species recovery programme.

Dr. Mayank Dwivedi, PHS and Lab Advisor, CDC India representative presented laboratory aspects for detecting emerging zoonotic pathogens of epidemic potential, testing for pathogens in wild animal. He discussed about need of diagnostic facility, resilient and integrated human disease surveillance and lab network, community engagement along with technology. He emphasized on the need of tiered system of laboratory network. **Shri Rajesh S**, IFS, CCF, Arunachal Pradesh addressed emerging zoonoses risk at Human Animal Interface status of ongoing efforts, and the challenges

and status of ongoing efforts from a wildlife and forest management perspective, unregulated wildlife trade, and importance of community engagements. His presentation also covered the remarkable contributions of wildlife surveillance in zoonoses control.

Technical Session 4: Global Initiatives for detection of emerging diseases and cross species spill over events

- The session was chaired by **Dr. Bharthi Malhotra**, Senior Professor, Microbiology, SMS Medical College Principal Consultant at the National Centre for Disease Control (NCDC), with **Dr. Meghna Desai**, Director, CDC, India and **Dr. C. Sreekumar**, Professor & Head of Madras Veterinary College, serving as co-chairs.
- **Dr. Nitish C Debnath**, PREZODE Steering Committee Member presented on PREZODE initiative
- Strategies and Lessons Learnt
- **Dr. Shiyong Wang**, Senior Health Specialist, World Bank Experience from the spillover of Congo Crimean Hemorrhagic Fever (CCHF) in Mongolia and Avian Influenza in Vietnam
- **Dr. Abhijit Pawde**, Sr. Scientist, IVRI presented the existing facilities and network for diagnosis and surveillance of zoonotic pathogens at IVRI.
- **Dr. Manoj Kumar**, Sr Scientist NIHSAD Bhopal presented Existing facilities and network for diagnosis and surveillance of zoonotic pathogens at NIHSAD. He stated that the mandates of NIHSAD includes basic and strategic research on exotic, emerging and re-emerging animal diseases and the bio-risk management and capacity building in the areas of biosafety, biosecurity and biocontainment for handling high risk pathogens. He briefed about the diagnostic facilities available at NIHSAD and the network of regional disease diagnostic laboratories and the animal quarantine centres present across the country.

Panel Discussion 2: Leveraging Sectoral Expertise for Optimally Utilizing Existing Resources for establishing augmented zoonotic disease surveillance at the Human-Wildlife Interface

During the panel discussion, the focus centered on the critical topic of "Leveraging Sectoral Expertise for Optimally Utilizing Existing Resources for establishing augmented zoonotic disease Surveillance at the Human-Wildlife Interface." Dr. Mala Chhabra, Senior Consultant at Dr RML Hospital and ABVIMS, New Delhi, expertly moderated the discussion.
The panelists were:

1. **Dr. Atul Anand**, Consultant, One Health, UNDP
2.Dr. Manoj Kumar, Senior Scientist, ICAR-NIHSAD, Bhopal
3. Dr Monil Singhai, Joint Director CAZD, NCDC
4. Dr. Mayank Dwivedi, PHS and Lab Advisor, CDC Atlanta USA.
5.Dr. Devi Shankar Suman, Scientist, Estuarine Biology Regional Centre, ZSI
6. Shri Rajesh S, IFS, CCF, Arunachal Pradesh.

This panel discussion unfolded with valuable insights and recommendations from distinguished experts:

Q) What role does animal husbandry departments envisage in establishing augmented zoonotic disease surveillance?

Dr Atul Anand, Consultant, One Health, UNDP provided a comprehensive overview of the veterinarian infrastructure across India, and stated that there are RDDLS (Regional disease diagnostic Laboratories) across India and nearly 220 labs are connected with these RDDLs. National Animal disease control programme regularly reports the vaccination of foot and mouth disease and Brucellosis across PAN India on INAF portal. National Digital Lifestock Mission (NDLM) running in 5 states encompasses various programmes, including data production, artificial insemination, animal registration, vaccination. Hence a tiered infrastructure is available in some form in animal husbandry department and limited passive surveillance of zoonotic disease is already in place which can be utilized for generating early warning signal. With proper coordination, collaboration and data sharing it may be possible to generate an ealy warning signal in terms of zoonotic disease outbreak.

Q) What role does Ministry of Environment and Forest envisage in establishing zoonotic disease surveillance system at human-wildlife interface?

Shri Rajesh S, IFS, CCF, Arunachal Pradesh recommended that there is a need to collaborated with the Wildlife preservation, GoI to make suitable changes in the management plans for wildlife sanctuaries and Zoo authorities of India so as to put in the protocols to monitor the symptoms/signs of zoonosis, how can they recognize a zoonotic disease and what steps may be taken. This may be followed by Integration of surveillance, Capacity building and skill development for wildlife management, community engagement, and leveraging the integration of diseases, cross cutting agriculture. The application of various technologies, akin to those used in managing COVID-19 was advocated, with a call for clinicians to train, and sensitize higher officers. There is a vaccination strategy already in place for life stocks in the fringe area and that may be expanded with, which spillover of zoonotic disease may be restricted to certain extent.

Q) How to source and integrate ecological parameters into surveillance of emerging zoonotic diseases?

Dr. Devi Shankar Suman, Scientist, Estuarine Biology Regional Centre, ZSI recommendations:
Vectors act as the bridge between the wildlife and the Humans. There is a need to have a map of the micro biome of prevailing vectors in the country. Since the vectors differs in their ecology, habitat, disease transmission capacity and feeding habits etc., a surveillance should be set up on vectors before disease spreads.

Q) What role can ICAR-NIHSAD play in setting up Augmented Zoonotic Disease Surveillance?

Dr. Manoj Kumar, Senior Scientist, ICAR-NIHSAD, Bhopal highlighted ongoing collaborations/expansions like Influenza disease, and recommended similar action may be taken for other diseases also, harmonization of diagnostics/ infrastructure of animal and human health.

Q) What assistance ICMR, NCDC & CDC can provide in strengthening lab and surveillance capacity for AZDS?

Dr. Mayank Dwivedi, PHS and Lab Advisor, CDC Atlanta USA recommended to support, strengthen labs and epidemiological capacities, develop SOPs, etc., advancing of biosafety, enhancing genomic surveillance, and establishing case definitions.

Dr. Monil Singhai, Joint Director CAZD, NCDC recommended there is a need to augment surveillance, enhance existing infrastructure, and map capacities to identify main centres. The Q&A session touched on community based early warning signals, a decentralized approach, active participation of Panchayati Raj Institutions (PRIs), and considerations for a One Health laboratory. The importance of inclusivity, sensitization of institutes, avoiding resource duplication, ensuring proper SOPs, and creating a One Health repository for research were discussed to address contamination issues and promote collaborative efforts in the field.

Panel discussion 3: Surveillance strategies for zoonotic spillover detection at human-wildlife interface

The panel discussion addressed the critical topic of "Surveillance strategies for zoonotic spillover detection at human-wildlife interface".
Dr. Tenzin Dikid, Joint Director and Head CME VM and PBA, NCDC, capably moderated the session.

Q) What preparedness do you envisage for natural and man-made biological disasters in the country? What are the initiatives taken by the disaster management cell ?

Dr. Pradeep Khasnobis, DDG at Disaster Management Cell, MoHFW, GoI, highlighted the importance of prioritizing diseases, establishing a unified data platform for One Health, ensuring data integration and interoperability, conducting gap analysis, and implementing joint risk assessments.

Q) What are the appropriate strategies do you envisage to identify the target/at-risk human population, livestock and wildlife host? & What should be Information management System and Data Sharing Strategy surveillance at Human -Wild Life Interface?

Dr. Sanket Kulkarni, Joint Director at IDSP, NCDC, emphasized the utilization of existing infrastructure, including IDSP, district Public Health labs, Rapid Response Teams at district and state levels, NARDE, NADRS, and the NARDL Mission in five states. He stated that Health IDSP is working with animal husbandry team for developing an AI based tool for early generation of reporting, to know the hotspot arears with respect to zoonotic disease. He proposed the integration of health personnel into joint forest committees to facilitate the sharing of critical data.

Q) What are the appropriate strategies do you envisage to identify the target/at-risk human population, livestock and wildlife host?

Dr. Vrinda Menon, Associate Professor at the College of Veterinary & Animal Science in Thissur, emphasized the importance of educating school children, addressing zoonoses in pets, strengthening laboratories in state and central universities, considering food safety, and conducting soil and water testing.

Dr. Devi Shankar Suman, Scientist E, Estuarine Biology Regional Centre, ZSI, called for a focus on peripheral and fringe areas for wildlife. These recommendations collectively underscored the significance of collaborative efforts, capacity building, and the strategic utilization of existing resources for effective surveillance and response in the realm of zoonotic diseases.

Q) What should be the Criteria for prioritization of pathogens for surveillance system at human-wildlife interface?

Dr. A. M. Pawde, Principal Scientist at the Centre for Wildlife, ICAR-IVRI, underscored the necessity for capacity building, the development of databases, and the establishment of a surveillance system Dr. Meera Dhuria, Joint Director and Head of the Division of Public Health Preparedness and NCD at NCDC, recommended the formation of multisectoral rapid response teams, the incorporation of biosafety modules, and active community engagement.

Q) What should be the criteria for advanced diagnostics for Zoonoses (including novel pathogen diagnostics)?

Dr. Mala Chhabra, Senior Consultant Microbiology at Dr. RML Hospital and ABVIMS, New Delhi, suggested leveraging existing resources, regional prioritization of diseases, a syndromic approach for diagnosis of diseases and initiating surveillance with a tiered system (certain rapid diagnostic tests should be done at PHC level moving forward to the secondary level and in case of such syndromes which cannot be diagnosed at lower levels, tertiary levels may be approached). She emphasized the need to expand the mandates of existing diagnostic facilities, strengthen diagnostics, and ensure quality assurance at the field level.

The key highlights of the panel discussion were:

1. Augment human surveillance on basis of priority list for known zoonotic diseases, with special focus on states with high biodiversity/ hotspots. Use stepwise approach for lab data capture.

2. For unknown spillovers, strengthen syndromic surveillance through sentinel populations (animal handlers, lab workers, forest fringe populations in biodiversity zones). Subject a fraction of samples to NGS metagenomics for pathogen discovery.

3. Enable the IHIP platform for plugins for surveillance data inputs from sentinel sites for wildlife/ animal husbandry/entomological zones, to receive data on forward and backward zoonosis as well as to capture conditions (through entomological surveillance) for epizoonosis.

4. Work through inter-sectoral committees such as joint forest committee. Periodic behaviour surveys or joint outbreak investigations in high risk groups to understand exposures

5. Capacity building need to be addressed in developing and strengthening animal side surveillance

6. Policy requirement should cover following: one data platform, one health cell, ongoing disease prioritization exercise.

Asia-Pacific Quadripartite: One Health workshop

Ajit Shewale[1]*, Ritu Chauhan[2], Priyanka Khuda[1]

[1]National Center for Disease Control
[2] World Health Organization

***Corresponding author**
Dr. Ajit Dadaji Shewale
Joint Director, Centre for One Health
National Centre for Disease Control (NCDC)
ajitshewalencdc@gmail.com

Abstract

One Health concept promotes collaboration across various sectors in order to identify and prevent health risks at the interface of humans, animals, and the environment. The Asia-Pacific Quadripartite One Health workshop was organized to address the unusual health events at the interface of humans, animals, and the environment. The goal of the workshop was to evaluate the progress of One Health projects, with a particular focus on the recently launched One Health Joint Plan of Action (2022–2026). The key points highlighted by Quadripartite partners was to implement a One Health strategy promptly, emphasize the importance of combating public health issues and the role of sustainable food systems in reducing impact of climate change. The workshop focused on the need of working together to address the complex issues the Asia-Pacific countries are facing. The workshop outcomes were the gathering of delegates from Asia-Pacific nations in one location, in-depth discussions about achievements and difficulties, and the formation of action plans through group work sessions. The Quadripartite proposed recommendations for the Member States, and emphasizing the implementation of One Health Joint Plan of Action by countries, improved governance, and enhanced the involvement of environmental sector. The Quadripartite partners effort to involve One Health stakeholders, provide support to Member States, and plan to organize a workshop in 2025 to review the progress of Asia-Pacific countries. In conclusion, the Asia-Pacific Quadripartite One Health workshop showed a collaborative commitment to address health issues which in turn lead to sustainable and healthy future.

Key words: World Health Organization (WHO), United Nations Environment Programme (UNEP), Agriculture Organization (FAO), World Organisation for Animal Health (WOAH).

Background

One Health approach promotes collaborative efforts across sectors to timely detect and prevent public health risks at the interface of humans, animals, and the environment[(1)]. Recent pandemics have highlighted the need of an integrated surveillance system, and enhance communication between humans, animals, and ecosystems interface. It can enhance the recognition of vulnerabilities, concurrent health threats through comprehensive risk assessment, risk profiling, and focused strategy [(2)].

A One Health approach has increasingly been adopted in national and international plans through Quadripartite (Food and Agriculture Organization (FAO), the United Nations Environment Programme (UNEP), the World Health Organization (WHO) and the World Organisation for Animal Health (WOAH), with aim to strengthen collaboration, communication, capacity building, and coordination equally across all sectors responsible for addressing health concerns at the human-animal-environment interface [(3)].

In response to global demands for preventing future pandemics and promoting sustainable health, the Quadripartite has come up with a comprehensive strategy called the One Health Joint Plan of Action (2022-2026). This approach aims to foster international cooperation and coordination to achieve better health outcomes for all [(4)].

In the view of above, The Asia-Pacific Quadripartite One Health workshop was successfully organized from September 5-8, 2023, in Bangkok, Thailand. The meeting lasted for four days and included seven technical sessions.

Representing the Ministry of Health, actively engaged in the group discussions and provided support for the collective efforts of the Indian delegation. The workshop gave an opportunity to network and share knowledge and experiences on One Health initiatives aimed to prevent pandemics in the future.

Goal

To assess the progress of countries, partners, and key experts involved in One Health issues in the Asia-Pacific region, specifically focusing on the recently launched One Health – Joint Plan of Action (2022-2026) by the Quadripartite.

Objectives

- To promote awareness and comprehension of the One Health Joint Plan of Action and its implementation guide, as well as One Health issues that affect the animal-animal-plant environment.
- To assess the current situation and plan for the future by examining the progress and challenges of One Health at the national level, creating a structure for a harmonized way
- To provide support to member States to adapt and translate the One Health Joint Plan of Action according to the national context.

Delegates

At the event, there were representatives from different sectors of One Health, which included human health, animal health, environment, wildlife, and other domains relevant to One Health. The delegation included representatives from the Member States in the Asia-Pacific region, Quadripartite organizations (WHO, FAO, OIE, UNEP), and other partners such as USAID, GIZ, ADB, and the UK Health Security Agency were also present. Additionally, the expert panel from the One Health High-Level Group (OHHLEP) were also present.

The Indian delegation included National Centre for Disease Control, MoHFW, Department of Animal Husbandry, MoAHDF, FAO India, WHO India, and UNEP. This ensured that both the Quadripartite partners and the Ministry of Health and Animal Husbandry were thoroughly represented. The delegation from South-East Asia Region (SEARO-WHO) & WHO Headquarters (HQ) as a key focal point for the activity also participated (picture 1).

Key points highlighted by Quadripartite partners

With the emergence and re-emergence of various zoonotic diseases, regions are facing unusual public health challenges. In this regard, the World Health Organization is providing support to Member States in addressing the COVID-19 pandemic and other public health events.

The FAO's role in addressing hunger, access to high-quality food, mitigate the effect of climate change, and now working to prevent diseases in livestock and fisheries. The Food and Agriculture Organization's (FAO) has now involved to implement all six action tracks of One Health-Joint Plan action. It is to be believed that the world needs to move towards a sustainable transformation of food systems, including adoption of sustainable agriculture, provide protection to the environment, and need of collaboration with the private sectors. It is important to consider that pandemic prevention is cost-effective approach than responsive measures. Therefore, we need to consider how the Joint Plan of Action (JPA) could be effectively implemented.

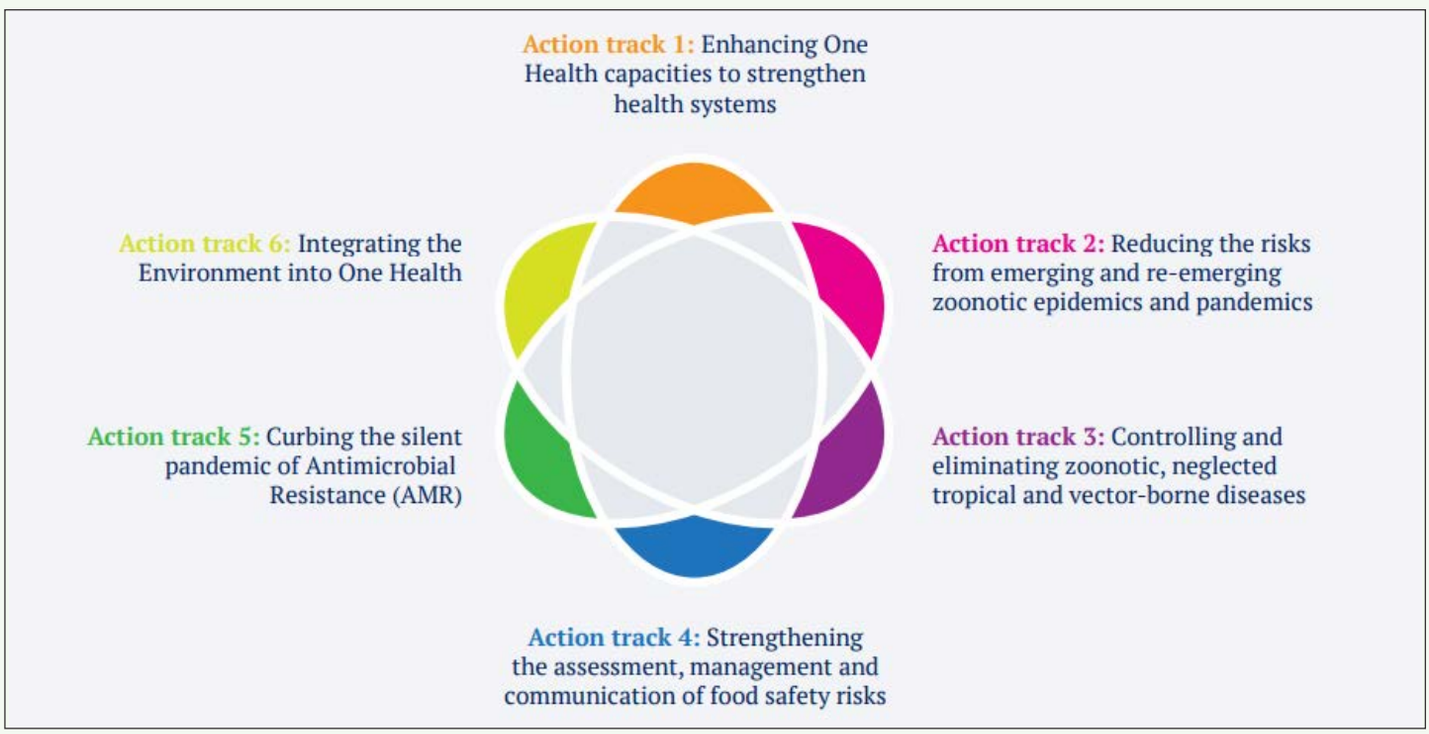
Picture 1: Delegates at the Asia-Pacific One Health Workshop

In addition to this, the environment provides us fresh air, food, medicines, and so on. However, these are at high risk due to environmental degradation that results in climate change.

It is important to emphasize that the collaborative efforts need to be undertaken to address the complex challenges such as emerging zoonotic diseases, pollution, antimicrobial resistance, chemical hazards, etc. through an integrated One Health approach. By adopting this strategy, world can shift towards

sustainable development, conservation of environment, and protect the well-being of human, animal, and ecosystem.

The development of the One Health Joint Plan of Action (2022-2026), which includes six action tracks were discussed, and shown in Fig. 1



Source: *World Health Organization. One health joint planof action (2022–2026): working together for the health of humans, animals, plants and the environment (who.int)*

Figure 1: The Six One Health- Joint Plan action tracks

Notably, several high-level One Health initiatives are currently underway in the Asia-Pacific Region, including the ASEAN Leaders' declaration on OH initiative, the G20 Health Ministers meeting, and projects related to the Pandemic fund were also discussed.

Discussions

One Health is not just a technical matter, it also has political significance and involves additional dimensions such as social and economic aspects. To ensure success, it is needed that there is long-term political commitment, inclusive community engagement, and a compelling investment case. Coordination and sustained fund flow are crucial factors that were highlighted to address both preparedness and respond to One Health approach. Integration of the environmental sector is also important. The Quadripartite (QPT) task force discussed a 'One Health accelerator' and its potential to connect countries with necessary funds for One Health initiatives.

The four group work sessions were conducted that used the Theory of Change approach to delve into the detailed implementation of the One Health Joint Plan of Action (OH JPA).
These sessions included: -

Group Work 1: Examining country successes within the OH JPA framework.
Group Work 2: Identifying existing gaps in One Health within the region.
Group Work 3: Identifying existing gaps in One Health within individual countries.
Group Work 4: Formulating actions and strategies to address the identified gaps in One Health within the region and planning for the future.

The country presentations, particularly India's, were enclosed and thoroughly discussed among all counterparts from the Indian ministry and partners present in the meeting, including representatives from WHO, FAO, and OIE.

Way Forward and Recommendations by Quadripartite: Member States

- Encourage country participants to take the lead in implementing the national One Health Joint Plan of Action (OH JPA), in collaboration with the Quadripartite (QPT) and other partners.
- Enhance One Health (OH) governance, policy, and implementation at the national level, through both bottom-up and top-down approaches.
- Foster increased involvement of the environmental sector in the One Health initiative by integrating environmental considerations across all action tracks.
- Strengthen the implementation of OH initiatives

through identifying the needs and mapping out the existing resources.

Quadripartite

Involve all One Health stakeholders, including academic and research institutions, regional economic communities, private and public sectors, NGOs, and other entities, fostering coordinated actions.

Provide support to Member States (MS) in the development of their national One Health Joint Plan of Action (OH JPA), ensuring alignment with existing One Health initiatives.

Organize a series of Asia-pacific webinars to promote OH JPA implementation and priority issues under each action tracks. Plan to organize a workshop in 2025 to review the progress in implementing the One Health Joint Plan of Action (OH JPA) at the country level.

Partners

Engaging in dialogue with partners is crucial to stay updated on ongoing initiatives related to One Health Regional coordination mechanisms should be identified to facilitate collaborations among donors and partners were encouraged to contribute to the use of OH JPA.

Conclusion

The Asia-Pacific Quadripartite One Health workshop in Bangkok was a crucial step in advancing collaborative efforts to address unusual public health events at the human-animal-environment interface. Representatives from various Ministries participated in productive discussions, emphasizing accomplishments, weaknesses, and approaches for further execution. The event highlighted the extensive dialogue on zoonotic diseases, environmental issues, and the need of collective actions. The Quadripartite partners emphasized the significance of national-level initiatives, enhance governance, and the active participation of environmental sector. Moreover, they are committed to conduct discussions, webinars, and a workshop in 2025 to achieve the One Health Joint Plan of Action objectives for sustainable development.

References

1. Machalaba C, Raufman J, Anyamba A, Berrian AM, Berthe FCJ, Gray GC et al. Applying a One Health Approach in Global Health and Medicine: Enhancing Involvement of Medical Schools and Global Health centres. Ann Glob Health. 2021 Mar 26;87(1):30. doi: 10.5334/aogh.2647. PMID: 33816135; PMCID: PMC7996453.

2. Noguera Z LP, Charypkhan D, Hartnack S, Torgerson PR, Rüegg SR. The dual burden of animal and human zoonoses: A systematic review. PLoS Negl Trop Dis. 2022 Oct 14;16(10):e0010540. doi: 10.1371/journal.pntd.0010540

3. World Health Organization. Available from: One Health High-Level Expert Panel Annual Report 2022 (who.int) ,accessed on 8 November, 2023

4. World Health Organization. One health joint plan of action (2022-2026): working together for the health of humans, animals, plants and the environment (who.int). Available from: One health joint plan of action (2022-2026) (who.int),accessed on 7 November, 2023

FAO: National Framework on One Health

Can be accessed at https://www.fao.org/publications/card/fr/c/CB4072EN/

ISBN 978-92-5-134192-6
FAO, 2021

Introduction

Importance of "One Health" approach in bringing together various sectors especially human health, animal health and the environment is being recognized increasingly across the world. This is based on the fact that there is an intricate relationship between the aforementioned three sectors. Working together or in tandem using One Health approach can be effectively used for early detection, prevention and launching efficient response to several zoonotic diseases. This approach is also vital for containing antimicrobial resistance which is driven by excessive use of antimicrobial agents in human and animal health sectors and is facilitated by a conducive environment for exchange of genetic material and survival of resistant pathogens and genes.

While the One Health approach looks a great logical concept with far reaching benefits, implementing it at national and subnational levels is complex. Traditionally, three major sectors have worked in silos and have essentially collaborated during public health emergencies, otherwise, there is minimum sustained and productive collaboration. The environment sector in most of the settings has remained aloof from contributing significantly.

Recognizing the need for efficient execution of true One Health approach, the Food and Agriculture Organization of the UN (FAO) has published a guidance document "National Framework on One Health". This has been developed through extensive consultations with leading scientists from human health, animal health, fisheries, environment sectors representing research and academic institutions and international agencies.

The document provides a simple to implement roadmap in consonance with ground realities in the developing countries. It highlights that One Health is not a de novo concept but is directed towards improved collaboration, coordination and commitment of relevant sectors in working together to minimize the impact of these diseases on human health and nutrition safety. It emphasizes that One Health is essentially a multi-sectoral, interdisciplinary, and collaborative approach towards optimal health of animals, humans and the environment. It calls for strengthening of capacity to prevent, detect, and respond to disease outbreaks; establish efficient national emergency response capacity; and promote cross-sectoral collaboration and partnerships for improving human and animal health.

Two core objectives for implementation of One Health that have been highlighted in this document are: (i) Improve national capacity for zoonotic diseases and AMR for prevention, detection and response; and (ii) Improve joint coordination and collaboration between major stakeholders for control of zoonoses and AMR. Within each of these broad objectives, several outcomes can be defined as well as monitored through a structured monitoring and evaluation framework.
The document explains One Health approach in simple terms, provides technical and financial evidence in its support, enunciates barriers that obstruct its implementation and underscores its importance in achieving Sustainable Development Goals.

The document promotes activities at human-animal-environment/ecosystem interfaces by providing generic guidance for comprehensive national response to prevent, prepare, detect, respond to, and recover from events especially pandemic and AMR, and assure human and animal health security. It provides essential elements in the shape of policy, programme and persons for initiating and executing One Health approach. It provides a step-by-step approach to implement the framework and the possible points of entry. Various objectives that can be met through this framework have

been explained in detail with their predicted outcomes.

It is an extremely valuable document for all public health professionals and their counterparts in other sectors simply because of its ease-of-reading and comprehensiveness for initiating and sustaining the One Health approach.

It must be considered by the policy makers while making decisions and allocating resources.

(Reviewed by Dr Mala Chhabra, Consultant Microbiology ABVIMS & Dr RML Hospital, New Delhi.)

Pioneering a New Era of One Health Collaboration: The Quadripartite Agreement - FAO, WHO, WOAH, UNEP

Can be accessed at WHO One Health https://www.who.int/teams/one-health-initiative/quadripartite-secretariat-for-one-health

Introduction

The necessity for resilient health systems and accelerated global action is evident in the face of recent international public health emergencies, including the COVID-19 pandemic, outbreaks of diseases like Mpox and Ebola, and persistent threats from other zoonotic diseases, antimicrobial resistance (AMR), food safety concerns, as well as ecosystem degradation and climate change. In response to these urgent and intricate challenges, One Health emerges as the primary approach to effectively address these and safeguard our society.

The four international agencies, the Food and Agriculture Organization of the United Nations (FAO),the World Health Organization (WHO), the World Organisation for Animal Health (WOAH : earlier known as OIE), and the UN Environment Programme (UNEP) have signed a ground breaking agreement to strengthen cooperation to sustainably balance and optimize the health of humans, animals, plants and the environment.

On 17 March 2022, the heads of the four organizations –Director-General of FAO, Director-General of WHO, Director-General of WOAH, and Executive Director of UNEP, -signed a Memorandum of Understanding (MoU) for joint One Health works. With this UNEP joined the former Tripartite (FAO, OIE and WHO) as an equal partner to form a new Quadripartite Collaboration for One Health.

The new Quadripartite MoU provides a legal and formal framework for the four organizations to tackle the challenges at the human, animal, plant and ecosystem interface using a more integrated and coordinated approach. This framework will also contribute to reinforce national and regional health systems and services.

The One Health Joint Plan of Action (OHJPA)

OH JPA was launched by the Quadripartite –FAO, WHO, WOAH and UNEP on 17 October 2022, developed through a participatory process, it provides a set of activities that aim to strengthen collaboration, communication, capacity building, and coordination equally across all sectors responsible for addressing health concerns at the human-animal-plant-environment interface. It aims to create a framework to integrate systems and capacity to collectively better prevent, predict, detect, and respond to health threats. Ultimately, this initiative seeks to improve the health of humans, animals, plants, and the environment, while contributing to sustainable development.

The five-year plan (2022-2026) focuses on supporting and expanding capacities in six areas: enhancing One Health capacities to strengthen health systems; reducing the risks from emerging and re-emerging zoonotic epidemics and pandemics; controlling and eliminating endemic zoonotic, neglected tropical, and vector-borne diseases; strengthening the assessment, management, and communication of food safety risks; curbing the silent pandemic of antimicrobial resistance; and integrating the environment into One Health.

This technical document is informed by evidence, best practices, and existing guidance. It covers a set of actions which endeavour to advance One Health at global, regional and national levels. These actions notably include the development of an upcoming implementation guidance for countries, international partners, and non-State actors such as civil society organizations, professional associations, academia and research institutions.

The plan sets out operational objectives, which include: providing a framework for collective and coordinated action to mainstream the One Health approach at all levels; providing upstream policy and legislative advice and technical assistance to help set national targets and priorities; and promoting multinational, multi-sector, multidisciplinary collaboration, learning and exchange of knowledge, solutions and technologies. It also fosters the values of cooperation and shared responsibility, multisectoral action and partnership, gender equity, and inclusiveness.

The first annual face-to-face meeting was held on 27 March 2023, the heads of the Quadripartite organizations working on One Health issued an unprecedented call for enhanced global action.

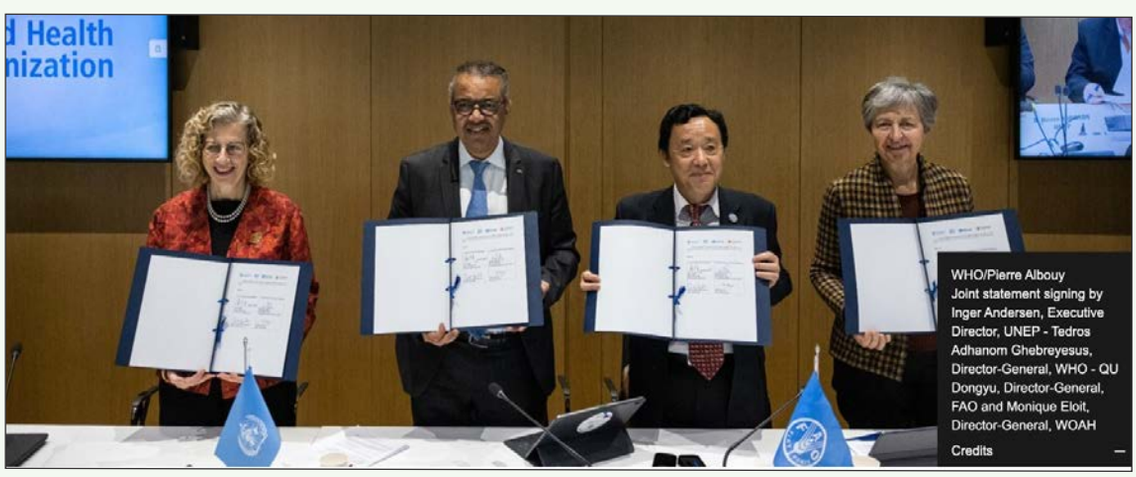
Stressing the need for enhanced collaboration and commitment to translate the One Health approach into policy action in all countries, the Quadripartite leaders urged all countries and key stakeholders to promote and undertake the following priority actions:

- Prioritize One Health in the international political agenda, increase understanding and advocate for the adoption and promotion of the enhanced intersectoral health governance. The One Health approach should notably serve as a guiding principle in global mechanisms; including in the new pandemic instrument and the pandemic fund to strengthen pandemic prevention, preparedness and response;

- Strengthen national One Health policies, strategies and plans, costed and prioritized in line with the Quadripartite One Health Joint Plan of Action (OH JPA), to foster wider implementation across relevant sectors and at all levels;

- Accelerate the implementation of One Health plans, including supporting of national One Health governance and multisectoral coordination mechanisms, development of situation analyses, stakeholder mapping, priority setting, and metrics for One Health monitoring and evaluation frameworks;

- Build intersectoral One Health workforces that have the skills, capacities and capabilities to prevent, detect, control, and respond to health threats in a timely and effective way, by strengthening joint pre-service and continuing education for human, animal, and environmental health workforces;



- Strengthen and sustain prevention of pandemics and health threats at source, targeting activities and places that increase the risk of zoonotic spillover between animals to humans;

- Encourage and strengthen One Health scientific knowledge and evidence creation and exchange, research and development, technology transfer and sharing and integrating of information and data and facilitate access to new tools and technologies;

- Increase investment and financing of One Health strategies and plans ensuring scaled up implementation at all levels, including funding for prevention of health threats at source.

To build one healthier planet we need urgent action to galvanize vital political commitments, greater investment and multisectoral collaboration at every level.

The Quadripartite has been playing a central role in promoting and coordinating a global One Health approach, in line with the OH JPA. To further support countries and governments putting the One Health approach into practice, the Quadripartite partners developed an OH JPA implementation guide released in 2023.

While the One Health concept has long been recognized as a vital approach, its implementation has often faced challenges and remained largely confined to theoretical discussions. However, the dawn of a new era has arrived with the Quadripartite Agreement, poised to breathe life into One Health initiatives. Actions of the Quadripartite, by fostering tangible results and transforming realm of paperwork to bring about real-world impact, will ignite enthusiasm within nations across the globe.

(Excerpted by Dr Mala Chhabra, Consultant Microbiology ABVIMS & Dr RML Hospital, New Delhi.)

Instructions to Authors

Original articles should ordinarily be limited to 250 words with about 30 references and 4-5 figures/tables.

Review/update articles should be limited to 3,000 words with not more than 45 references. Reports of Outbreak Investigations must not exceed 800 words with one figure or table and about 10 references. Scientific research communications should be limited to 350 words, with 5 references and no figure or table. Commentary should be under 500 words with 5 latest references, running to maximum 1.5 pages. Letter to Editor - 250 words, 6 references, no figure/table.

All manuscripts must be accompanied by a signed Copyright Transfer Form. This can be submitted as a scanned copy. This form states that "The undersigned author(s) certify (ies) that the article is original, is not under consideration by any other journal, and has not been previously published.

All copyright ownership of the manuscript entitled (title of article) is hereby transferred to the publishers of the e-Journal."

The authors should state in the manuscript that ethical clearance was obtained for the research project. The journal has the right to ask for a copy of ethical clearance.

Articles will be edited for style and grammar. Technical jargon is to be kept to a minimum. The book entitled "Scientific Style and Format - The CSE Manual for Authors, Editors and Publishers", 8th edition, 2014 published by Council of Science Editors is a good guide. British spellings are used in the Journal.

All statement and opinions expressed in the manuscripts are those of the authors, and not those of the editor(s) or publishers. The editor(s) and publishers disclaim any responsibility for such material.

A manuscript will be reviewed for possible publication with the clear understanding that it is being submitted to the Journal alone at that point in time and has not been published anywhere, simultaneously submitted, or already accepted for publication elsewhere.

Editorial and Peer Review

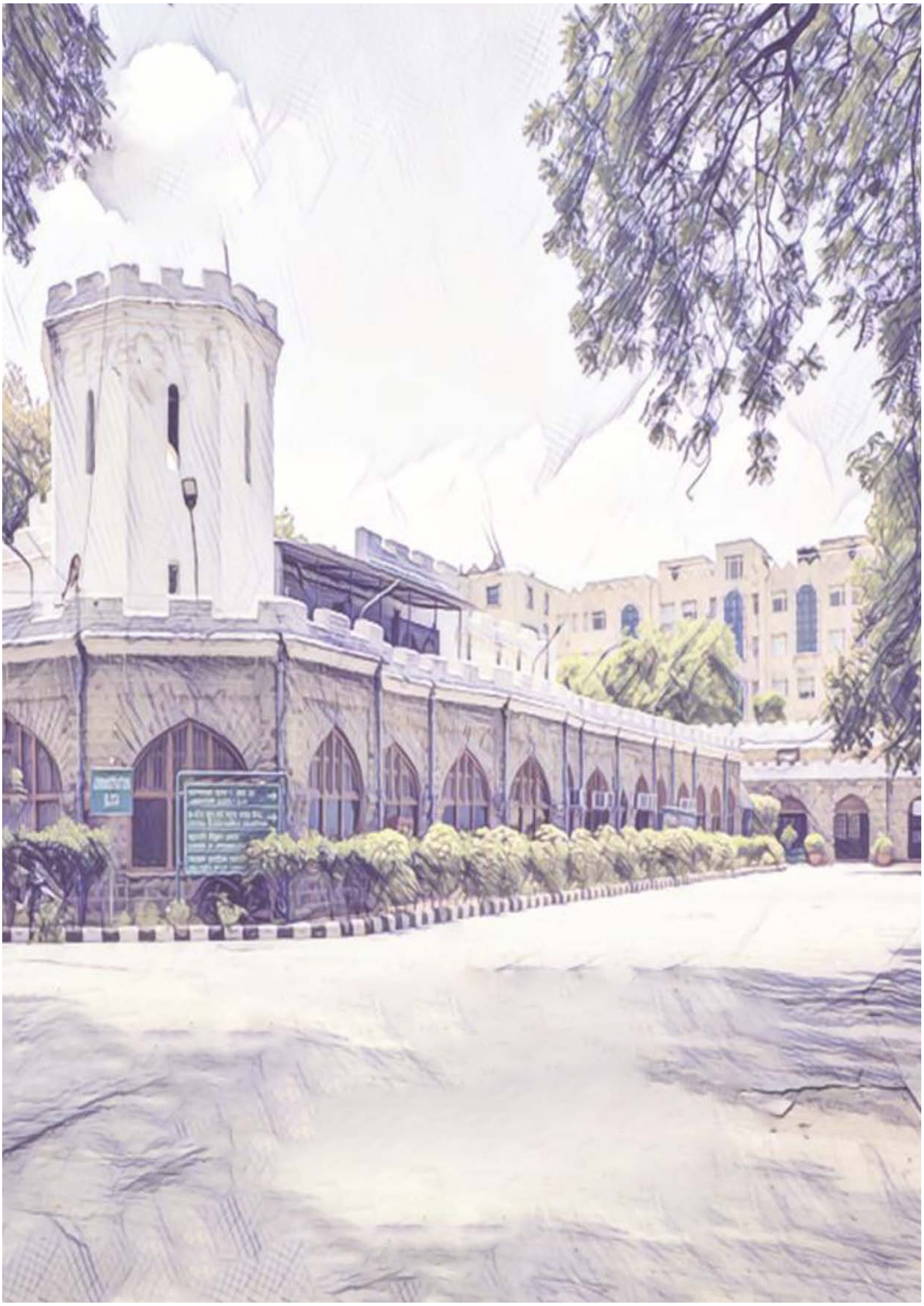
On submission, all submitted manuscripts are reviewed initially for suitability for formal review and any plagiarism. Only such manuscripts as show sufficient originality, without serious scientific or technical flaws, and providing a significant message will be sent to two or more expert reviewers for formal peer-review.

Manuscripts unlikely to be of interest to the readers of the Journal will be liable to be rejected. The journal follows a double-blind review process, where the reviewers and authors are unaware of each other's identity. The comments and suggestions received from reviewers are conveyed to the corresponding author. If required, the author is required to respond to reviewers' comments and submit a revised version of the manuscript. Articles accepted would be copy edited for grammar, punctuation, print style, and format.

Acknowledgement

We acknowledge contributions of following offices and staff of the Centre for One Health, NCDC for this issue

1. Dr. Tushar Nanasaheb Nale, Deputy Director
2. Dr. Raghavendra A.H., Assistant Director
3. Dr. Mahesh C. Kaushik, Entomologist
4. Dr. Priyanka Khuda, Consultant
5. Dr. Sowntappan, EIS Officer
6. Mr. Dhaneswar Dey, Technical Officer (IT-GIS)
7. Dr. Arvind Srivastava, Senior Public Health Specialist
8. Dr. Dipti Mishra, Consultant
9. Dr. Nidhi Khandelwal, Technical officer (Life Sc./Ecology)
10. Dr. Aastha Singh, Research Officer
11. Dr. Gajendra Singh, Wildlife Officer
12. Dr. Hanul Thukral, Epidemiologist
13. Dr. S Balaji, Consultant -Microbiologist
14. Dr. Musheera, Communication Officer
15. Dr. Ashwini Yadav, EIS Officer
16. Mr. Ashwani Chauhan, Consultant IT (GIS)
17. Mr. Mukesh Saxena, Consultant - Admin/Finance
18. Mrs. Isha Gupta, Grant Manager
19. Mrs. Saumya Dwivedi, Statistical Officer
20. Ms. Aachal Saxena, Data Manager & Operations
21. Ms. Deepika Sharma, Data Entry Operator
22. Ms. Geetika, Data Entry Operator



Epi-Dis-PHERE (Publication of Health Resilience)
Quarterly e-Journal

National Centre for Disease Control (NCDC)
Directorate General of Health Services
Ministry of Health & Family Welfare, Government of India
22-Sham Nath Marg, Delhi- 110054
E-mail ID : journalncdc@gmail.com
Website: http://www.ncdc.gov.in
Contact No: +91-11-23971272, 23971060