



One health collaboration for a resilient health system in India: Learnings from global initiatives



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ABSTRACT

Inter-sectoral collaborations are now recognized as key importance for health system strengthening and health system integration, globally; however, its application in the domain of One Health remains unclear. Over time, as the complexity of the health system has increased within the domain of One Health approach, there is an urgent need for developing collaboration for successful implementation of the One Health. This review focuses on the global One Health collaboration strategies and discusses which type of collaboration might work for the health system of India. We conducted a review in the following three steps: identification of key One Health Collaboration strategies, documentation of the global initiatives and scoping into the initiatives of India in the domain of One Health.

We found three major types of collaborations discussed in the One Health literature: level-based collaboration (individual, population or research), solution-based collaboration, and third-party-based collaboration. Twenty-five key global and six Indian One Health initiatives or collaboration strategies are documented in the present review. Although, many initiatives are being undertaken globally for disease prevention and control from the viewpoint of One Health; however, in India, solution-based approaches during emergencies and outbreaks and some sort of level-based collaborations are in place. It is high time to develop a sustainable level-based collaboration integrated with third-party based collaboration within the larger domain of One Health for a resilient health system.

1. Introduction

One Health recognizes that the health of humans, animals and ecosystems are interconnected [1]. One Health was initiated as a concept [2], was upgraded to an approach [3,4] and is recently being considered as a movement [5]. It involves application of a coordinated, collaborative, multi-disciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface [1,6]. It also encourages synergistic collaboration to achieve common public health goals. Collaboration requires a platform to engage multiple sectors and understand different health systems; it provides an opportunity to learn about health systems and its resilience [7]. The One Health approach cannot be operationalized without effective collaboration and facilitation among various actors within a complex health system. Therefore, exploring collaboration in One Health (including system resilience) is vital prior to implementing a

countrywide One Health Collaboration (OHC) policies and strategies.

Terms referring to collaboration for health have been employed ambiguously and interchangeably including but not limited to such terms as partnership, alliance, coalition, network, inter-organizational relationship, joint advocacy campaign, and taskforce [8]. The idea of intersectoral cooperation for health can be traced back to the Conference of Alma-Ata on Primary Health Care in 1978 and the movement it started when among others “agriculture, animal husbandry, food”, i.e. some of the main sectors in One Health, have been explicitly mentioned “as vital for improving the health and the well-being of the population” [9]. In 1997, a conference took up an Australian definition of intersectoral action or cooperation as: “a recognized relationship between part or parts of the health sector with part or parts of another sector, which has been formed to take action on an issue to achieve health outcome, in a way that is more effective, efficient or sustainable than could be achieved by the health sector acting alone” [10].

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Collaborations between the human and the animal health systems are not new. As early as 1984, American epidemiologist Calvin Schwabe proposed a unified human and veterinary approach against zoonotic diseases in “Veterinary Medicine and Human Health”, which is considered the origin of current One Health concepts [11–15]. However, collaboration in public health is a challenge at various levels of the health system [16,17] and it becomes more complex if OHC needs to be developed at a larger system level.

1.1. Overview on health system and disease control mechanism of India

There are multiple disease burdens such as burdens from the non-communicable diseases, maternal and child health problems, infectious diseases, re-emerging of diseases exists within the Indian health system [18–20]. It is challenging to respond to these burdens because of the nation's limited public health infrastructure and human resources, socio-cultural diversity and rural-urban divide [21,22]. A mixed health care market of public and private providers is a reality in India, as the private sectors catered for two third services [23]. Because of limited access to the public sector, both the formal and informal private providers remain the main source for primary health care services in the country [22,24].

Literature suggests that disease control mechanism in India is bi-phasic. The management of the human health system is shared between the central (federal) and state governments; while the Government of India is responsible for health policies, regulatory functions, and control of diseases and outbreaks. State governments are responsible for health care and training of personnel [25]. The apex body responsible for optimal health within country is Ministry of Health and Family Welfare (MoH&FW) that comprises of the Department of Health & Family Welfare and the Department of Health Research, but has no designated Department of Public Health. The Indian Government uses two strategies for control of infectious diseases.

1.1.1. Strategy 1

Vertical disease control programs, like Revised National Tuberculosis Control Programme, National AIDS Control Programme, National Vector-Borne Diseases Control Programme etc. [26]. These programs are controlled by the Department of Health & Family Welfare, are virtually autonomous, each with its own central, state, and district officers, and field staff [26]. Although this approach helps to improve the management of programmes, it is too expensive to be replicated for the control of all other diseases [27,28]. Another critique of this mechanism is lack of integration between programs or with the health-care system at large. This restricts disease control to be effective, efficient and sustainable.

1.1.2. Strategy 2

Provision of ad-hoc assistance for outbreak investigations and control [29]. On invitation and/or request from respective Indian states, teams from the National Centre for Disease Control (NCDC, formerly known as National Institute of Communicable Diseases), a semi-autonomous institution that is controlled by the Directorate General of Health Services, provide technical and field based assistance [30]. In India usually, disease outbreaks are brought to the attention of program managers and community by the media, and they tend to sensationalize the outbreaks, whereas the state departments either tends to deny or underestimate the magnitude of the outbreak [31]. Further, this strategy also does not help control endemic infectious diseases, irrespective of the magnitude. Some major milestones for controlling infectious diseases in India were: the execution of the Epidemic Disease Act of 1897, initiation of National Surveillance Programme on Communicable Diseases in 1997 and the launching of the Integrated Disease Surveillance Project (IDSP) in 2004 [29]. IDSP currently captures syndromic, probable and laboratory-confirmed cases. It also predicts disease trends through its state and district surveillance units [32].

Animal health is a subject of the Department of Animal Husbandry

and Dairying (AH&D), now renamed as Department of Animal Husbandry Dairying & Fisheries (DADF) under the Ministry of Agriculture and Farmers Welfare (MoA&FW). In each district of each state, there are offices of a deputy director of animal husbandry or assistant director animal husbandry, which direct institutions such as veterinary dispensaries, branch veterinary dispensaries, mobile veterinary dispensaries and first aid veterinary centers. They not only provide disease specific diagnostic services and treatment to livestock but also implement various individual beneficiary schemes. As per the World Organization for Animal Health (OIE), the central government is responsible for animal disease surveillance [33]. There are two key surveillance systems for animal health functional now in the country i.e. National Animal Disease Reporting System (NADRS) and another by National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI) [34,35]. NADRS aims to record and monitor livestock disease situation in the country with a view to initiate preventive and curative action on the basis of outbreaks reported [34]; whereas NIVEDI is a weather based animal disease forecasting surveillance system [35]. About 143 animal diseases are currently reported as per the Prevention and Control of Infectious and Contagious Diseases in Animals Act, 2009 [36].

1.2. Missing link between the human and animal health

India has documented several large outbreaks in the last decades, with a high burden of zoonotic diseases [37]. While Bangladesh has started a ‘One Health’ policy and Nepal is working towards it, India does not have the same in place yet, despite facing a greater burden of zoonotic diseases. India's response has by far been reactive, jumping from one outbreak to the next [37–40]. Though the essence of One Health has been well understood not only from the veterinary perspective [41] but also from the human health perspective [42], the actions are largely limited to few collaborative strategies. There are few collaborative models tried at pan-India level for delivering equitable health services or for making the health system more resilient [43,44]. To fill this gap, this review focuses on the global OHC strategies and discusses which type of collaboration might work for the health system of India.

2. Method

The present review was conducted as per the PRISMA guidelines (Fig. 1) [45] in the following three steps:

- *Step One:* Identification of key collaboration strategies that are discussed in One Health
- *Step Two:* Identification of global OHC strategies or initiatives through seminal articles and reports that are pertinent to country specific collaboration
- *Step Three:* Identification of One Health initiatives in India

We used PubMed and Web of Science databases for this review. We accessed national and international websites looking for reports and documents on OHC and initiatives. To include all possible evidences of collaboration, the exclusion and inclusion criteria for the papers were kept flexible and conducted without any time frame. Only studies published in the English language were included in the review. Studies producing a new viewpoint on how human health could collaborate with other sectors for control of zoonotic diseases were also included for the review. Studies that had assessed the knowledge gap among these professionals on zoonoses risk and management or teamwork communication within the respective profession were excluded. Studies not discussing the strategies for collaboration were excluded from the review. The scope of the review was increased based on findings from the review of key papers and reports. We restricted our search boundary to the prevention and control of zoonoses within the domain of One Health and available collaboration strategies. Relevant published and unpublished technical documents were accessed

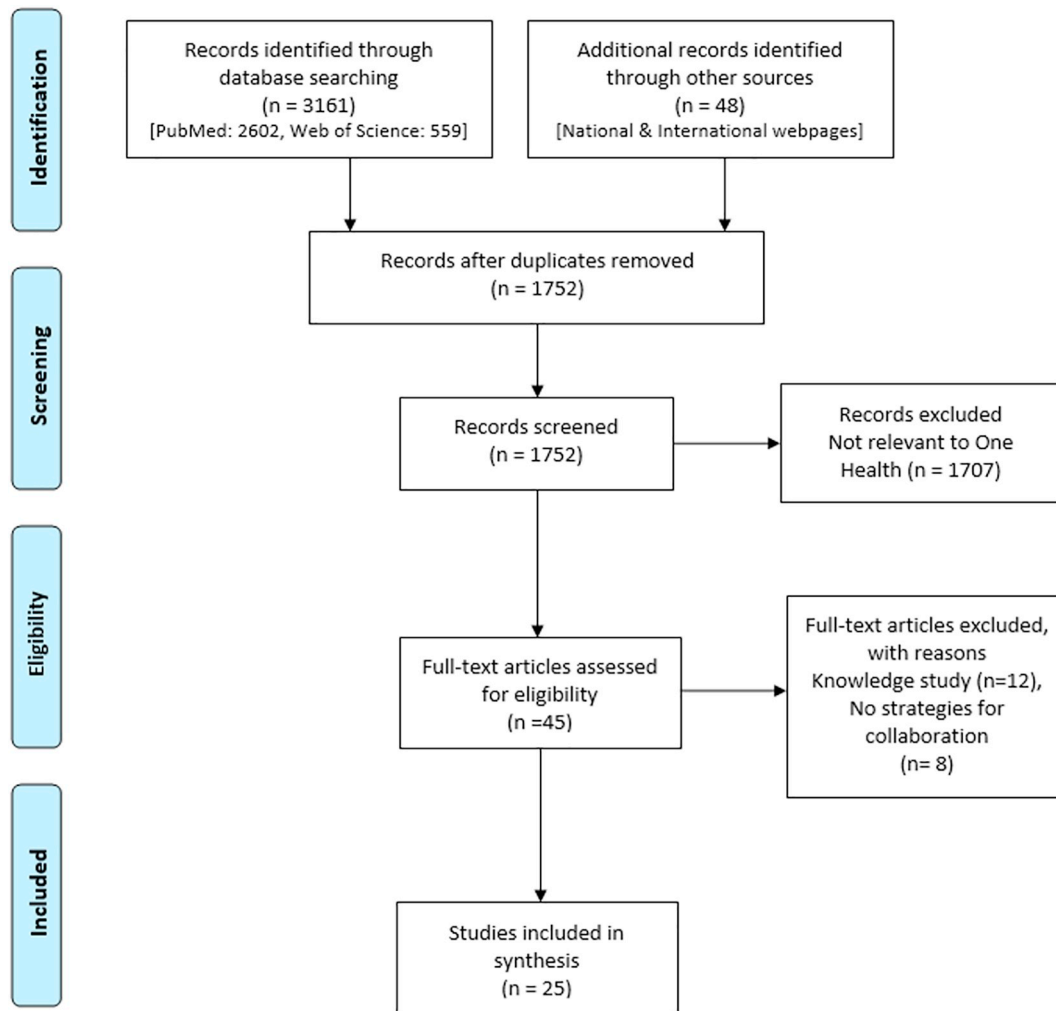


Fig. 1. PRISMA Chart showing the reviewed seminal articles/reports for the country-specific collaboration strategies and/or initiatives.

Table 1
Summary of key collaboration strategies for One Health

Author, year	Key collaboration strategy	Key findings
Kahn, [46]	Level-based collaboration	Individual-level collaborations, population-level collaborations, and comparative medicine research collaborations are the potential levels of collaboration between human and animal health systems.
Zinsstag et al., [47]	Solution-based collaboration	Solution-based collaboration is emphasized with combined immunization program including economic savings from the integration of animal and human health systems.
Anholt et al., [48]	Third-party-based collaboration	A third party based collaboration that can act as a knowledgeable and trusted intermediary between the human and the animal health systems.

for review. The search terms used were: (“collaboration” OR “joint effort” OR “partnership” OR “interprofession*” OR “interdisciplin*” OR “inter-occupation*” OR “interinstitution*” OR “interdepartment*” OR “inter-organization*” OR “multiprofession*” OR “multidisciplin*” OR “multi-occupation*” OR “multiorganisation*” OR “multigorganization*” OR “intersector*” OR “multisector*”) AND (“public health” OR “human health” OR “animal health” OR “animal husbandry” OR “physician” OR “veterinary*” OR “health system”).

3. Results

3.1. Key OHC strategies and/ or initiatives

Based on the first search, we found three different key collaboration strategies that have been discussed for One Health, as mentioned in Table 1.

Kahn [46] emphasized level-based collaboration

- *at the individual level*: collaboration between the physicians and the veterinarians for individual health in assessing the zoonotic disease risk and early detection
- *at the population level*: collaborations during outbreaks between the human and animal health systems
- *at the research level*: collaboration between human and animal research institutes forms a new potential to gain new scientific insights into agent-host interactions.

It is clear from the viewpoint of the author, that there is the possibility of level-based collaboration for various strategies.

Zinsstag et al. [47] discussed solution-based collaboration, which requires both human and animal health system actors to collaborate for a specific purpose. One of the examples mentioned is the integration of

health services, such as a joint vaccination program in Chad, where a trial was successfully conducted among pastoralists' women, children and cattle. Further, the authors explained that laboratory collaborations for diagnostic data sharing are much easier than establishing the communication between public health and veterinary authorities. The authors argue that health system reform towards the One Health approach should be solution-oriented.

Anholt et al. [48] discussed third-party-based collaboration, where a third party acts as knowledge broker between the human and animal health professionals. The authors believe that, there is a potential role for centralized agencies, government and not-for-profit organizations as third-party knowledge brokers to facilitate OHC.

3.2. Global OHC strategies and/or initiatives

Based on the second search, 25 initiatives for collaboration were identified across the globe. Table 2 summarizes all the global initiatives stratified with the key strategies identified in step 1.

3.2.1. Level-based collaboration

Individual level-based collaboration that is, between human and animal health practitioners that is practiced in Tanzania [49]. Also in developed nations (such as the United States or Europe) there are some efforts to integrate these professionals through combined education [50,51]. There are also unique initiatives in East African countries for strengthening the clinical knowledge of these professionals through two years of field epidemiology training [52,53]. The MSc in One Health Analytical Epidemiology course in Zambia aims to create a cadre of epidemiologists with a broad understanding of disease control and prevention. Those who complete this course will be able to conceptualize and design holistic programs for informing health and disease control policy decisions [53]. The feasibility of such initiative is also supported by findings from Thailand, where field epidemiologist-veterinarians are promoted [54]. A unique way of collaboration identified in the United States is through the development of One Health clinics, which were established using an interdisciplinary approach to individual and community health, where both human and animal health services are combined together for targeted communities [55].

Most of the population-based strategies identified are surveillance-based. There are various attempts to integrate the human and animal health surveillance across the global south as well as in developed nations. For example disease-specific surveillance such as of arbovirus in Serbia [56], *Campylobacter* in Switzerland [57], antibiotic resistance in Vietnam [58] and system-based geo-spatial and clinical data capture in Africa [59].

There are examples of various research institutes collaborating for the development of the OHC. Two examples for developing skills and interdisciplinary training are from the South East Asian Network [60] and Egypt [61]. These initiatives are mostly at the academic institution level in the form of funding activities. A unique research-based collaboration was developed between the zoo and the public health institutes in Kenya and United States [62] for conducting various zoonotic researches.

3.2.2. Solution-based collaboration

These collaborations are geared towards specific diseases or for overcoming outbreak conditions. Two examples are managing the H7N9 outbreak in China [63] and disrupt the sleeping sickness in Uganda [64]. Initially in China, the human and the animal authorities managed the H7N9 outbreaks separately, until the evidence gathered proved that poultry were the original source of the virus. It took about five years for the agricultural departments and public health departments to turn from reserved collaboration to reinforced collaboration to prevent the further spread of H7N9 in China, where the collaborative preventive measures were implemented in poultry [63]. Similarly in Uganda, the mass treatment to destroy the trypanosomes in the cattle

population was initiated primarily through research and scaled-up to larger population [64]. There is evidence that developing multi-sectoral strategies also solved some other One Health issues, such as controlling leptospirosis in Fiji [65] and managing pathogenic *E. coli* in Latin America [66]. The latter strategies have been developed within the research group, which also signifies the level-based research collaboration in addition to the solution-based collaboration.

To overcome the shortage of veterinarians, two unique initiatives were made; one in the Republic of Chad, where a combined immunization program was conducted [67] and another in Sierra Leone, where Animal Health Clubs were initiated to strengthen the local capacity [68].

3.2.3. Third-party-based collaboration

A third-party or intermediary knowledge broker leads this type of collaboration. The intermediary unit or secretariat leads OHC by overcoming the barriers among all the engaged stakeholders. A classic example is from Kenya, where a One Health coordinating unit under the Zoonotic Disease Unit was established to develop the One Health approach [69]. This unit bridges the animal and human health sectors by deploying a senior epidemiologist from each ministry in order to maintain collaboration at the animal and human health interface towards better prevention and control of zoonoses. In addition, an ecologist was added to the unit to ensure that environmental risks are adequately addressed in emerging disease control [69].

Similar efforts have been made in Mongolia. Guided by the Asia Pacific Strategy for Emerging Diseases, Mongolia has established a functional coordination mechanism between the animal and human health sectors. With the four pillars of zoonoses framework i.e. surveillance, information exchange and risk assessment, risk reduction, coordinated response capacity and collaborative research, it established the OHC in the country [70].

Bangladesh has formulated a One Health secretariat by providing an additive administrative power to this inter-ministerial taskforce for developing a strategic One Health framework and action plans for the country [71].

3.3. Indian OHC strategies and/or initiatives

There are a few instances of collaboration in India for the control of outbreaks [37–40]. The initiatives that have been commenced so far in India are either solution-based collaborations or level-based (research) collaborations.

Institutions like ICMR and ICAR collaborated for joint research priorities [72], whereas RCZI was formulated in PHFI for zoonotic research [73], which signifies the level-based (research) collaboration initiatives in the country. Similarly, there are few examples of solution-based approaches, such as the national influenza pandemic committee to control avian influenza [74] and leptospirosis [75].

A unique state-specific level-based collaboration strategy was developed for controlling rabies in the state of Tamil Nadu [76]. The strategy adapted in Tamil Nadu involved triangulating the dog bite surveillance data with vaccine consumption and dog population to find out the trend at the district and state level. Further the activities were conducted by separate departments at various levels and all the departments were linked with similar and specific objectives.

Another recent initiative that signifies the role of a third party is by Department of Biotechnology (DBT) under the Ministry of Science and Technology, who has proposed to have a One Health roadmap for India with the Ministry of Health and Family Welfare, Ministry of Agriculture and Farmers Welfare and the Ministry of Environment, Forest and Climate Change. The details of the initiatives have been shown in Table 3.

Table 2
Key review findings on global One Health strategies and/or initiatives with reference to the key collaboration strategies.

Type	Author	Country/region	Type of initiative	Key findings
Level-based (Individual) Collaboration	Amuguni HJ et al., [52]	Rwanda	Integrated One Health module for multi-disciplinary groups of professionals.	Integrated module on OH through stakeholder analysis and curriculum development workshop.
	Kayunze KA et al., [49] Sweeney JM et al., [55]	Tanzania USA	Collaboration of health experts with other disciplines in OH. Establishment of One Health Clinics.	12% health experts collaborated with animal experts and 27% vice-versa. One Health-based clinic was established using an interdisciplinary approach to individual and community health.
Level-based (Population) Collaboration	Wilkes MS et al., [50]	USA	Inter-professional training through an integrated OH module.	Inter-professional collaboration in the context of a One Health clinical problem.
	Eussen BGM et al., [51]	Europe	Collaboration through mutual knowledge sharing.	Common goals stimulate collaboration.
	Muma JB et al., [53]	Zambia	One Health Analytical Epidemiology Course	Two-year program for better understanding of disease control.
	Sommanustweechai A et al., [54]	Thailand	Collaboration among field epidemiologists in the OH nexus.	Thai One Health Coordinating unit and establishment of FETP for Vet and wildlife.
	Dente MG et al., [56]	Serbia, Tunisia and Georgia	Integrated surveillance for the arbovirus infection.	Integration exists across sectors and levels except in data collection and data analysis.
	Martins SB et al., [57]	Switzerland	Cross-sectional surveillance for <i>Campylobacter</i> .	Increase in cost associated with integrated surveillance with increased burden of disease.
Level-based (Research) collaboration	Mulder AC et al., [92]	Europe	Network and database for sharing sequences and accompanying metadata collected from human, animal, food and environmental sources.	Joint repository of molecular and epidemiological data aiming to explore the root cause of zoonoses.
	Jindai K et al., [7]	Japan	Formulation of Anti-microbial Resistance One Health Surveillance Committee.	Tackling AMR through compilation of data from different monitoring and surveillance systems.
	Bordier M et al., [58]	Vietnam	Inter-sectoral surveillance initiatives.	Operationalization of the collaborative surveillance strategy.
	Karimuribo E et al., [59]	South Africa	Development of One health integrated surveillance.	Developing integrated mechanism through geo-spatial and clinical data capture and transmission from the field to the remote hubs for storage, analysis, feedback and reporting.
	Mohd ZSN et al., [60]	South East Asia	Capacity building through networking, mentoring and nurturing.	Strengthening soft skills for developing research based collaboration among young scholars.
	Roess A et al., [61]	Egypt	Multi-disciplinary training/ workshop by a OH team.	Interactive multi-disciplinary on-site workshops are necessary to build basic understanding of disease control.
	Robinette C et al., [62]	Kenya & USA	Zoo and public health agencies collaboration.	Teaching and operationalization of trans-disciplinary research through collaboration.
	Reid SA et al., [65]	Fiji	Multi-sectoral strategies for leptospirosis through facilitated workshop.	Human mortality and morbidity is the key to develop collaboration strategies.
	Zheng Z et al., [63]	China	Formulation of inter-departmental alliances.	Management and learning from the H7N9 outbreak.
	Morton J., [64]	Uganda	Inter-ministerial platform coordinates policy for all stakeholders involved in tsetse and trypanosomiasis control.	Stamp out sleeping sickness through multiple stakeholder engagement under one platform.
Solution-based collaboration	Torres AG, [66]	Latin America	Establishing a multi-disciplinary group of scientists for <i>Escherichia coli</i> Research.	Way for national as well as international collaboration for E.coli.
	Suluk R, [68]	Sierra Leone	Development of Animal Health Clubs to overcome the shortage of veterinary professionals.	Engagement of school children, universities in one health sensitization.
	Schelling E et al., [67]	Republic of Chad	Combined immunization delivery to humans and animals.	By optimizing use of limited logistical and human resources, both public health and veterinary services become more effective, especially at the district level.
	Mbabu M et al., [69]	Kenya	Establishment of One Health coordinating unit.	National strategies on OH and step-wise approach for disease control.
	Batsukh Z et al., [70]	Mongolia	Inter-sectoral Coordination Committee on Zoonoses through Asia Pacific Strategy on Emerging Diseases (inter-ministerial).	Strong human and animal health sectors, together with emergency response and national inspection agencies working in partnership towards the attainment of a healthier community.
	Bangladesh Secretariat, [71]	Bangladesh	Initiation of national professional organization One Health.	Strategic framework for One health and its action plan at country level.

Table 3
Review of One Health collaboration strategies and/or initiatives in India.

Type of collaboration	Type of initiative	Collaborative partners	Criticism of the collaboration
Solution-based	NSCZ [93]	MoHFW	Lack of ownership of other ministries and uncertainty on the policy/ guidelines.
Level-based (Research)	ICMR-ICAR Collaboration [72]	ICMR and ICAR	Unclear guidelines on identifying the prioritized research sectors for common funding.
Solution-based	NIP Committee [74]	NICD-MoHFW & DAH-MoAFW	Disease-specific and only for pandemic duration. Lack of sustainable guidelines.
Level-based (Research)	RCZI Initiative [94]	PHFI	Lack of advocacy at the GoI level except few initiatives.
Level-based (Population, Individual)	RCI-TN [76]	DPH, DME, DHS, TNMSC, DAH & CSO	Integrated disease control program only for rabies and project-specific.
Third-party based	OHR [95]	DBT with other ministries	Lack of evaluation plans for OHR activities

NSCZ: National Standing Committee on Zoonoses; ICMR: Indian Council of Medical Research; ICAR: Indian Council of Agricultural Research; NIP: National Influenza Pandemic; RCZI: Road Map to Combat Zoonoses; MoHFW: Ministry of Health and Family Welfare; MoAFW: Ministry of Agriculture and Farmers' Welfare; NICD: National Institute of Communicable Diseases; DAH: Department of Animal Husbandry; PHFI: Public Health Foundation of India; RCI-TN: Rabies Control Initiative-Tamil Nadu; DPH: Directorate of Public Health & Preventive Medicine; DME: Directorate of Medical Education; DHS: Directorate of Rural Health & Medical Services; TNMSC: State Surveillance Office and Tamil Nadu Medical Services Corporation; CSO: Civil Society Organizations; OHR: One Health Roadmap; DBT: Department of Biotechnology

4. Discussion

The emerging interest in health system strengthening provides an opportunity to discuss inter-sectoral collaborations especially for the One Health approach in the prevention of zoonotic diseases. There are certain health system shortcomings highlighted in the literature such as lack of awareness, lack of access, human resource crisis, affordability, lack of accountability [18,19,77]. These challenges that also have an impact on One Health issues can be overcome through a sustainable collaboration, which is one among other potential solution [78]. Several global OHC initiatives are considered in this review. These might be potential approaches to be adapted to the Indian context. However, as there is no documented evaluation of these types of collaborations, it is very difficult to speculate which of these will help to develop a resilient Indian health system, capable of adapting the One Health approach. Further, there is no one-size-fits-all health system; therefore specific local strategies need to be developed for the Indian context.

Considering the available global OHCs, currently India is into the level-based (research) and solution-based collaboration. For continuity of One Health research in India, level-based (research) collaborations like ICMR-ICAR/RCZI need to be strengthened further in terms of financing, staff, material, resources and political support.

An outbreak control mechanism (solution-based) is generally robust, having been planned at the central and state level and implemented at the grassroots level; however, this needs to be sustained in the post-outbreak era for early detection and prevention. For example, although the initiative in Tamil Nadu for rabies control is by far the ideal model of population and individual-based collaboration at different levels of the system in the country, the sustainability of this model may be a challenge. After the research funding ends, the system should be resilient enough to continue with the collaborative strategies. Further, the vertical disease control mechanism need to be improved to capture multiple diseases; for these functions, the system needs to be corroborated.

There is a scope for two types of collaboration to be integrated in the Indian health system. One, the third party based i.e. recent initiatives by Department of Biotechnology, has a potential to coordinate all the ministries required for One Health. Second, level-based collaborations especially at the provider level. For example, the establishment of One Health clinics, at least in the areas of high human-animal density [55], or the joint One Health training programs [50–53] for workers from both systems need to be incorporated into the health system of the country. In addition, due to lack of human resources and budgetary constraints, it will be worthwhile to initiate combined delivery of health services at least in the hard-to-reach areas of the country. Though there is some sort of solution-based and level

(research) based collaboration are already in the place; the future for the India would be forming a combination of third-party and level-based composite collaboration for strengthening the health system.

4.1. Way forward: envisaged OHC strategies for the Indian health system

Convening joint political discussions or acting only during outbreaks, at times of emergency or crisis is not sufficient to yield successful results [79]. Ongoing dialogue and continuous action is necessary for a sustainable collaboration across the health system. Based on documented global initiatives and considering the health system of India, the envisaged One Health strategies for the Indian health system is presented below. It aims to develop a composite collaboration with a combination of third-party and level-based collaboration:

4.1.1. Level-based (individual) collaboration

The level (individual) based collaboration can be of two types: strengthening One Health education and improving One Health practices.

Incorporating One Health into university education [80] as well as engaging in interdisciplinary teaching [81,82] can foster collaboration at the individual level in the long-term. The learnings from developing a One Health module in African states [49,52], Europe [51], USA [50] can be considered for the Indian scenario. One way is to develop an integrated One Health module by engaging professional bodies such as the Indian Medical Association and the Indian Veterinary Association.

Initiatives such as field epidemiology from Zambia [53] and Thailand [54], with strengthened clinical aspects can be integrated into the training and education of Indian system. The current field epidemiology run by NCDC should make an effort to involve animal health experts and could be designated as One Health Field Epidemiology Program.

In Australia, at the practitioner-level, there is a systematic case-referral mechanism, especially between the physicians and the veterinarians for early detection of disease. This should be emulated in India. [83]. Patients, if given a chance, are interested in consulting specialists from both fields; this needs to be realized in the Indian setting too. Initiatives like public-private partnerships [84] need to be considered for developing such types of collaborations at a system level, with a structured framework and with specific goals [85].

One Health Clinics are in place in USA [55] and can be adapted to the Indian system. One strategy could be the recent initiative of providing comprehensive primary care through Health & Wellness Centers. These centers have the potential to be developed into One Health Centers [86]. Thus, the future can be envisaged as *One Health & Wellness Center* at the grass-root level addressing all preventive and promotive aspects.

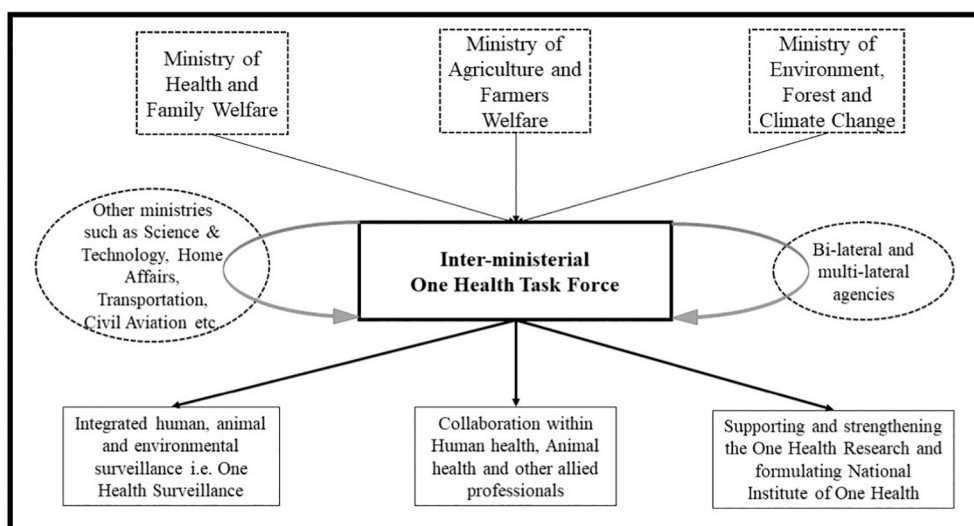


Fig. 2. Envisaged One Health Collaboration model for India.

4.1.2. Level-based (population) collaboration

The level (population) based collaboration strategies are essential to develop One Health surveillance. In this review, two types of One Health surveillance are documented:

- disease-specific surveillance such as of arbovirus in Serbia [56], *Campylobacter* in Switzerland [57] and antibiotic resistance in Vietnam [58]
- System-based geo-spatial and clinical data capture as in Africa [59].

Though both human disease (IDSP) and animal disease (NADRS) surveillances are in place in India, it is essential to develop strategies to integrate these two-surveillance systems and prepare a roadmap for One Health surveillance in the country. To enhance multi-sectoral coordination, recently a veterinarian has been recruited in the IDSP for looking into the One Health aspect [87]. This is a welcome initiative and needs to be strengthened at the district and sub-district level for early prediction of outbreaks.

4.1.3. Level-based (research) collaboration

Research approaches to address complex health issues at the animal-human-ecosystem interface is on the global agenda for implementing OHC [88]. Systematic reviews and meta-analyses have so far been independent and discipline oriented. Therefore research initiatives from the viewpoint of One Health need to be promoted [89], which is already in place in South East Asia [60]. Evidence-based decision-making and transformation of observations into narratives detailing how situations emerge and might unfold in the future can be achieved by system thinking or participatory epidemiology research [59,90]. Finally, trans-disciplinary approaches can be used both to improve the effectiveness of existing systems and to develop novel networks for collective action [91]. Efforts such as ICMR-ICAR collaboration need to be scaled up and should reach the local-level medical university-agriculture university collaboration for joint research. The zoo and public health research collaboration as in Kenya can also be adapted to the Indian setting [62].

4.1.4. Third-party-based (Inter-ministerial One Health task force) collaboration

Initiatives like the One Health Secretariat and the One Health strategic framework in Bangladesh might constitute the learning framework for India [71]. The recent effort by Department of Biotechnology under the Ministry of Science and Technology can act as an inter-ministerial One Health task force. If it succeeds, all the essential

ministries can be brought under its umbrella. This can become part of the current One Health roadmap for India. It should focus on integrated surveillance, developing collaboration at the practitioner level and research aspects. An envisaged OHC model considering the Indian health system is shown in Fig. 2.

Many experts voice that India must have a One Health policy with specific focus on OHC [38,39]. Thus far, inter-sectoral mechanisms aimed at operationalising One Health appear to currently be a set of uncoordinated ad-hoc efforts. Further, collaboration in India should not be restricted to the country; ideally to reduce threats and strengthen global health security, India should seek global scientific collaboration.

Although this review compiles global One Health initiatives on collaboration strategies based on a methodologically sound search, we understand that there must have been more efforts that have not been captured through this review. As we only screened the publications with titles and the key words referring to terms connected to One Health and collaboration, there is always a chance that reports and articles that do not use those terms, but have relevant content might have not been included in this review.

5. Conclusion

Present review found that collaborations in the domain of One Health are mainly of three types:

- level-based collaboration (individual, population or research),
- solution-based collaboration
- third party based collaboration.

Although, many initiatives are being undertaken globally for disease prevention and control from the viewpoint of One Health; however, in India, solution-based approaches during emergencies and outbreaks and some sort of level-based collaborations are in place. It is high time to develop a sustainable level-based collaboration that integrates with third-party based collaboration with in larger domain of One Health. As there is no one-size-fits-all approach for developing OHC between various actors of the health system, it is necessary, before any collaboration approach, to gain a deep understanding of the local needs and chances for collaboration. A composite collaboration with a combination of third-party (inter-ministerial One Health task force) and level-based collaborations comprising individual (among the clinicians and through the One Health module in education and training), population (integrated surveillance), research (One Health integrated), will lead to a more resilient Indian health system. In addition, there is a need for

further studies on the system and contextual factors responsible for OHC strategies prior to their implementation.

Author contributions

All authors contributed equally to the development of this study. SY, WB, DS and TF participated in the conception and design of the review. SY & TF conducted the review. SY drafted the first draft of the paper. WB, DS and TF critically reviewed the paper. All authors critically revised the manuscript and provided final approval of the version to be published.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethical concerns and consent

The present study does not involve human research subjects or use confidential data. For the overall research project i.e. Research to explore Intersectoral Collaborations for the One Health Approach (RICOHA) study [96], ethics approval has been obtained from the Research Ethics Committee, Center for Development Research (ZEF), University of Bonn, Germany and the Institutional Ethics Committee of Indian Institute of Public Health Gandhinagar, India.

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Paper context

Collaboration is a key strategy for successful adaption of the One Health approach. This review aims to summarize the global One Health Collaboration (OHC) strategies and/or initiatives globally, that are required to be understood prior to establishing a OHC in India. Further, it looks upon these global collaborations as a framework for developing a resilient health system for India and to provide an insight on how health system collaborations needs to be envisaged with reference to One Health.

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