Research to explore Intersectoral Collaborations for One Health Approach (RICOHA)

A health system study in Ahmedabad, India

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Abstract

The One Health (OH) approach is becoming popular across the globe, and some countries are underway to implement it. For the effective implementation of OH, the operationalization of intersectoral collaboration (ISC) is essential; however, there is a lack of evidence available on factors affecting the degree of collaboration and strategies to enhance it. The factors affecting ISC operationalization are further multifaceted by the health system structure and its degree of resilience. With the dynamic changes of health system resilience and destabilization at the interfaces of the human-animal-environment, the implementation of OH is becoming mercurial. Therefore, the Research to explore Intersectoral Collaboration for One Health Approach (RICOHA) study attempted to understand the health system complexity for operationalization of ISC with the help of a systems approach.

The RICOHA study used mixed-methods, where both qualitative and quantitative health system data were collected between September 2018 to October 2019 in one of the western cities of India, Ahmedabad. The exploration process started with the prioritization of diseases followed by a bottom-up approach data collection process. The data was first collected from the community level (supply-side: health system actors and demand side: households) and progressed upwards to the provider level (clinicians such as physicians, veterinarians) and then to the administrative level with managers, decision-makers, program coordinators from the human and animal health system. The qualitative data were collected through key informant interviews, focus group discussions, participatory workshops, vignettes, and modified policy Delphi method, to prioritize diseases, understand the current degree of collaboration, and to document what factors influence collaboration. The quantitative data was collected through cross-sectional surveys to understand the network cohesion of the health system actors and to capture the zoonotic disease awareness level, including the practices. The software packages used were Atlas. Ti version 7 for qualitative data, R version 3.4.1 for quantitative data, UCINET 6 for network data, and Sensitivity Model of Vester to explore the system factors.

The RICOHA study prioritized zoonotic diseases such as rabies, brucellosis, avian influenza (H5N1), influenza A (H1N1), which require collaborative efforts from the human and animal health system for its effectual prevention and control in the local setting of

Ahmedabad, India. This research explored all potential OH actors across the three health system levels (i.e., administrative, provider, community) from the human and the animal health system. In addition to the presence of the city level actors, there was another layer of administrative actors of the top authorities (either from district/state/nation) found to have an integral role in decision making in the prevention of zoonoses. Although the administrative actors of the human and the animal health system have collaborated as instructed by the top authorities during outbreak situations, there was a low network cohesion during non-outbreak situations. In addition, there was low interest in collaborative activities among the actors of the provider level, and the private and non-governmental actors were not integrated into collaborative activities. As RICOHA identified a lack of community actors from the animal health system, the human health community workers' vibrant presence was investigated for the level of motivation to act as OH activists. Despite the low motivation among the community health workers, some have produced an interest in acting as OH activists if additional financial incentives are provided to them. Overall, there is low interest in ISC, and a low acknowledgment of the advantages of ISC has been documented in this study. ISC is instead considered a burden and would not be operationalized unless the top authorities were instructed to do so. However, in the short term, the third-party based ISC could be envisaged by addressing the micro enablers identified at the individual level. Whereas in the long term, level-based ISC is recommended after addressing the organizational and systemic factors identified in the local context. RICOHA study contributed both conceptually and empirically to the OH implementation process. The documented innovative ISC strategies from this study might assist the ISC operationalization process in Ahmedabad. In addition, the bottom-up approach of exploring a health system also envisaged a useful method in health system research towards developing the people-centered health system. Thus, this study concludes that not only ISC is needed for OH among the sectors pertaining to the human and the animal health system but also across the governance level for effective implementation.

Key Words: Intersectoral collaboration, One Health, Zoonotic disease, Systems approach, Health system

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List of abbreviations

AMC	Ahmedabad Municipal Corporation
ASHA	Accredited Social Health Activist
CDC	U.S. Centers for Disease Control and Prevention
CHW	Community Health Worker
CNCD	Cattle Nuisance Control Department
FAO	Food and Agriculture Organization of the United Nations
HPSR	Health Policy and System Research
HRH	Human Resources for Health
ISC	Intersectoral collaboration
LMIC	Low and middle-income countries
OH	One Health
OHA	One Health Activist
OHC	One Health Commission
OHGN	One Health Global Network
OHITF	One Health Initiative Task Force
OHTFA	One Health Task Force of Ahmedabad
OHZDP	One Health Zoonotic Disease Prioritization tool
OIE	World Organization for Animal Health
PCHS	People-Centered Health System
PPP	Public-Private Partnership
RICOHA	Research to explore Intersectoral collaborations for One Health approach
SARS	Severe Acute Respiratory Syndrome
SDG	Sustainable development goals
WHO	World Health Organization

1. Introduction

1.1. One Health approach for zoonotic disease prevention

The recurrent emerging and re-emerging of zoonotic diseases are attributed to complex linkages at the interface of humans and animals in their shared environment [1,2]. The factors like ecological changes, human behavior, technology, and industrial development, breaking down the host's defenses or public health control measures affecting the recurrence of (re)emerging diseases [3,4]. Combating the burden of zoonotic diseases brings the momentum of 'One Health' (OH), which started as a concept [5,6], become an approach [7–9], and now became a movement [10,11], inspiring the 'One welfare' [12]. As there is not a single definition agreed upon globally, one of the most used definition is by the US Centers for Disease Control and Prevention (CDC). CDC defined "*OH as a collaborative, multisectoral, and transdisciplinary approach-working at the local, regional, national, and global levels with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment*" (pg.1) [13]. Further, international institutions like the One Health Commission (OHC) [14], One Health Global Network (OHGN) [15], One Health Initiative Task Force (OHITF) [16], World Health Organization (WHO) [17], World Organization for Animal Health (OIE) [18], Food and Agriculture Organization of United Nations (FAO) [19] have also stated the similar key features of the OH approach. Among others, the key features are inter-, multi- and/or transdisciplinary actions, which require the collaboration among various actors in dealing with disease control or risk mitigation and promoting the health, wellbeing of humans, animals, and the environment [9,20,21].

As suggested in the literature, the integrated risk management at the interface of humans and animals with their shared environment through the OH approach has certain advantages and benefits in the prevention and control of zoonoses [8,22]. Globally, some of OH initiatives documented both in controlling diseases like Severe Acute Respiratory Syndrome (SARS) or Ebola [23,24] and in preventing diseases like avian influenza or rabies [25]. The OH approach provides strategies to control the disease outbreaks and to prevent the transmission from animal to human or vice-versa [22,26,27]. Moreover, the OH approach also claims economic advantages in terms of marginal benefits against the minimal cost of such collaborative actions and structural

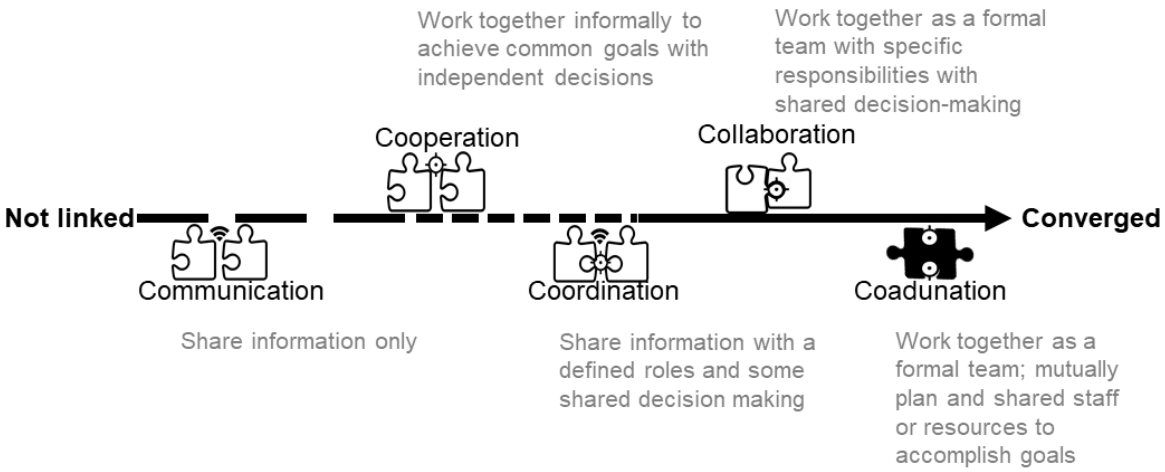
changes [28,29]. As the OH approach for zoonotic disease prevention and/or control addresses the interconnectedness of health with its social, ecological, and economic determinants, it aligns with the Sustainable Development Goals (SDGs) [3]. On the one hand, the involvement of multiple actors across multiple boundaries; on the other hand, the complexity of the interactions between humans and animals within biological and ecological dimensions make the OH approach challenging to implement [5,30,31].

1.2. Implementation of the One Health approach with the operationalization of Intersectoral collaboration

The term operationalization is used for a process by which the OH approach would be effectively implemented. The implementation of the OH approach is broadly considered either for disease control [32], especially (re)emerging zoonotic diseases, or for risk mitigation [33] in considering the environment. On the one hand, OH implementation relies on the collaboration across diverse sectors and actors [34]; on the other hand, there is a lack of understanding on the required level of integration due to differences in health system structure, responsiveness, and accommodative culture of the actors [35–37]. As the literature suggests, the stages of integration occur over time as a continuum [38], or process [39], or convergence [40], i.e., communication, cooperation, coordination, collaboration, and coadunation describing the stages of the convergence [41–45], collectively considered as intersectoral collaboration (ISC). Figure 1 illustrates the graphical representation of the ISC as a continuum process.

The WHO provided two definitions of ISC over time. In 1998, the Health Promotion Glossary defined ISC as "*cooperation between different sectors of society, such as the public sector, civil society, and the private sector*" [46]. In 2008, ISC was defined as "*actions undertaken by sectors outside the health sector, possibly, but not necessarily, in collaboration with the health sector, on health or health equity outcomes or on the determinants of health or health equity*" [47]. However, during the implementation of the OH approach, it is essential to have the right balance between autonomy and integration. Thus, understanding the current degree of convergence among the actors and developing ISC strategies to reach the next levels of integration over time is essential.

Figure 1. Intersectoral collaboration (ISC) as a continuum process of convergence



Source: Author's compilation based on the literature review [39–44]

1.3. Systems approach for understanding and developing ISC

The systems approach is beneficial in understanding the process of ISC when multiple actors need to be engaged to address a complex issue [48,49]. The systems approach relies on the principle of looking at the complexity of interconnected sub-systems as a whole, i.e., the elements (characteristics of the system), interconnections (the way these characteristics are related in different situations), and the purpose (the idea behind) of it [50–52]. As ISC is a continuum of processes, the understanding of actors and their interconnectedness in the different situations within the complex system is essential to be explored through the principles of the systems approach. As the health system complexity is increasing over time, this systems approach helps enormously in health policy and system research (HPSR) [53,54]. While conducting HPSR, the system approaches enable understanding of the 'hardware-software' of a health system [55,56]. The hardware of a health system refers to the visible elements, and the software refers to the less visible elements. Among others, hardware refers to the infrastructure, human resources for health (HRH), the information system, health financing, medical and health supplies. In contrast, software refers to the relations among the HRH, interests, and ideas, norms and values, power [55,56]. Both of them are important for providing health care services. This helps to understand the health system as a whole, complex interrelated and interdependent parts rather than seeing its separate entities [57,58]. An HPSR study needs to account for not only the hardware like structures but also for the patterns of interaction as components of the whole complexed system. In addition to this principle, systems thinking is superior to

the linear and reductionist approaches in testing innovative ideas and presenting interconnectedness [57].

The evidence indicates that ISCs have been planned, operationalized, and sustained not only in the health sector but also in other sectors [42,43,59,60]. In most situations, ISCs have been commenced when the top authorities required some sectors to work together in “convergence” with other sectors to achieve the targets of health programs and/or interventions of specific healthcare services [40,61]. The global recommendations of ISCs for effectual prevention and control of zoonotic diseases like avian influenza (H5N1) or rabies provide a basic understanding of the implementation of the OH approach.

1.4. The role of the local health system for One Health implementation

Some countries adopted a top-down approach of implementation, i.e., policy formulation with clear instructions of command and control with the top authorities and implementation actions at the interface of the people, animal, and environment. Example are the integrated surveillance programs in Japan [62], Vietnam [63], South-Africa [64], and Switzerland [65], or an inter-ministerial/inter-departmental workforce for OH activities in China [66], Uganda [67], Kenya [68], Mongolia [69], and Bangladesh [70]. Although there is no systematic impact evaluation available of any of these top-down approaches, as suggested in the literature, that the top authorities tend to neglect the opinion and value of the implementation actors from the local level [71]. However, the contextual local level issues and perception of the local actors are essential to be considered during the OH implementation [72,73]. Without the involvement of local-level actors, it is difficult to envisage sustainable ISCs for the implementation of OH [74].

In the absence of top-down approaches, it is important to explore any health system with the bottom-up approach, i.e., from the community level (i.e., community health workers, community, households) and then to investigate the provider level (i.e., clinicians, nurses, and other service providers) and administrative level (i.e., policymakers, program managers) to understand the local realities and the scopes for OH implementation [75–77]. The bottom-up approach provides an opportunity to explore the problem from the grass-root level for the formulation of the evidence-based policy [78,79]. This approach helps in understanding the operational realities, the

needs of the people; thus, the local challenges could be addressed by identifying the network of actors and asking them about their goals, strategies, activities. This bottom-up approach is also helpful with rising concern on developing a people-centered health system (PCHS) [80,81]. As OH approach implementation involves multiple actors with their intersectoral involvement [27,82], this bottom-up approach provides a mode to understand this complex problem from the systems' perspective. While the complexity of the health system is intensifying [83], this bottom-up approach offers an opportunity to pursue the exploration in identifying actors and their networks in the local context.

The architecture of the health system differs across the spatial entities, i.e., regions, states, and localities are different in several ways of their politics, culture, and environment [84,85]. India is not exceptional to this, where the health system functionality differs across the geographic regions (either urban or rural), the governance structures of the state [86–88]. It urges the necessity of exploring each local health system for its priority-setting and evidence-informed policy-making.

1.5. Research to explore intersectoral collaboration for One Health approach (RICOHA) study aim and objectives

The overall aim of the RICOHA study was to understand the generic structure and network cohesion of the health system actors and how the convergence could be enhanced for OH, especially in effective prevention and control of zoonotic diseases in Ahmedabad. The system boundary of this current investigation was limited to the human and animal health systems as the prime focus is on disease control; thus, the boundary was not extended to include the environment and related allied sectors. The investigation attempted to document the systemic factors for implementing OH. Thus, the specific objectives were defined based on the presence of actors at various levels of the health system, as shown in Table-1. The exploration of the local health system of Ahmedabad followed the bottom-up approach with three-layered dissection, i.e. (a) at the community-level with households and the community health workers, (b) at the provider level with clinicians such as physicians, specialists, or veterinarians and (c) at the administrative level with policy planners, program managers, and coordinators.

Table 1. Specific objectives and key methods used in the RICOHA study

Level of investigation	Specific Objectives	Key methods
Structural design	To review the initiatives on the ISC strategies for OH on the global level and discuss which types of collaborations might work for the health system of India	Scoping literature review
Programmatic design	To determine which zoonoses need to be prioritized for collaboration among the actors of the human and the animal health system	Participatory workshop
Community (Demand-side)	To document the health system contact and its effect on the awareness level of zoonotic diseases	Cross-sectional community survey
Community (Supply-side)	To understand the motivation to become an OH activist at the community level	Mixed method (Focus group discussion and cross-sectional survey)
Administrative & provider (clinical)	To identify, categorize OH actors and examine the strength of the health system network for implementation of OH with a focus on prevention and control of zoonotic diseases	Mixed-method (In-depth interviews and cross-sectional network survey)
Programmatic design	To document and validate the innovative strategies for ISC with a focus on OH implementation in the prevention and control of zoonoses and to document the enabling factors to boost the ISC between the human and animal health systems	Mixed method (Vignette interview, modified policy Delphi online survey, participatory workshop)

ISC: Intersectoral collaboration; OH: One Health; RICOHA: Research to explore Intersectoral Collaboration for One Health Approach

The specific study methods, sample and sampling for each objective, study setting overview, and the analysis plan was published as the study protocol (Publication 1) [89]. To understand which type of ISCs is being undertaken at the global level, a scoping review in the form of structural design was conducted, and different levels of ISCs were discussed (Publication 2) [90]. To start the exploration process in the local health system setting, first, disease prioritization was conducted (Publication 3) [91]. This was achieved through a participatory workshop, applying the One Health

Zoonotic Disease Prioritization (OHZDP) tool of the U.S. Centers for Disease Control and Prevention (CDC) [92]. This prioritization of zoonotic diseases provided an insight into developing the specific ISC strategies for zoonotic diseases of public health importance and local relevance. Following the prioritization, the exploration started from the bottom of the health system with the supply side (community health workers) and the demand side (households at the community) of the community level. On exploring the demand side at the community level, people living in communities with and without animals were surveyed for their awareness about the prioritized zoonotic diseases (Publication 4) [93]. Following this, the system side at the community level was explored in identifying the potential community actor to act as One Health activists (Publication 5) [94]. Further, potential OH actors for the local setting was identified, and the network cohesion during various situations was investigated (Publication 6) [95]. Although the system boundary was limited to the human and the animal health system, there were few actors from environmental sectors also identified during the exploration. Finally, innovative ISC strategies for the local health system were documented through a Vignette study and validated through the modified Policy Delphi method, followed by a system workshop for documenting the enabling factors (Publication 7) [96].

2. Publications

2.1. Publication 1

Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. Convergence model for effectual prevention and control of zoonotic diseases: A health system study on 'One Health' approach in Ahmedabad, India. Health Research Policy and Systems. 2018; 16 (1): 124.

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Convergence model for effectual prevention and control of zoonotic diseases: a health system study on 'One Health' approach in Ahmedabad, India

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Abstract

The complexity and increasing burden of zoonotic diseases create challenges for the health systems of developing nations. Public health systems must therefore be prepared to face existing and future disease threats at the human–animal interface. The key for this is coordinated action between the human and the animal health systems. Although some studies deal with the question of how these two systems interact during unforeseen circumstances such as outbreaks, a dearth of literature exists on how these systems interact on early detection, prevention and control of zoonotic diseases; assessing this problem from the health system perspective in a developing nation adds further complexity. Systems thinking is one of the promising approaches in understanding the factors that influence the system's complexity and dynamics of health maintenance. Therefore, this study aims to understand the generic structure and complexity of interaction between these actors within the domain of One Health for the effectual prevention and control of zoonotic diseases in India.

The present study will be executed in Ahmedabad, located on the Western part of India, in Gujarat state, using a mixed methods approach. For the first step, zoonotic diseases will be prioritised for the local context through semi-quantitative tools. Secondly, utilising semi-structured interviews, stakeholders from the human and animal health systems will be identified and ranked. Thirdly, the identified stakeholders will be questioned regarding the current strength of interactions at various levels of the health system (i.e. managerial, provider and community level) through a quantitative network survey. Fourthly, utilising a vignette method, the ideal convergence strategies will be documented and validated through policy Delphi techniques. Finally, through a participatory workshop, the factors that influence convergence for the control and prevention of zoonotic diseases will be captured.

This study will provide a comprehensive picture of the current strength of collaboration and network depth at various levels of the health system. Further, it will assist different actors in identifying the relevance of possible One Health entry points for participation, i.e. it will not only contribute but will also develop a system convergence model for the effectual prevention and control of zoonotic diseases.

Keywords: Systems thinking, prevention and control, zoonotic diseases, One Health, health systems

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Introduction

The research literature cites an increasing burden of emerging, re-emerging and endemic zoonotic diseases that are attributed to complex linkages at the human–animal–ecosystem interfaces [1, 2]. The One Health approach, which recognizes that the health of people is connected to the health of animals and the environment, is the most appropriate approach for the sustainable management of zoonotic diseases [3], as well as for their prevention and control [4–6]. At both the national and global levels, an increasing trend can be witnessed towards One Health approaches in order to tackle the challenges of zoonotic diseases in the most effective way [7–9]. Various challenges, such as the complex nature of zoonotic diseases as well as the limited resources of developing countries, make implementation of the One Health approach more crucial [2]. As the One Health approach focuses on collaboration with various stakeholders, its implementation represents a complex process for health systems, especially for those with feeble structures in developing nations [10–12].

The operationalisation of the One Health approach endures challenges in both developing and developed nations [13–15] due to the lack of a shared vision and culture, which should be more collaborative and accommodative of all sectors concerned with the human–animal interface in health. Furthermore, this approach can only be successfully operated if backed by enabling governance structures with clearly defined roles and responsibilities for each sector [15, 16]. Available evidence also indicates that the collaborative efforts between physicians and veterinarians in communication, sharing of public health knowledge and research settings could do much in managing and controlling zoonoses [17–19].

Our literature review indicates three different types of collaboration and partnerships for implementing One Health. The first type is 'solution-based' collaboration [7], i.e. joint outbreak management or planned integrated health services like the case of the Chad joint immunisation programme [20]. Here, solving a defined problem, e.g. difficulties in controlling an acute epidemic or in reaching remote populations for preventive interventions, is the starting point for joint action between human and animal health services. The second type is 'third-party based' collaboration [21], i.e. establishing a third party that can act as a knowledgeable or trusted intermediary between the stakeholders, for example, the strategic framework of the Bangladeshi One Health secretariat [22]. The third type is the most sustainable kind of collaboration, based on respective level (individual level, population level or research level) collaboration [10]. Establishing such a 'level oriented' collaboration requires a profound understanding of the complexity of the respective health systems, especially in a country like India, with its lack of existing or effective mechanisms to bring together the stakeholders who need to be involved in zoonoses research or control management [23–25].

To build resilience in the health system, efficient resource allocation is vital [26]. Systems thinking has been tested and proven a successful approach for understanding the complexity and dynamics of health networks [27–30]. General systems theory is also anchored in the One Health approach [31]. Essentially, systems thinking is an approach to problem solving and designing solutions, where the role and mutual influence of stakeholders and context is unclear [28, 32, 33]. With an axiomatic approach, systems thinking can complement the linear and reductionist approaches by permitting the testing of new ideas in social systems [29]. In systems thinking, an organisation and its respective environment (context) are viewed as an entangled whole of interrelated and interdependent parts rather than separate entities [29, 34]. This takes into account the structures, patterns of interaction, events and organisational dynamics as components of larger structures, helping to anticipate rather than react to events, and to prepare better for emerging challenges.

Therefore, this study aims to understand the generic structure and convolutedness of interaction between the various sections of the human and animal health systems within the domain of One Health for an effective prevention and control of zoonotic diseases in India. More specifically, it aims to build an understanding of how the various sections within the human and animal health systems are currently interacting. Further, the study will attempt to document the factors facilitating or hampering the development of effective convergence between these two health systems in Ahmedabad, India.

The specific research objectives are:

1. To identify the major zoonotic diseases of public health importance in Ahmedabad city
2. To identify and categorise the stakeholders within the human and animal health systems responsible for prevention and control of zoonotic diseases in Ahmedabad city
3. To examine the current strength of collaboration between the identified stakeholders at various levels of the health system
4. To develop new convergence strategies for effective prevention and control of zoonotic diseases
5. To document the factors that influence enhancing convergence between the human and animal health systems

Methods

Study design

This study entails a mixed methods approach consisting of both quantitative and qualitative data collection (interviews, survey and participatory workshops).

Study setting

This study will be implemented in the city of Ahmedabad. It is the seventh most populous city in India and the largest city of the Western state of Gujarat, India [35]. It is located on the banks of the Sabarmati River with a population of 7,650,000 [36].

The Union Ministry of Health and Family Welfare at central level governs human health in India. In each State, there is a State Department of Health and Family Welfare that is headed by a State Minister and a Secretariat under the charge of the Secretary/Commissioner (Health and Family Welfare). The Indian health system consists of both allopathy and AYUSH (Ayurveda, Yoga, Unani, Siddha and Homeopathy). There is a three-tier system, wherein the primary level includes village teams, sub-centres and primary health centres, the secondary level is composed of community health centres and sub-district hospitals, and the tertiary level consisting of district hospitals and medical colleges to provide rural healthcare. In contrast, the urban health system relies upon urban health centres and medical colleges [37]. Animal health is one of the subjects of the Department of Animal Husbandry, Dairying and Fisheries under the Ministry of Agriculture. In all districts there are Offices of Deputy Director of Animal Husbandry or Assistant Director of Animal Husbandry, directing veterinary dispensaries, branch veterinary dispensaries, mobile veterinary dispensaries, first aid veterinary centres, etc.

Specifically in Ahmedabad, human health services are controlled by two different governance systems, i.e. urban health governed by the Department of Health at Ahmedabad Municipal Corporation and rural health governed by District Panchayat of Ahmedabad district. The rural areas of Ahmedabad have one district hospital, six community health offices and 36 primary health centres [38], whereas the urban areas of Ahmedabad have six urban health centres, six medical colleges and one homeopathy college as well as being well facilitated by private companies for human health [35]. Similarly, animal health is controlled by the Cattle and Nuisance Control Department under Ahmedabad Municipal Corporation for urban areas and the Department of Animal Husbandry under District Panchayat for rural Ahmedabad. There are 26 veterinary hospitals and 17 primary animal treatment centres, which are available throughout the rural part of Ahmedabad [38] compared to only four veterinary dispensaries across the city. Healthcare provision by trusts (non-profit agencies) and profitable private sector facilities are also available widely to contribute towards animal healthcare in the city.

Research design

The analytical framework (Fig. 1) illustrates the research design of the study. The study will begin with prioritisation of zoonotic diseases of public health importance in Ahmedabad city (Objective 1). The system exploration will commence by defining and categorising the stakeholders in order to understand the influence of the various actors in the health system(s) (Objective 2). This will be followed by assessing the strength of the current interaction and the collaboration strategies through a network survey (Objective 3). After having analysed the system actors and their current level of interaction, the possible ways to further develop the systemic interaction will then be analysed through a vignette approach, which will be validated through the policy Delphi method (Objective 4). Finally, based on the consensus documented throughout the previous phases, the factors essential for developing the convergence will be captured through a participatory workshop. A sensitivity analysis will be conducted to conclude the important factors for developing convergence in relation to the local health system (Objective 5). The One Health entry points, which will have been explored during the previous objectives (Objectives 1–3), will be validated (Objectives 4 and 5) further through qualitative (vignette) and quantitative (sensitivity analysis) approaches.

The system convergence model from this study will be a qualitative system model, generally used to explain the system's internal feedback loops to make its relationships easier to understand. This approach has also been successfully employed to enhance the development of health policies and programmes [39, 40].

Sample and sampling strategy

As this study consists of harmonised objectives, information from previous objectives is required to proceed to the next objective. This study will draw samples from three different strata of the health system structure, i.e. from the managerial/decision-making level, from the service provider level and from the community.

a) **For the managerial level:** The sampling unit for this category will be individual actors in managerial positions in either the human health or animal health system or other related environmental programmes at the city level. The purposive sampling strategy will be adapted to recruit subjects from this category. This category involves the following types of actors:
   - *Managerial actors:* Individuals working as managers, programme officers or decision-

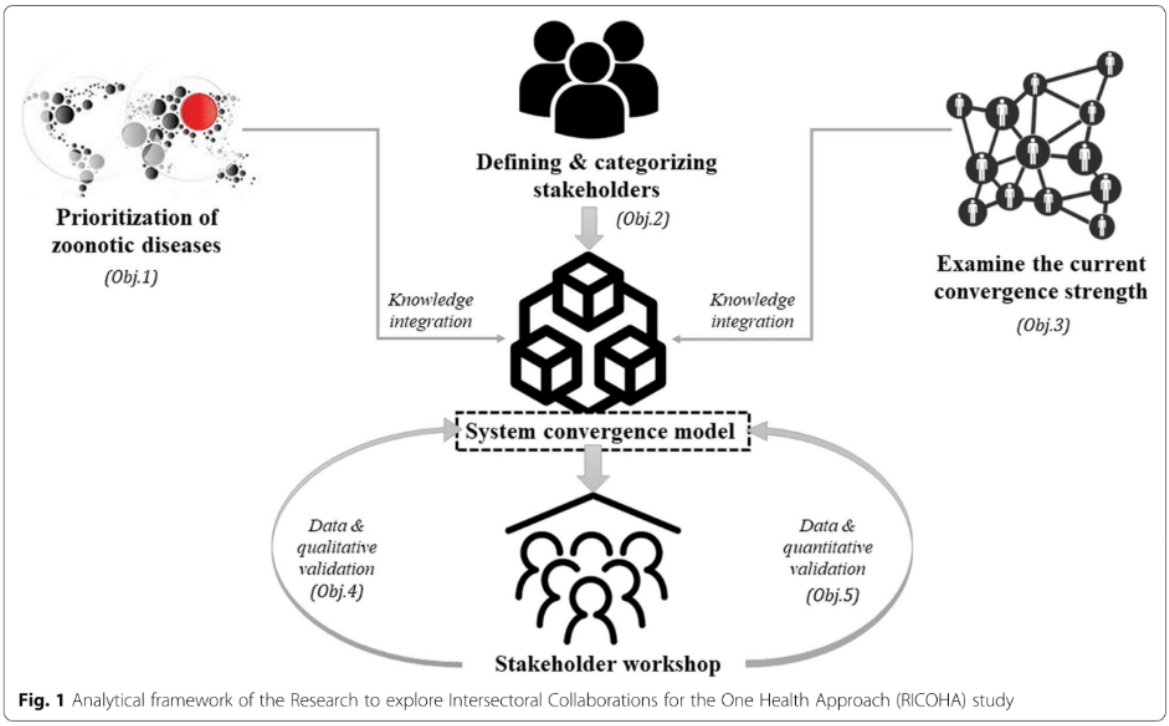

Fig. 1 Analytical framework of the Research to explore Intersectoral Collaborations for the One Health Approach (RICOHA) study

makers, involved in the planning of human health services at the Ahmedabad Municipal Corporation or at the Animal Husbandry Department for animal health services.

■ *Surveillance actors*: Individuals such as epidemiologists, entomologists, statistician or managers, working in the surveillance system, i.e. Integrated Disease Surveillance Project for human health or National Animal Disease Reporting System for animal health.

b) **For the service provider level:** The sampling unit for this category will be individual actors from both the human and the animal health systems who are involved in delivering health services directly or indirectly. Both the public and private sector actors will be considered for this category. The snowball sampling strategy will be applied to recruit actors within this category, as no complete list of private service providers is available. This category involves the following types of actors:

■ *Clinicians:* Physicians who are involved in managing infectious diseases or veterinarians providing animal healthcare.

■ *Laboratories:* The laboratories that are involved in conducting tests on human or animal samples for zoonotic diseases.

■ *Professional bodies:* The professional bodies such as the Indian Medical Association, Gujarat branch, and the Gujarat Veterinary Association will belong to the key actors under this category.

c) **For the community level:** The sampling unit for this category will be those individuals who have contact to both the human and the animal health systems, i.e. from households having any domestic animals (either for profit or for non-profit). The person responsible for taking care of the animals will be the interviewee for this category. In addition to this, directors of non-governmental organisations working in the community related to zoonotic diseases will be included under this category. The simple random sampling will be adapted to select the households that have contact to both systems. Initially, a list of households affected by the last zoonotic outbreaks will be obtained and then selection will be done randomly to recruit for this study.

d) **Additional sample:** An additional sample of experts will be recruited for objective 4. Experts from academia, research, government, international/national agencies, etc. will be approached purposively.

Method for objective 1

Joint prioritisation of zoonotic diseases has the potential to benefit both the human and the animal health systems, especially in resource-scarce settings. It might be of help for comprehensive planning to conduct efficient

and effective surveillance, develop laboratory capacity, target outbreak response and implement disease control strategies. However, prioritisation of zoonotic diseases is more important where there is a paucity of quantitative data for decision-making. Taking a collaborative approach to the priority-setting process ensures equal input from stakeholders in both human and animal health sectors, and ideally results in a ranked list of zoonoses that can inform joint efforts in areas of overlapping interest. Prioritisation of zoonoses is becoming an integral step for initiating One Health collaboration and is being implemented in both developed [41] and developing nations [42]. The specific purpose of this joint prioritisation within the study is to rank the zoonotic diseases that are especially important for Ahmedabad city. Purposive sampling is proposed to recruit 10–12 stakeholders from the managerial level (i.e. both managerial and surveillance actors). A participatory workshop is planned for this objective and the guidelines from the United States Centers for Disease Control and Prevention will be followed [43].

To prioritise zoonotic diseases in the city, a semi-quantitative tool, i.e. the One Health Zoonotic Disease Prioritisation tool developed by Rist et al. [43], will be adapted for this local setting. Prior to the administration of this tool, a literature review will be conducted to collect secondary information on zoonotic diseases concerning India and Gujarat, including outbreak information from the last 5 years. This tool will be administered in five steps, either through individual or group work, consisting of listing of zoonotic diseases, deciding the criteria for weighing, developing the questions under each criteria, ranking the criteria and ranking the diseases based on the criteria. These data from the workshop is planned to be analysed with help of the Analytical Hierarchy Process [44] and decision tree analysis to highlight the top prioritised diseases [43].

Method for objective 2

Stakeholder identification is an important step for understanding the diverse actors for prevention and control of zoonotic diseases within the human and the animal health systems. Stakeholder identification is an iterative process in health system research that provides better insights into system complexity regarding roles and engagement [45, 46]. This method is used extensively in various fields of social science, e.g. identifying stakeholders for a specific project [47, 48].

The sample for this objective will be recruited from the managerial level (i.e. both managerial and surveillance actors) and from the service provider level. Approximately 10–12 key influential actors from both the systems will be recruited for this objective or until the saturation of responses. Semi-structured interviews will be conducted with the sampled actors. If, during the interviews, any new actors are identified, then they will be added to the stakeholders list and considered for further interviews. To understand their influence at different levels of the health system (managerial, providers, community), a quantitative ranking of actors will be applied. The ranking scale is based on the response to a question about 'high-medium-low' influence, which will be asked to each participant in order to rank other actors during the interview. In addition, the type of collaboration exercised by these stakeholders will also be documented.

Transcripts will be made the same day based on the verbatim notes from the interview. Both inductive and deductive codes will be generated; similar codes will be combined into themes [49]. To ensure that the results are a reflection of the data, the codes/themes will be related back to the original data [50]. The qualitative data will be reported by using the Consolidated Criteria for Reporting Qualitative Research [51] after analysing through ATLAS.ti version 8 [52]. The stakeholder analysis will be conducted based on the Hyder model [53]. The final stakeholder analysis is performed as a stakeholder metric emphasising the Interest and Influence Matrix [54, 55], which is usually implemented in workshops. However, power relationships during workshops could hinder the assessment process in the study area, so we preferred interviews to allow respondents to assess the other actors confidentially [56].

Method for objective 3

To examine the strength and pattern of the current convergence between the actors, a network survey is planned. Network surveys have been extensively used not only in public health research [57–59], but also in health systems research [60].

All three sample categories will be applied for this objective. To recruit samples under this objective, the purposive sampling for the actors from the managerial level, the snowball sampling for the actors from the providers' level and the simple random sampling for the households will be adapted.

A structured network questionnaire will be administered to each participant. This structured network questionnaire will differ between stakeholder categories, as the actors have different roles within the system. Here, we are interested in examining the complete networks, i.e. all actors, including public and private actors from the human and animal health system. We will be applying both types of choices, namely stakeholders are chosen from a given list or by free calling, i.e. stakeholders are chosen unrestrictedly, to document the interaction with different actors within the boundary [61]. We will administer different types of structured and pre-validated (through pilot testing) questionnaires.

The first one will include aspects of demographic information, knowledge of the system, their interaction within the category and beyond the category, and factors driving for the interaction, for the managerial and provider level actors. The network questionnaire aims to collect the frequency of contact and level of collaboration within the own system as well as with the other system [57, 59]. Collaboration will be assessed with a scale adapted from established network analytic methods [62]. Participants will be asked to select the response that best describes the current relationship with each of the actors from different levels. In addition to this, some specific details for different actors will also be collected. The second questionnaire, which will be administered to the community households, contains some demographic details, socioeconomic information, animal handling practices, attitude towards preventive practices, and contact and experiences with both the human and animal health system during and after the outbreak and during non-outbreak periods.

To assess the current convergence points of the human and animal health system actors with their strengths we will adapt network analysis for the network data. Social network analysis provides insights into stakeholder relationships, especially the dynamics within a health system [60]. Social network analysis is defined as a distinctive set of methods used for mapping, measuring and analysing the social relationships between people, groups and organisations [63, 64]. As social network analysis has proved that it can be used to help understand the nature of relations between actors within a system and how these relationships influence the structure of a system [64, 65]. A visualisation of the current interactions and quantified outcomes, such as betweenness, centrality, density, distance and reachability, will be the result of this analysis. UCINET version 6 [66] will be used for this analysis.

Method for objective 4

Development of a convergence strategy is an iterative process exploring the best possible options for establishing horizontal collaboration between two vertical systems. In this phase, we attempt to document how convergence between the two systems could be strengthened through a vignette approach. The Vignette technique is a qualitative approach that documents the decision-making and possible convergence pattern between actors of two systems. The Vignette technique can elicit perceptions, opinions, beliefs and attitudes from responses or comments to stories depicting scenarios and situations [67]. Vignette methods are being used not only in clinical settings [68] for decision-making, but also in public health settings [69] to solve complex issues. A semi-structured Vignette questionnaire hypothesising the ideal convergence and collaborative actions amongst the health system actors will be administered to the sampled stakeholders through face-to-face interviews. Thus, we will gather as many convergence strategies as possible through interviews and then validate these strategies to ensure their feasibility. This validation will be done through the policy Delphi technique with health system experts. The Delphi methodology was developed at the RAND Corporation in the 1950s in order to make more reliable forecasts of the future [70]. Though certain basic principles of procedure and selection are the same, this technique has considerably changed its applications and objectives until now. The key difference of the traditional Delphi method is that the objective is not to develop consensus but to identify the widest possible range of valid options/solutions to a policy problem [71, 72].

The sample for this objective will be recruited from the managerial level and providers' level. All actors who will not yet have been interviewed will be sampled based on purposive sampling. Initially, 10–12 actors from each level will be interviewed; subsequently, we will proceed in recruiting new subjects until a certain saturation of responses is reached. For the policy Delphi survey, additional samples, i.e. experts from the academia, research, government, international/national agencies, etc., who have experience in policy formulation will be approached purposively. These experts are not necessarily from the study area. We will approach national policy-makers, national health mission, health policy and planning division, academia from the field of infectious diseases and veterinary science, national nodal persons from surveillance agencies, etc. We will send all documented options of potential horizontal collaboration to these experts and will seek the opinions and feedback through an online survey. We will use Survey Monkey software [73] to develop the online survey and invite potential health system experts via email. Participants will be asked to rank the importance of items in the grid by rating each item on a Likert rating scale (1–10; 1 – strongly disagree, 10 – strongly agree). They also will be asked to provide recommendations regarding any addition and/or deletions to the list of proposed items and for any other comments/suggestions. Each survey will take 15–25 min to complete, with the option to complete it over several sessions and to allow participants to review their answers prior to final submission. In case of high non-response, the investigator will personally approach these experts to document their responses through face-to-face interaction.

Vignette data will be handled like other qualitative data and will be reported using the Consolidated Criteria for Reporting Qualitative Research [51], after analysis through ATLAS.ti version 8 [52]. The Policy Delphi

responses will be in quantitative form as collected with a Likert scale as well as qualitative statements consisting of feedback, suggestions and comments. Therefore, de-identified results comprising overall scores for each item (analysed in a number of ways, e.g. percentage, mean, median, SD, range and proportions for the quantitative data and thematic analysis for the qualitative data) and narrative summary of findings, comments and suggestions will be obtained. Although most research recommends having a consensual mean score of at least 7 out of 10 in the Delphi survey to be included for further consideration, at this point we are not fixing any strategy for the same. After obtaining all responses, we will decide the consensual mean score cut off for inclusion criteria. Finally, a ranking of item importance will be made to rationalise the number of items and model this according to the CONSORT statement and TIDieR checklist for consistency [74, 75]. Final options from this survey outcome will be considered to develop a system convergence model and will be presented through a graphical system figure.

Method for objective 5

To address this objective, participatory stakeholder workshops are planned to capture the factors essential for convergence. This participatory method is well established in public health research for various purposes [76]; herein, we will employ it to capture the factors that play a role between the health systems to develop a convergence.

Approximately 10–12 actors, who have previously attended the prioritisation workshop from the managerial and the providers' level, will be recruited for this objective. The workshop will provide the most important input for the analysis. It is highly important that all stakeholder groups are adequately represented and get an equal voice during this process. During the workshop, all stakeholders will be briefed about the aim of the workshop and will be presented with the findings of the previous objectives. The workshop will consist of three phases, as described below.

- *Phase I:* Describing the system (system image, system problems), setting up the variables of interplay (acquisition of hard or soft variables with a description) and criteria matrix (check the representativeness of variables from a system viewpoint)
- *Phase II:* Consensus effect matrix (define and assess variable interlinkages) with the role of variables (evaluate and systematic role allocation of variables)
- *Phase III:* Cause–effect system (visual representation of variable linkages) with system model (selecting and analysing relevant feedback loops)

To begin the brainstorming and listing of the health system factors, these elements need to be categorised into aggregate variables. The Sensitivity Model® [77] provides a tool (Criteria Matrix) to ensure the variable set is representative of the system. It should be noted that the Sensitivity Model® is not set up linearly, so that the choice of variables and their definitions can be altered during any stage of the process. Ultimately, a set of 20 to 30 variables influencing convergence, such as human resources, common budget, knowledge about zoonoses, etc., should be defined. Information from the brainstorming can flow into variables as qualitative inputs; additionally, both quantitative and qualitative data is entered during discussion. During the next stage of the workshop, the participant group will be divided into 3–4 sub-groups. Each sub-group needs to complete the Cross-Impact-Matrix of the Sensitivity Model®, where the strength of impact between the various system variables is determined. The results of the sub-groups are then discussed and a consensus Cross-Impact-Matrix is created. During this stage, some variables may be redefined to ensure consensus. The Sensitivity Model® utilises the data from the Cross-Impact-Matrix to determine the systemic role of each system variable. The next workshop stage requires the development of the Effect System, which is similar to the Cross-Impact-Matrix but does not focus on the strength of impact but the direction. This step is highly important, as the Effect System forms the basis for the identification of the regulating feedback system. The Sensitivity Model® provides a tool to visualise the relationships between the various variables and aids with the analysis of the feedback system. The resulting Effect System forms a key output and enables the identification of important and less important system variables. The Effect System also indicates the viability and self-regulation of the system and thus is crucial for testing all the possible convergence options.

After the workshop phase, data collection will be completed. The model developed during the workshop will be used to test the various hypotheses. Initially, the viability and sustainability of the system is analysed through the eight basic bio-cybernetic principals. The number of feedback loops, as well as the dominance of negative feedback over positive feedback are important indicators for the viability of the system. The role of health system convergence can be determined through various simulations.

The analysis of the workshop will use the computerised Sensitivity Model® developed by Vester [77], which has its foundation in cybernetics and is designed to guide stakeholders to visualise and analyse the dynamics of complex systems. Through various policy simulation tests, the outcome of this participatory workshop and the simultaneous analysis will provide a

comprehensive and visual description of the variable interactions in the convergence of the health systems.

Expected outcomes

The expected outcome from this study will be a system model for describing and enhancing convergence between the human and the animal health system, based on the factors that affect the convergence process for effective prevention and control of zoonotic diseases in Ahmedabad, India. This will provide an insight into the entry points for One Health thinking (exploring the points for horizontal linking) within the complex (public as well as private) health system at a city level.

As far as we can see, this will be the first study of its kind to understand the health system from a One Health perspective in an Indian city. With the synchronised objectives of this study, it will not only document the current degree of interaction between One Health stakeholders, but also develop a convergence model for the human and the animal health systems, which will facilitate the One Health approach at city level. Recommendations from this study could be a potential source for future One Health policy and planning.

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Availability of data and materials
Data from this study will be available at the Center for Development Research (ZEF), Bonn, Germany, after the completion of this study. Researchers who meet the criteria for access to confidential data are encouraged to approach Dr Timo Falkenberg, Coordinator Fortschrittskolleg 'One Health', Center for Development Research (ZEF), Bonn, Genscherallee 3, 53,113 Bonn, Germany. Email: falkenberg@uni-bonn.de

Authors' contributions
All authors contributed equally to the development of this study. SY, WB, DS and TF participated in the conception and design of the protocol. SY drafted the first draft of the paper. WB, DS and TF critically reviewed the paper. All authors read and approved the final manuscript.

Ethics approval and consent to participate
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 the Indian Institute of Public Health Gandhinagar, India.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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References

1. 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. https://doi.org/10.1038/nature06536 .
2. Gebreyes WA, Dupouy-Camet J, Newport MJ, Oliveira CJB, 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. https://doi.org/10.1371/journal.pntd.0003257 .
3. Vandersmissen A, Welburn SC. Current initiatives in One Health: consolidating the One Health Global Network. Rev Sci Tech. 2014;33:421–32.
4. Bidaisee S, Macpherson CNL. Zoonoses and One Health: a review of the literature. J Parasitol Res. 2014;2014:874345. https://doi.org/10.1155/2014/874345 .
5. 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;23(13). https://doi.org/10.3201/eid2313.170418 .
6. Mazet JAK, Clifford DL, Coppolillo PB, Deolalikar AB, Erickson JD, Kazwala RR. A "One Health" approach to address emerging zoonoses: the HALI project in Tanzania. PLoS Med. 2009;6:e1000190. https://doi.org/10.1371/journal.pmed.1000190 .
7. Zinsstag J, Schelling E, Wyss K, Mahamat MB. Potential of cooperation between human and animal health to strengthen health systems. Lancet. 2005;366:2142–5. https://doi.org/10.1016/S0140-6736(05)67731-8 .
8. Kakkar M, Abbas SS, Roadmap to Combat Zoonoses in India (RCZI) Initiative. One Health: moving from concept to reality. Lancet Infect Dis. 2011;11:808. https://doi.org/10.1016/S1473-3099(11)70298-5 .
9. Degeling C, Johnson J, Kerridge I, Wilson A, Ward M, Stewart C, et al. Implementing a One Health approach to emerging infectious disease: reflections on the socio-political, ethical and legal dimensions. BMC Public Health. 2015;15:1307. https://doi.org/10.1186/s12889-015-2617-1 .
10. Kahn LH. Confronting zoonoses, linking human and veterinary medicine. Emerg Infect Dis. 2006;12:556–61. https://doi.org/10.3201/eid1204.050956 .
11. American Veterinary Medical Association. One Health: A New Professional Imperative. One Health Initiative Task Force; 2008. https://www.avma.org/KB/Resources/Reports/Documents/onehealth_final.pdf. Accessed 17 Jan 2018.
12. Papadopoulos A, Wilmer S. One Health: A Primer; 2011. http://ncceh.ca/sites/default/files/One_Health_Primer_Nov_2011.pdf. Accessed 17 Jan 2018.
13. Conrad PA, Meek LA, Dumit J. Operationalizing a One Health approach to global health challenges. Comp Immunol Microbiol Infect Dis. 2013;36:211–6. https://doi.org/10.1016/j.cimid.2013.03.006 .
14. Lee K, Brumme ZL. Operationalizing the One Health approach: the global governance challenges. Health Policy Plan. 2013;28:778–85. https://doi.org/10.1093/heapol/czs127 .
15. Kakkar M, Hossain S, Abbas SS. One Health: a perspective from the human health sector. Rev Sci Tech. 2014;33:407–12.
16. Queenan K. Roadmap to a One Health agenda 2030. CAB Reviews. 2017. https://doi.org/10.1079/PAVSNNR201712014 .
17. Bögel K, Griffiths RB, Mantovani A. Intersectoral collaboration in animal and human health. Ann Ist Super Sanita. 1992;28:445–50.
18. Stöhr K, Meslin FX. The role of veterinary public health in the prevention of zoonoses. Arch Virol Suppl. 1997;13:207–18.
19. Islam MA. Zoonoses in Bangladesh: the role of veterinarian in public health. Bangladesh J Vet Med. 2014;12:93–8. https://doi.org/10.3329/bjvm.v12i2.21257.
20. Schelling E, Bechir M, Ahmed MA, Wyss K, Randolph TF, Zinsstag J. Human and animal vaccination delivery to remote nomadic families, Chad. Emerg Infect Dis. 2007;13:373–9. https://doi.org/10.3201/eid1303.060391 .

21. Anholt RM, Stephen C, Copes R. Strategies for collaboration in the interdisciplinary field of emerging zoonotic diseases. Zoonoses Public Health. 2012;59:229–40. https://doi.org/10.1111/j.1863-2378.2011.01449.x .
22. One Health Bangladesh Secretariat. Strategic Framework for One Health Approach to Infectious Diseases in Bangladesh. Bangladesh; 2012. http://www.iedcr.gov.bd/pdf/files/One Health/Strategic_framework_for_One_Health_Bangladesh-26 Jan.pdf. Accessed 26 Jan 2018.
23. Sekar N, Shah NK, Abbas SS, Kakkar M. Research options for controlling zoonotic disease in India, 2010–2015. PLoS One. 2011;6:e17120. https://doi.org/10.1371/journal.pone.0017120 .
24. Varma GBSNP. India needs "One Health" policy to eradicate zoonotic diseases. Nat India. 2014. https://doi.org/10.1038/nindia.2014.97 .
25. Chatterjee P, Kakkar M, Chaturvedi S. Integrating one health in national health policies of developing countries: India's lost opportunities. Infect Dis Poverty. 2016;5:87. https://doi.org/10.1186/s40249-016-0181-2 .
26. Blanchet K, Nam SL, Ramalingam B, Pozo-Martin F. Governance and capacity to manage resilience of health systems: towards a new conceptual framework. Int J Heal Policy Manag. 2017;6:431–5. https://doi.org/10.15171/ijhpm.2017.36 .
27. Leischow SJ, Best A, Trochim WM, Clark PI, Gallagher RS, Marcus SE, et al. Systems thinking to improve the public's health. Am J Prev Med. 2008;35(2 Suppl):S196–203. https://doi.org/10.1016/j.amepre.2008.05.014 .
28. de Savigny D, Adam T. Systems Thinking for Health Systems Strengthening; 2009. http://apps.who.int/iris/bitstream/10665/44204/1/9789241563895_eng.pdf. Accessed 22 Aug 2017.
29. Atun R. Health systems, systems thinking and innovation. Health Policy Plan. 2012;27(suppl 4):iv4–8. https://doi.org/10.1093/heapol/czs088 .
30. Peters DH. The application of systems thinking in health: why use systems thinking? Heal Res Policy Syst. 2014;12:51. https://doi.org/10.1186/1478-4505-12-51 .
31. Xie T, Liu W, Anderson BD, Liu X, Gray GC. A system dynamics approach to understanding the One Health concept. PLoS One. 2017;12:e0184430. https://doi.org/10.1371/journal.pone.0184430 .
32. Checkland P. From optimizing to learning: a development of systems thinking for the 1990s. J Oper Res Soc. 1985;36:757. https://doi.org/10.2307/2582164 .
33. Adam T, de Savigny D. Systems thinking for strengthening health systems in LMICs: need for a paradigm shift. Health Policy Plan. 2012;27(suppl 4):iv1–3. https://doi.org/10.1093/heapol/czs084 .
34. Koskinen KU. Systemic view and systems thinking. In: Knowledge Production in Organizations. Heidelberg: Springer International Publishing; 2013. p. 13–30. https://doi.org/10.1007/978-3-319-00104-3_3 .
35. Ahmedabad Municipal Corporation. Ahmedabad City: Ahmedabad Municipal Corporation. About Ahmedabad City. 2017. https://ahmedabadcity.gov.in/portal/jsp/Static_pages/about_us.jsp. Accessed 2 Jan 2018.
36. Ministry of Home Affairs, Government of India. Office of the Registrar General and Census Commissioner, India. Indian Census 2011. 2011. http://www.censusindia.gov.in/. Accessed 2 Jan 2018.
37. Gupta I, Bhatia M. The Indian Health Care System. 2013. http://international.commonwealthfund.org/countries/india/. Accessed 2 Jan 2018.
38. Ahmedabad District Panchayat, Government of Gujarat. Ahmedabad District Panchayat. 2017. https://ahmedabaddp.gujarat.gov.in/ahmedabad/sakhao/pashupalan-shakha/prastavna.htm. Accessed 2 Jan 2018.
39. Royston G, Dost A, Townshend J, Turner H. Using system dynamics to help develop and implement policies and programmes in health care in England. Syst Dyn Rev. 1999;15:293–313.
40. Ghaffarzadegan N, Lyneis J, Richardson GP. How small system dynamics models can help the public policy process. Syst Dyn Rev. 2011;27:22–44. https://doi.org/10.1002/sdr.442 .
41. Ng V, Sargeant JM. Prioritizing Zoonotic Diseases: Differences in Perspectives Between Human and Animal Health Professionals in North America. Zoonoses Public Health. 2016;63:196–211. https://doi.org/10.1111/zph.12220 .
42. Pieracci EG, Hall AJ, Gharpure R, Haile A, Walelign E, Deressa A, et al. Prioritizing zoonotic diseases in Ethiopia using a one health approach. One Health. 2016;2:131–5. https://doi.org/10.1016/J.ONEHLT.2016.09.001 .
43. Rist CL, Arriola CS, Rubin C. Prioritizing zoonoses: a proposed one health tool for collaborative decision-making. PLoS One. 2014;9:e109986. https://doi.org/10.1371/journal.pone.0109986 .
44. Saaty TL. Decision Making with the Analytic Hierarchy Process. 2008. http://www.rafikulislam.com/uploads/resourses/197245512559a37aadea6d.pdf. Accessed 8 Oct 2018.
45. Schiller C, Winters M, Hanson HM, Ashe MC. A framework for stakeholder identification in concept mapping and health research: a novel process and its application to older adult mobility and the built environment. BMC Public Health. 2013;13:428. https://doi.org/10.1186/1471-2458-13-428 .
46. Leventon J, Fleskens L, Claringbould H, Schwilch G, Hessel R. An applied methodology for stakeholder identification in transdisciplinary research. Sustain Sci. 2016;11:763–75. https://doi.org/10.1007/s11625-016-0385-1 .
47. Mulvaney K, Tenbrink M. The Need for Systematic Identification of Stakeholders for Public Engagement with Environmental Research. International Symposium for Society and Resource Management. Charleston, SC; 2015. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=308316. Accessed 27 Feb 2018.
48. Kumar V, Rahman Z, Kazmi AA. Stakeholder identification and classification: a sustainability marketing perspective. Manag Res Rev. 2016;39:35–61. https://doi.org/10.1108/MRR-09-2013-0224.
49. Creswell J, Plano Clark V. Designing and Conducting Mixed Methods Research. London: Sage Publications Ltd.; 2007.
50. Lincoln YS, Guba EG. Naturalistic Inquiry. New York: SAGE Publications, Inc.; 1985.
51. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19:349–57.
52. ATLAS.ti Development Team. ATLAS.ti. 1999. https://atlasti.com/. Accessed 17 Sep 2017.
53. Hyder A, Syed S, Puvanachandra P, Bloom G, Sundaram S, Mahmood S, et al. Stakeholder analysis for health research: Case studies from low- and middle-income countries. Public Health. 2010;124:159–66. https://doi.org/10.1016/j.puhe.2009.12.006 .
54. Varvasovszky Z, Brugha R. How to do (or not to do)... A stakeholder analysis. Health Policy Plan. 2000;15:338–45.
55. Bryson JM. What to do when stakeholders matter. Public Manag Rev. 2004;6:21–53. https://doi.org/10.1080/14719030410001675722 .
56. Ackermann F, Eden C. Strategic Management of Stakeholders: Theory and Practice. Long Range Plan. 2011;44:179–96. https://doi.org/10.1016/J.LRP.2010.08.001 .
57. Schoen MW, Moreland-Russell S, Prewitt K, Carothers BJ. Social network analysis of public health programs to measure partnership. Soc Sci Med. 2014;123:90–5. https://doi.org/10.1016/j.socscimed.2014.10.057 .
58. Long JC, Cunningham FC, Carswell P, Braithwaite J. Patterns of collaboration in complex networks: the example of a translational research network. BMC Health Serv Res. 2014;14:225. https://doi.org/10.1186/1472-6963-14-225 .
59. Luke DA, Harris JK. Network analysis in public health: history, methods, and applications. Annu Rev Public Health. 2007;28:69–93. https://doi.org/10.1146/annurev.publhealth.28.021406.144132 .
60. Blanchet K, James P. How to do (or not to do) ... a social network analysis in health systems research. Health Policy Plan. 2012;27:438–46. https://doi.org/10.1093/heapol/czr055 .
61. Hennig M, Brandes U, Pfeffer J, Mergel I. Studying Social Networks: A Guide to Empirical Research. Frankfurt: Campus Verlag; 2012.
62. Harris JK, Luke DA, Burke RC, Mueller NB. Seeing the forest and the trees: Using network analysis to develop an organizational blueprint of state tobacco control systems. Soc Sci Med. 2008;67:1669–78. https://doi.org/10.1016/J.SOCSCIMED.2008.07.013 .
63. Scott J. Social network analysis. Sociology. 1988;22:109–27. https://doi.org/10.1177/0038038588022001007 .
64. Borgatti S, Mehra A, Brass D, Labianca G. Network analysis in the social sciences. Science. 2009;323:892–5. https://doi.org/10.1126/science.1165821 .
65. Webb C, Bodin Ö. A network perspective on modularity and control of flow in robust systems - Stockholm Resilience Centre. In: Norberg J, Cumming G, editors. Complexity Theory for a Sustainable Future. New York: Columbia Press; 2008. p. 85–118. http://www.stockholmresilience.org/publications/artiklar/2010-01-05-a-network-perspective-on-modularity-and-control-of-flow-in-robust-systems.html. Accessed 27 Feb 2018.
66. Borgatti SP, Everett MG, Freeman L. Ucinet for Windows: Software for Social Network Analysis; 2002. https://sites.google.com/site/ucinetsoftware/home. Accesssed 19 Feb 2018.
67. Finch J. The vignette technique in survey research. Sociology. 1987;21:105–14. https://doi.org/10.1177/0038038587021001008 .
68. Evans SC, Roberts MC, Keeley JW, Blossom JB, Amaro CM, Garcia AM, et al. Vignette methodologies for studying clinicians' decision-making: validity, utility, and application in ICD-11 field studies. Int J Clin Heal Psychol. 2015;15:160–70. https://doi.org/10.1016/J.IJCHP.2014.12.001.

69. Jackson M, Harrison P, Swinburn B, Lawrence M. Using a qualitative vignette to explore a complex public health issue. Qual Health Res. 2015;25:1395–409. https://doi.org/10.1177/1049732315570119 .
70. Helmer-Hirschberg O. Analysis of the Future: The Delphi Method. RAND Pap. 3558. 1967. https://www.rand.org/pubs/papers/P3558.html. Accessed 2 May 2018.
71. Turoff M. The design of a policy Delphi. Technol Forecast Soc Change. 1970; 2:149–71. https://doi.org/10.1016/0040-1625(70)90161-7 .
72. de Meyrick J. The Delphi method and health research. Health Educ. 2003; 103:7–16. https://doi.org/10.1108/09654280310459112 .
73. Finley R. Survey Monkey: An Online Survey Tool; 1999. www.surveymonkey.com. Accessed 21 Apr 2018.
74. Moher D, Schulz KF, Simera I, Altman DG. Guidance for developers of health research reporting guidelines. PLoS Med. 2010;7:e1000217. https://doi.org/10.1371/journal.pmed.1000217 .
75. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. BMJ. 2014;348:g1687. https://doi.org/10.1136/BMJ.G1687 .
76. Schmittdiel JA, Grumbach K, Selby JV. System-based participatory research in health care: an approach for sustainable translational research and quality improvement. Ann Fam Med. 2010;8:256–9. https://doi.org/10.1370/afm.1117 .
77. Vester F. The Art of Interconnected Thinkging: Ideas and Tools for a New Approach to Tackling Complexity. Saarbrücken: MCB Publishing House; 2007.

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CORRECTION Open Access

Correction to: Convergence model for effectual prevention and control of zoonotic diseases: a health system study on 'One Health' approach in Ahmedabad, India

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It was highlighted that the original article [1] contained an error in the Methods section, specifically in Study Section. The number urban health centres should be 72 instead of 6. This Correction article shows the incorrect and correct statement in the Methods section.

Incorrect statement:

The rural areas of Ahmedabad have one district hospital, six community health offices and 36 primary health centres [3], whereas the urban areas of Ahmedabad have six urban health centres, six medical colleges and one homeopathy college as well as being well facilitated by private companies for human health [2].

Correct statement:

The rural areas of Ahmedabad have one district hospital, six community health offices and 36 primary health centres [3], whereas the urban areas of Ahmedabad have 72 urban health centres, six medical colleges and one homeopathy college as well as being well facilitated by private companies for human health [2].

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References

1. Yasobant, et al. Convergence model for effectual prevention and control of zoonotic diseases: a health system study on 'one health' approach in Ahmedabad, India. Health Res Policy Syst. 2018;16:124. https://doi.org/10.1186/s12961-018-0398-6.
2. Ahmedabad Municipal Corporation. Ahmedabad city: Ahmedabad municipal Corporation. About Ahmedabad city. 2017. https://ahmedabadcity.gov.in/ portal/jsp/Static_pages/about_us.jsp. Accessed 2 Jan 2018.
3. Ahmedabad District Panchayat, Government of Gujarat. Ahmedabad District Panchayat. 2017. https://ahmedabaddp.gujarat.gov.in/ahmedabad/sakhao/pashupalan-shakha/prastavna.htm. Accessed 2 Jan 2018.

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2.2. Publication 2

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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 fil 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

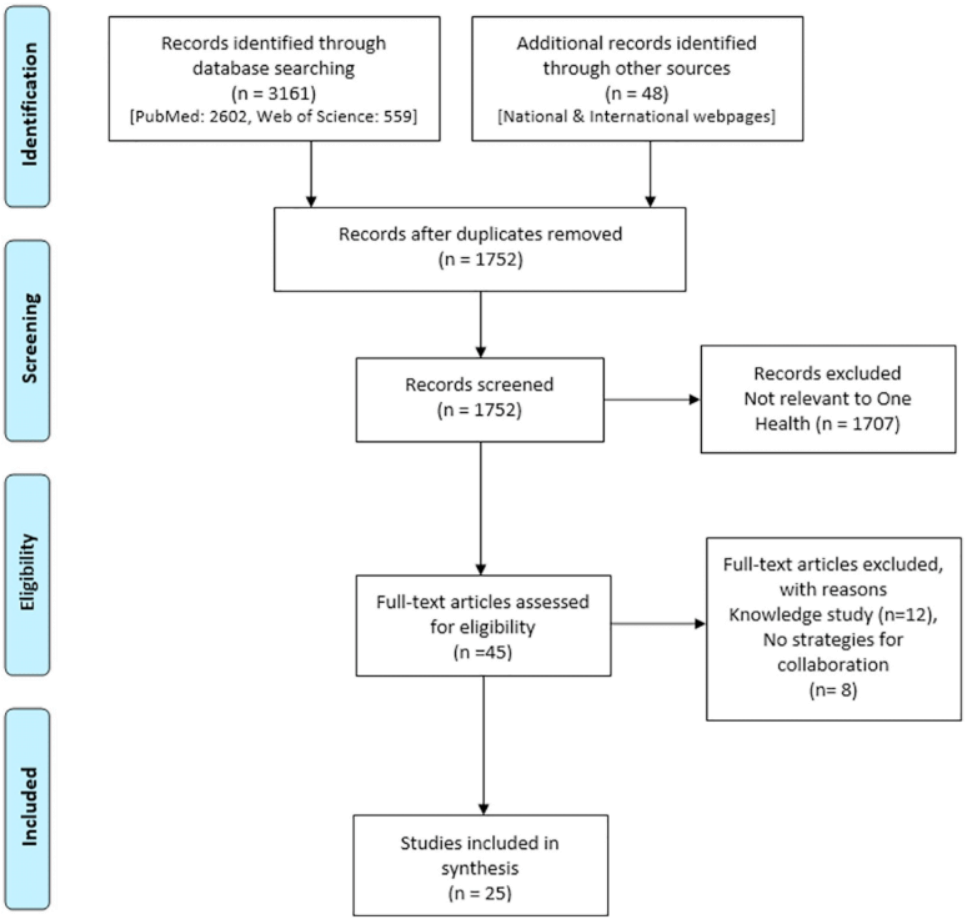

Fig. 1. PRISMA Chart showing the reviewed seminal articles/reports for the country-specific collaboration strategies and/or initiatives.

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 initiates 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]	Tanzania	Collaboration of health experts with other disciplines in OH.	12% health experts collaborated with animal experts and 27% vice-versa.
	Sweeney JM et al., [55]	USA	Establishment of One Health Clinics.	One Health-based clinic was established using an interdisciplinary approach to individual and community health.
	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.
Level-based (Population) Collaboration	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 *Campylobacter*.	Increase in cost associated with integrated surveillance with increased burden of disease.
	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.
Level-based (Research) collaboration	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.
Solution-based 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]	Uganada	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.
	Torres AG, [66]	Latin America	Establishing a multi-disciplinary group of scientists for *Escherichia coli* Research.	Way for national as well as international collaboration for E.coli.
	Suluku 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.
Third-party based collaboration	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.

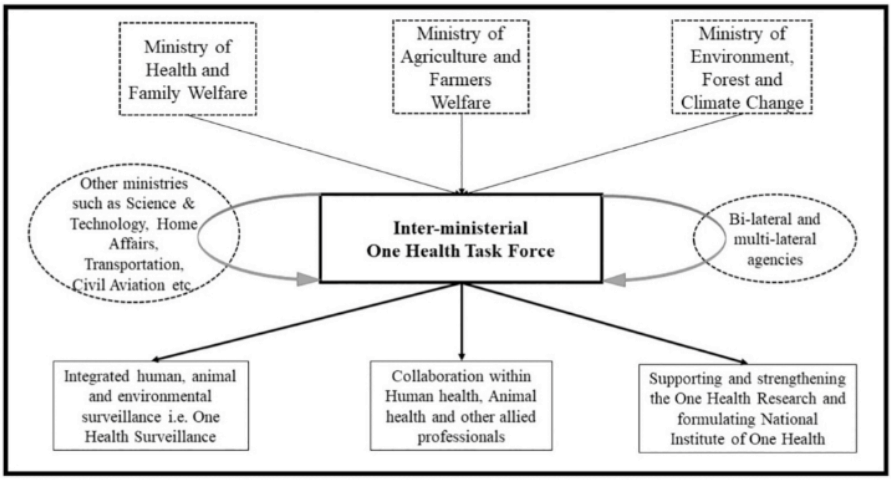

Fig. 2. Envisaged One Health Collaboration model for India.

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 gloablly, 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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References

[1] H. Lerner, C. Berg, The concept of health in one health and some practical implications for research and education: what is one health? Infect. Ecol. Epidemiol. 5 (2015) Internet. cited 2018 Jun 4. 25300. Available from http://www.ncbi.nlm.nih.gov/pubmed/25660757.

[2] World Organisation for Animal Health, One Health: As a Concept [Internet], OIE, 2000 [cited 2018 Jun 4]. p. 1. Available from: http://www.oie.int/en/for-the-media/onehealth/.

[3] Centers for Disease Control and Prevention, One Health Basics [Internet], National Center for Emerging and Zoonotic Infectious Diseases (NCEZID), 2006 [cited 2018 Jun 4]. p. 1. Available from: https://www.cdc.gov/onehealth/basics/index.html.

[4] World Health Organization, One Health: As an approach [Internet], WHO. World Health Organization, 2005, p. 1 cited 2018 Jun 4. Available from http://www.who.int/features/qa/one-health/en/.

[5] One Health Global Network, What Is One Health? [Internet], OHGN, 2011 [cited 2018 Jun 4]. Available from: http://www.onehealthglobal.net/what-is-one-health/.

[6] S. Bidaisee, C.N.L. Macpherson, Zoonoses and one health: a review of the literature, J. Parasitol. Res. (2014), https://doi.org/10.1155/2014/874345 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3928857/ Internet. 2014:874345. Available from:.

[7] K. Jindai, R.T. McLellan, S. Takakura, H. Noda, K. Miyake, Nippon AMR one health report: the first step towards multisectoral collaboration, Lancet Infect. Dis. 18 (11) (2018 Nov 1) Internet. cited 2019 Apr 2. 1179–80. Available from http://www.ncbi.nlm.nih.gov/pubmed/30507398.

[8] K. Buse, G. Walt, The World Health Organization and global-public private health partnerships: in search of "good" global health governance, in: N. Yeates, C. Holden (Eds.), The Global Social Policy Reader [Internet], Policy Press, Bristol, 2009[cited 2019 Apr 2]. p. 169–95. Available from: https://books.google.co.in/books?hl=en&lr=&id=qd01DwAAQBAJ&oi=fnd&pg=PA195&dq=13.Buse+K,+Walt+G.+2002.+++The+World+Health+Organization+and+global+public-private+health+partnerships:+in+search+of+"good"+global+health+governance.+See+Ref.+46,+pp.+169–95&ots.

[9] World Health Organization, Intersectoral action for health: the role of intersectoral cooperation in national strategies for Health for All [Internet]. Geneva, (1986) [cited 2019 May 22]. Available from: https://apps.who.int/iris/bitstream/handle/10665/41545/9241560967_eng.pdf?sequence=1&isAllowed=y.

[10] World Health Organization, Intersectoral Action for Health [Internet], WHO. World Health Organization, 2014 [cited 2017 Dec 26]. p. 1. Available from: http://www.who.int/kobe_centre/interventions/intersectorial_action/en/.

[11] C.W. Schwabe, Veterinary Medicine and Human Health, Williams & Wilkins, 1984, p. 680.

[12] P.A. Conrad, L.A. Meek, J. Dumit, Operationalizing a one health approach to global health challenges, Comp. Immunol. Microbiol. Infect. Dis. 36 (3) (2013 May), https://doi.org/10.1016/j.cimid.2013.03.006 https://www.ncbi.nlm.nih.gov/pubmed/23711930 Internet. 211–6. Available from:.

[13] R. Coker, J. Rushton, S. Mounier-Jack, E. Karimuribo, P. Lutumba, D. Kambarage, et al., Towards a conceptual framework to support one-health research for policy on emerging zoonoses, Lancet Infect. Dis. 11 (4) (2011 Apr), https://doi.org/10.1016/S1473-3099(10)70312-1 https://www.ncbi.nlm.nih.gov/pubmed/21376670 Internet. 326–31. Available from:.

[14] A.L. Okello, E.P.J. Gibbs, A. Vandersmissen, S.C. Welburn, One health and the neglected zoonoses: turning rhetoric into reality, Vet. Rec. 169 (11) (2011) 281–285 Internet. Available from https://doi.org/10.1136/vr.d5378.

[15] T. Marcotty, E. Thys, P. Conrad, J. Godfroid, P. Craig, J. Zinsstag, et al., Intersectoral collaboration between the medical and veterinary professions in low-resource societies: the role of research and training institutions, Comp. Immunol. Microbiol. Infect. Dis. 36 (3) (2013), https://doi.org/10.1016/j.cimid.2012.10.009 https://www.ncbi.nlm.nih.gov/pubmed/23260374 Internet. 233–9. Available from:.

[16] I. Supper, O. Catala, M. Lustman, C. Chemla, Y. Bourgueil, L. Letrilliart, Interprofessional Collaboration in Primary Health Care: A Review of Facilitators and Barriers Perceived by Involved Actors, cited. Available from, 2019 Apr 2. https://academic.oup.com/jpubhealth/article-abstract/37/4/716/2362834.

[17] M. Karam, I. Brault, T. Van Durme, J. Macq, Comparing interprofessional and interorganizational collaboration in healthcare: a systematic review of the qualitative research, Int. J. Nurs. Stud. 79 (2018 Mar 1) 70–83 Internet. cited 2019 Apr 2. Available from https://www.sciencedirect.com/science/article/pii/S0020748917302559.

[18] J.P. Narain, Public health challenges in india: seizing the opportunities, Indian J. Community Med. 41 (2) (2016) cited 2018 May 18. 85–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27051080.

[19] K.D. Rao, D.H. Peters, Urban health in India: many challenges, few solutions, Lancet Glob. Health 3 (12) (2015 Dec 1) Internet. cited 2018 May 18. e729–30. Available from http://linkinghub.elsevier.com/retrieve/pii/S2214109X15002107.

[20] J.R. Kumar, Role of public health systems in the present health scenario: key challenges, Indian J. Public Health 57 (3) (2013 Jan 1) Internet. cited 2016 Apr 5. 133–7. Available from: http://www.ijph.in/article.asp?issn=0019-557X;year=2013;volume=57;issue=3;spage=133;epage=137;aulast=Kumar.

[21] L. Kant, Combating emerging infectious diseases in India: orchestrating a symphony, J. Biosci. 33 (4) (2008) Internet. cited 2018 May 18. 425–7. Available from https://www.ias.ac.in/article/fulltext/jbsc/033/04/0425-0427.

[22] R. Srinivisan, Healthcare in India- Vision 2020: Issues & Prospects [Internet], Planning Commission of India, 2010 Available from planningcommission.nic.in/reports/genrep/bkpap2020/26_bg2020.doc.

[23] A. Sengupta, S. Nundy, The private health sector in India. BMJ (Clinical research ed) [Internet], 331 (7526) (2005 Nov 19) cited 2018 May 18. 1157–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16293815.

[24] K.B. Thadani, Public private partnership in the health sector: boon or bane, Procedia Soc. Behav. Sci. 157 (2014 Nov 27) Internet. cited 2018 May 18. 307–16. Available from https://www.sciencedirect.com/science/article/pii/S1877042814058534.

[25] T.J. John, L. Dandona, V.P. Sharma, M. Kakkar, Continuing challenge of infectious diseases in India, Lancet (London, England) 377 (9761) (2011 Jan 15) Internet. cited 2019 Mar 31. 252–69. Available from http://www.ncbi.nlm.nih.gov/pubmed/21227500.

[26] National Institute of Health and Family Welfare, National Health Programs in India [Internet], Ministry of Health and Family Welfare, Government of India, 2019 [cited 2019 May 9]. p. 1. Available from: https://www.nhp.gov.in/healthprogramme/national-health-programmes.

[27] K.D. Rao, S. Ramani, I. Hazarika, S. George, When do vertical programmes strengthen health systems? A comparative assessment of disease-specific interventions in India, Health Policy Plan. 29 (4) (2014 Jul 1) 495–505 Internet. cited 2019 May 9. Available from https://academic.oup.com/heapol/article-lookup/doi/10.1093/heapol/czt035.

[28] National Health Systems Resource Centre, National Health Accounts: Etimates for India [Internet]. New Delhi, [cited 2019 May 9]. Available from: https://mohfw.gov.in/sites/default/files/National Health Accounts Estimates Report 2014-15.pdf.

[29] PS R, The epidemic diseases act of 1897: public health relevance in the current scenario, Indian J Med Ethics 1 (3) (2016 Jul-Sep) NS:156–NS:160.

[30] National Centre for Disease Control . About NCDC [Internet]. Directoarte General of Health Services, Ministry of Health & Family Welfare, Governemnt of India. [cited 2019 Mar 31]. p. 8. Available from: https://ncdc.gov.in/index4.php?lang=1&level=0&linkid=28&lid=33

[31] Centre for Health Informatics, National Institute of Health and Family Welfare (NIHFW), Outbreak investigation [Internet], Ministry of Health and Family Welfare (MoHFW), Government of India, 2019 cited [2019 March 10]. Available from: https://www.nhp.gov.in/outbreak-investigation_pg.

[32] National Centre for Disease Control- Directorate General of Health Services, Integrated Disease Surevillance Programme (IDSP) [Internet], Ministry of Health & Family Welfare, Governement of India, 2010 [cited 2017 Oct 10]. Available from: http://www.idsp.nic.in/.

[33] Ministry of Agriculture and Farmers Welfare, Department of Animal Husbandry [Internet], Government of India, 2019 [cited 2019 May 9]. p. 12. Available from: http://www.dahd.nic.in/.

[34] Department of Animal Husbandry, Dairying & Fisheries, National Animal Disease Reporting System (NADRS) [Internet], Ministry of Agriculture and Farmers Welfare, Government of India, 2012 [cited 2017 Aug 16]. Available from: http://nadrsapps.gov.in/.

[35] D. Kshirsagar, C. Savalia, I. Kalyani, R. Kumar, D.N. Nayak, Disease alerts and forecasting of zoonotic diseases: an overview, Vet. World 6 (11) (2013) Internet. cited 2019 May 9. 889–96. Available from: www.veterinaryworld.org/Vol.6/Nov-2013/12.pdf.

[36] The Gazette of India, The Preventive and Control of Infectious and Contagious Diseases in Animals Act, 2009 [Internet], Ministry of Law and Justice, New Delhi, 2009 p. 04/007/2003-09. Available from: http://dahd.nic.in/sites/default/filess/Gazette_20-03-09.pdf09.pdf.

[37] N. Sekar, N.K. Shah, S.S. Abbas, M. Kakkar, Research options for controlling zoonotic disease in India, 2010-2015, PLoS One 6 (2) (2011), https://doi.org/10.1371/journal.pone.0017120 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0017120 Internet. e17120. Available from:.

[38] G.B.S.N.P. Varma, India needs "one health" policy to eradicate zoonotic diseases, Nat. India (2014), https://doi.org/10.1038/nindia.2014.97 https://www.natureasia.com/en/nindia/article/10.1038/nindia.2014.97 Internet. Available from:.

[39] P. Chatterjee, M. Kakkar, S. Chaturvedi, Integrating one health in national health policies of developing countries: India's lost opportunities, Infect. Dis. Poverty 5 (1) (2016) 87 Internet. Available from https://doi.org/10.1186/s40249-016-0181-2.

[40] G.V. Asokan, V. Asokan, P. Tharyan, One health national programme across species on zoonoses: a call to the developing world, Infect. Ecol. Epidemiol. (2011) 1 Internet. Available from https://doi.org/10.3402/iee.v1i0.8293.

[41] S. Ghatak, B.B. Singh, Veterinary public health in India: current status and future needs, Rev. Sci. Tech. (Int. Off. Epizootics) 34 (3) (2015) 713–727.

[42] M. Kakkar, S. Hossain, S.S. Abbas, One health: a perspective from the human health sector, Rev. Sci. Tech. (Int. Off. Epizootics) 33 (2) (2014) 407–412.

[43] A. Sharma, S.P. Zodpey, Transforming public health education in India through networking and collaborations: opportunities and challenges, Indian J. Public Health 57 (3) (2013) Internet. cited 2019 Apr 2. 155–60. Available from http://www.ncbi.nlm.nih.gov/pubmed/24125930.

[44] Sustainable Strategies for a Healthy India, Imperatives for Consolidating the Healthcare Management Ecosystem [Internet], [cited 2019 Apr 2]. Available from: www.deloitte.com/in.

[45] A. Liberati, D.G. Altman, J. Tetzlaff, C. Mulrow, P.C. Gøtzsche, J.P.A. Ioannidis, et al., The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration, BMJ (Clin. Res. ed) 339 (2009 Jul 21) Internet. [cited 2019 May 20];339:b2700. Available from http://www.ncbi.nlm.nih.gov/pubmed/19622552.

[46] L.H. Kahn, Confronting zoonoses, linking human and veterinary medicine, Emerg. Infect. Dis. 12 (4) (2006), https://doi.org/10.3201/eid1204.050956 https://wwwnc.cdc.gov/eid/article/12/4/05-0956_article Internet. 556–61. Available from:.

[47] J. Zinsstag, E. Schelling, K. Wyss, M.B. Mahamat, Potential of cooperation between human and animal health to strengthen health systems, Lancet (London, England) 366 (9503) (2005 Dec 17) Internet. cited 2017 Dec 27. 2142–5. Available from http://www.ncbi.nlm.nih.gov/pubmed/16360795.

[48] R.M. Anholt, C. Stephen, R. Copes, Strategies for collaboration in the interdisciplinary field of emerging zoonotic diseases, Zoonoses Public Health 59 (4) (2012 Jun 1), https://doi.org/10.1111/j.1863-2378.2011.01449.x https://www.ncbi.nlm.nih.gov/pubmed/22273426 Internet. 229–40. cited 2018 Jan 26. Available from:.

[49] K.A. Kayunze, A. Kiwara, E. Lyamuya, D.M. Kambarage, J. Rushton, R. Coker, et al., Practice of one health approaches: bridges and barriers in Tanzania, Onderstepoort J Vet Res 81 (2) (2014 Apr 23) Internet. cited 2019 Apr 7. E1–8. Available from http://www.ncbi.nlm.nih.gov/pubmed/25004794.

[50] M.S. Wilkes, P.A. Conrad, J.N. Winer, One health–one education: medical and veterinary inter-professional training, J. Vet. Med. Educ. 46 (1) (2019 Feb 25) 14–20 Internet. cited 2019 Apr 7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30418808.

[51] Eussen BGM, J. Schaveling, M.J. Dragt, R.J. Blomme, Stimulating collaboration between human and veterinary health care professionals, BMC Vet. Res. 13 (1) (2017 Dec 13) 174 Internet. cited 2019 Apr 21. Available from: http://bmcvetres.biomedcentral.com/articles/10.1186/s12917-017-1072-x.

[52] H.J. Amuguni, M. Mazan, R. Kibuuka, Producing interdisciplinary competent professionals: integrating one health core competencies into the veterinary curriculum at the University of Rwanda, J. Vet. Med. Educ. 44 (4) (2017 Nov) Internet. cited 2019 Apr 7. 649–59. Available from http://www.ncbi.nlm.nih.gov/pubmed/27779918.

[53] J. Muma, M. Simuunza, K. Mwachalimba, M. Munyeme, B. Namangala, C. Hankanga, et al., Development of a curriculum for training in one health analytical epidemiology at the University of Zambia, Onderstepoort J. Vet. Res. 79 (2) (2012 Jun 26) Internet. cited 2019 Apr 8. Available from http://ojvr.org/index.php/ojvr/article/view/475.

[54] A. Sommanustweechai, S. Iamsirithaworn, W. Patcharanarumol, W. Kalpravidh, V. Tangcharoensathien, Adoption of one health in Thailand's national strategic plan for emerging infectious diseases, J. Public Health Policy 38 (1) (2017 Feb 17) Internet. cited 2019 Apr 7. 121–36. Available from http://www.ncbi.nlm.nih.gov/pubmed/28275255.

[55] J.M. Sweeney, P.Z. Crook, N. Deeb-Sossa, B. Tu, J.D. Dear, Mazet JAK, Clinical one health: A novel healthcare solution for underserved communities, One Health 6 (34) (2018) Internet. cited 2019 Apr 7. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6205339/.

[56] M.G. Dente, F. Riccardo, F. Bolici, N.A. Colella, V. Jovanovic, M. Drakulovic, et al., Implementation of the one health approach to fight arbovirus infections in the Mediterranean and Black Sea Region: assessing integrated surveillance in Serbia, Tunisia and Georgia, Zoonoses and Public Health, 2019 Feb 5 Internet. [cited 2019 Apr 7];zph.12562. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30724030.

[57] S. Babo Martins, J. Rushton, K. Stark, Economics of zoonoses surveillance in a 'one health' context: an assessment of campylobacter surveillance in Switzerland, Epidemiol. Infect. 145 (06) (2017 Apr 23) Internet. cited 2019 Apr 7. 1148–58. Available from http://www.ncbi.nlm.nih.gov/pubmed/28112074.

[58] M. Bordier, A. Binot, Q. Pauchard, D.T. Nguyen, T.N. Trung, N. Fortané, et al., Antibiotic resistance in Vietnam: moving towards a one health surveillance system, BMC Public Health 18 (1) (2018 Dec 24) 1136 Internet. cited 2019 Apr 7. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-6022-4.

[59] E.D. Karimuribo, K. Sayalel, E. Beda, N. Short, P. Wambura, L.G. Mboera, et al., Towards one health disease surveillance: the Southern African centre for infectious disease surveillance approach, Onderstepoort J. Vet. Res. 79 (2) (2012 Jun 20) 7 Internet. cited 2019 Apr 20. Available from: https://ojvr.org/index.php/ojvr/article/view/454/565.

[60] S.N. Mohd Zain, M.-G. Basáñez, Collaborate or collapse: capacity building in zoonotic and neglected tropical disease modelling, Trends Parasitol. 34 (5) (2018 May) Internet. cited 2019 Apr 7. 356–8. Available from http://www.ncbi.nlm.nih.gov/pubmed/29358040.

[61] A. Roess, S. Lahm, I. Kabbash, A. Saad-Hussein, A. Shaalan, O. Rasslan, et al., Responding to emerging diseases requires multi-disciplinary and one health training, Egypt, Ann. Global Health 84 (4) (2018 Nov 5) Internet. cited 2019 Apr 7. 650–3. Available from http://www.ncbi.nlm.nih.gov/pubmed/30779513.

[62] C. Robinette, L. Saffran, A. Ruple, S.L. Deem, Zoos and public health: a partnership on the one health frontier, One Health 3 (2017 Jun) 1–4 Internet. cited 2019 Apr 8. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2352771416300283.

[63] [Internet], Z. Zheng, Y. Lu, K.R. Short, J. Lu, One health insights to prevent the next HxNy viral outbreak: learning from the epidemiology of H7N9, BMC Infect. Dis. 19 (1) (2019) 138 2019 Dec 11 [cited 2019 Apr 7]; Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-019-3752-6.

[64] J. Morton, The Innovation Trajectory of Sleeping Sickness Control in Uganda: Research Knowledge in its Context [Internet]. California, [cited 2019 Apr 20]. Report No.: 08. Available from: https://assets.publishing.service.gov.uk/media/57a08b29e5274a31e00009f4/riu10discuss08ssickcntrl-ug.pdf.

[65] S.A. Reid, A. Rodney, M. Kama, P.S. Hill, A process for developing multisectoral strategies for zoonoses: the case of leptospirosis in Fiji, BMC Public Health 17 (1) (2017) 671 Internet. Available from https://doi.org/10.1186/s12889-017-4673-1.

[66] A.G. Torres, Escherichia coli diseases in Latin America—a 'One Health' multidisciplinary approach, Pathog. Dis. 75 (2) (2017 Mar 1) Internet. cited 2019 Apr 8. Available from https://academic.oup.com/femspd/article-lookup/doi/10.1093/femspd/ftx012.

[67] E. Schelling, M. Bechir, M.A. Ahmed, K. Wyss, T.F. Randolph, J. Zinsstag, Human and animal vaccination delivery to remote nomadic families, Chad, Emerg. Infect. Dis. 13 (3) (2007 Mar) Internet. cited 2018 Mar 8. 373–9. Available from http://www.ncbi.nlm.nih.gov/pubmed/17552089.

[68] R. Suluku, Animal health clubs in Sierra Leone, American Association for the Advancement of Science, 2012, p. 14 Internet. Available from https://www.cdc.gov/onehealth/pdf/atlanta/roland_suluku.pdf.

[69] M. Mbabu, I. Njeru, S. File, E. Osoro, S. Kiambi, A. Bitek, et al., Establishing a one health office in Kenya, Pan Afr. Med. J. 19 (2014) 106 Internet. cited 2019 Apr 7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25722779.

[70] Z. Batsukh, B. Tsolmon, D. Otgonbaatar, B. Undraa, A. Dolgorkhand, O. Ariuntuya, One Health in Mongolia ([cited 2019 Apr 8]. p. 123–37. Available from:),, 2012. http://link.springer.com/10.1007/82_2012_253.

[71] One Health Bangladesh Secretariat, Strategic Framework for One Health Approach to Infectious Diseases in Bangladesh [Internet]. Bangladesh, [cited 2018 Jan 26]. Available from, 2012. http://www.iedcr.gov.bd/pdf/files/OneHealth/Strategic_framework_for_One_Health_Bangladesh-26 Jan.pdf.

[72] Indian Council of Medical Research, Joint ICMR-ICAR Meeting to Establish National Institute of Zoonoses at Nagpur, [Internet]. Media Release. [cited 2018 May 18]. p.

1. Available from: http://icmr.nic.in/mou/ICAR-ICMR1.pdf.
[73] N. Sekar, N.K. Shah, S.S. Abbas, M. Kakkar, Roadmap to Combat Zoonoses in India initiative on behalf of the R to CZ in I (RCZI). Research options for controlling zoonotic disease in India, 2010–2015, PLoS One 6 (2) (2011 Feb 25) Internet. cited 2018 Aug 7. e17120. Available from http://www.ncbi.nlm.nih.gov/pubmed/21364879.
[74] Directorate General of Health Services, Contingency Plan for Management of Human Cases of Avian Influenza [Internet]. New Delhi, [cited 2019 May 21]. Available from: http://www.fao.org/docs/eims/upload/221470/national_plan_ai_ind_en.pdf.
[75] National Centre for Disease Control, National Guidelines Diagnosis, Case Management Prevention and Control of Leptospirosis [Internet]. New Delhi, [cited 2019 May 21]. Available from: https://ncdc.gov.in/WriteReadData/l892s/File558.pdf.
[76] S.S. Abbas, V. Venkataramanan, G. Pathak, M. Kakkar, Rabies control initiative in Tamil Nadu, India: a test case for the 'one health' approach, Int. Health 3 (4) (2011 Dec 1) Internet. cited 2019 Apr 21. 231–9. Available from https://academic.oup.com/inthealth/article-lookup/doi/10.1016/j.inhe.2011.08.001.
[77] A. Kasthuri, Challenges to healthcare in India - the five A's, Indian J. Community Med. 43 (3) (2018) cited 2019 May 21. 141–3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30294075.
[78] R.C. Swanson, A. Cattaneo, E. Bradley, S. Chunharas, R. Atun, K.M. Abbas, et al., Rethinking health systems strengthening: key systems thinking tools and strategies for transformational change, Health Policy Plan. 27 (2012) 54–61 Internet. cited 2019 May 21. Available from: https://academic.oup.com/heapol/article-abstract/27/suppl_4/iv54/621407.
[79] British Veterinary Association, One health: collaboration on all levels is key, concludes joint meeting, Vet. Rec. 174 (26) (2014 Jun 28) 644 Internet. cited 2018 Feb 23. Available from http://www.ncbi.nlm.nih.gov/pubmed/24970622.
[80] P.M. Rabinowitz, B.J. Natterson-Horowitz, L.H. Kahn, R. Kock, M. Pappaioanou, Incorporating one health into medical education, BMC Med. Educ. 17 (1) (2017 Dec 23) 45 Internet. cited 2019 Apr 7. Available from http://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-017-0883-6.
[81] S. Jasani, Using a one health approach can foster collaboration through transdisciplinary teaching, Med. Teacher (2018 Aug 3) 1–3 Internet. cited 2019 Apr 7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30071742.
[82] J. Harries, Collaboration on one health: starting with students, Vet. Rec. 176 (21) (2015 May 23) 538 Internet. cited 2019 Apr 7. Available from http://www.ncbi.nlm.nih.gov/pubmed/25998764.
[83] R. Speare, D. Mendez, J. Judd, S. Reid, S. Tzipori, P.D. Massey, Willingness to consult a veterinarian on physician's advice for zoonotic diseases: a formal role for veterinarians in medicine? PLoS One 10 (8) (2015), https://doi.org/10.1371/journal.pone.0131406 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0131406 Internet. e0131406. Available from:.
[84] K. Ramani, D. Mavalankar, Health System in India: Opportunities and Challenges for Improvements [Internet]. Ahmedabad, [cited 2018 Jun 4]. Report No.: WP No. 2005-07-03. Available from: https://web.iima.ac.in/assets/snippets/workingpaperpdf/2005-07-03ramani.pdf.
[85] P. Garg, J. Nagpal, A review of literature to understand the complexity of equity, ethics and management for achieving public health goals in India, J. Clin. Diagn. Res. 8 (2) (2014 Feb) 1–6 cited 2018 Jun 4. Available from http://www.ncbi.nlm.nih.gov/pubmed/24701465.
[86] National Institute of Health & Family Welfare, Comprehensive Primary Health Care through Health and Wellness Centers: Operational Guidelines [Internet]. New Delhi, [cited 2019 Apr 21]. Available from: http://nhsrcindia.org/sites/default/files/Operational Guidelines For Comprehensive Primary Health Care through Health and Wellness Centers.pdf.
[87] Ministry of Health and Family Welfare, Training Manual for Veterinary Consultants under IDSP [Internet]. New Delhi, [cited 2019 Apr 21]. Available from: https://idsp.nic.in/showfile.php?lid=3793.
[88] L.K. Allen-Scott, B. Buntain, J.M. Hatfield, A. Meisser, C.J. Thomas, Academic institutions and one health: building capacity for transdisciplinary research approaches to address complex health issues at the animal-human-ecosystem interface, Acad. Med. 90 (7) (2015 Jul) Internet. cited 2019 Apr 7. 866–71. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25650827.
[89] G.V. Asokan, V. Asokan, Z. Fedorowicz, P. Tharyan, Use of a systems approach and evidence-based one health for zoonoses research, J. Evid.-Based Med. 4 (2) (2011 May) Internet. cited 2019 Apr 7. 62–5. Available from http://www.ncbi.nlm.nih.gov/pubmed/23672696.
[90] S.J. Leischow, A. Best, W.M. Trochim, P.I. Clark, R.S. Gallagher, S.E. Marcus, et al., Systems thinking to improve the public's health, Am. J. Prev. Med. 35 (2 Suppl) (2008 Aug) Internet. cited 2018 Feb 28. S196–203. Available from http://www.ncbi.nlm.nih.gov/pubmed/18619400.
[91] M. Hitziger, R. Esposito, M. Canali, M. Aragrande, B. Häsler, S.R. Rüegg, Knowledge integration in one health policy formulation, implementation and evaluation, Bull. World Health Organ. 96 (3) (2018 Mar 1) 211 Internet. cited 2019 Apr 7. Available from http://www.ncbi.nlm.nih.gov/pubmed/29531420.
[92] A.C. Mulder, A. Kroneman, E. Franz, H. Vennema, A.D. Tulen, J. Takkinen, et al., HEVnet: a one health, collaborative, interdisciplinary network and sequence data repository for enhanced hepatitis E virus molecular typing, characterisation and epidemiological investigations, Eurosurveillance 24 (10) (2019 Mar 7) Internet. cited 2019 Apr 7. Available from http://www.ncbi.nlm.nih.gov/pubmed/30862334.
[93] Government of India, National Standing Committee on Zoonoses [Internet]. Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India, 2010 [cited 2018 May 18]. Available from: https://www.india.gov.in/standing-committee-zoonoses.
[94] M. Kakkar, S.S. Abbas, R.C.Z.I. initiative, One health: moving from concept to reality, Lancet Infect. Dis. 11 (11) (2011 Nov 1) 808 Internet. cited 2017 Dec 29. Available from http://www.ncbi.nlm.nih.gov/pubmed/22035611.
[95] Department of Biotechnology, One health roadmap, One Health India Conference Declaration [Internet]. New Delhi, 2019, p. 4 cited 2019 Mar 31. Available from https://img1.wsimg.com/blobby/go/bdf18a05-5d66-48cb-8cad-38ee88a6d879/downloads/OHIC 2019_Declaration.pdf.
[96] S. Yasobant, W. Bruchhausen, D. Saxena, T. Falkenberg, Convergence model for effectual prevention and control of zoonotic diseases: A health system study on 'One Health' approach in Ahmedabad, India, BMC Health Res. Policy Syst. 16 (1) (2018 Dec 19) Available from https://www.ncbi.nlm.nih.gov/pubmed/30567599.

2.3. Publication 3

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RESEARCH ARTICLE

Multi-sectoral prioritization of zoonotic diseases: One health perspective from Ahmedabad, India

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Abstract

Background

Prioritizing zoonotic diseases is one of the emerging tasks for developing multi-sectoral collaboration within One Health. Globally, many efforts have been made to prioritize zoonotic diseases at national levels, especially in low resource settings. Prioritization of zoonoses has been conducted in different countries at different levels (i.e. national, regional and local) for different purposes. India has also initiated prioritization of zoonotic diseases at the national level. However, in a country like India with wide climatic variations, different animal-human and vector densities, it is important to look at these zoonotic conditions in local settings too. The present study aims to determine which zoonoses should be prioritized for collaboration between stakeholders in the Indian city of Ahmedabad.

Methods

The present study followed a participatory research method, entailing a stakeholder workshop for prioritizing zoonotic diseases in Ahmedabad. It was carried out through a facilitated consultative process involving 19 experts in zoonoses from the human and animal health systems during a one-day workshop in September 2018. To prioritize the zoonotic diseases, the One Health Zoonotic Disease Prioritization (OHZDP) tool of the U.S. Centers for Disease Control and Prevention was adopted. The Analytical Hierarchical Process (AHP) and decision-tree analysis were used to rank the diseases.

Results

Out of 38 listed zoonotic diseases, 14 were selected for prioritization. These were scored and weighed against five criteria: severity of disease in humans, potential for epidemic and/or

Competing interests: The authors have declared that no competing interests exist.

pandemic, availability of prevention and/or control strategies, burden of animal disease existing inter-sectoral collaboration.

The top five diseases that have been prioritized for Ahmedabad are Rabies, Brucellosis, Avian Influenza (H5N1), Influenza A (H1N1) and Crimean-Congo Hemorrhagic Fever. Sensitivity analysis did not indicate significant changes in zoonotic disease prioritization based on criteria weights.

Conclusion

Prioritization of zoonotic diseases at the local level is essential for development of effective One Health strategies. This type of participatory disease prioritization workshop is highly recommended and can be replicated in other Indian cities, as well as in other low and middle-income countries.

Background

Emerging and re-emerging zoonotic diseases are increasing globally, particularly in places with high host species richness and a high intensity of contact between animals and humans, as well as those located in lower latitudes [1–3]. Multi-sectoral collaboration through a One Health approach is being popularized either for management or for effective prevention of zoonotic diseases [4–8]. However, there is no blueprint for implementing One Health in a specific setting because of extensive challenges in bringing multiple stakeholders of the human, animal and environmental health sectors together. The major challenge in multi-sectoral collaboration often is the unspecified roles and responsibilities of stakeholders, and poor governance [9,10]. Despite challenges, some initiatives have been taken at national [11] and local levels [12]. However, evidence suggests that such collaborations are limited to outbreaks and are not sustained in endemic periods [13]. To establish a sustained, proactive and routine system, prioritization of zoonotic conditions through multi-sectoral collaboration within the respective settings is of utmost importance. Joint prioritization of zoonoses should benefit for the efficient and effective surveillance, developing laboratory capacity, targeting efficient outbreak prediction, implementing common disease control strategies, and identifying integrated research activities across sectors: human, animal, environmental [14].

Historically, infectious disease prioritization was within the purview of public health officials [15,16]. However, with progress of public health strategies, prioritization became an important tool for various stakeholders to receive common funding or for implementing joint research projects. The approaches used to prioritize diseases are: qualitative, semi-quantitative or quantitative [17–19].

With respect to zoonoses, prioritization has been conducted at different sites, such as Congo [20], Ethiopia [21], Kenya [22], Tanzania [23], Uganda [24] and North America [25]. Similarly, in India there have been some efforts for prioritizing zoonotic diseases at the national level [26,27]. However, to date, there is no zoonoses prioritization documented at local levels, such as cities. It is important to prioritize these emerging zoonotic diseases, especially in rapidly growing cities. As part of the larger project: 'Research in exploring Inter-sectoral Collaboration for One Health Approach' (RICOHA), we conducted zoonotic disease prioritization in an Indian city, Ahmedabad.

Prioritizing zoonotic diseases at a local level will not only emphasize the most important diseases to focus on but can also facilitate the development of One Health collaboration between local stakeholders [14]. Ahmedabad has documented various zoonotic diseases, ranging from outbreaks of Crimean-Congo hemorrhagic fever [28] and bird flu [29], to the long epidemic of chikungunya [30] and the recent epidemic of Zika [31]. The present study aims to determine which zoonoses need to be prioritized for collaboration between stakeholders in Ahmedabad, India.

Methods

This study is part of the comprehensive RICOHA study, which aims at developing a One Health convergence model in Ahmedabad. The detailed study methodology is described elsewhere [32]. The present paper adopts the already established participatory method (stakeholder workshop) for prioritizing zoonotic diseases in Ahmedabad, India. The methodology follows the instrument of the U.S. Centers for Disease Control and Prevention (CDC), i.e. One Health Zoonotic Disease Prioritization (OHZDP) tool [14], which was adopted to the local context. In 2014, the CDC developed the OHDZP tool to be used in situations where comprehensive quantitative data is not available [33]. Further information on the OHZDP tool can be found with the CDC [14].

Data was collected through a facilitated consultative process involving 19 experts in zoonoses from the human and animal health systems during a one-day workshop in September 2018. To select participants, institutions (government, research and academia) and departments that work on zoonoses in the areas of surveillance, research and diagnostics in either the human or animal health sector were identified (S1 Table). These were invited to nominate the most appropriate individual to attend the workshop. The process of contacting stakeholders was initiated three months prior to the workshop. Among the participants were: medical officer of health, epidemic officer, malaria officer, entomologist, microbiologists, surveillance officer from the human health system, zoo veterinarian, superintendent of cattle nuisance control department, foot and mouth disease laboratory director, animal husbandry department director, veterinarian responsible for zoonotic diseases from the human health surveillance system.

The process of OHZDP tool consists of five steps:

1. Identification of zoonoses to be prioritized
2. Development of five criteria to prioritize diseases
3. Development of questions with categorical answers for each criterion based on available data
4. Weighting of the criteria
5. Ranking of the zoonoses using a decision tree analysis

With respect to the feasibility in the local context, we adopted these steps for prioritization as shown in Fig 1.

Step I (Identification of zoonoses to be prioritized)

Prior to the workshop, a list of 33 zoonotic diseases relevant to Ahmedabad was developed. This list was developed based on informal discussions with five imperative stakeholders and literature search. The literature search included website searches of human and animal health organizations involved in zoonotic disease prevention and control, including national organizations, inter-governmental organizations, provincial organizations and academic institutions;

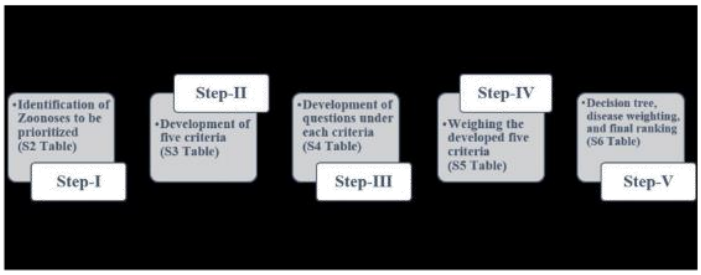

Fig 1. Schematic presentation of the steps involved in the prioritization process in Ahmedabad, Western city of India during September 2018.

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reference textbooks and PubMed cataloged peer-reviewed publications without any time frame. This search aimed to compile all possible zoonotic diseases that was performed one month prior to the participatory workshop relevant to the local level.

Key search terms used included the disease criterion, the scientific and/or common name of diseases, and a combination of the two (e.g. case-fatality rate and/or brucellosis). The literature search was not a comprehensive literature review, but a focused search to compile the diseases. Further, at the beginning of the workshop, stakeholders were requested to enrich the list, if they felt any disease of local relevance was missing (S2 Table).

Step II (Development of five criteria)

This step involved the development of five criteria, which were used to rank the importance of each zoonosis. These criteria were agreed upon during the workshop through a moderated discussion. Initially, the criteria used previously at different sites ([20], [21], [22], [23], [24], [25]) were reviewed and summarized. A list of eight criteria was provided to each stakeholder and each was requested to indicate the most relevant, while also giving them the chance to extend the list. The rank of each criterion, provided by the stakeholders, was averaged. The five criteria with the highest average rank were used for prioritization (S3 Table).

Step III (Development of questions for each criterion)

This step involved a group discussion among the participants to develop questions to operationalize the criteria developed in step II. During the group discussion, five questions were developed, which were either binomial or multinomial. The answers of binomial questions were either yes or no. The multinomial questions had the following options: None (does not exist in any of the systems); Either (exists in any one of the systems); Both (exists in both the systems) (S4 Table).

The different answer options were assigned scores by the stakeholders. The score for each answer was guided by a group discussion. For each binomial question, 'no' and 'yes' were scored as 0 and 1 respectively. In multinomial questions, 'none', 'either, or 'both' were scored as 0, 1 and 2 respectively. To avoid complications, we used neither ordinal scale questions nor specified cut-off values unlike other prioritization workshops [34,35]. In case of discrepancy, the question was further discussed until consensus was reached.

Step IV (weighing the criteria)

Using the OHZDP tool Microsoft Excel spreadsheet [14], a semi-quantitative analytic hierarchy process was applied to assign the most important criteria with the highest weight, and the

least important criteria with the lowest weight [14,19,36]. For this purpose, we divided the participants into groups of three to four, each group having a representative from each sector, thus forming six well-balanced groups. Although the process of OHZDP tool states that each member individually needs to rank the criteria, here a group exercise was applied, as we intend to have a common consensus across the sectors. Subsequently, each group ranked the five criteria according to their importance on a scale of 1 to 9, as previously done by another research group [36]. The group results were combined to produce the overall rank and weight of each criterion through an approximation method [37]. Regardless of how many factors were involved in making the decision, the approximation method only compares pairwise priorities for the criterion to calculate the overall weights. By doing this, we assessed the consistency of responses after combining them, ensuring adherence to both completeness and transitivity among the group choices for each criterion as per the Analytical Hierarchical Process (AHP). [14,17]. A consistency ratio of 0.01 or less was considered satisfactory (S5 Table).

Step V (Decision-tree, disease weighting, and final ranking)

In accordance with the decision tree approach of the OHZDP tool, each group scored each of the 14 zoonotic diseases for each criterion. For example, the criterion 'severity of disease in humans' for rabies had the question "Does the disease cause morbidity and/or mortality among humans?"; if all agreed to option 'No' then that question received '0', if all agreed to option 'Yes' then the question received '1'. The final score of the criterion was the sum of scores from all questions for the criterion. Two different total scores were calculated for each criterion i.e. weighted and unweighted. The calculation of the unweighted score simply uses the average of responses, while in the weighted final score the criteria weights assigned in step IV were applied (S6 Table).

For example: for the criterion 'severity of disease in humans' for rabies, all agreed on 'Yes' for the first question, so the unweighted score of the criterion was 1, whereas the weighted score of the criterion was 5 (as the criterion 'severity of disease on humans' received the rank 5). The final weighted score of the disease was then calculated by summing the product of the weight of each criterion with its unweighted score, obtained by averaging the scores of all the questions. For example, the final score for rabies was 15. Both the weighted and unweighted final scores of each disease were then normalized to the highest scoring disease, which consequently received a score of '1'. All workshop participants reviewed the disease-ranking results, which facilitated further discussion. The stakeholders then, through a facilitated discussion, collectively finalized the priority ranking of zoonotic diseases for Ahmedabad. During the facilitated discussion, if 2/3 of stakeholders agreed to a consensus, it was accepted.

Sensitivity analysis

In the sensitivity analysis, the robustness of the prioritization outcome was assessed. In this step, three types of sensitivity analysis were conducted.

1. We assigned the five selected criteria equal weights and assessed how normalized disease scores compared to weighted disease scores.
2. A reverse weighting of the five criteria were done and normalized scores were compared.
3. We systematically removed each of the five developed criteria and assessed normalized disease scores with the four remaining criteria.

Pearson's product-correlation coefficient was used to assess the relationships between these three normalized disease scores, with a coefficient p-value <0.01 considered significant. The analysis was conducted in R version 3.4.1 [38].

Ethics approval

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 the Indian Institute of Public Health Gandhinagar, India.

Results

Out of 38 zoonoses included in the present study, stakeholders individually voted for diseases that should be used in the next steps of the workshop. At the end of step I, the number of diseases were reduced to 14 (Table 1), by averaging the votes of the stakeholders. The following five criteria were developed and presented from high to low importance:

1. Severity of disease in humans
2. Potential for epidemic/pandemic in humans and/or animals
3. Existence of prevention and control strategies in the human and/or animal health system
4. The burden of disease in animals
5. Existence of inter-sectoral collaboration for the disease

The results of the group exercise for weighting the criteria are shown in Table 2.

With the help of a decision-tree analysis, the weight of each criterion was applied and a final weighted score was obtained to rank the diseases, which is shown in Table 1. Based on discussion, the stakeholders reached a consensus that the top two diseases remain unchanged, however, there was a change in the priority of other prioritized diseases (Table 3). This adjustment was done in view of the emerging cases in the city as well considering the outbreak history.

The city of Ahmedabad experienced an outbreak of avian influenza in 2017 [39] and is currently documenting a series of new cases of influenza A [40]. Therefore, the Crimean-Congo hemorrhagic fever was moved to the fifth priority, while H5N1 and H1N1 were ranked as third and fourth prioritized zoonotic diseases of the city respectively.

Table 1. Normalized weighted score of prioritized zoonotic diseases of Ahmedabad, Western city of India during participatory workshop, September 2018.

Zoonotic disease	Normalized Weighted Score
Rabies	1.000
Brucellosis	1.000
Crimean-Congo Hemorrhagic Fever (CCHF)	0.867
Avian Influenza (H5N1)	0.856
Influenza A (H1N1)	0.822
Tuberculosis	0.800
Salmonellosis	0.789
Japanese Encephalitis	0.767
Leptospirosis	0.722
Plague	0.722
Chikungunya	0.656
Dengue	0.633
Anthrax	0.400
Cholera	0.356

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Table 2. Group ranking of criteria using the analytic hierarchy process from the prioritization workshop of Ahmedabad, Western city of India during September 2018.

Criteria	Group-1#	Group-2#	Group-3#	Group-4#	Group-5#	Group-6#	Overall Ranking#
Severity of Disease in Humans	0.03 (5)	0.42 (1)	0.56 (1)	0.29 (2)	0.53 (1)	0.52 (1)	0.223 (1)
Potential for Epidemic and/or Pandemic	0.13 (3)	0.04 (5)	0.10 (3)	0.48 (1)	0.30 (2)	0.26 (2)	0.207 (2)
Prevention and Control strategy	0.58 (1)	0.06 (4)	0.26 (2)	0.14 (3)	0.08 (3)	0.13 (3)	0.206 (3)
Burden of animal disease	0.17 (2)	0.25 (2)	0.06 (4)	0.04 (5)	0.06 (4)	0.06 (4)	0.184 (4)
Existing inter-sectoral collaboration	0.09 (4)	0.22 (3)	0.03 (5)	0.06 (4)	0.04 (5)	0.04 (5)	0.178 (5)
Consistency Ratio*	0.09	0.05	0.2	0.07	0.1	0.09	NA

(*) A consistency ratio of <0.1 is acceptable (Group 3 & 5 were excluded from the approximation for the final weights)

(#) Score gained during the Analytical Hierarchy process (Individual group rank)

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To assess the reliability of the finalized list a sensitivity analysis was conducted. Fig 2 indicates the sensitivity analysis with different strategies. The sensitivity analysis showed a strong positive correlation between scores produced by the OHZDP tool and normalized disease scores using equal weighted ($r = 0.96$, $p < 0.01$) or reverse weighted criteria ($r = 0.86$, $p < 0.01$). There was also a strong positive correlation when excluding each criterion, then comparing disease scores to those produced by the OHZDP tool ($r = 0.89–0.99$, $p < 0.01$).

Discussion

Participatory workshops for the prioritization of zoonotic diseases have been conducted in multiple countries, generating a unique list of priority zoonosis for each country. However, this is the first time such a workshop was conducted at a city level in India. The final list of priority zoonotic diseases in Ahmedabad was rabies, brucellosis, influenza (H5N1 & H1N1) and Crimean-Congo hemorrhagic fever. The prioritizations conducted at national level with the OHZDP tool had different objectives as per the need of the site. For example, Kenya conducted prioritization of zoonoses to provide guidelines for resource allocation to enhance surveillance, prevention, and control. Tanzania conducted zoonotic disease prioritization to understand which emerging zoonotic diseases should be jointly addressed through inter-ministerial collaboration. Comparing our findings to other sites such as Ethiopia, Tanzania and Congo; the top criterion was 'severity of disease in humans' in all these prioritization workshops, which indicates the strength and robustness of the process of OHZDP tool. The process of OHZDP tool helped to allocate resources, budgeting, and provide policy guidance. Further, to our knowledge this is the first study, which adopted the process of zoonotic disease prioritization through OHZDP tool at the local level.

In India, there are some efforts at the national level to prioritize zoonotic diseases in order to prioritize research needs for the control of zoonoses, such as the Roadmap to Combat

Table 3. Final prioritized disease rankings one health zoonotic disease prioritization workshop from the Ahmedabad, Western city of India during September 2018.

Disease	Final Ranking
Rabies	1
Brucellosis	2
Avian Influenza (H5N1)	3
Influenza A (H1N1)	4
Crimean-Congo Hemorrhagic Fever	5

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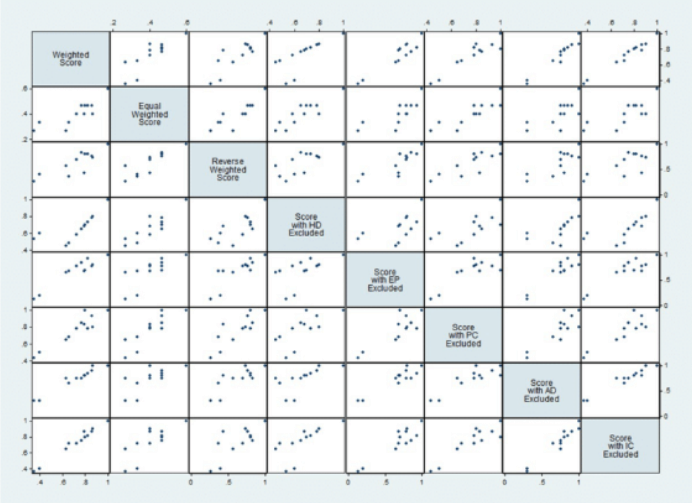

Fig 2. Comparison of normalized disease prioritization scores obtained from weighted criteria and with equal criteria weights, with reverse criteria weights and excluding each of the five criteria in the prioritization process in Ahmedabad, Western city of India during September 2018. (HD) Human disease, (EP) Epidemic potential, (PC) Prevention control, (AD) Animal disease, (IC) Intersectoral collaboration.

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Zoonoses in India (RCZI) [26] and the simple ranking of disease by Kurian *et al.* [27]. RCZI adopted the priority setting methods developed by the Child Health and Nutrition Research Initiative [26], whereas Kurian *et al.* adopted a composite index method based on the trends and distribution of each disease and their adverse effects on human health, economy, trade and industry [27]. The objective of these two prioritizations differed. For example, RCZI prioritized the zoonoses that should be given priority with respect to research in next decade, while Kurian *et al.* prioritized the zoonoses based on the burden of disease in India. There are various limitations to the methodologies used in these prioritizations. For example, the RCZI method involved an assumption that the Child Health and Nutrition Research Initiative's (CHNRI) five recommended scoring criteria are also applicable to the Indian zoonoses context. Moreover, they represent the key metrics that stakeholders would use to prioritize research options rather than taking a disease burden point of view.

The challenges posed by children's health issues, for which the CHNHRI was originally developed, may be substantially different from those posed by zoonoses prioritization used by RCZI group. Similarly, the composite index method used by Kurian *et al.*, usually requires exact data to measure the disease burden. Considering the zoonoses database and surveillance system in India, there is a lack of zoonotic data at the national and local level, thus the approach followed in this current study is better suited to setting with low data availability. Nonetheless, the past Indian zoonotic disease prioritizations done by the RCZI and Kurian *et al.* were compared with the prioritization of the current study conducted at the local level and is summarized in Table 4. Like other global sites, prioritizations in India also ranked rabies as the top priority irrespective of the goal and method of the workshops. In addition, brucellosis ranks high in all three models. Interestingly leptospirosis received a high rank at the national level but was only in the last place at the local level; this highlights that diseases are context-specific and need to be assessed locally in order to develop target-oriented interventions. An important observation from this exercise is that local priorities may be different

Table 4. Summary of prioritized zoonotic diseases in India with respect to time, region and aim of prioritization.

Level	National (India)	National (India)	Local (Ahmedabad)
Author	Sekar et al., March 2009	Kurian et al., September 2013	Current Study, September 2018
Goal	To prioritize research options needed to control zoonoses.	To identify and rank the most important zoonotic diseases in India.	To determine which zoonoses should receive high concern for collaboration between the stakeholders in a smart city of India, Ahmedabad.
Method	Child Health and Nutrition Research Initiative's priority setting method.	Composite index method based on the trends of disease, adverse effects on human health, economy, trade and industry.	Centers for Disease Control and Prevention's One Health Zoonotic Disease Prioritization tool.
Prioritized diseases in descending order	Rabies, Leptospirosis, Brucellosis, Anthrax, Tuberculosis, Pandemic Flu, Helminths, Arbovirus, Food borne	Rabies, Avian Influenza (H5N1), Anthrax, Brucellosis, Leptospirosis, Tuberculosis, Japanese encephalitis, Porcine cysticercosis	Rabies, Brucellosis, Avian Influenza (H5N1), Influenza A (H1N1), Crimean-Congo Hemorrhagic Fever, Tuberculosis, Salmonellosis, Japanese encephalitis, Leptospirosis

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from national aggregated priorities, which emphasizes the need for this type of prioritization at each local setting.

The OHZDP tool that the current study adopted as the prime tool for prioritization has certain limitations that became evident during the process. The selection of prioritization criteria are specific to the workshop participants and the weighting and scoring of these is highly affected by the participants and their background. It is important to note that when diverse stakeholders such as health officials and administrators come together, some bias is introduced, including group thinking and politics; however, a strong moderator can overcome these by focusing on the key objective of the workshop and creating a single platform. The questions chosen for the evaluations of the criteria are also highly dependent on the workshop participants and may not be applicable to the impact of all zoonoses. From this study, we learnt that although avoiding non-ordinal questions makes the OHZDP process quicker and easily palatable to a diverse range of stakeholders, it leads to less robust results, as the severity of human health is only scored yes/no for example, giving no room to highlight the differing burden of different diseases. Another modification was the use group ranking in the AHP process (Step-IV) rather than individual ranking, because we intended to develop a common consensus across the sectors. Therefore, each group consisted of stakeholders from the different sectors. Such debate between the sectors has to be considered at the time of planning of a similar kind of participatory workshop for disease prioritization, if the group exercise is considered as part of the AHP at the local level. When the same tool is applied at national level then there must be more options to include diverse stakeholders; however, at the local level, the numbers of stakeholders are much limited and it becomes a challenge when a particular stakeholder is unable to make it on the day of workshop. Therefore, considering the flexible nature of OHZDP, we recommend these changes while adopting at the local level.

Conclusion

Prioritization of zoonotic diseases on the local level is essential for development of One Health strategies. In addition to its established usefulness at national level, the OHZDP tool of the CDC can also assist local policy makers or program managers to make such prioritization to facilitate better planning and collaboration. The prioritization of diseases can vary according to the aim of the participatory workshop, as the aim affects the criteria selection and scoring of diseases. It is therefore very important to highlight the main goal of the workshop to the participants in order to achieve the desired outcomes. The selection of the workshop participants is also highly important and attention should be paid to engaging a wide range of stakeholders and balancing stakeholders from different sectors and with different expertise. This type of

participatory workshop for disease prioritization is highly recommended and can be replicated in other cities in India or in other lower-middle income countries. Among others, this study concludes that OHZDP tool can be adopted to local level, provided the stakeholders are selected carefully as per the objective of collaborative disease prioritization.

Supporting information

S1 Table. List of anonymized stakeholders who have participated in the zoonotic disease prioritization in Ahmedabad, Western city of India during participatory workshop, September 2018. (*) Public, (#) Private/ Non-Governmental Organization
(AMC) Ahmedabad Municipal Corporation, (GVC) Gujarat Veterinary Council, (CNCD) Cattle Nuisance Control Department, (DP) District Panchayat Office, (ADIO) Animal Disease Investigation Office
(DOCX)

S2 Table. List of zoonotic diseases for the prioritization in Ahmedabad, Western city of India during participatory workshop, September 2018. (Note) An initial list of diseases were compiled from literature review and informal discussion with experts. The open list of the diseases were provided to the participants and asked to select the relevant diseases in context to Ahmedabad, which need to be prioritized.
(S) Stakeholder
(DOCX)

S3 Table. Deciding the criteria for the prioritization in Ahmedabad, Western city of India during the participatory workshop, September 2018. (S) Stakeholder
(DOCX)

S4 Table. Questionnaires developed under each criterion for the prioritization of zoonotic diseases in Ahmedabad, Western city of India during the participatory workshop, September 2018. (OIE) World Organization for Animal Health
(DOCX)

S5 Table. Group ranking of criteria for prioritizing zoonotic diseases using the Analytic Hierarchy Process in Ahmedabad, Western city of India during the participatory workshop, September 2018. (HD) Severity of disease in humans, (PC) Prevention and Control strategy, (EP) Potential for Epidemic and/or Pandemic, (AD) Burden of animal disease, (IC) Existing inter-sectoral collaboration
(DOCX)

S6 Table. Weighing of prioritized zoonotic diseases using decision tree analysis fin Ahmedabad, Western city of India during the participatory workshop, September 2018. (HD) Severity of disease in humans, (PC) Prevention and Control strategy, (EP) Potential for Epidemic and/or Pandemic, (AD) Burden of animal disease, (IC) Existing inter-sectoral collaboration
(DOCX)

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References

1. Gebreyes WA, Dupouy-Camet J, Newport MJ, Oliveira CJB, 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 neglected tropical diseases. Public Library of Science; 2014; 8: e3257. https://doi.org/10.1371/journal.pntd.0003257 PMID: 25393303
2. Allen T, Murray KA, Zambrana-Torrelio C, Morse SS, Rondinini C, Di Marco M, et al. Global hotspots and correlates of emerging zoonotic diseases. Nature communications. Nature Publishing Group; 2017; 8: 1124. https://doi.org/10.1038/s41467-017-00923-8 PMID: 29066781
3. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. Nature. 2008; 451: 990–993. https://doi.org/10.1038/nature06536 PMID: 18288193
4. Stephen C, Stemshorn B. Leadership, governance and partnerships are essential One Health competencies. One Health. 2016; 2: 161–163. http://dx.doi.org/10.1016/j.onehlt.2016.10.002 PMID: 28616493
5. Zinsstag J, Schelling E, Waltner-Toews D, Tanner M. From "one medicine" to "one health" and systemic approaches to health and well-being. Preventive veterinary medicine. 2011; 101: 148–156. https://doi.org/10.1016/j.prevetmed.2010.07.003 PMID: 20832879
6. Rubin C, Dunham B, Sleeman J. Making One Health a Reality—Crossing Bureaucratic Boundaries. One Health. American Society of Microbiology; 2014. pp. 269–283. https://doi.org/10.1128/microbiolspec.OH-0016-2012 PMID: 26082124
7. Conrad PA, Meek LA, Dumit J. Operationalizing a One Health approach to global health challenges. Comparative Immunology, Microbiology and Infectious Diseases. 2013; 36: 211–216. https://doi.org/10.1016/j.cimid.2013.03.006 PMID: 23711930
8. Mazet JAK, Clifford DL, Coppolillo PB, Deolalikar AB, Erickson JD, Kazwala RR. A "One Health" Approach to Address Emerging Zoonoses: The HALI Project in Tanzania. PLoS Medicine. Public Library of Science; 2009; 6: e1000190. https://doi.org/10.1371/journal.pmed.1000190 PMID: 20016689
9. Okello AL, Gibbs EPJ, Vandersmissen A, Welburn SC. One Health and the neglected zoonoses: turning rhetoric into reality. The Veterinary record. 2011; 169: 281–285. https://doi.org/10.1136/vr.d5378 PMID: 21908565

10. Tangcharoensathien V, Srisookwatana O, Pinprateep P, Posayanonda T, Patcharanarumol W. Multisectoral Actions for Health: Challenges and Opportunities in Complex Policy Environments. International journal of health policy and management. Kerman University of Medical Sciences; 2017; 6: 359–363. https://doi.org/10.15171/ijhpm.2017.61 PMID: 28812831

11. One Health Bangladesh Secretariat. Strategic framework for One Health approach to infectious diseases in Bangladesh [Internet]. Bangladesh; 2012. Available: http://www.iedcr.gov.bd/pdf/files/One Health/Strategic_framework_for_One_Health_Bangladesh-26 Jan.pdf

12. Schelling E, Wyss K, Béchir M, Moto DD, Zinsstag J. Synergy between public health and veterinary services to deliver human and animal health interventions in rural low income settings. BMJ (Clinical research ed). British Medical Journal Publishing Group; 2005; 331: 1264–7. https://doi.org/10.1136/bmj.331.7527.1264 PMID: 16308393

13. McPherson A, Hill PS, Kama M, Reid S. Exploring governance for a One Health collaboration for leptospirosis prevention and control in Fiji: Stakeholder perceptions, evidence, and processes. The International Journal of Health Planning and Management. 2018; 33: 677–689. https://doi.org/10.1002/hpm.2521 PMID: 29602256

14. Rist CL, Arriola CS, Rubin C. Prioritizing zoonoses: a proposed one health tool for collaborative decision-making. PloS one. 2014; 9: e109986. https://doi.org/10.1371/journal.pone.0109986 PMID: 25302612

15. Humblet M-F, Vandeputte S, Albert A, Gosset C, Kirschvink N, Haubruge E, et al. Multidisciplinary and evidence-based method for prioritizing diseases of food-producing animals and zoonoses. Emerging infectious diseases. Centers for Disease Control and Prevention; 2012; 18: e1. https://doi.org/10.3201/eid1804.111151 PMID: 22469519

16. Rushdy A, O'Mahony M. PHLS overview of communicable diseases 1997: results of a priority setting exercise. Communicable disease report CDR weekly. 1998; 8 Suppl 5: S1–12. Available: http://www.ncbi.nlm.nih.gov/pubmed/9842117

17. Brookes VJ, Der Rio Vilas VJ, Ward MP. Disease prioritization: what is the state of the art? Epidemiology and Infection. 2015; 143: 2911–2922. https://doi.org/10.1017/S0950268815000801 PMID: 25876939

18. Stebler N, Schuepbach-Regula G, Braam P, Falzon LC. Use of a modified Delphi panel to identify and weight criteria for prioritization of zoonotic diseases in Switzerland. Preventive Veterinary Medicine. 2015; 121: 165–169. https://doi.org/10.1016/j.prevetmed.2015.05.006 PMID: 26036342

19. Kadohira M, Hill G, Yoshizaki R, Ota S, Yoshikawa Y. Stakeholder prioritization of zoonoses in Japan with analytic hierarchy process method. Epidemiology and Infection. 2015; 143: 1477–1485. https://doi.org/10.1017/S0950268814002246 PMID: 25195643

20. Muhemedi S, Masumu J, Lubula L, Kabambi P, Okitolonda E. Prioritization of Zoonotic Diseases in the Democratic Republic of the Congo, 2016. Journal of Zoonotic Diseases and Public Health. iMedPub; 2018; 2. Available: http://www.imedpub.com/articles/prioritization-of-zoonotic-diseases-in-thedemocratic-republic-of-the-congo-2016.php?aid=22215

21. Pieracci EG, Hall AJ, Gharpure R, Haile A, Walelign E, Deressa A, et al. Prioritizing zoonotic diseases in Ethiopia using a one health approach. One Health. Elsevier; 2016; 2: 131–135. https://doi.org/10.1016/j.onehlt.2016.09.001 PMID: 28220151

22. Munyua P, Bitek A, Osoro E, Pieracci EG, Muema J, Mwatondo A, et al. Prioritization of Zoonotic Diseases in Kenya, 2015. Markotter W, editor. PLOS ONE. Public Library of Science; 2016; 11: e0161576. https://doi.org/10.1371/journal.pone.0161576 PMID: 27557120

23. Center for Disease Control and Prevention. One Health Zoonotic Disease Prioritization for Multisectoral Engagement in Tanzania [Internet]. Dar es Salaam, Tanzania; 2017. Available: https://www.cdc.gov/onehealth/pdfs/tanzania-report-508.pdf

24. Sekamatte M, Krishnasamy V, Bulage L, Kihembo C, Nantima N, Monje F, et al. Multisectoral prioritization of zoonotic diseases in Uganda, 2017: A One Health perspective. Kuhn JH, editor. PLOS ONE. Public Library of Science; 2018; 13: e0196799. https://doi.org/10.1371/journal.pone.0196799 PMID: 29715287

25. Ng V, Sargeant JM. A Quantitative Approach to the Prioritization of Zoonotic Diseases in North America: A Health Professionals' Perspective. Speybroeck N, editor. PLoS ONE. Public Library of Science; 2013; 8: e72172. https://doi.org/10.1371/journal.pone.0072172 PMID: 23991057

26. Sekar N, Shah NK, Abbas SS, Kakkar M. Research options for controlling zoonotic disease in India, 2010–2015. PloS one. 2011; 6: e17120. https://doi.org/10.1371/journal.pone.0017120 PMID: 21364879

27. Kurian A, Dandapat P, Jacob S, Francis J. Ranking of zoonotic diseases using composite index method: An illustration in Indian context. Indian Journal of Animal Sciences. 2014; 84: 357–363. Available: https://krishi.icar.gov.in/ohs-2.3.1/index.php/record/view/107133

28. Patel AK, Patel KK, Mehta M, Parikh TM, Toshniwal H, Patel K. First Crimean-Congo hemorrhagic fever outbreak in India. The Journal of the Association of Physicians of India. 2011; 59: 585–9. Available: http://www.ncbi.nlm.nih.gov/pubmed/22334974 PMID: 22334974

29. Integrated Disease Surveillance Program (IDSP). Bird flu scare: Foresters order autopsies of birds in Ahmedabad, Gujarat [Internet]. Ahmedabad, India; 2017. Available: https://idsp.nic.in/WriteReadData/Media_Alert_Jan-2017/3820.pdf

30. Mavalankar D, Shastri P, Parmar J, Ramani K V. Chikungunya Fever: A Killer Epidemic in Ahmedabad City, India [Internet]. Ahmedabad, India; 2007. Available: https://web.iima.ac.in/assets/snippets/workingpaperpdf/2007-06-02Mavalankar.pdf

31. World Health Organization. Zika virus infection: India. Emergencies preparedness, response [Internet]. World Health Organization; 2017 [cited 20 Nov 2018]. Available: http://www.who.int/csr/don/26-may-2017-zika-ind/en/

32. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. Convergence model for effectual prevention and control of zoonotic diseases: a health system study on "One Health" approach in Ahmedabad, India. Health research policy and systems. BioMed Central; 2018; 16: 124. https://doi.org/10.1186/s12961-018-0398-6 PMID: 30567599

33. Centers for Disease Control and Prevention. Zoonotic disease prioritization. National Center for Emerging and Zoonotic Infectious Diseases (NCEZID) [Internet]. 2014 p. 1. Available: https://www.cdc.gov/onehealth/global-activities/prioritization.html

34. Havelaar AH, van Rosse F, Bucura C, Toetenel MA, Haagsma JA, Kurowicka D, et al. Prioritizing Emerging Zoonoses in The Netherlands. Ratner AJ, editor. PLoS ONE. Public Library of Science; 2010; 5: e13965. https://doi.org/10.1371/journal.pone.0013965 PMID: 21085625

35. Ng V, Sargeant JM. A Quantitative and Novel Approach to the Prioritization of Zoonotic Diseases in North America: A Public Perspective. Lasmezas CI, editor. PLoS ONE. Public Library of Science; 2012; 7: e48519. https://doi.org/10.1371/journal.pone.0048519 PMID: 23133639

36. Saaty TL. Decision making with the analytic hierarchy process [Internet]. Int. J. Services Sciences. 2008. Available: http://www.rafikulislam.com/uploads/resourses/197245512559a37aadea6d.pdf

37. Kou G, Ergu D, Lin C, Chen Y. Pairwise comparison matrix in multiple criteria decision making. 2016; https://doi.org/10.3846/20294913.2016.1210694

38. R Core Team. R: A language and environment for statistical computing [Internet]. R Foundation for Statistical Computing, Vienna, Austria; 2017. Available: https://www.r-project.org/

39. Ministry of Agriculture and Farmers Welfare. India declares itself free from Highly Pathogenic Avian Influenza (H5N1 and H5N8) [Internet]. Press Information Bureau, Government of India; 2017 p. 1. Available: http://pib.nic.in/newsite/PrintRelease.aspx?relid=167184

40. The Times of India. Swine Flu in Ahmedabad: 408 new cases and 10 deaths in September 2018. The Time of India. 2018: 1. Available: https://timesofindia.indiatimes.com/city/ahmedabad/408-swine-flu-cases-10-deaths-this-september/articleshow/65956967.cms

2.4. Publication 4

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Publication 4

Type of the Paper (Original research)

Health system contact and awareness of zoonotic diseases: Can it serve as One Health entry point in the urban community of Ahmedabad, India?

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Abstract

One Health is emphasized globally to tackle the (re)emerging issues at the human-animal-ecosystem interface. However, the low awareness about zoonoses remain a challenge in global south, thus this study documented the health system contact and its effect on the awareness level of zoonoses in the urban community of Ahmedabad, India. A community-based household survey was conducted between October 2018 and July 2019. A total of 460 households (HHs) were surveyed from two zones and twenty-three wards of the city through cluster sampling. A structured, pilot-tested and researcher-administered questionnaire in the vernacular language was used to collect the information on demographic details, socio-economic details, health-seeking behavior for both the humans and their animals, human and animal health system contact details and the participants' awareness on selected zoonotic diseases based on the prioritization (rabies, brucellosis, swine flu and bird flu). Out of 460 surveyed households, 69% of HHs and 59% of HHs had a health system contact to the human and animal health system respectively at the community level. There are multiple health workers active on the community level that could potentially serve as One Health liaisons. The investigation of the knowledge and awareness level of selected zoonotic diseases revealed that 58.5%, 47.6% and 4.6% know about rabies, swine and/or bird flu and brucellosis, respectively. The mixed-effect linear regression model indicates that there is no significant effect on the zoonotic disease awareness score with the human health system contact; however, a minimal positive effect with the animal health system contact was evident.

Key Words: Health system contact, zoonotic diseases, community awareness, One Health, India

1. Introduction

The identification and management of simple illnesses at the household level and/or referral to the appropriate health centers by the community health workers is one of the greatest health system revolutions in low and middle income countries so far [1,2]. For decades, these workers have been part of the health care delivery system in countries around the world [3–5]. In India, these workers are the backbone of primary health care, not only in the human health system [6,7], but also in the animal health system [8,9]. Most often, these workers are considered as the first point of health system contact for the respective health system in India.

In the recent past, India has witnessed various outbreaks of emerging infections and the majority of them were of zoonotic origin [10,11]; which leads to a more complex infectious disease burden in the country and poses increased challenges for the health care system [11]. Available evidence suggests an increasing burden of zoonoses and also poor community awareness and preventive practices in regard to zoonoses [12,13]. The global movement for more zoonotic disease prevention i.e. One Health (OH) (at the interface of human-animal-ecosystem) approach [14,15] provides an opportunity to tackle this burden.

In absence of any OH focused national program for the zoonoses prevention [16], the health system functionality is yet to be explored in Indian context. It is very important to understand the potential actors and/or entry points for operationalizing OH in the Indian health system. Poor awareness about the zoonotic diseases and non-specific roles of the health system actors, demand an investigation into health system actors, their outreach in the zoonoses prevention, and operationalization of OH at the community level. Therefore, this study aims to document the reach and roles of the community health worker and to identify those that may be suitable to serve as OH entry point. Further, it is assessed whether contact to a health worker affects the relevant awareness of the community.

Hypothesis: Regular contact with the health system and its actors increases the awareness of zoonotic diseases.

2. Materials & methods

2.1. Study Design

This cross-sectional study is part of a larger health system study i.e. RICOHA (Research to explore Intersectoral Collaborations for the One Health Approach), protocol published elsewhere [17]. This specific study was conducted from October 2018 to July 2019.

2.2. Setting

General setting: The study was conducted in one of the most populous cities of the Western state Gujarat: Ahmedabad. It is the seventh most populous city in India and is the largest city of the Western state Gujarat [18]. It is located on the banks of the Sabarmati River with a population of 7,650,000 [19]. Ahmedabad is one among the cities selected for the smart city model in 2016 [20] and India's first UNESCO World Heritage City [21].

Community Setting: For administrative purposes, the city is at present divided into 6 zones i.e. Central, East, West, North, South and New West zone. Each zone is further split into wards. Presently, there is a total of 64 wards. About 1,191,843 households are spread across the city. About 2,000,000 dogs live in the city [22], about 7,000,000 livestock and 2,000,000 poultry spread over both the urban and rural areas of Ahmedabad [23].

This study was conducted in the two most densely populated zones of the city i.e. East and South zone, where the human-animal population density is highest.

2.3. Study population

All wards (i.e. 23 wards) from the East and South zone of Ahmedabad city were incorporated into the study. Further, each ward was sub-divided into multiple clusters based on the population (average of 1,000) and/or presence of an Anganwadi Centre (a community center, which delivers the child care and nutrition related activities under the public health system of India [24]). From each ward two clusters with a high human-animal population density were selected randomly, thus the study collected data from 46 clusters. Further, from each cluster 10 households were sampled. Households of each cluster were further stratified into two categories i.e. 5 households with any

animal(s) (livestock, dog, and poultry) and 5 households without any animal. As there was no line listing of households with or without animals, this study adapted systematic sampling, i.e. each 10th household was sampled until the number of 5 households for each category in the respective cluster was achieved. In case of non-response, the particular household was skipped and the next 10th household was sampled. As the households with animals were limited in number and no line listing of such households was available, the snowball sampling (only to seek the information) was adopted to identify 5 households with animals per cluster as fast as possible. The overall non-response rate was 20%. The total sample size of the study was 460 households.

2.4. Operational definition: 'Health system contact' (HSC) in this study is defined as a person from the health system that is contacted when a new health or medical need arises, or a person providing preventive health care services at the community level. The HSC at the community level either provides care directly or serves as a facilitator, directing patients to more appropriate sources of care at the appropriate time. In order to be considered as providing HSC care, the services must be accessible (a structural characteristic) and used by the population each time a new need or problem arises (a behavioral characteristic).

2.5. Study data collection

A structured, pilot-tested questionnaire in the vernacular language was used to collect the information on the basic demographic and socio-economic characteristics, health seeking behavior (for both the humans and their animals) and contacts to the human and animal health system as well as details on awareness for rabies, brucellosis, swine flu and bird flu. Based on the prioritization of zoonotic diseases in the local context, these four zoonotic diseases were selected against others [25]. A trained researcher administered the 10-15-minute questionnaire to the available adult of the sampled household. When missing data (<5%) were encountered during the data cleaning phase, the researcher re-visited those households and/or called their mobile phones to capture the missing information.

2.6. Measurement

Two measures were calculated for further analysis i.e. HSC score and the awareness score for the selected zoonotic diseases. The HSC score was based on the

dimensions: *comprehensiveness of service delivery* (refers to the availability of clinical and preventive services of the provider), *first contact* (is defined as the accessibility to and use of primary care services when a new health or medical problem arises), *community orientation* (refers to the provider's knowledge of community health needs), *coordination* (refers to the interpersonal linkage of care between different levels of providers or informational linkage of care), *family centeredness* (is defined as the inclusion of family health concerns in decision-making), *cultural competence* (is defined as patients' willingness to recommend their primary care provider to others/satisfaction level) [26,27]. A 4-point Likert-type scale was applied to measure each of these dimensions of the HSC, coded as "1" ("never"), "2" (rarely), "3" (sometimes) "4" ("always"). Thus, each dimension score ranged from minimum of 1 to maximum of 4, the total HSC score, thus ranged from 6 to 24.

The awareness score, as the prime measure of outcome, was calculated in two ways- a) as "1" (correct response), "0" (no response) and "-1" (wrong response) and b) as "1" (correct response), "0" (no/wrong response), where the wrong beliefs were not accounted for each zoonotic disease. In option a, if a person has complete awareness, he/she will receive the highest score, whereas a person having wrong beliefs will receive a lower score as compared to the person indicating not having any knowledge. A normalized score was derived for each disease. The total zoonotic awareness score was calculated as the simple sum of all disease scores and normalized for the analysis.

2.7. Analysis and Statistics

The quantitative data collected was entered, validated and analyzed using EpiData version 3.1 for entry and version 2.2.2.182 for descriptive analysis [28]. The descriptive statistics were segregated between households with animals and households without animals. Categorical variables were expressed as frequencies, percentages, whereas the scores and continuous variable were expressed as means with standard deviation. To assess differences between these groups, chi-square tests were used for categorical variables and t-tests were applied for continuous variables. The linear mixed regression model was conducted to understand the interaction of the zoonoses awareness score with the other independent variables such as socio-demographic

factors, health seeking behavior, and the health system contact. The analysis was conducted in R version 3.4.1 [29].

3. Results

3.1. Socio-demographic characteristics

Table 1, presents the socio demographic characteristics of the surveyed households stratified by the ownership of animals. The majority (72.2%) of respondents were female with a mean (SD) age of 39.3 ± 13.3 years. About 26% of the respondents were illiterate, whereas nearly half of them completed secondary education. The majority (82.4%) belongs to the Hindu religion. About one-fourth (26.1%) belongs to the scheduled caste/tribes and another 5.4% belongs to the lowest/privileged caste. Less than one-fourth were living below the poverty line. Most of the interviewees were permanent residents with a mean (SD) of 37 ± 29 years of residency. The average income per household per month was found to be 204 ±168 US$. The descriptive findings indicated that, the two groups are rather homogenous with only significant difference in gender, occupation, total HH members and duration of residency.

3.2. Health system contact (HSC)

The majority of the surveyed household members preferred to seek primary health care services from private health care providers. On enquiring about the reasons for this, the ease of geographic access (nearer to the place of residence) was most commonly indicated. Similarly, the preferred mode of animal health services was also from the private sector; however, for these no public options are available anyway. On enquiring about the HSC at the community level, it was found that human health workers only visited 69.3% of HHs during the last year. Among them, the most frequent healthcare workers are female health workers (Accredited Social Health Activist [ASHA] and/or Aanganwadi Worker [AWW]) followed by the male health workers (Multi-Purpose Health Worker [MPHW] and/or Malaria Sanitary Inspector [MSI]). Similarly, from the animal health system, any of the animal healthcare workers visited 58.7% HHs during the last year. Among them, private veterinarian doctor (87.4%) visited most often to provide healthcare services during the last year at the doorstep as shown in table 2.

On calculating the HSC score, it was found that for the human health system, the mean (SD) score was 15.11 ± 6.01 and for the animal health system, it was 12.09 ± 3.43. The details are shown in table 3. Overall, the score for both the system are significantly difference in the form of first contact, coordination, family centeredness. This indicates that the healthcare workers of the human health system are perceived well by the community. These three dimensions are in the same line, as when there are any problem, community members first prefer to contact these health care workers (first contact) and then the health care worker coordinates the care between different levels of providers (coordination). In addition, healthcare workers were also value of family health concerns in decision-making (family centeredness). Whereas for the animal health system, this was not the case, as there were no community animal health workers among the surveyed population and veterinarians are the only source of contact. In both the cases, these actors are compete enough culturally and able to provide comprehensive services.

3.3. Awareness of zoonoses and preventive practices

The investigation of the knowledge and awareness level of selected zoonotic diseases revealed that 58.5%, 47.6% and 4.6% know about rabies, swine and/or bird flu and brucellosis, respectively. Further, enquiring about the preventive practices for the above mentioned zoonoses, awareness was found to be poor with mean (SD) zoonoses score of 0.32 ± 0.26 and for the respective diseases: 0.34 ± 0.31 for rabies, 0.21 ± 0.26 for flu, 0.02 ± 0.1 for brucellosis as shown in table 4. About 30% of HHs reported that they had at least one case of dog bite during their lifetime and nearly all of them (96.7%) knew that the mode of transmission for rabies was through dogs. About half (47.2%) were unaware of the general symptoms of rabies and 16.4% preferred unscientific practices such as applying turmeric/snuff powders to the wound as treatment. However, most of them (86.2%) reported that the anti-rabies vaccine was available in either public or private health care facilities. 63% of respondents indicated that they report dog bite cases to the municipality health office. On enquiring about the flu, the mode of transmission was not known to 42.5% of the HHs. In addition, general preventive practices for any flu, such as wearing a mask (36.1%), covering the face while sneezing (16%), and reducing contact with crowded places (14.2%) were found to be low among the surveyed population. Only 2.3% of the population had ever received the flu vaccine and 76.7% were not aware of its

availability. Overall, the brucellosis awareness level was found to be very low (4.6%). About one-third of the population, still prefer to drink raw milk in their daily life.

3.4. Health system contact and Zoonoses awareness

With the zoonoses awareness score as the dependent variable and other factors as independent variables, the regression model indicated that zoonoses knowledge is significantly influenced by age, education and contact with the animal health system. An increase of one year of age was associated with a mean increase of the zoonoses awareness score of 0.3% (Coef. 0.003; 95% CI: 0.001 to 0.005). Having formal education leads to a 16% (Coef. 0.168; 95%CI: 0.109 to 0.228) increase of the zoonoses awareness score. Among the other socio-demographic factors, gender, living above the poverty line, duration of residence in the surveyed community, or higher income have not shown any significant correlation with the zoonoses score. Although significance was not reached, a negative correlation between animal keeping and zoonoses awareness was observed i.e. households without animals have a 3.4% (Coef. 0.034; 95%CI: -0.027 to 0.096) higher zoonoses awareness score. On the one hand, people that prefer public health facilities have 2% higher awareness scores (Coef. 0.019; 95%CI: -0.031 to 0.071). On the other hand, more health system contacts at the community level correspond to higher chances of awareness of zoonoses, for the human health system 1.3% (Coef. 0.013; 95%CI: -0.039 to 0.065) and the animal health system 8.6% (Coef.0.086; 95%CI:0.017 to 0.154). Among HSC, the animal health system contact found to be significantly correlated with the awareness of the zoonoses i.e. households who have contacted any veterinarian within the last year found to be aware about the zoonoses. On accounting the myths/wrong beliefs this animal HSC score reduced from 8.6% to 7.7% (Coef. 0.077; 95%CI: 0.014 to 0.141). Another interesting finding is about the preferred source for the awareness of zoonoses found to be mass media, it appears to increase the awareness score by almost 5% in the model-II (Coef. 0.047; 95%CI: 0.001 to 0.093), compared to 0.5% (Coef. 0.006; 95%CI: -0.039 to 0.053) for community workers. The regression outcome indicates non-significance for all factors except age, education and animal health system contact, the details are shown in table 5. It also signifies that there is no difference between the two models, i.e. accounting for the wrong beliefs in the awareness score, except the mass media as preferred source of awareness in the second model.

4. Discussion

The HSC as one of the accountable factors for the zoonoses awareness (as hypothesized) is investigated deeply in this study with its different dimensions. The majority of HSC to the human health system occurs through female and/or male health workers; whereas for the animal health system, it was through private veterinarians at the community level. For the human health system, these grass root healthcare workers are often seen as heroes of the Indian public health system [7,30]; however, the impact of these workers on the healthy behavioral changes remains a challenge to date [31,32]. The HSC with the animal health system was mostly with private veterinarians, who visit the household only when there is a need for diagnosis or treatment. This might be because of the dearth of community animal health workers for the service delivery at the community level [8,33].

Comparing the HSC score of both systems, significant differences in the dimensions first contact, coordination, and the family centeredness are evident. This difference of impact between the human and the animal HSC might be attributed to the type of person who acts as prime contact and their different scope for the visit. A private veterinarian will not have high family centeredness and does not really serve as first contact, because he/she is the ultimate choice for explicit diagnosis and treatment. Interestingly the coordination score is also low in the animal sector, which indicates that the service is more scattered (done by different private actors) rather than a coordinated government-led service as for the human health system. For the human health system, the minimal qualification of the health workers is below matriculation, whereas for the animal health system it is a veterinary practitioner. Among the health workers of the human health system, coverage by the female health workers i.e. ASHAs and/or AWWs was higher than by the male health workers, which is evinced in the research literature, too [34,35]. For the animal health system, although the contact point was only through veterinarian, they might not serve as entry-point, because most of them were private practitioners and curative service providers. This provides an insight into the shortcomings of the current health system and the need for more coordinated and integrated services to be provided at the community level.

As the regression result indicated that animal health system contact has (significant) influence on the degree of awareness, whereas on the contrary (but without

significance) having an animal leads to lower knowledge, this seemingly contradictory finding might be attributed to the type of zoonoses assessed in this study. The factor contributing most to this negative correlation is the brucellosis awareness score (p=0.004). Rabies and flu are common to the public, whereas brucellosis is mostly of occupational origin and thus only or mostly mentioned in contacts with veterinarians.

There are dearth number of studies, which looked at more than one zoonotic disease in a single research study in the general community in India [12,36]. Most of the studies focus either on a specific target population or a specific disease. The level of awareness on zoonoses found, defined and measured quite differently, ranges from as low as 4% to as high as 80% [12,13,36,37]. In this study, awareness about zoonoses was found to be rather low at the community level, depending on the type of zoonotic disease. This might be attributed to the type of sample selected in this study i.e. mixed general community (both HHs with and without animals), as compared to other studies where target population were specific e.g. farmers. Although 58% of the community were aware of rabies, and 47% were aware of the flu, a detailed understanding of the diseases was widely lacking. Similar findings from the literature could be traced in various studies conducted in different parts of India [38–40]. A study by Singh *et al.* [41] in the same geographic region among the rural communities highlighted traditional practices i.e. after dog-bites either doing nothing or adopting some religious practices, which was also observed in this study. Unlike other studies the high awareness level for flu but low awareness about the vaccine availability [42,43], we found nearly half of the population to be aware of swine /bird flu, however, unaware of the availability of vaccines for prevention. Like Zhang *et al.* [44] in their worldwide review, who found the awareness level of Brucellosis to be lowest in India, this study also demonstrated that only 4.7% of the population had at least heard of the disease without any detailed awareness about the disease. Although literature cites the differential practices of animal vaccination in India [45]; this study documented that about half of the households with animal(s) vaccinated their livestock in the last year.

Although non-significant, a finding indicated that, the households, who reported the public health facilities as their preferred place for receiving primary health services (beyond the community level) showed higher awareness of zoonoses. The most attributed reason would be the high availability of information, education, and communication (IEC) materials at the public health facilities of India [46,47]. Similarly,

mass media as preferred mode of awareness found to be correlated with the higher awareness score. Mass media appears to be an important channel for health promotion [48] and found to be an effective channel in changing health behavior in India since decade [49]. Therefore, as a policy recommendation zoonosis specific (particularly awareness building for brucellosis (the risks of raw milk) and the availability of the flu vaccine) mass media campaigns may be more cost-effective and very viable than trying to create a whole new system of animal health workers or strengthening the human health actors to visit door-to-door.

The hypothesis that was assumed in this study that regular contact with the health system and its actors increases awareness of zoonotic diseases has to be partially accepted. Having contact to an animal health system increases zoonotic awareness, therefore leading to the acceptance of the hypothesis. However, for the human health system the hypothesis is rejected. In order for either of these community health workers (in this case the human health actors) to serve as One Health entry point in near future, further exploration of the health system (supply-side) perspective is required.

There were several limitations of this study. First, this study was conducted in only two zones of Ahmedabad city, therefore not reaching representativeness for the whole city population. Second, the response collected for the HSC to the human system could not be clearly categorized, as respondents were not sure if the person was ASHA or AWW. Therefore, we were not able to attribute the effort to one of the cadres (ASHA is under the Department of Health & Family Welfare and AWW is under the Department of Women & Child Development). Thirdly, as the study adapted the snow balling (only to seek the information) in recruiting the HHs with animals, there might be a potential selection bias, which leads to non-representativeness of the study with certain personal networks eventually over-represented. Fourthly, having just one interview partner per HH does not represent the awareness of the whole household, but usually of those who are either the most present, the most responsible or the most articulate person in the respective HH, which means that the actual awareness would be even lower.

5. Conclusion

At the community level, the most common HSC was the female health care worker for the human health system and the private veterinarian for the animal health system. Although this contact was more common with the human health system (in about two-thirds of the households), it was not significantly correlated with the zoonoses awareness in this case. Households with a HSC to the animal health system showed a significantly higher awareness level. The dimensions of the personal qualities of the HSC, especially their relation to the family, community, the cultural expectations and the health system with all its elements, also need to be strengthened for these identified actors of the human health system for more coordinated and integrated services to be provided at the community level. In addition, the mass media as a public health promotion tool need to be focused for improving overall zoonoses awareness. The outreach to the households and the health system entry point at the community level is positioned with an elaborate network, which could be strengthened further to initiate preventive OH activities.

5.1. Key points

- Regular contact with the human health system and its actors does not increase the awareness of zoonotic diseases in this setting, while contact with the animal health system increases the zoonotic awareness score.
- The most common HSC were female health care workers for the human health system and private veterinarians for the animal health system.
- The awareness on zoonoses and the HSC dimensions need to be strengthened through OH initiatives at the community level.

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Availability of data and materials

Data from this study will be available at the Center for Development Research (ZEF), Bonn, Germany, after the completion of this study. Researchers who meet the criteria for access to confidential data are encouraged to approach Dr. Timo Falkenberg, Coordinator Fortschrittskolleg 'One Health', Center for Development Research (ZEF), Bonn, Genscherallee 3, 53113 Bonn, Germany. Email: falkenberg@uni-bonn.de

Authors' contributions

All authors contributed equally to the development of this study. SY, WB, DS and TF participated in the conception and design of the study protocol. SY & FM collected the data. SY analyzed the data and drafted the first draft of the paper. DS, WB and TF critically reviewed the paper. All authors read and approved the final manuscript.

Ethics approval and consent to participate

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 the Indian Institute of Public Health Gandhinagar, India.

Competing interests

The authors declare that they have no competing interests.

References

1. Zhang D, Unschuld PU. China's barefoot doctor: past, present, and future. Vol. 372, The Lancet. Elsevier Limited; 2008. p. 1865–7.

2. Lehmann U, Sanders D. Community Health Workers: What do we know about them?- The state of the evidence on programmes, activities, costs and impact on health outcomes of using community health workers. 2007.

3. Schneider H. The governance of national community health worker programmes in low-and middle-income countries: An empirically based framework of governance principles, purposes and tasks. International Journal of Health Policy and Management. 2019 Jan 1;8(1):18–27.

4. Global Health Workforce Alliance G, World Health Organization W. Global Experience of Community Health Workers for Delivery of Health Related Millennium Development Goals: A Systematic Review, Country Case Studies, and Recommendations for Integration into National Health Systems [Internet]. 2010 [cited 2019 Dec 13]. Available from: www.creapixel.ch

5. World Health Organization W. Community health workers: A strategy to ensure access to primary health care services. 2016.

6. Strodel RJ, Perry HB. The National Village Health Guide Scheme in India: Lessons four decades later for community health worker programs today and tomorrow. Human Resources for Health. 2019 Oct 28;17(1).

7. Saprii L, Richards E, Kokho P, Theobald S. Community health workers in rural India: Analysing the opportunities and challenges Accredited Social Health Activists (ASHAs) face in realising their multiple roles. Human Resources for Health. 2015 Dec 9;13(1).

8. Collinson A. Assessing the feasibility of a community animal health worker project in Rajasthan. Veterinary Record. 2011 Jan 22;168(3):68–70.

9. Agriculture Skill Council of India A. Livestock Health Management: Animal Health Worker Facilitator Guide, India [Internet]. 2016 [cited 2019 Dec 13]. Available from: www.asci-india.com

10. Dikid T, Jain SK, Sharma A, Kumar A, Narain JP. Emerging & re-emerging infections in India: an overview. The Indian journal of medical research [Internet]. 2013 [cited 2019 Aug 20];138(1):19–31. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24056553

11. John TJ, Dandona L, Sharma VP, Kakkar M. Continuing challenge of infectious diseases in India. Lancet (London, England) [Internet]. 2011 Jan 15 [cited 2019 Mar 31];377(9761):252–69. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21227500

12. 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 Jan 1;189:15–21.

13. Patel K, Saxena D. Self-reported selected zoonotic diseases among animal handlers in Urban Ahmedabad, India. 2019 [cited 2019 Dec 6]; Available from: www.veterinaryworld.org/Vol.12/January-2019/26.pdf

14. Berrian AM, Smith MH, van Rooyen J, Martínez-López B, Plank MN, Smith WA, et al. A community-based One Health education program for disease risk mitigation at the human-animal interface. One health (Amsterdam, Netherlands) [Internet]. 2018 Jun

[cited 2019 Jul 17];5:9–20. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29270459

15. Mazet JAK, Clifford DL, Coppolillo PB, Deolalikar AB, Erickson JD, Kazwala RR. A “One Health” Approach to Address Emerging Zoonoses: The HALI Project in Tanzania. PLoS Medicine [Internet]. 2009 Dec 15 [cited 2017 Dec 5];6(12):e1000190. Available from: http://dx.plos.org/10.1371/journal.pmed.1000190

16. Asokan G V, Asokan V, Tharyan P. One health national programme across species on zoonoses: a call to the developing world. Infection ecology & epidemiology [Internet]. 2011;1. Available from: https://doi.org/10.3402/iee.v1i0.8293

17. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. Convergence model for effectual prevention and control of zoonotic diseases: a health system study on “One Health” approach in Ahmedabad, India. Health research policy and systems [Internet]. 2018 Dec 19 [cited 2019 Jan 18];16(1):124. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30567599

18. Ahmedabad Municipal Corporation A. Ahmedabad City: Ahmedabad Municipal Corporation [Internet]. About Ahmedabad City. 2017 [cited 2018 Jan 2]. p. 7. Available from: https://ahmedabadcity.gov.in/portal/jsp/Static_pages/about_us.jsp

19. Ministry of Home Affairs G. Office of the Registrar General & Census Commissioner, India [Internet]. Indian Census 2011. 2011 [cited 2018 Jan 2]. p. 7. Available from: http://www.censusindia.gov.in/

20. Ministry of Housing and Urban Affairs- Government of India G. Smart Cities Mission [Internet]. Ministry of Housing and Urban Affairs, Government of India. 2016 [cited 2018 Jan 2]. p. 8. Available from: http://www.smartcities.gov.in/content/

21. The Times of India T. 600-year-old smart city gets World Heritage tag. Ahmedabad: The Economic Times- The Times of India [Internet]. 2017 Jul 9;1. Available from: https://timesofindia.indiatimes.com/city/ahmedabad/600-year-old-smart-city-gets-world-heritage-tag/articleshow/59510439.cms

22. Sehgal R, Chawla S, Reece J. Population Survey (Census) of Stray Dog Population in Ahmedabad, Gujarat. Stray and Feral Animal Populations-Animal Studies Repository [Internet]. 2011 [cited 2019 Jul 17];7. Available from: https://animalstudiesrepository.org/strfapop/7

23. Ministry of Agriculture . 19th Livestock Census-2012 All India Report [Internet]. New Delhi; 2014 [cited 2017 Dec 29]. Available from: http://dahd.nic.in/sites/default/files/19th Livestock 2012.pdf

24. Sachdev Y, Dasgupta J. Integrated Child Development Services (ICDS) scheme. Medical journal, Armed Forces India [Internet]. 2001 Apr [cited 2019 Jul 17];57(2):139–43. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27407319

25. Yasobant S, Saxena D, Bruchhausen W, Memon FZ, Falkenberg T. Multi-sectoral prioritization of zoonotic diseases: One health perspective from Ahmedabad, India. Samy AM, editor. PLOS ONE [Internet]. 2019 Jul 30 [cited 2019 Aug 20];14(7):e0220152. Available from: http://dx.plos.org/10.1371/journal.pone.0220152

26. Shi L, Starfield B, Xu J. Validating the Adult Primary Care Assessment Tool. The Journal of Family Practice [Internet]. 2001 Feb 1 [cited 2019 Aug 5];50(2). Available from: https://www.mdedge.com/familymedicine/article/60464/validating-adult-primary-care-assessment-tool

27. Hu R, Liao Y, Du Z, Hao Y, Liang H, Shi L. Types of health care facilities and the

quality of primary care: a study of characteristics and experiences of Chinese patients in Guangdong Province, China. BMC Health Services Research [Internet]. 2016 Dec 2 [cited 2019 Aug 5];16(1):335. Available from: http://bmchealthservres.biomedcentral.com/articles/10.1186/s12913-016-1604-2

28. Christiansen T, Lauritsen J. EpiData- Comprehensive Data Management and Basic Statistical Analysis System [Internet]. EpiData Association, Odense Denmark; 2010. Available from: http://www.epidata.dk

29. R Core Team R. R: A language and environment for statistical computing [Internet]. R Foundation for Statistical Computing, Vienna, Austria; 2017. Available from: https://www.r-project.org/

30. Scott K, George AS, Ved RR. Taking stock of 10 years of published research on the ASHA programme: examining India's national community health worker programme from a health systems perspective. Health Research Policy and Systems [Internet]. 2019 Dec 25 [cited 2019 Dec 4];17(1):29. Available from: https://health-policy-systems.biomedcentral.com/articles/10.1186/s12961-019-0427-0

31. Sundararaman T, Ved R, Gupta G, Samatha M. Determinants of functionality and effectiveness of community health workers: results from evaluation of ASHA program in eight Indian states. BMC Proceedings. 2012 Sep;6(S5).

32. Agarwal S, Curtis SL, Angeles G, Speizer IS, Singh K, Thomas JC. The impact of India's accredited social health activist (ASHA) program on the utilization of maternity services: a nationally representative longitudinal modelling study. Human Resources for Health [Internet]. 2019 Dec 19 [cited 2019 Dec 4];17(1):68. Available from: https://human-resources-health.biomedcentral.com/articles/10.1186/s12960-019-0402-4

33. Catley A, Leyland T, Mariner JC, Akabwai DMO, Admassu B, Asfaw W, et al. Para-veterinary professionals and the development of quality, self-sustaining community-based services. Vol. 23, OIE Revue Scientifique et Technique. Office International des Epizootes; 2004. p. 225–52.

34. Ved R, Scott K, Gupta G, Ummer O, Singh S, Srivastava A, et al. How are gender inequalities facing India's one million ASHAs being addressed? Policy origins and adaptations for the world's largest all-female community health worker programme. Human Resources for Health. 2019 Jan 8;17(1).

35. Gopalan SS, Mohanty S, Das A. Assessing community health workers' performance motivation: A mixed-methods approach on India's Accredited Social Health Activists (ASHA) programme. BMJ Open. 2012;2(5).

36. Rajkumar K, Bhattacharya A, David S, Hari Balaji S, Hariharan R, Jayakumar M, et al. Socio-demographic study on extent of knowledge, awareness, attitude, and risks of zoonotic diseases among livestock owners in Puducherry region. Veterinary World. 2016;9(9):1018–24.

37. Tiwari HK, O'Dea M, Robertson ID, Vanak AT. Knowledge, attitudes and practices (KAP) towards rabies and free-roaming dogs (FRD) in Shirsuphal village in western India: A community based cross-sectional study. Kamhawi S, editor. PLOS Neglected Tropical Diseases [Internet]. 2019 Jan 25 [cited 2019 Dec 6];13(1):e0007120. Available from: http://dx.plos.org/10.1371/journal.pntd.0007120

38. Ichhpujani R, Chhabra M, Mittal V, Bhattacharya D, Singh J, Lal S. Knowledge, attitude and practices about animal bites and rabies in general community-a multi-centric study. Journal of Communicable diseases [Internet]. 2007 [cited 2019 Dec 6];38(4):355–61. Available from:

https://www.researchgate.net/publication/5932212_Knowledge_attitude_and_practices_about_animal_bites_and_rabies_in_general_community-a_multi-centric_study

39. Prakash M, Bhatti VK, Venkatesh G. Rabies menace and control - An insight into knowledge, attitude and practices. Medical Journal Armed Forces India. 2013;69(1):57–60.

40. Herbert M, Basha S R, Thangaraj S. Community perception regarding rabies prevention and stray dog control in urban slums in India. Journal of Infection and Public Health. 2012 Dec;5(6):374–80.

41. Singh U, Choudhary S. Knowledge, Attitude, Behavior and Practice Study on Dog-Bites and Its Management in the Context of Prevention of Rabies in a Rural Community of Gujarat. Indian Journal of Community Medicine [Internet]. 2005 [cited 2019 Dec 6];30(3):81. Available from: http://www.ijcm.org.in/text.asp?2005/30/3/81/42854

42. Verma R, Chayal V, Kumar R, Bhalla K, Dhankar M, Dhaka R, et al. Community perception about swine flu in an urban slum of Haryana: A cross-sectional study. Journal of Family Medicine and Primary Care [Internet]. 2018 [cited 2019 Dec 6];7(6):1515. Available from: http://www.jfmpc.com/text.asp?2018/7/6/1515/246458

43. Datta S, Sen S, Sengupta B. A study on knowledge and practice related to bird flu in a rural community of Hooghly District of West Bengal. Indian Journal of Public Health [Internet]. 2010 [cited 2019 Dec 6];54(4):216. Available from: http://www.ijph.in/text.asp?2010/54/4/216/77265

44. Zhang N, Zhou H, Huang D-S, Guan P. Brucellosis awareness and knowledge in communities worldwide: A systematic review and meta-analysis of 79 observational studies. Samy AM, editor. PLOS Neglected Tropical Diseases [Internet]. 2019 May 2 [cited 2019 Dec 6];13(5):e0007366. Available from: http://dx.plos.org/10.1371/journal.pntd.0007366

45. Rathod P, Chander M, Bangar Y. Livestock vaccination in India: an analysis of theory and practice among multiple stakeholders. Rev Sci Tech Off Int Epiz [Internet]. 2016 [cited 2019 Dec 6];35(3):729–39. Available from: www.gbpuat.ac.in

46. Sharma N, Nath A, Taneja DK, Ingle GK. A qualitative evaluation of the information, education, and communication component of the tuberculosis control program in Delhi, India. Asia-Pacific Journal of Public Health. 2009 Jul;21(3):321–32.

47. Thakur J, Jaswal N, Grover A. Is focus on prevention missing in national health programs? A situation analysis of IEC/BCC/Health promotion activities in a district setting of Punjab and Haryana. Indian Journal of Community Medicine [Internet]. 2017 [cited 2019 Dec 5];42(1):30. Available from: http://www.ijcm.org.in/text.asp?2017/42/1/30/199795

48. Wakefield MA, Loken B, Hornik RC. Use of mass media campaigns to change health behaviour. Vol. 376, The Lancet. NIH Public Access; 2010. p. 1261–71.

49. Suresh K. Evidence based communication for health promotion: Indian lessons of last decade. Indian Journal of Public Health [Internet]. 2011 Oct [cited 2020 Feb 11];55(4):276. Available from: http://www.ijph.in/text.asp?2011/55/4/276/92405

Table 1. Demographic and Socio-economic characteristics of the participants of the surveyed households with or without animals in Ahmedabad, India from October 2018 to July 2019

Variables	Total N=460 (%)	HHs with animal(s) n=230 (%)	HHs without animal(s) n=230 (%)	*p*-value
Age	39.3 ± 13.3	39.7 ± 13.5	39 ± 13.1	0.551
Female gender	332 (72.2)	148 (64.4)	184 (80)	0.000*
Education				
Illiterate	119 (25.9)	67 (29.1)	52 (22.6)	0.327
Primary level	77 (16.7)	42 (18.3)	35 (15.2)	
Secondary level	201 (43.7)	93 (40.4)	108 (47)	
Higher secondary	40 (8.7)	17 (7.4)	23 (10)	
Graduate or above	23 (5)	11 (4.8)	12 (5.2)	
Occupation				
Farmer/Agriculture	16 (3.5)	14 (6.1)	2 (0.9)	0.000*
Livestock dependent	98 (21.3)	98 (42.6)	NA	
Daily laborer	13 (2.8)	3 (1.3)	10 (4.4)	
Public/Private employed	13 (2.8)	5 (2.2)	8 (3.5)	
Housewife	231 (50.2)	69 (30)	162 (70.4)	
Others	89 (19.4)	41 (17.8)	48 (20.9)	
Marital status				
Married	422 (91.7)	210 (91.3)	212 (92.2)	0.235
Single	28 (6.1)	17 (7.4)	11 (4.8)	
Widowed	10 (2.2)	3 (1.3)	7 (3)	
Religion				
Hindu	379 (82.4)	193 (83.9)	186 (80.9)	0.392
Muslim	81 (17.6)	37 (16.1)	44 (19.1)	
Caste				
Scheduled Caste/Tribe	120 (26.1)	72 (31.3)	48 (20.9)	0.058
Other privileged Castes	25 (5.4)	13 (5.7)	12 (5.2)	
General	259 (56.3)	122 (53)	137 (59.6)	
Not expressed	56 (12.2)	23 (10)	33 (14.4)	
Living with below poverty line	107 (23.3)	60 (26.1)	47 (20.4)	0.207
Total HH member	6± 3	7 ± 3	6 ± 3	0.002[#]
HH monthly income (US$)	204 ±168	203 ± 164	206 ± 173	0.852
Duration of residency (in years)	37 ±29	44 ± 31	32 ± 29	0.000[#]

**p<0.05 is considered as significant, derived from the Chi-squared test for the HHs with or without animals*

[#]p<0.05 is considered as significant, derived from the t-test for the HHs with or without animals

HH: Household; US$: Data collected in INR and converted to US$ @ 1US$=70INR

Table 2. Health system contact and primary care among the surveyed households in Ahmedabad, India from October 2018 to July 2019

Variables	Total N=460 (%)	HHs with animal(s) n=230 (%)	HHs without animal(s) n=230 (%)	*p*-value
Preferred place to seek health services				
Public sector	179 (38.9)	76 (33)	103 (44.8)	0.081
Private sector	260 (56.5)	145 (63)	115 (50)	
Others (Pharmacy/Traditional)	21 (4.6)	9 (4)	12 (5.2)	
Preferred mode of getting health awareness and/or education				
Mass media	227 (49.3)	108 (47)	119 (51.7)	0.305
Health worker	250 (54.3)	132 (57.4)	118 (51.3)	0.190
Relatives/Friends	56 (12.2)	19 (8.3)	37 (16.1)	0.010*
Visit of any human health provider at door step (in last one year)	319 (69.3)	168 (73)	151 (65.7)	0.175
Type of human health provider at the doorstep (n=319) [#]				
Female HW (ASHA/AWW)	307 (66.7)	163 (70.9)	144 (62.6)	0.060
Male HW (MPHW/MSI)	159 (34.6)	81 (35.2)	78 (33.9)	0.539
Doctor	3 (0.7)	3 (1.3)	--	--
Visit of any animal health provider at door step (in last one year)	--	135 (58.7)	--	--
Type of animal health provider at the doorstep (n=135)[#]				
Animal Health worker		8 (5.9)		
Public Veterinarian	--	25 (18.5)	--	--
Private Veterinarian		118 (87.4)		
Prefer place for animal health services				
Public sector	--	58 (25.2)	--	--
Private sector		150 (65.2)		
Others (Pharmacy/Traditional)		22 (9.6)		

**p<0.05 is considered as significant and derived through chi-squared test*

[#]Data are n (%) or n unless otherwise stated

HW: Health worker; ASHA: Accredited Social Health Activist; AWW: Aanganwadi Worker; MPHW: Multi-purpose Health Worker; MSI: Malaria Sanitary Inspector

Table 3. Perception on different dimensions of health system contact among the surveyed households in Ahmedabad, India from October 2018 to July 2019

Dimensions of HSC	HSC for the human health system (n=319)	HSC for the animal health system (n=135)	*p*-value
Comprehensiveness of service delivery	2.55 ± 1.39	2.33 ± 1.34	0.051
First contact	2.16 ± 1.39	1.11 ± 0.48	0.000*
Community orientation	2.53 1.38	2.69 ± 1.35	0.123
Coordination	2.15 ± 1.39	1.16 ± 0.61	0.000*
Family centeredness	2.31 ± 1.41	1.39 ± 0.89	0.000*
Cultural competence	3.41 ± 0.94	3.41 ± 0.79	0.451
Total HSC score	15.11 ± 6.01	12.09 ± 3.43	0.000*

***p<0.05 is considered as significant and derived from two-sample T-test using variables with unequal variance*
Min-Max for the individual dimension is liker scale of 1-4 (least to highest satisfaction)
Min-max for the total score is 6-24 (least to highest satisfaction)

Table 4. Awareness of selected zoonotic diseases among the surveyed households in Ahmedabad, India from October 2018 to July 2019

Variables	**Total**	**HHs with animals(s)**	**HHs without animals(s)**	***p*-value**
	N (%)	***n (%)***	***n (%)***	
Heard of Rabies	269 (58.5)	140 (60.9)	129 (56.1)	0.372
Heard of Brucellosis	21 (4.6)	18 (7.8)	3 (1.3)	0.004*
Heard of Flu	219 (47.6)	105 (45.7)	114 (49.6)	0.570
Heard of zoonoses	345 (75)	176 (76.5)	169 (73.5)	0.568
	Mean* ± *SD	***Mean* ± *SD***	***Mean* ± *SD***	***p*-value**
Awareness score for Rabies	0.34 ± 0.31	0.35 ± 0.31	0.33 ± 0.32	0.284
Awareness score for Brucellosis	0.02 ± 0.1	0.03 ± 0.01	0.01 ± 0.01	0.004[#]
Awareness score for Flu	0.21 ± 0.26	0.19 ± 0.26	0.21 ± 0.27	0.189
Awareness score for zoonoses	0.32 ± 0.26	0.32 ± 0.26	0.32 ± 0.27	0.443

**p<0.05 is considered as significant and derived from the Chi-squared test*
[#]p<0.05 is considered as significant and derived from the two-sample T-test

Table 5. Factors accountable for the zoonoses awareness among the surveyed households of Ahmedabad, India from October 2018 to July 2019

Factors	Coef. [95%CI] of Model-I[#]	Coef. [95%CI] of Model-II*
Age (cont. per year)	0.003 [0.001 to 0.005]	0.002 [0.001 to 0.004]
Gender (Female Vs Male)	0.013 [-0.041 to 0.068]	0.022 [-0.028 to 0.073]
Education (No vs Formal)	0.168 [0.109 to 0.228]	0.157 [0.102 to 0.212]
Living with APL (BPL vs APL)	0.017 [-0.039 to 0.072]	0.016 [-0.035 to 0.067]
Income (cont. per what sum?)	$1.98e^{-6}$[$-5.26e^{-8}$ to $4.00e^{-6}$]	$1.88e^{-6}$[$1.51e^{-8}$ to $3.75e^{-6}$]
Residency in the surveyed area (cont. per year?)	0 [-0.000 to 0.001]	0 [-0.001 to 0.001]
Households without animal(s) (No vs Yes)	0.034 [-0.027 to 0.096]	0.036 [-0.020 to 0.092]
Public health facilities as preferred point of care (Pvt. vs Public)	0.019 [-0.031 to 0.071]	0.018 [-0.028 to 0.065]
Mass media as preferred source of awareness (No vs Yes)	0.047 [-0.003 to 0.097]	0.047 [0.001 to 0.093]
Healthcare worker as preferred source of awareness (No vs Yes)	0.005 [-0.042 to 0.059]	0.006 [-0.039 to 0.053]
Human health system contact (No vs Yes)	0.013 [-0.039 to 0.065]	0.008 [-0.040 to 0.056]
Animal health system contact (No vs Yes)	0.086 [0.017 to 0.154]	0.077 [0.014 to 0.141]

Normalized zoonoses score as the dependent variable
Adj. R-squared= 0.083 (Model-I) and 0.084 (Model-II) for the surveyed HHs (N=460)
#Model-I: Awareness score does not accounted for the wrong beliefs i.e. correct, no/wrong responses(scored as 1-0)
**Model-II: Awareness score accounted for the myths and/or wrong beliefs i.e. correct, no, wrong (scored as 1-0-(-1))*

2.5. Publication 5

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Who could be One Health Activist at the community level?: A case for India

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Abstract

Background: Community health workers (CHWs) are the mainstay of the public health system, serving for decades in low-resource countries. Their multi-dimensional work in various health care services, including the prevention of communicable diseases and health promotion of non-communicable diseases, makes CHWs, the frontline workers in their respective communities in India. As India is heading towards the development of One Health (OH), this study attempted to provide an insight into potential OH activists (OHA) at the community level. Thus, this case study in one of India's western cities, Ahmedabad, targeted identifying OHA by exploring the feasibility and the motivation of CHWs in a local setting.

Methods: This case study explores two major CHWs, i.e., female (Accredited Social Health Activists/ASHA) health workers (FHWs) and male (multipurpose) health workers (MHWs), on their experience and motivation for becoming an OHA. The data were collected between September 2018 and August 2019 through a mixed design, i.e., quantitative data (cross-sectional structured questionnaire) followed by qualitative data (focus group discussion with a semi-structured interview guide).

Results: The motivation of the CHWs for liaisoning as OHA was found to be low; however, the FHWs have a higher mean motivation score [40 (36–43)] as compared to MHWs [37 (35–40)] out of a maximum score of 92. Although most CHWs have received zoonoses training or contributed to zoonoses prevention campaigns, their awareness level was found to be different among male and female health workers. Comparing the female and male health workers to act as OHA, higher motivational score, multidisciplinary collaborative work experience, and way for incentive generation documented among the female health workers.

Conclusion: ASHAs were willing to accept the additional new liaison role of OHAs if measures like financial incentives and improved recognition are provided. Although this study documented various systemic factors at the individual, community, and health system level, which might, directly and indirectly, impact the acceptance level to act as OHA, they need to be accounted for in the policy regime.

Keywords: CHW, Motivation, ASHA, OHA, One Health, India

Background

The health workforce's skill and motivation directly influence the health system functionality across the globe [1, 2]. Evidence from low- and middle-income countries (LMICs) denoted a shortage of the health workforce, leading to gaps in service coverage and undermining the achievement of the health-related Sustainable Development Goals [3, 4]. According to the World Health Organization, 18 million additional health workers are needed to achieve universal health coverage by 2030 in LMICs [4]. One among other strategies is to address this shortfall through "task-shifting", i.e., allocation of tasks to actors at

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the lowest level who can perform them successfully [5, 6]. In this context, the concept of using community health workers (CHWs) has gained acceptance again [7].

The umbrella term "community health worker" includes frontline functionaries to deliver patient-centric, comprehensive primary health care, address social determinants of health, and respond to various health challenges and outcomes at the community level [8]. With an intimate understanding of the respective communities, CHWs are frontline health workers who serve their community as liaisons between health/social services and the community [7, 9]. In promoting universal health coverage, these CHWs play a major role and have been deployed globally as a local, low-cost health resource in communities [10]. According to various country reports, the role of CHWs generally includes health promotion, disease prevention, treatment of basic medical conditions, and collection of health data [7, 11, 12]. In addition, CHWs also have been considered a valuable asset during outbreaks for social mobilization and the distribution of health information, thus improving health security and community-level resilience[13].

In LMICs, CHWs are fronting challenges in effective healthcare delivery not only for achieving universal health coverage [14], but also due to the several large outbreaks and (re) emerging diseases with an increased burden of zoonotic diseases [15]. While the One Health (OH) approach is emerging on the global agenda to tackle zoonotic (re-)emerging diseases, it also emphasizes the importance of a skilled workforce and intersectoral collaboration among human, animal, and environmental health sectors for its operationalization [16, 17]. So far, different countries have attempted to reinforce their health workforce to act collaboratively [18, 19], and few piloted combined human and animal health services [20]. Unpacking qualitative and quantitative problems in the skilled workforce becomes further challenging when intersectoral collaboration is promoted across the OH domains [21]. This is one reason why the current research was focused on investigating who could be a potential activist, liaised either for risk identification or disease control (or both) at the interface of the human–animal–environment in communities of India. This idea has primarily emerged for two reasons: first, the risk is not being identified in an intersectoral exchange or manner, which leads us to face uncontrolled epidemic or pandemic situations, and second, the disease control strategies in the human and animal sector are not being implemented uniformly. For example, India's human health sector's surveillance collects symptom-based information [22], whereas the animal health sector collects the only laboratory-confirmed diagnosed cases [23]. Therefore, there is an urgent need to identify the risks from the human–animal–environment interface at the community level in a comparable manner through health activists, who could be framed as "One Health Activist" (OHA). Due to its interdisciplinarity nature, these actors at the community level were considered activists rather than workers (supposed to be a formal health workforce). The assumption is that without this label, the OHAs should not automatically be assumed to be progressive [24]. Thus, authors assumed this workforce as activists rather than workers, although these activists could be promoted later as workers. Among these three domains (human, animal, and environmental health) in India, the health workforce has the maximum reach at the community level through the CHWs, including Accredited Social Health Activists (ASHAs), Multipurpose health workers (MPHW), and Anganwadi Workers (AWWs) [25]. In one of our previous studies under the RICOHA (Research to explore intersectoral collaboration for One Health approach) project [26], we have documented the absence of governmental community actors from the animal health system in urban India [27]. Other evidence also indicates an acute shortage of an animal health workforce both at the clinical and the community level over decades [28], therefore identifying actors from the health workforce, who already have a good reach at the community level, might provide an opportunity for smooth operationalization of OH activities at the grass-root level. Recognizing that CHWs already play a role in pandemic preparedness and represent a trusted voice in the community, these CHWs were examined for their potential role as OHA in one of the western cities of Gujarat state, Ahmedabad. According to the literature, there are diverse motivational factors that influence the work performance of these CHWs [10, 29], this particular case study attempted to explore the motivational factors to become an OHA at the community level.

Objective(s)

1. To assess the awareness level of selected zoonotic diseases among the CHWs.
2. To document the multi-dimensional work pattern and performance of the CHWs.
3. To understand the level of motivation of the CHWs for becoming an OHA.

Methods

Study type

This case study used a mixed-method design. Quantitative data collection (cross-sectional survey) was followed by qualitative data collection (focused group discussion) from September 2018 to August 2019.

Study setting

The study was conducted in one of the most populous cities of the western state of Gujarat, Ahmedabad. It is the seventh most populous city in India and is the largest city of the western state Gujarat [30]. The city is further divided into zones and wards for administrative purposes. About 1500 CHWs are working across the six zones and 64 wards of the city and serving to a population of 7,650,000 [31]. Each CHW (predominantly female) ideally caters to the average population of 1000–2500 in India's urban setting [32]. This particular case study was carried out in two administrative zones of the city, i.e., East and South zones, with their 23 wards. The reason for the purposive selection of these two zones was the high population density, higher quantity of community healthcare workers, and higher risk of disease outbreaks.

Study sample

CHWs are working as an interface between the community and the public health system. These CHWs have been engaged in disease awareness, promote good health practices, and help the community in accessing health services for decades. In this study, two types of CHWs were targeted, i.e., Accredited Social Health Activists (ASHAs) as a female health workers (FHWs) and malaria/multipurpose male health workers as a male health workers (MHWs) based on gender. Initially, ASHAs were devoted to reproductive health services and family planning [33], but with the recent assignment for non-communicable diseases, their roles were expanded to other public health domains [34]. MHWs were involved in controlling communicable diseases, including malaria, TB, leprosy, water- and vector-borne diseases, environmental sanitation, detection of disease outbreaks, and their control [35]. In Ahmedabad, especially in the study area, the ratio of FHWs to MHWs per ward was 23:3. For the quantitative survey, all FHWs (~500) and MHWs (~70) were approached to participate in the study, and those who provided consent for the study were included in the final sample. The response rate was 58% in the case of FHWs and 87% in the case of MHWs. Therefore, the final sample for the study was 349 CHWs (288 FHWs and 61 MHWs). For the qualitative study, to participate in the focus group discussion (FGD), participants were contacted during the quantitative survey. About one-third of the participants provided their consent and availability were invited to participate in the FGD. Upon deciding a date and place, about 2–4 FHWs per each ward accepted final invitation, among which one per each ward was selected randomly and 5–6 FHWs were grouped for each FGD, based on the geographic convenience. Thus, four FGDs were conducted among the FHWs in two zones of the city. For the FGDs among the MHWs, similar rules were applied to randomly recruit MHWs from each ward. As the number of MHWs was less, one FGD was conducted per zone, thus two FGDs were conducted for the MHWs.

Study data collection

For the quantitative component, a structured, pilot-tested questionnaire in the vernacular language was used to collect information on the socio-professional details, training in zoonoses, knowledge, and practices about the selected zoonotic diseases, details on the previous collaborative work, perception about the required factors for becoming an OHA and the motivation level. The zoonotic diseases rabies, brucellosis, swine flu, and bird flu had been selected during the previously conducted prioritization workshop for Ahmedabad [36]. A standardized tool, validated in the Indian setting by Tripathy et al. [37] and originally developed by Bennet et al. [38], was used to measure the motivation. The motivation tool of Tripathy et al. [37] consists of 23 items with eight primary constructs, i.e., general motivation, burnout, job satisfaction, conscientiousness, timeliness, and personal issues. The responses were captured through an agreement scale of 1 to 4, i.e., strong disagreement (1) to a strong agreement (4). For negative questions, reverse coding was implemented before analysis. A trained research assistant administered the tool, which required 20–30 min of time from each participant.

FGDs were conducted for the qualitative component. The FGDs were conducted face-to-face at a time and place (mostly at the health centers) convenient to the participants, using an interview guide in the vernacular language. The empty hall of the health centers was utilized to conduct these FGDs, there was no other healthcare staff allowed to be present during the discussion, and the disclaimer was made to ensure the information confidentiality, which resulted in the improved degree of comfort and participation in the discussion. The interview guide focused on their current job tasks and the motivation for becoming an OH activist. Each FGD was conducted in the presence of the researcher and participants only and lasted over 1 h. At the end of each FGD, the major points of discussion were summarized for the participants based on the field notes. All FGDs were recorded with due consent from the participants.

Study data analysis

For the quantitative component, data were entered in Epi-Info (7.2.3.1) and exported to EpiData Analysis (version 2.2.2.183) for analysis [39]. The descriptive statistics were segregated between the groups of FHWs and MHWs. Categorical variables were expressed as frequencies or percentages, whereas the continuous variable was expressed as means with standard deviation. The total

motivation score for each respondent was computed by adding the individual agreement score of all 23 items. The minimum and maximum possible score of the tool was 23 and 92, respectively. The motivation score was expressed in the form of a mean score. To assess differences between these groups, Chi-square tests were used for categorical variables, and t-tests were applied for continuous variables.

For the qualitative component, the recordings and field notes were uploaded to Atlas.Ti (version 7.5.18) [40]. The recordings were transcribed for the development of the final transcripts. The transcripts were analyzed based on the previously decided themes, i.e., the current level of motivation and challenges at the individual, community, health system level, and the motivations for becoming an OH activist. The quantitative motivational score was compared and discussed with the qualitative findings.

Results

Quantitative findings

Out of the 349 CHWs sampled from two zones of the Ahmedabad city, 288 were FHWs, and 61 were MHWs, with a mean age of 40.38 ± 7.65, 36.25 ± 6.48, respectively. Although secondary education is the minimum qualification for the FHWs, we have documented that one-third of the sampled FHWs only completed primary education. Most of the MHWs were found to have at least a bachelor's degree. The professional experience in both categories was found to be similar: 8.29 ± 4.56, 8.40 ± 3.78 years, respectively. The mean catering population per FHWs was 3,183 ± 2,108, compared to the 47,718 ± 66,966 for the MHWs. The mean working hours per day were 4.49 ± 0.73 and 8.13 ± 0.81 for FHWs and MHWs, respectively. As the FHWs are on incentive-based working models, their mean income in INR was 4098 ± 1190, whereas MHWs are on salary-based models with mean incomes of 28,662 ± 6914. The detailed differences are presented in Table 1.

Table 1 Socio-professional details of the community health workers in Ahmedabad, India, during 2018–19

Profile	FHWs *n* = 288(%)	MHWs *n* = 61(%)
Age (in years)	40.38 ± 7.65	36.25 ± 6.48
Education		
Up to secondary	88 (30.6)	0
Secondary/higher	132 (45.8)	13 (21.3)
Graduate/above	68 (23.6)	48 (78.7)
Professional experience (in years)	8.29 ± 4.56	8.40 ± 3.78
Catering population	3183 ± 2108	47,718 ± 66,966
Monthly income (INR)	4098 ± 1190	28,662 ± 6914
Working hours per day	4.49 ± 0.73	8.13 ± 0 .81

Continuous variables are expressed as mean ± SD

FHWs Female Health Workers, *MHWs* Male Health workers, *INR* Indian rupee

Training and knowledge on zoonoses

Table 2 represents the awareness of the selected zoonotic diseases, which was higher overall among the FHWs as compared to the MHWs, except for the national program on rabies and brucellosis symptoms. Most of the FHWs were aware of the anti-rabies vaccination, which was reflected in their practice, such as the higher proportion of ARV counseling or ARC referral. Similarly, the higher awareness about the flu symptoms was reflected in the practices of FHWs, such as either providing basic medications or UHC referral in case of flu-like cases. Overall, a higher proportion of FHWs than MHWs was aware of at least one symptom of human rabies, influenza.

Multi-dimensional work of CHWs and prerequisites for OHAs

Upon enquiring about their previous work experience with other sectors, it was found that about 55% of FHWs have worked with the Women and Child Department (especially with Anganwadi Workers) in their normal daily routine. About 10% have worked with the higher administrative authorities from various departments during health emergencies; whereas, only 6% of MHWs mentioned previous collaborative work with any other sectors. Most health workers (97%) said their involvement in outbreak management in the past, and 80% agreed to additional engagements other than their primary task. Table 3 presents the summarized required factors that are strongly agreed by both groups to become an OHA. An essential element needed was institutional support (indicating the top-down directives) from all respective sectors, followed by structured guidelines with specific roles and responsibilities. Further, both groups mentioned adequate training on zoonoses, and leadership skills will be required, followed by social skills. Health workers also mentioned that there should be specific objectives and they need to be trained on coordinated roles with a focus on building trust with other actors.

Level of the motivation of the CHWs

Overall, the motivation score of FHWs was 40 (36–43), higher as compared to the MHWs 37 (35–40) out of a maximum score of 92. The mean motivational score was significantly different among these groups. The overall mean motivation score was 1.8 ± 0.2 higher among FHWs, compared to 1.6 ± 0.2 among MHWs. Both these groups were found to have low motivation and they sensed burnout in their daily routine work, as shown in Table 4. The general motivation was found to be low

Table 2 Awareness and practices on selected zoonotic diseases among the community health workers in Ahmedabad, India, during 2018–19

Factors	FHWs *n* = 288 (%)	MHWs *n* = 61 (%)	*p*-value
Awareness			
Awareness about National Rabies control Programme	99 (34.4)	45 (73.8)	0.000*
Awareness about the influenza vaccine?	246 (85.4)	54 (88.5)	0.526
Awareness about anti-rabies vaccines	287 (99.7)	59 (96.7)	0.024*
Aware about at least one symptom of rabies	226 (86.6)	41 (67.2)	0.060
Aware about at least one symptom of brucellosis	3 (1.1)	3 (4.9)	0.034*
Aware about at least one symptom of flu	285 (98.9)	60 (98.3)	0.690
Practices			
Ever received zoonosis training	229 (79.5)	16 (26.2)	0.000*
Ever participated zoonosis campaigning	194 (67.6)	49 (80.3)	0.049*
What you do when you come across a case of a dog bite?			
Counsel for ARV	43 (14.9)	6 (9.8)	0.298
Refer to UHC/ARC	203 (70.5)	29 (47.5)	0.001*
Inform to FHS/MO	15 (5.2)	0	0.068
What you do when you come across a case of flu-like symptoms?			
Give basic medicines	117 (40.6)	1 (1.6)	0.000*
Refer to UHC	256 (88.9)	47 (77)	0.013*
Inform to FHS/MO	9 (3.1)	3 (4.9)	0.485

FHWs Female Health Workers, *MHWs* Male Health workers, *ARV* anti-rabies vaccine, *UHC* Urban Health center, *ARC* anti-rabies clinic, *FHS* Female Health Supervisor, *MO* Medical Officer

*$p < 0.05$ is considered as significant, derived from the Chi-squared test for the female and male health worker

Table 3 Required factors for becoming an OH activist as expressed with 'Strongly agree' by the sampled health workers of Ahmedabad, India, during 2018–19

Factors	FHWs *n* = 288 (%)	MHWs *n* = 61 (%)	*p*-value
Training on coordinating roles	208 (72.5)	39 (63.9)	0.182
Relation between staff members	87 (30.4)	22 (36.1)	0.388
Knowledge and skills training	235 (81.9)	56 (91.8)	0.057
Individuals' social skills	239 (83.6)	53 (86.9)	0.519
Trust with other actors/departments	216 (75.3)	54 (88.5)	0.024*
Specific objective	234 (81.5)	52 (85.2)	0.491
Conflict resolution authority	141 (49.3)	20 (32.8)	0.019*
Institutional support	279 (97.2)	59 (96.7)	0.835
Leadership skills	252 (87.8)	58 (95.1)	0.098
Structured guidelines	268 (93.4)	60 (98.4)	0.129

FHWs Female Health Workers, *MHWs* Male Health Workers

*$p < 0.05$ is considered as significant, derived from the Chi-squared test for the female and male health worker

overall, with a slightly higher score of 2.1 ± 0.6 among the FHWs compared to a score of 1.9 ± 0.5 of the MHWs. The mean constructs of motivation scores such as job satisfaction, organization commitment, conscientiousness, timeliness, personal issues were found to be low (with a mean score of less than 2) and similar among the FHWs and MHWs. However, job satisfaction and self-efficacy are significantly different in these groups. The detailed distribution of the motivation score among these groups is presented in Table 4.

Qualitative findings

Six FGDs (four among the FHWs and two among the MHWs) were conducted across two zones of the city. On exploring the current challenges and their motivation for becoming OHAs, the opinions were clustered on the individual, community, and health system levels based on the thematic analysis.

Individual level

The current job activities and work profile of the FHWs were to implement most of the national health programs like maternal child health, non-communicable diseases, or immunization. Although they are the backbone of the health system at the grass-root level, they felt demotivated due to several reasons. One of the primary reasons might be the absence of appreciation of their dedication by neither the employer nor the community. In contrast, the MHWs are under fixed-term salaries, and they are bound to be transferred to other departments within the city municipal corporation, indicating their lack of

Table 4 Mean construct-wise motivation scores of community health workers in Ahmedabad, India, during 2018–19

Constructs of motivation	FHWs (mean ± SD)	MHWs (mean ± SD)	*p*-value
General motivation	2.1 ± 0.6	1.9 ± 0.5	0.099
Burnout	2.5 ± 0.9	2.3 ± 1.2	0.045*
Job satisfaction	1.2 ± 0.3	1.1 ± 0.2	0.001*
Intrinsic job satisfaction	1.5 ± 0.5	1.5 ± 0.5	0.824
Organization commitment	1.5 ± 0.5	1.4 ± 0.5	0.133
Conscientiousness and self-efficacy	1.7 ± 0.6	1.5 ± 0.6	0.007*
Timeliness	1.8 ± 0.4	1.8 ± 0.4	0.954
Personal issues	1.7 ± 0.6	1.8 ± 0.7	0.463
Overall motivation	1.8 ± 0.2	1.6 ± 0.2	0.001*

Min–max for the individual dimension under each construct was captured through an agreement scale of 1 to 4, i.e., strong disagreement (1) to a strong agreement (4)

FHWs Female Health Workers, *MHWs* Male Health Workers

*$p < 0.05$ is considered as significant and derived from two-sample *t*-test using variables with unequal variance

consistency in the current role. The low appreciation from the community also remained the same for the MHWs.

> *"Our name is 'ASHA' (in the vernacular language it means Hope!), but we do not have any 'ASHA' (in the vernacular language it means also Expectations), they do not appreciate us, ASHA has no any appreciation" (FHWs-FGD-3)*
> *"The problem is we are not working for the malaria department only, right now I am working in the malaria department, but I may get transferred to some other department within a few months. Like I was working in the solid waste management department before current assignment" (MHWs-FGD-2)*

In addition, both of these workers perceived more motivation when they have been involved in larger team activities like the last outbreaks of swine flu or bird flu. Most of these workers worked extensively during the outbreaks with or without formal training. Apart from routine work, FHWs also evinced working on the implementation of any new public health programs or piloting new interventions. They are also working with schoolteachers in school health programs and some of them are also involved in mass sanitation campaigning (i.e., Sabarmati River cleaning). This indicates the multidisciplinary working culture of FHWs compared to that of the MHWs.

Community level

The community members' support is a major driving force for these FHWs; they felt motivated to work hard when the community accepted them. There was mixed opinion documented for the community perceptions. Although the appreciation was low for the FHWs in most cases, most of them mentioned a positive reception by community members, from which they gain goodwill and recognition. However, some CHWs reported adverse reactions from the community while disseminating their daily routine. This might be one of the other contributing factors for the low motivation among these CHWs.

> *".....we feel proud that we are doing some good work, we feel good as they listen to us if we don't go then they call us and tell that why we did not go there, even if we don't go for a single day than also, they ask for us, they miss us!" (FHWs-FGD-1)*
> *".....in field people still do not understand, they think we are a beggar and came for begging something, so they use to treat us like a beggar and say 'aage jao' means go to next door" (FHWs-FGD-2)*
> *"People do not cooperate with us! If we go for fogging in the morning, they ask to come in the afternoon, and when we go in their time, then the houses found to be locked and if we request to access to a rooftop or the water tank, they don't allow us nor follow our any instructions" (MHWs-FGD-1)*

Health system level

FHWs are prime actors at the grass-root level with the multidisciplinary working culture for various health programs. Due to the inception of new programs, the activities are increasing tremendously among the FHWs, which sometimes resulted in non-scheduled work. In addition, failure to receive the financial incentives due to the non-completion of tasks or unavailability of data forms a vital system challenge. The primary issue remained the incentive-based payment system. Some of them mentioned that introducing a fixed payment for a package of services would increase their motivation for their work. There

were no such system-level challenges documented by the MHWs.

> *"We don't have any fixed work schedule, they (superiors) give us diverse fieldwork if it is from the health department than 'okay', but it's not like that. Today they tell to do this and next day anything else, everyday new work." (FHWs-FGD-1)*
> *"Even though all ASHA workers are working more or less the same, but do not get equal incentives, someone has more population so earning more and someone has not that much population so not getting that much. Even if we work during an outbreak, it was free; we did not get any extra incentives for that." (FHWs-FGD-3)*
> *"At present, we do not have fix pay, we people are doing work on incentive, we will get incentive according to completion of our task, the problem is if we have started any work and couldn't complete it because of the patient side problem than we will not get the incentive for that. For an example of immunization, we have worked from the first dose of vaccination and in case if a patient would not ready to get measles dose or patient had migrated so, in that case, we would not get incentive even though we worked for rest all." (FHWs-FGD-2)*

Motivation for becoming OHAs

Although FHWs have low motivation scores, certain factors documented might increase the motivation of FHWs. One aspect is confidence in what they do, and another is financial, which might motivate them to take on the additional task of OHAs. Some of them voiced concerns about the additive task from the community perspective, i.e., the opposite gender might not respond well. In addition, the acceptance of new tasks produced a concern as most of their current time is spent on data documentation. Most FHWs indicated that if the new assignment generated additional incentives, they would be pleased to do so. Therefore, an incentive package is the most important driver for the FHWs to become OHAs. In contrast, the concerns of the MHWs are mostly operational rather than financial. MHWs were found to be least concerned about the financial matters, as they are on fixed payroll as a salaried employee. MHWs have also produced similar concerns except for financial matters. Further, some of the MHWs refused to consider these additional responsibilities.

> *"We (ASHA) people were entered in reproductive child health care, that time we didn't know anything, gradually family planning, vaccination, now noncommunicable diseases, yoga many more we are expert, now you can send us anywhere, we can do everything" (FHWs-FGD-3)*
> *"Whether we get an incentive or not, but we always do all work for goodness of our area, all people do not think like that if incentive will be more than we will work more dedicatedly" (FHWs-FGD-2)*
> *"There should be a specific day for that, and it should be merged with your routine work so you can work in between and instead of two different reports it should go at one place so whoever wants to share about their field they can" (MHWs-FGD-1)*
> *"…first of all, we don't have time. We already have our routine work which we have to finish as per the deadline" (MHWs-FGD-2)*

In addition, both types of workers have expressed their interest in proper training and skill development in the domain of OH, as this is entirely new for them. They have also requested vigorous handholding training and practices across the domains of OH. On the one hand, one group proposed that OH activities should happen on a specific day of each week (like currently Mamata day, a day for maternal/childcare); on the other hand, another group proposed OH activities need to be integrated into their daily routine. In summary, promoting MHWs as OHAs requires more stringent top-down directives while FHWs require additional financial incentives to act as OHAs.

Discussion

OH's operationalization is highly dependent on the development of intersectoral collaboration strategies among all the relevant stakeholders at the global, national, and local levels [41–43]. However, this intersectoral collaboration until now is an elusive paradigm [44, 45], especially at the grass-root level of implementation. This might be attributed to a lack of health system research on identifying potential actors at the grass-root level who could act as OHA. The speculative role of an OHA at the grass-root level could be direct engagement in disease control, identification of potential hazards, risk mitigation, and early recognition across the interface of human–animal–environment and overall promotion of health and well-being for all. Thus, an OH activist would not work only as a bridge between the community and the system, but also have an imperative role in reporting to different authorities responsible for diverse risk management. The potential OHAs in a local setting would be highly beneficial in operationalizing OH activities and in understanding the local challenges and community strengths.

This case study highlighted the current zoonotic disease awareness and certain activities among the CHWs and explored their motivation for becoming an OH

activist in the near future. Although the overall motivation of the studied CHWs was found to be poor, they still provided themselves with positive feedbacks to act as OHA, if certain prerequisites are fulfilled. Measures like financial incentives, structured reporting patterns, assignment of clear roles and responsibilities have to be introduced before CHWs to accept the role of OHAs. Evidence indicates the importance of social recognition [46, 47] and fair monetary incentives [37, 48] for FHWs, which was also reflected in both the quantitative and qualitative findings of this study. A multi-stakeholder perspective study on the work performance of ASHAs by Sharma et al. [49] documented professional factors such as training and job security strengthening that would improve their performance, which was also documented in the health system-level qualitative findings of this study. Given the low density of the MHWs compared to the FHWs in India [50], the FHWs have an advantage in being considered OHAs. A systematic review found that the health system of LMICs is demotivating to the CHWs rather than motivating them to improve their performance [51], which indicates the strong need for reforms of the health system to strengthen the motivation of the health workforce. As per our observation, FHWs were more motivated to take on additional duties compared to the MHWs. However, specific financial incentives would be essential if they would be promoted to OH activists. Other studies from eastern and northern India also highlighted the importance of financial incentives to increase the level of motivation among the FHWs [37, 46]. Given the issues and challenges, some of India's state governments started to formalize the payment to FHWs as a monthly salary rather than incentives, which is one of the most welcome steps towards improving their motivation. In addition, the intervention studies on enhancing the motivation of CHWs recommend interdisciplinary actions, such as cross-cutting approaches, training, supervision, incentives, career development, and ownership [52, 53]. While the OH activities are drawing attention to the cross-cutting approaches with its interdisciplinary nature, these might attract the targeted FHWs in building and developing more satisfaction from their work performance.

As the current OH operational strategies emphasize the education and training programs including the interdisciplinary research collaborations [41], the scope needs to be extended to train these CHWs to become OHAs. Although CHWs were trained for the selected zoonoses or participated in the zoonoses campaigning in the local setting, they urged for more intense OH training before being captivated as OHAs. Although the evidence already indicates the involvement of CHWs in pandemic control [54] and their multidisciplinary roles in infectious disease control [55] and surveillance [56], CHWs urged for more OH training on multidisciplinary teamwork. Thus, the OH training should strengthen social and leadership skills, as well as training on coordinating roles in a multidisciplinary team along with the subject knowledge. Similar factors have also been prioritized in previous research, especially when these CHWs were targeted as change agents at the community level [57, 58]. Therefore, OHA's proposed role also needs to be envisaged in a similar pattern while promoting the FHWs as OHAs in the study setting. Despite mentioning the financial incentives as a requirement for the FHWs and as a driving force compared to the MHWs (as they were on the payroll), they are certainly not sufficient for turning the FHWs into OHAs or explaining their motivation.

When this case study recommends considering FHWs as future OHA with specific financial incentive packages, this is based on their advantages in their reach of presence, current multidisciplinary working culture, acceptance of the new health programs, higher awareness about zoonoses and current practices, and last, but not least higher motivation score as compared to the MHWs. In India so far, there have been no plans to establish a liaison between animal and human health care services at the lowest level, i.e., in the communities. Here, the OHA's potential role could be disease reporting to the human and animal health system simultaneously while also spreading awareness about zoonoses, promoting the health of animals and humans through early detection of hazards and risks. These are no more than speculative roles and responsibilities of OHA. Policy challenges include deciding the amount for incentives, improving their motivation for OH and other health services, and taking organizational structural barriers into account.

Limitation

This study has certain limitations: first, data collection was limited to only two zones of the city, and two types of CHWs were investigated in this study. Second, the other relevant sectors of OH need to be investigated for the presence of such community actors and recommended to test their motivation for becoming OHA. The third concern would be that approximately half of the FHWs did not respond to this study invitation, which might hint to exclusion due to educational level, social standing, or location and have had an implication on the perceptions generated herein. Therefore, there is a probability that the results might have emphasized some aspects that could restrict the generalizability of these study findings to a broader setting. Fourth, there might be other systemic factors that were not studied here and might directly or indirectly impact the CHWs and their motivation to be OHAs. Therefore, future research should consider these

limitations and conduct similar studies in India's diverse geographic settings prior to the finalization of policy recommendations.

Conclusion

This case study highlighted the different awareness levels of selected zoonotic diseases and preventive practices among the CHWs. In addition, the overall motivation was found to be low, and most of them expressed a feeling of "burnout" in their current schedule, which needs to be accounted for during the implementation of any health programs. There were several advantages of promoting FHWs to future OHAs at the community level documented in this study, including their reach in presence, higher awareness about the selected zoonotic diseases except for brucellosis, reach in their current practices, current multidisciplinary working culture, and overall higher motivation as compared to the MHWs. However, specific measures like improving their social and institutional recognition, additive financial incentives, and top-down directives with structured guidelines need to be considered for improving their motivation as documented in the study. In addition, FHWs also emphasized gaining more training on social and leadership skills in addition to the subject matter training. FHWs could potentially serve as OHA if all identified challenges (primarily the provision of financial incentives and clear top-down guidance) are addressed before the time of commissioning them. Although this study also documented multiple systemic factors influential in shaping the OHA role outside the OH context, we recommend increasing the scope and the geographic context to understand the dynamics of the health system and account for the decisive factors beyond the OH area.

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Authors' contributions

All authors contributed equally to the development of this study. SY, WB, DS and TF participated in the conception and design of the study protocol. SY and FM collected the field data and conducted the interviews. SY and FM analyzed the data. SY drafted the first draft of the paper. DS, WB and TF critically reviewed the paper. All authors read and approved the final manuscript.

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Availability of data and materials

Data from this study will be available at the Center for Development Research (ZEF), Bonn, Germany, after the completion of this study. Researchers who meet the criteria for access to confidential data are encouraged to approach Dr. Timo Falkenberg, Coordinator Fortschrittskolleg 'One Health', Center for Development Research (ZEF), Bonn, Genscherallee 3, 53113 Bonn, Germany. Email: falkenberg@uni-bonn.de.

Ethics approval and consent to participate

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 the Indian Institute of Public Health Gandhinagar (IIPHG), India.

Competing interests

The authors declare that they have no conflict of interest.

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References

1. Paliwal A, Luoma M, Avila C. Strengthening India's public health workforce: a landscape analysis of initiatives and challenges. 2014. https://www.hfgproject.org/strengthening-indias-public-health-workforce-a-landscape-analysis-of-initiatives-and-challenges/.
2. Liu JX, Goryakin Y, Maeda A, Bruckner T, Scheffler R. Global health workforce labor market projections for 2030. Hum Resour Health. 2017;15:11. https://doi.org/10.1186/s12960-017-0187-2.
3. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19:349–57.
4. World Heath Organization. Working together for health: the World Health Report 2006. Geneva; 2006. https://www.who.int/whr/2006/whr06_en.pdf?ua=1.
5. World Health Organization. Task shifting to tackle health worker shortages. Geneva; 2007. http://www.who.int/whr/2006/en.
6. Okyere E, Mwanri L, Ward P. Is task-shifting a solution to the health workers' shortage in Northern Ghana? Kumar S, editor. PLoS ONE. 2017;12:e0174631. https://doi.org/10.1371/journal.pone.0174631.
7. Lehmann U, Sanders D. Community Health Workers: what do we know about them?-The state of the evidence on programmes, activities, costs and impact on health outcomes of using community health workers. 2007.
8. Kane S, Kok M, Ormel H, Otiso L, Sidat M, Namakhoma I, et al. Limits and opportunities to community health worker empowerment: a multi-country comparative study. Soc Sci Med. 2016;164:27–34.
9. Javanparast S, Windle A, Freeman T, Baum F. Community health worker programs to improve healthcare access and equity: are they only relevant to low-and middle-income countries? Int J Heal Policy Manag. 2018;7:943–54.
10. Mohajer N, Singh D. Factors enabling community health workers and volunteers to overcome socio-cultural barriers to behaviour change: Meta-synthesis using the concept of social capital. Hum Resour Health. 2018;16:63.
11. Hazarika I. Health workforce in India: assessment of availability, production and distribution. WHO South-East Asia J Public Health. 2013;2:106.
12. Olaniran A, Smith H, Unkels R, Bar-Zeev S, van den Broek N. Who is a community health worker?—a systematic review of definitions. Glob Health Action. 2017. https://doi.org/10.1080/16549716.2017.1272223.
13. Boyce MR, Katz R. Community health workers and pandemic preparedness: current and prospective roles. Front Public Health. 2019;7:62.
14. Bredenkamp C, Evans T, Lagrada L, Langenbrunner J, Nachuk S, Palu T. Emerging challenges in implementing universal health coverage in Asia. Soc Sci Med. 2014;145:243–8.

15. 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.
16. Papadopoulos A, Wilmer S. One health: a primer. 2011. http://ncceh.ca/sites/default/files/One_Health_Primer_Nov_2011.pdf.
17. Gebreyes WA, Dupouy-Camet J, Newport MJ, Oliveira CJB, 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.
18. Mazet JAK, Uhart MM, Keyyu JD. Stakeholders in One Health. Rev Sci Tech. 2014;33:443–52.
19. Kimani T, Ngigi M, Schelling E, Randolph T. One Health stakeholder and institutional analysis in Kenya. Infect Ecol Epidemiol. 2016;6:31191.
20. Schelling E, Wyss K, Béchir M, Moto DD, Zinsstag J. Synergy between public health and veterinary services to deliver human and animal health interventions in rural low income settings. BMJ. 2005;331:1264–7.
21. Bennett S, Glandon D, Rasanathan K. Governing multisectoral action for health in low-income and middle-income countries: unpacking the problem and rising to the challenge. BMJ Glob Health. 2018;3:e000880. https://doi.org/10.1136/bmjgh-2018-000880.
22. National Centre for Disease Control- Directorate General of Health Services. Integrated Disease Surevillance Programme (IDSP). Minist. Heal. Fam. Welfare, Government India. 2010. http://www.idsp.nic.in/. Accessed 10 Oct 2017.
23. Department of Animal Husbandry, Dairying & Fisheries. National Animal Disease Reporting System (NADRS). Minist. Agric. Farmers Welfare, Gov. India. 2012. http://nadrsapps.gov.in/. Accessed 16 Aug 2017.
24. Huang J. Defining health activism: from MADD to mad activists: Health activism in the 20th century. Yale J Biol Med. Yale Journal of Biology and Medicine; 2011. p. 51–3. http://www.sshm.org/. Accessed 8 Dec 2020.
25. Mehdi A, Chaudhry D, Tomar P, Joshi P. Prevention of chronic diseases: reorienting primary health systems in India. 2016.
26. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. Convergence model for effectual prevention and control of zoonotic diseases: a health system study on "One Health" approach in Ahmedabad, India. Health Res Policy Syst. 2018;16:124.
27. Yasobant S, Bruchhausen W, Saxena D, Memon FZ, Falkenberg T. Health system contact and awareness of zoonotic diseases: Can it serve as One Health entry point in the urban community of Ahmedabad, India. Yale J Biol Med. 2020;Accepted.
28. Rao S, Rasheed Sulaiman V, Natchimuthu K, Ramkumar S, Sasidhar P, Gandhi R. Improvement of veterinary services delivery in India. Rev Sci Tech. 2015;34.
29. Saprii L, Richards E, Kokho P, Theobald S. Community health workers in rural India: analysing the opportunities and challenges Accredited Social Health Activists (ASHAs) face in realising their multiple roles. Hum Resour Health. 2015a;13:95. https://doi.org/10.1186/s12960-015-0094-3.
30. Ahmedabad Municipal Corporation A. Ahmedabad City: Ahmedabad Municipal Corporation. About Ahmedabad City. 2017. p. 7. https://ahmedabadcity.gov.in/portal/jsp/Static_pages/about_us.jsp. Accessed 2 Jan 2018.
31. Ministry of Home Affairs G. Office of the Registrar General & Census Commissioner, India. Indian Census 2011. 2011. p. 7. http://www.censusindia.gov.in/. Accessed 2 Jan 2018.
32. National Health Mission. About Accredited Social Health Activist (ASHA). Minist. Heal. Fam. Welfare, Gov. India. 2010. p. 1–2. https://nhm.gov.in/index1.php?lang=1&level=1&sublinkid=150&lid=226. Accessed 24 Aug 2020.
33. Agarwal S, Curtis SL, Angeles G, Speizer IS, Singh K, Thomas JC. The impact of India's accredited social health activist (ASHA) program on the utilization of maternity services: a nationally representative longitudinal modelling study. Hum Resour Health. 2019;17:68. https://doi.org/10.1186/s12960-019-0402-4.
34. Abdel-All M, Abimbola S, Praveen D, Joshi R. What do Accredited Social Health Activists need to provide comprehensive care that incorporates non-communicable diseases? Findings from a qualitative study in Andhra Pradesh. India Hum Resour Health. 2019;17:73. https://doi.org/10.1186/s12960-019-0418-9.
35. Ministry of Health and Family Welfare. Guidelines for multipurpose health worker (male) in India. New Delhi; 2010. http://www.nihfw.org/pdf/Guidlines_MPHW(M)_29dec2011.pdf.
36. Yasobant S, Saxena D, Bruchhausen W, Memon FZ, Falkenberg T. Multisectoral prioritization of zoonotic diseases: one health perspective from Ahmedabad, India. PLoS ONE. 2019;14:e0220152. https://doi.org/10.1371/journal.pone.0220152.
37. Tripathy JP, Goel S, Kumar AMV. Measuring and understanding motivation among community health workers in rural health facilities in India-a mixed method study. BMC Health Serv Res. 2016;16:366. https://doi.org/10.1186/s12913-016-1614-0.
38. Bennett S, Franco LM, Kanfer R, Stubblebine P. The development of tools to measure the determinants and consequences of health worker motivation in developing countries. 2001. http://www.phrplus.org/Pubs/m5tp2.pdf.
39. Christiansen T, Lauritsen J. EpiData—comprehensive data management and basic statistical analysis system. EpiData Association, Odense Denmark; 2010. http://www.epidata.dk.
40. ATLAS.ti Development Team. ATLAS.ti [Computer Software]. Berlin: Scientific Software Development; 1999.
41. Connolly J. Governing towards 'One Health': establishing knowledge integration in global health security governance. Glob Policy. 2017;8:483–94. https://doi.org/10.1111/1758-5899.12505.
42. Anholt RM, Stephen C, Copes R. Strategies for collaboration in the interdisciplinary field of emerging zoonotic diseases. Zoonoses Public Health. 2012. p. 229–40.
43. Stephen C, Stemshorn B. Leadership, governance and partnerships are essential One Health competencies. One Health. Elsevier B.V.; 2016. p. 161–3.
44. Osoro E, Mbabu M, Njeru I, Kairu-Wanyoike S, Muturi M, Kiambi S, et al. Implementing one health intersectoral collaboration at country level. Sess 4 (OIE Conf Oper dog Transm rabbies Elimin through Prev source. 2010. p. 24–5. http://www.oie.int/fr/RABIES2015/abstracts/Session_4.3_Osoro_One_Health_abstracts.pdf. Accessed 16 Jan 2018.
45. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. One health collaboration for a resilient health system in India: learnings from global initiatives. One Health. 2019;8:100096.
46. Gopalan SS, Mohanty S, Das A. Assessing community health workers' performance motivation: a mixed-methods approach on India's Accredited Social Health Activists (ASHA) programme. BMJ Open. 2012. https://doi.org/10.1136/bmjopen-2012-001557.
47. George MS, Pant S, Devasenapathy N, Ghosh-Jerath S, Zodpey SP. Motivating and demotivating factors for community health workers: a qualitative study in urban slums of Delhi, India. WHO South-East Asia J Public Health. 2017;6:82–9.
48. Saprii L, Richards E, Kokho P, Theobald S. Community health workers in rural India: analysing the opportunities and challenges Accredited Social Health Activists (ASHAs) face in realising their multiple roles. Hum Resour Health. 2015b;13:1–13.
49. Sharma R, Webster P, Bhattacharyya S. Factors affecting the performance of community health workers in India: a multi-stakeholder perspective. Glob Health Action. 2014;7:25352.
50. Karan A, Negandhi H, Nair R, Sharma A, Tiwari R, Zodpey S. Size, composition and distribution of human resource for health in India: new estimates using National Sample Survey and Registry data. BMJ Open. 2019;9:e025979.
51. Shipton L, Zahidie A, Rabbani F. Motivating and demotivating factors for community health workers engaged in maternal, newborn and child health programs in low and middle-income countries: a systematic review. J Coll Physicians Surg Pakistan. 2017;157–65. http://ecommons.aku.edu/pakistan_fhs_mc_chs_chs/261. Accessed 13 Aug 2020.
52. Strachan DL, Källander K, Ten Asbroek AHA, Kirkwood B, Meek SR, Benton L, et al. Interventions to improve motivation and retention of community health workers delivering integrated community case management (iCCM): Stakeholder perceptions and priorities. Am J Trop Med Hyg. 2012;87:111–9.
53. Jigssa HA, Desta BF, Tilahun HA, McCutcheon J, Berman P. Factors contributing to motivation of volunteer community health workers in Ethiopia: the case of four woredas (districts) in Oromia and Tigray regions. Hum Resour Health. 2018;16:57. https://doi.org/10.1186/s12960-018-0319-3.
54. Bhaumik S, Moola S, Tyagi J, Nambiar D, Kakoti M. Community health workers for pandemic response: a rapid evidence synthesis. BMJ Glob Health. 2020;5:e002769.

55. Rashid J, Taiwo OO, Barraza-Roppe B, Lemus M. Using community health workers to prevent infectious diseases in women1. Emerg Infect Dis. 2004;10:e11.
56. Nabukalu D, Ntaro M, Seviiri M, Reyes R, Wiens M, Sundararajan R, et al. Community health workers trained to conduct verbal autopsies provide better mortality measures than existing surveillance: results from a cross-sectional study in rural western Uganda. PLoS ONE. 2019;14:e0211482. https://doi.org/10.1371/journal.pone.0211482.
57. Ingram M, Chang J, Kunz S, Piper R, de Zapien JG, Strawder K. Women's health leadership to enhance community health workers as change agents. Health Promot Pract. 2015;17:391–9.
58. Schneider H, Nxumalo N. Leadership and governance of community health worker programmes at scale: a cross case analysis of provincial implementation in South Africa Lucy Gilson. Int J Equity Health. 2017;16:72.

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Article

'One Health' Actors in Multifaceted Health Systems: An Operational Case for India

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Abstract: The surging trend of (re)emerging diseases urges for the early detection, prevention, and control of zoonotic infections through the One Health (OH) approach. The operationalization of the OH approach depends on the contextual setting, the presence of the actors across the domains of OH, and the extent of their involvement. In the absence of national operational guidelines for OH in India, this study aims to identify potential actors with an attempt to understand the current health system network strength (during an outbreak and non-outbreak situations) at the local health system of Ahmedabad, India. This case study adopted a sequential mixed methods design conducted in two phases. First, potential actors who have been involved directly or indirectly in zoonoses prevention and control were identified through in-depth interviews. A network study was conducted as part of the second phase through a structured network questionnaire. Interest and influence matrix, average degree, network density, and degree of centralization were calculated through Atlas.Ti (ATLAS.ti Scientific Software Development GmbH, Berlin, Germany), UCINET (Analytic Technologies, Lexington, KY, USA) software. The identified actors were categorized based on power, administrative level (either at the city or district level), and their level of action: administrative (policy planners, managers), providers (physicians, veterinarians), and community (health workers, community leaders). The matrix indicated that administrative actors from the district level were 'context setters' and the actors from the city level were either 'players' or 'subjects'. The network density showed a strength of 0.328 during the last outbreak of H5N1, which decreased to 0.163 during the non-outbreak situation. Overall, there was low collaboration observed in this study, which ranged from communication (during non-outbreaks) to coordination (during outbreaks). The private and non-governmental actors were not integrated into collaborative activities. This study concludes that not only collaboration is needed for OH among the sectors pertaining to the human and the animal health system but also better structured ('inter-level') collaboration across the governance levels for effective implementation.

Keywords: One Health; intersectoral collaboration; actors; health system; India

1. Introduction

The interaction of humans and animals in their shared environment results in dynamic circumstances in which the health of all is inextricably linked to that of the others [1,2]. Over the last two decades, the surging trend of emerging and re-emerging diseases has been creating significant challenges across the globe [3]. South-Asia is a major hotspot for (re)emerging diseases with India

being one of the greatest contributors to the burden of zoonoses [4]. The One Health (OH) approach and its strategies are promoting collaborative actions at the human-animal-environment interface [5–8], providing opportunities for the prevention and management of zoonoses and guiding zoonoses research and policy. Although the OH approach is not well institutionalized and is facing many challenges in South Asian countries—such as lack of institutional capacity, issues with ownership (lack of mutual interest), each sector have their own mandate, responsibility, priority, and constraints [9]—the emerging outbreaks demonstrate the urgent need for strong coordination and collaboration between the human and animal health sectors to combat zoonotic diseases [3,4,10]. In the case of unforeseeable onset and rapid (re)emergence of zoonotic diseases, the public health system should quickly be able to identify the early signs and react promptly to minimize the threats [11]. This type of situation is the time to embrace an OH approach as a framework for public health action against zoonoses, as indicated by the tripartite (WHO, FAO, OIE) zoonotic guide [12].

Despite having a large number of zoonotic outbreaks, India is one of the other South Asian countries that has not yet implemented a national OH policy and/or operational guidelines. On the one hand, it is indicated that large knowledge gaps on emerging diseases remain in India, due to the lack of data on the social, economic, and public health impact of zoonotic pathogens [13–16]. On the other hand, zoonotic disease research is largely ad hoc, and the majority of research focuses on the development of vaccines, therapeutics, and diagnostic tests rather than exploring sustainable disease control strategies within the local context [5,17]. Prioritization and appropriate utilization of available resources are of critical importance for the effectual control and prevention of these diseases [3,18]. Multiple actors' perspectives and participatory actions are important approaches for identifying and implementing sustainable solutions that are adapted to local contexts in consideration of culture and needs [8,19]. In summary, understanding the local context, the collaboration pattern at the human–animal health interface, the detection and response strategies are forming an important foundation for the prevention of zoonotic diseases. The World Bank emphasizes a "more general, permanent system for coordinated national and international surveillance and control" that would entail "more regular channels of collaboration than the current communication between agencies that prevails to date, which is based on temporary arrangements formed in response to various contingencies" [20], therefore highlighting the need to explore the sustainability of existing collaborations and developing strategies to establish sustainable collaborations across sectors.

Exploring and understanding collaboration patterns is a complex process, as the health systems for humans or animals are shaped by informal rules and relations [21,22]. Inter-sectoral collaboration (ISC) is a continuum of varying stages of integration between actors: i.e. communication, cooperation, coordination, collaboration, and coadunation [23]. The different degrees of integration range from fully independent functioning to fully integrated systems [24,25]. Thus, to understand the degree of integration, it is essential to explore its actors at the interface of human–animal–environmental health, their relationships, and interactions [26], which comprises not only the human health system but also the animal health system. It was recognized that multiple actors' perspectives are essential to understand the level of integration and to address issues like ownership, institutional capacity, or the different mandate of each sector. Research on health system performance indicated the urgent need to understand the actors and institutions along with the formal and informal rules governing the health system at the local context [27].

Therefore, in the absence of an OH policy and/or national operational guidelines, mapping of actors, understanding the existing capacities, and networks in the local context are becoming an important task in India. In India, so far, the zoonoses prevention and control remained under the purview of the division of the zoonotic disease programs under the National Centre for Disease Control, Ministry of Health & Family Welfare for the humans [28]. Whereas the zoonoses among domestic and livestock animals are addressed by the Ministry of Fisheries, Animal Husbandry, and Dairying which is newly formed from the department of the same name under the Ministry of Agriculture and Farmers Welfare in 2019, the Wildlife Institute of India focuses on zoonoses in wildlife [29]. This indicates the

fragmented approach to the problem of zoonoses control in the country [13]. The principle of action by these authorities remained as 'need-based collaboration': however, the 'need' has been documented so far during the outbreak situations only. In absence of national OH policy and/or operational guidelines in India, investigating the presence and distribution of actors for zoonotic disease prevention is required to enable the implementation of OH in the local context. Thus, the overall aim of this study is to identify and categorize actors at the human–animal health system interface and attempted to document the issues and challenges pertaining to the ISC in two different situations (one during an outbreak and another during non-outbreak) with a focus on prevention and control of zoonotic diseases in Ahmedabad, India.

2. Materials and Methods

2.1. Study Setting

2.1.1. General Setting

India has a quasi-federal form of government, called 'union' or 'central' government, with elected officials at the union, state, and local levels. The cities of the country rely on the municipal or local governance which refers to the third tier of governance in India, at the level of the municipality or urban local body, and have a great degree of fiscal autonomy and functions, which, however, varies from state to state. In contrast, the rural government system relies on Panchayati raj, a three-tier governance structure with elected bodies at the village, block, and district level.

2.1.2. Specific Setting

This study was conducted in Ahmedabad city of the western Indian state of Gujarat. The Ahmedabad city is selected for two prime reasons: first, it has encountered different zoonotic outbreaks over the past few decades—including Crimean-Congo hemorrhagic fever [30], H1N1 [31], and H5N1 [32]; second, the city has become one of the innovation corners for various governance models [33]. Like other cities of India, Ahmedabad city is governed by a corporate body, the Ahmedabad Municipal Corporation (AMC). The public urban health system for humans relies upon Urban Health Centres (UHCs) and Medical Colleges [34] and is commissioned by the health department of the AMC. The human health system is also enriched by private providers throughout the city [35]. The animal health system is managed by the Cattle Nuisance Control Department with few veterinary dispensaries. In addition, there are few trust (non-profit) agencies and for-profit private facilities also contributing to the animal care across the city.

2.2. Study Design

This case study adopted a mixed-method design to collect the information in Ahmedabad, India from September 2018 to October 2019. It is part of a larger health system study called RICOHA (Research to explore Intersectoral Collaborations for the One Health Approach), the detailed study protocol is published elsewhere [36]. In this case study, there were two phases of data collection: phase-I, the qualitative data collection through in-depth interviews (method for objective 2 in RICOHA study protocol); and phase-II, the quantitative data collection through a network survey (method for objective 3 in RICOHA study protocol).

2.3. Study Concepts

We have conceptualized OH as a policy or institutional innovation, whose institutionalization process analysis requires a systems approach [37]. We have used the systems approach for two different reasons: first, in a rather theoretical perspective, for understanding OH as a system of functional sub-systems, like in the theory of social systems (by Niklas Luhmann), where the interaction of sub-systems creates new challenges; and second, by seeing social structures as empirically quantifiable

constituents of a system, for analyzing the degree of involvement in the collaborative work. This use of two different notions of the system was based on two assumptions. The first assumption was that the ISC process starts with the identification of institutions or groups of stakeholders (defined in social systems theory as sub-systems and here named as collective actors), which are essential to perform the ISC activities on the issues at the human–animal interface and have their own logics and interests. The second assumption was that the development and/or the sustainability of ISC activities might require a simpler or more complex system change across the different sectors [38]. In this case, the social network analysis (SNA) provides the analytical framework for the understanding of actors in the health system and guiding the research process [39].

2.4. Study Sample and Sampling

The study was limited to the boundaries of the human and the animal health system, consisting of samples from the top two levels of the health system, i.e., actors from the administrative level (working on planning and decision-making) and actors from the provider level (working in clinical settings and providing healthcare services). As there were very few actors present at the administrative level, we have approached all the actors of the human and the animal health system and most of them provided consent to participate in the study. Thus, from for the qualitative data collection, we recruited almost all the administrative actors working at the AMC and purposively selected the lead non-governmental organizations and private bodies. Similarly, we purposively also selected a few actors from the provider level until the saturation of responses. For the quantitative data collection, in addition to the above participants, we sent an open invitation to all the clinicians working in the human and animal health system of the city and those who agreed to participate (40% response rate) and who provided consent, were recruited for the survey.

2.5. Study Data Variables and Data Collection

2.5.1. Phase-I (Qualitative Data Collection)

In-depth interviews were conducted with the actors purposively selected from the administrative and provider level. The one-to-one interviews were done at the date and time convenient to participants after obtaining their consent to participate in the study. An interview guide with broad, open-ended questions on the respondents' collaboration with other actors during different situations (i.e., outbreak vs. non-outbreak). In addition, a ranking scale was used to collect information on the perceived influence and interest in the prevention of zoonoses activities of different actors. Audio recording and verbatim notes were taken during the interview.

2.5.2. Phase-II (Quantitative Data Collection)

An open invitation to participate in the network survey was sent to all actors from the administrative and provider level of the human and animal health system of Ahmedabad. A structured network questionnaire was administered personally by a trained research assistant to those who responded and provided consent. The demographic information, professional practices, interactions, and collaborative activities (especially across the sectors) were collected as part of the network survey. A list of actors was prepared prior to the survey based on the qualitative findings of the interviews of phase I. These were presented to each participant and all participants were asked to describe their frequency of interaction with each actor on the list on a six-point scale (i.e., no contact, yearly, quarterly, monthly, weekly, and daily). Furthermore, they were asked to describe the degree of ISC with the other actors on a six-point scale from minimal to highest integration (i.e., not linked, communication, cooperation, coordination, collaboration, fully linked). A network tie between actors was defined as at least monthly interaction as frequency and a communication relationship as integration. These relationships were explored under two distinct situations, i.e., during the last outbreak (i.e., H5N1 in 2017) and during the current non-outbreak (at the time of data collection in 2019) situation.

2.6. Study Analysis

2.6.1. Phase-I (Qualitative Analysis)

Transcripts from the interview recordings were made on the same day. Content analysis in Atlas.Ti version 8 [40] was used to identify each actor mentioned at least once in the transcript. The need for collaboration was assessed based on themes. The Interest and Influence Matrix (IIM) [41,42] was conducted to understand the presence of actors and their roles in the prevention and control of zoonotic diseases. The IIM categorizes four major types of actors, i.e., players (high interest, high influence), subjects (high interest, low influence), context setters (low interest, high influence), and the crowd (low interest, low influence) [41,42]. Actors with high levels of interest and influence are termed as 'players', these are important key elements in the collaboration process. They also help highlight coalitions to be encouraged or discouraged, what kind of decision to be fostered, and also provide information on how to convince other actors. 'Subjects' have high levels of interest but low levels of influence. Therefore, although by definition they are supportive, they are unlikely to be able to play a significant role in supporting the implementation. However, by engaging subjects in the implementation process, they might become influential in a later stage by forming an alliance with other influential actors. The actors with high influence but low interest is known as 'context setters'; however, they might have a significant influence in implementation, but might be difficult to engage in each process. Even sometimes, additional effort is required to engage these actors. It is important to consult these actors for their opinions, concerns, and ideas for successful implementation. The 'crowd' are the actors with low interest and influence; thus, little need to consider them in much detail. However, their interest or influence might change over time. It is equally important to inform them of each implementation process.

2.6.2. Phase-II (Quantitative Analysis)

Network analysis was carried out to understand the strength of the interaction between these actors in the outbreak and non-outbreak situations. A visualization of the interactions and quantified outcomes such as average degree (the average number of links each node in the network has), density (the proportion of possible links in the network), and degree of centralization (the extent to which only a few nodes have a large number of ties) were analyzed in UCINET version 6 [43]. The average degree is denoted by the total number of edges or links divided by the total number of nodes in a network. Thus, the value of average degrees depends on the number of actors and their frequency of connections. Similarly, the density is defined as the number of connections a participant has divided by the total possible connections of a participant could have (e.g., if there are 20 people, each person could potentially connect to 19 others, thus if a person were connected to all other persons the density would be 100% (19/19)). The degree of centralization is an indicator of centrality and a good measure of the total number of connections a certain node has, but will not necessarily indicate the importance of each node in connecting to others or how central it is in the network. The values of degree of centralization range from 0 to 1, with 0 indicating no connection and 1 indicating all are highly connected. For the quantitative data, descriptive statistics were created in R version 3.4.1 [44].

2.7. Ethics Approval and Consent to Participate

Ethics approval has been obtained from the Research Ethics Committee of Center for Development Research (ZEF), University of Bonn, Germany (ZEF dated 18/06/2018), and the Institutional Ethics Committee of the Indian Institute of Public Health Gandhinagar (IIPHG), India (TRC-IEC No. 02/2018 dated 25/07/2018). The written consent was collected from each participant, who were recruited in this study.

3. Results

A total of 30 interviews were conducted as part of the phase-I (12 from administrative, 12 from the provider, 6 from private/non-governmental organizations), followed by 6 actors from the administrative level and 66 actors from the provider level participated in the phase-II.

3.1. One Health Actors of the Complex Health System

The presence of two-layered actors—i.e., actors of the local government body (AMC) and actors from the district administrative body—was documented. Although there were similar actors also present at the top level—i.e., at the state or the national level—it was difficult to get information on them from the current interview data. The two layers of actors on the two administrative levels of district and city resulted in a strong influence from the district or even higher authorities on the action of zoonoses prevention in the city. These actors (city, district/higher) have a direct or indirect role in the decision and/or implementation process of the collaborative activities. The actors were broadly categorized by their level of action in the health system: top, middle, or bottom. At the top level, the policymakers, program managers, and planners were considered as 'administrative actors', followed by the actors involved in the clinical service provision such as physicians and veterinarians, considered as 'provider actors'. At the bottom, community leaders, health workers, and non-governmental organizations were considered as 'community actors'. The analysis revealed that the administrative level held the highest power of influence for zoonoses prevention activities. Although this study was focused on the city level, there were actors from the district or higher authority, who influenced these city-level actors directly or indirectly. This is especially evident during outbreak situations when actors were involved in collaborative activities initiated by the district authority. The administrative actors were acting across the district and city level, as well as across sectors during outbreak situations. Although the governance structure remains the same in the outbreak and non-outbreak situations, the increased influence of the district/higher administrative actors is noteworthy during the outbreak situation. Table 1 represents most of the potential OH actors who have been involved directly or indirectly in the prevention and control of zoonotic diseases of the Ahmedabad city.

Table 1. OH actors for zoonotic disease prevention and control in Ahmedabad, India segregated by level of action and with status in the interest–influence matrix.

Health System Level	One Health Actors	Status in the Interest–Influence Matrix (IIM)
Administrative level [$]	Human health administrators [#]	Player
	Animal health administrators [§]	Subject
	Parks & Gardens administrators	Crowd
	Solid waste management administrators	Crowd
	Professional associations	Context setter
	City zoo administrators	Crowd
Provider level	Health centers/hospitals	Player
	Medical officers/physicians	Subject
	Private clinics/hospitals	Subject
	Private physicians & infectious disease specialists	Crowd
	Nurses/Mid-Wives	Crowd
	Pharmaceutical stores	Crowd
	Laboratories	Crowd
	Animal dispensaries/clinics	Player
	Government veterinarians	Subject
	Private veterinarians	Subject
	Livestock inspectors/Animal workers	Crowd

Table 1. *Cont.*

Health System Level	One Health Actors	Status in the Interest–Influence Matrix (IIM)
Community level	Community health workers	Subject
	Non-governmental organizations	Crowd
	Community leaders	Crowd
	Research institutes	Crowd
	Media/journalists	Crowd
	Households and community	Crowd
	Dairy farms	Crowd
	Police	Crowd

[§] Influenced by the actors from the top directives such as district/state human health administrators (Context setter), animal health administrators (Context setter), forest and environment administrators (Crowd). [#] Consists of chief medical officer of health, deputy health officer—epidemic, nodal officer of National Urban Health Mission, assistant health officer—entomologist, deputy health officers (zonal level). [§] Consists of the superintendent of the Cattle Nuisance Control Department, inspectors.

3.2. Interest–Influence Matrix (IIM)

The level of interest and the influence on prevention and control of zoonoses was assessed based on the analysis of the semi-structured interviews. Table 1 also represents the actors as 'players', 'subjects', 'context setters', or 'crowd' in the study setting. In this case, the city human health administrators, health centers/hospitals, and animal dispensaries/clinics were found to be the key 'players', implying that they were strong actors for zoonoses prevention and control with high interest and high influence. However, the city animal health administrators were found to be with relatively low influence although with high interest for zoonoses and are, thus, considered as 'subjects'. Although 'subjects' have low power, there were minimal collaborative activities documented. In addition to the city animal health administrators, the veterinarians, private human health clinics, and community actors, who were assessed as 'subjects', need to be strengthened with certain powers. The low influence of the animal health administrators on zoonotic disease prevention and control compared to the human health administrative actors indicates the issue of power rivalry. The overall context was managed by the 'context setters', in this case, the top authorities of human and animal health, who influence the overall collaborative activities. There were many actors categorized as 'crowd', i.e. with low interest and influence, implying that they were seen as potential actors rather than actual actors, such as NGOs, the city zoo, community leaders, research institutes, private physicians, environment personnel of city and district level, police department, dairy farms, etc.

3.3. Issues and Challenges for Intersectoral Collaboration

3.3.1. Perceived Need for ISC

On enquiring about the need for collaboration, most of the actors stressed that outbreaks or health emergencies were the situations during which they require support from other actors. There was no perceived need for ISC activities unless it is directed by the top authorities. Importantly, it was found that collaborative activities only happen after initiation from higher authorities. It was emphasized that these collaborative actions were initiated from the state or national level during outbreaks and that the subordinated actors followed the top-down directive. Otherwise, there was no need for any collaborative actions across the sectors as stroked by the participants. It is, therefore, regarded as necessary by several actors to sensitize all actors about the importance and benefits of collaborative actions to sustain any level of ISC beyond outbreak situations.

> " . . . Our teamwork is not by need; it's by demand. During the outbreak, the Collector (prime administrative authority of a district) sensitizes all the actors based on the demand for action. And our collaborative effort was very good during the last outbreak" (Human health actor)

> "We need stringent collaboration for the diseases which are not reported currently in the system … and all actors need to understand their respective contribution towards the collaborative work … " (Animal health actor)

> "We get information on the outbreak alert from state or center and they tell us what to do and how to proceed." (Human health actor)

In addition, the need for collaboration was only expressed when deficiencies were found within the respective sector. When services and/or resources were required from other sectors and/or beyond the administrative boundary, only then was the need for collaboration emphasized.

> "City administration is different and also the city has limited strength for Animal Husbandry, so we wish to collaborate with district officials … " (Animal health actor)

> "We (in Human health) have our own system in place and we do have animal husbandry cell at the corporation level. We at AMC meet them (in Animal Health) regularly; however, if we need help like a laboratory or additive human resources, then only we approach the district animal husbandry department." (Human health actor)

On the one hand, actors at the provider level indicated that physicians only need to interact with veterinarians during emergencies, otherwise it would be a waste of capacities, as most of the practitioners were overloaded with their daily caseload. On the other hand, some of them stated that there was no system in place to interact with cross-disciplinary professionals, so it was never realized.

3.3.2. Challenges for Collaboration

There were different challenges for collaboration highlighted by the actors, one of the major challenges was who is interested or motivated to lead such action. As observed in the local context, collaborations only happen with top-down directives during outbreaks, the power issue that emerges leads to the question of what needs to be done and who should do it in the non-outbreak situations. In addition, the collaborations were perceived as a burden rather than benefits, which is even more problematic than the power issues. Most of the actors did not want to develop ISC as they have perceived it as additional work.

> "Within the human health sector, the administrative system is different for the city (urban) and rural … so difficult to collaborate sometime; we directly communicate with the state government regarding any epidemic, outbreak situation … " (Human health actor)

> "Animal Husbandry should be the lead for prevention of zoonotic diseases with some support from the human health sectors and transparency is essential for collaboration" (Anima health actor)

> "We are in short of human resource, there is a huge shortage of veterinarians and livestock inspectors, with this situation how to collaborate with other sectors … ; I am afraid it would increase the burden on our department" (Animal health actor)

Challenges such as information flow, disease-reporting patterns, knowledge gaps, limited resources, and awareness level were among other challenges for collaborative work. Within the human and animal health system differences in the pattern of information flow and disease, reporting was reported by the participants. Most actors agreed that in the absence of a structured guideline indicating who is to take on which role, collaboration is not possible. As all collaborations were based on specific instructions from the top authorities during an outbreak situation, the actors could not visualize any form of collaboration during non-outbreak periods or see the need for such collaboration. Nonetheless, some made recommendations on how to develop collaboration in the local context if needed.

> "All staffs need to undergo training on the need of collaborations for zoonoses disease management, prevention, control through a common platform at the city level including the private actors" (Human health actor)

> "Circular training is essential for the front line health workers, who never studied what zoonoses are! If we train and sensitize our multipurpose healthcare workers, then they could also work on zoonoses prevention, as they have a good reach to every house of the community" (Human health actor)

> "Whatever and however we collaborate, if people will not (be) aware enough then prevention of any zoonoses will be difficult, sometimes we provide awareness without the help of a medical doctor ... and media may play a vital role in sensitization" (Animal health actor)

3.3.3. Continuing Neglect of Private Actors in Collaborations

Collaborating with the actors from the private sectors was not evident in the local setting. Most private and non-governmental actors were neither involved in any collaborations nor contributed to zoonoses prevention significantly. However, some non-government actors, i.e., animal welfare organizations, were working with the AMC on activities such as animal birth control, census, etc.

> "Non-governmental organizations are great helping hands in livestock care, so we should strengthen their effort by providing further training and educating them on various preventive activities." (Animal health actor)

> "We (NGOs) do not get any support (neither financial nor technical) from Govt., so why we will collaborate with them?" (NGO actor)

> "Govt. never ask us (private providers) to collaborate for anything, I am trained abroad and I can contribute in many things, but Govt. never provided a scope to work with them ... ." (Animal health actor)

> "Private practitioners are never prioritized to be part of the health system, although we contribute largely to the healthcare and also there is no guideline for involving private actors, thus we lack cooperation!" (Human health actor)

3.4. Interconnectedness of the Actors in the Health System Network

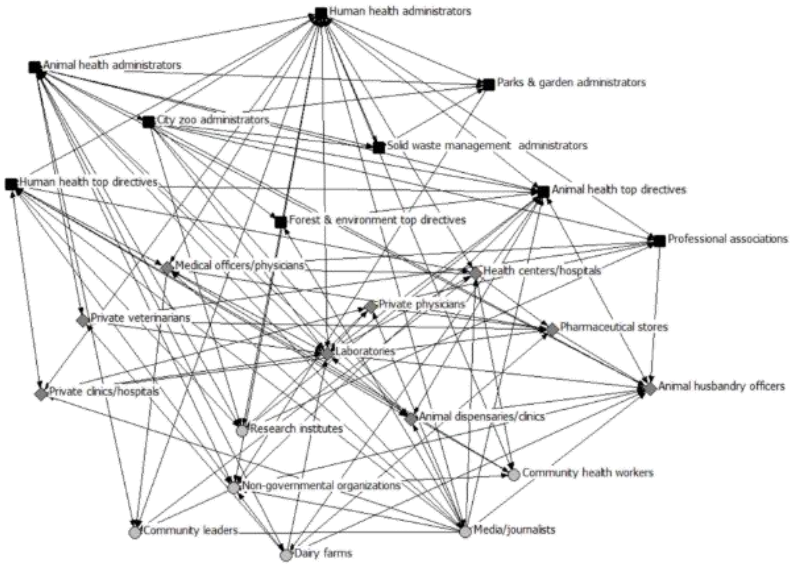
The health system network analysis provided quantitative support to the qualitative findings and compared the interaction among the actors during the last outbreak (H5N1 in 2017) with those of non-outbreak situations. The analysis of different network parameters for both outbreak and the non-outbreak situation are shown in Table 1. A density value of '1' is expected in a fully collaborated network. The overall network density signified higher interaction among the actors (0.328) during the outbreak as compared to the non-outbreak situation (0.163). This pattern was also observed upon disaggregating the data by the health system level (see Table 2). The other two network parameters—i.e., average degree and degree of centralization—have also exhibited higher values during outbreak compared to non-outbreak situations. The degree of centralization signified that few nodes have higher ties, especially among the administrative actors. Although the degree of centralization among the administrative actors (0.564, 0.473) and provider actors (0.625, 0.607) remained the same in the outbreak and non-outbreak situation respectively, the degree reduced (from 0.556 to 0.205) among the interaction between administrative and provider actors. This highlights that cross-level interaction varies greatly between outbreak and non-outbreak situations. At the same time the higher degree of centralization, which remained the same across outbreak and non-outbreak situations, indicated that few actors govern the collaboration pattern and information flow and are; therefore, the key actors to establish sustainable collaboration patterns. Figure 1 presents the nodes and

their ties in the two discussed situations. For visualization purposes, different shapes and colors were used: dark-colored squares for administrative actors, medium grey diamond shapes for provider actors, and light grey circles for community actors. One important finding was that the prime administrative actors, who were well-positioned and highly interconnected during outbreaks, significantly reduced the number of ties during non-outbreak situations. The IIM matrix also reflected that the district level administrative actors have a high influence on most city-level actors, which resulted in coordinated activities during the outbreak. These density values could not be attributed directly to the stage in the continuum of ISC, nonetheless, a qualitative attribution indicates a range from the communication (during non-outbreak) to the coordination (during an outbreak) as per the need in the local context. In summary, there was significantly lower interactions during non-outbreak situations across all the network measures, very low ISC both during the outbreak and non-outbreak situations; however, a high centrality remained at the administrative level both in the outbreak and non-outbreak situation.

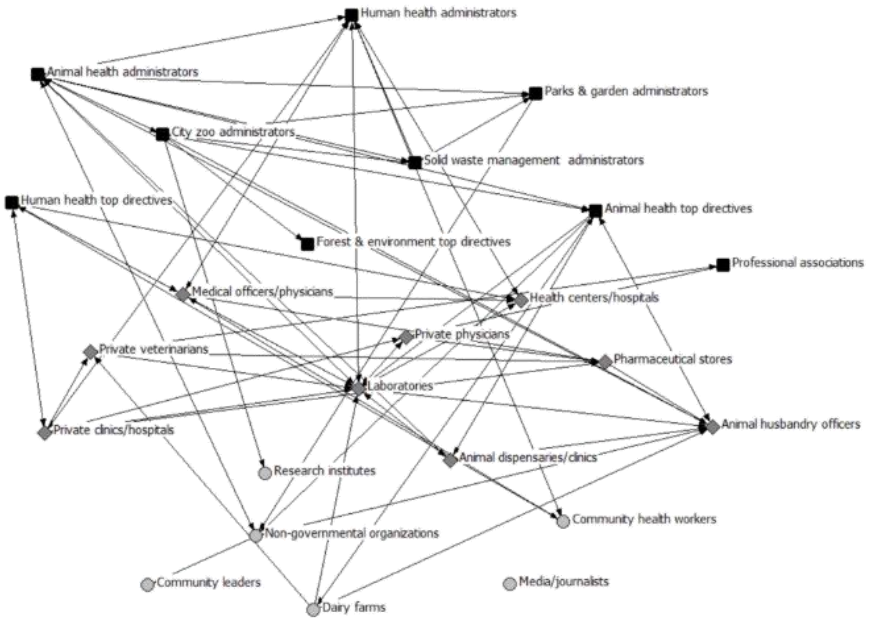
Figure 1a,b represents the network cohesion during the outbreak and non-outbreak situation. The lines between actors represent their respective interactions. Whereas an arrow pointing away from an actor towards another actor shows the former mentioned the latter, a line with arrows at both ends is a mutual relationship. Table 3 represents the collaboration details of 66 medical officers, physicians, and veterinarians who participated in the network survey. As there were few actors from the administrative level, no such descriptive analysis was conducted. Among the 66 actors from the provider level, there were 74% and 26% belonging to human health and animal health respectively. Most (84%) were held bachelor degrees and had 12 ± 8 mean years of professional experience. One quarter (26%) were working in the private or non-governmental sectors. Among the participants, only 27% had collaborated with other actors during the outbreak situation. Among the rest, reasons given for non-collaboration were that collaboration among physician and veterinarians were not at all required (58%), followed by lack of any policy/guidelines (24%), and lack of knowledge (18%).

Table 2. Network strength of actors disaggregated by the health system level in the operational setting of Ahmedabad, India.

Network Measures	Sub-Groups	During Outbreak			During Non-Outbreak		
		Admin	Provider	Community	Admin	Provider	Community
Average degree	Overall		2.652			1.406	
	Admin	5.833	3.001	1.500	2.667	1.417	0.417
	Provider		3.2222	0.556		3.111	0.222
	Community			1.800			0.600
Network density	Overall		0.328			0.163	
	Admin	0.530	0.333	0.136	0.242	0.157	0.038
	Provider		0.403	0.069		0.389	0.028
	Community			0.450			0.150
Degree of centralization	Overall		0.424			0.257	
	Admin	0.564	0.556	0.382	0.473	0.205	0.173
	Provider		0.625	0.232		0.607	0.125
	Community			0.183			0.167



(**a**) During the outbreak



(**b**) During the non-outbreak

Figure 1. Network view of actors (**a**) during the outbreak and (**b**) during the non-outbreak situations in Ahmedabad, India. Administrative actors: dark-colored squares; Provider actors: medium grey diamond shapes; and Community actors: light grey circles.

Table 3. Characteristics and collaboration details among the actors at the provider level especially physicians and veterinarians of Ahmedabad, India.

Variables		*N* = 66 (%)
Type of provider		
	Human health	49 (74.2)
	Animal health	17 (25.8)
Gender		
	Male	43 (65.2)
	Female	23 (34.8)
Education		
	Bachelor degree (MBBS/BVMS)	55 (83.7)
	Specialist (MD/MVM)	11 (16.6)
Total years of professional experience (years)		12 ± 8
Work setting		
	Government	49 (74.2)
	Private/Non-governmental	17 (25.8)
Ever involved in inter-sectoral collaborative activities		
	Outbreak management	18 (27.3)
	Advocacy/Administrative	11 (16.7)
Reasons for lack of collaboration		
	No policy/guidelines/opportunity	16 (24.2)
	Lack of knowledge	12 (18.2)
	Not at all required	38 (57.6)
Potential actor who can bridge the human and animal health system		
	At the administrative level	19 (28.8)
	At the provider level	28 (42.4)
	At the community level	42 (63.6)
Ever received any training on zoonoses		39 (59.1)
Ever attended health campaigns related to zoonoses		43 (65.2)

Upon exploring their viewpoint on the potential actors, who could bridge between the human and animal health system, the majority of the participants at the provider level (64%) mentioned that actors from the community level could act as such bridging actors by identifying symptoms at the early stage and reporting to the corresponding authorities. This signified that the preventive actions need to be shifted towards the bottom of the health system rather than developing collaborations at the administrative and/or provider level. Formal training on any zoonotic diseases was found to be absent in 40% of participants although about 65% participated directly in the health campaigns related to zoonoses. In summary, a low perceived need for collaboration was voiced at the provider level further indicating that collaboration is perceived as a burden, thus these provider actors urged to shift the support of ISC to the bottom level.

4. Discussion

This study identified actors from various levels of the health system in the local setting of Ahmedabad for the prevention and control of zoonoses. Although the city level actors were having prime actions, there was another layer of administrative actors from the district or the top authorities found to influence the city actors. During outbreaks, the top authorities from the district and/or state directed the collaborative work with the city actors. This type of collaborative activities has been documented in the literature [45–47], where actors have to perform or enable interdisciplinary work in addition to their specific roles and responsibilities of the routine work. Thus, a firmer borderline between the actors of the city and higher authorities (governance structure) could not be drawn in the collaborative activities, as ISC also does not intend to do so. It is indicated that local government bodies are often weak and powers devolved to them with limited resources might have resulted in being neglected or overlooked on issues of zoonoses [48,49]. In the current study, the district authorities were superimposed over the city authorities for the collaborative actions during health emergencies, while the

city actors were also found to be dependent on the district authorities for the required resources, especially skilled human resources. This type of resource dependence between these two layers of actors (i.e., state vs. city level) was also observed in other healthcare settings of the country [50,51]. Although the OH approach has especially emphasized the need to promote ISC among the human and animal sectors [12,52], we found that collaboration across administrative levels, across state and city sectors, are also of utmost importance. One of the international committees—i.e., Federation of Veterinarians of Europe (FVE)—and the Standing Committee of European Doctors (CPME) also emphasized that collaboration across all levels is essential for the operationalization of OH [53]. In this case, the city actors should not be isolated from other actors (district/top-level) during the operationalization process, as high inter-dependency was observed. Furthermore, this study identified that private and non-governmental actors had minimal or no interaction with the governmental actors. Yet, there are several public-private partnership programs evinced in strengthening the health system globally [54] or nationally [55] and the importance of private actor engagement in reducing the disease burden in India is documented [56,57]. One Health Network analysis by Spencer J. et al., indicated the minimal engagement of private for-profit sectors as part of the OH [58]. In global health governance, the private and non-governmental actors contributing significantly towards improving the health for all [59]. Therefore, private and non-governmental actors should not be neglected in developing ISC for OH implementation.

This study documented very low interest in ISC across all actors and that any form of collaboration depended on top-down directives. The operationalization of OH is, therefore, difficult to realize in Ahmedabad, unless all actors are sensitized about the advantages of collaborative actions and clear top-down regulations are developed. Challenges, such as differences in working culture, lack of skilled human resources, and capacities of the respective sectors leads to the shifting of responsibility for zoonoses to other authorities and make ISC a perceived burden rather than an advantage in Ahmedabad. As some of these operational challenges have been documented in the literature [60–63], it is recommended to sensitize the actors first about the advantages of ISC in the local context by utilizing the current health system network. Degeling et al., also pointed out political and legal issues in the OH decision-making processes and that these should be considered in the local context during operationalization [64]. While it was evinced that administrative actors do work collaboratively during health emergencies or disasters [65,66], they also tend to collaborate with required actors from different levels for their routine work [67]. However, in this study, collaborative work has been documented during outbreaks only, with minimal interactions being sustained during non-outbreak periods among the administrative actors. Although this collaboration was only possible because of the top-down directive, either from the state or the higher authorities, the actual collaborative actions took place at the grass-root level with the help of these administrative actors. This signifies the leadership capacity of the city administrators and could provide opportunities for strengthening and operationalizing ISC during non-outbreak situations [68]. It is indicated that leadership and managerial skills are essential for OH capacity development [69,70], which is recommended to strengthen ISC at the administrative level.

The collaboration at the provider level, especially between physicians and veterinarians, were found to be very poor. However, there is some supportive global evidence that OH collaboration at the provider level is possible through case referral systems or combined OH clinics [71,72]. A study by Speare et al., explored the possibilities for physicians and veterinarians to formally collaborate in managing zoonoses in clinical situations and documented that 90% of actors agreed to collaborate if the appropriate insurance covers the cost [73]. As this is not the case in this study, some sensitization through OH training would be recommended. Another review also discusses the role of veterinarians and physicians in confronting zoonoses and discusses the importance of multi-sector partnerships in controlling zoonoses [74]. Furthermore, this type of ISC has also been envisaged in developed nations, where physicians and veterinarians are involved in joint patient counseling or joint clinical services for minimizing the risk of zoonoses [75–77]. In the local context, the actors from the provider level indicated that ISC should be at the community level rather than at the provider level. This might be

due to the high caseload in their daily routine, absence of clinical knowledge on zoonoses, or lack of awareness. In the local context, the horizontal collaboration between the human and animal health system at the community level is not possible, as there are no active actors from the animal health system; however, the existing network of community health workers of the human health system could be utilized for raising the community awareness and risk mitigation. Similar community-based risk mitigation through an OH approach has been documented in other parts of the globe [78]. The network cohesion among the provider level actors did not differ much between the outbreak situation and the non-outbreak situation. One of the potential reasons could be the presence of private veterinarians in the network, and the other reason could be few of the provider actors were only engaged in collaborative activities during the outbreak resulted in the minimal difference in the network cohesion at the provider level.

In absence of studies on how to explore the ISC for OH, this study is the first of its kind to recommend the methodologies that have been used in this exploration process. A mixed-method of exploration is beneficial in terms of assessing the situation and understanding how and why in a glance. The qualitative interviews in this study provided an insight on the potential actors of OH as well as the issues on ISC and the same time the quantitative network survey provided the measurements on the network cohesion in the outbreak and non-outbreak situation. Furthermore, exploring the health system at two different levels—i.e., at the administrative level and the provider level—indulged a comprehensive scenario for the OH. Therefore, this mixed-method could be used in any other setting not only within India but also in any other setting across the globe for exploring the OH actors and their network cohesion to understand the ISC.

Given the low interest and lacking perception of a need for ISC in Ahmedabad, coupled with the consensus that top-down directives are required for any collaborative activities, developing such top-down guidance for the administrative actors along with extensive training on ISC at the provider level is urgently needed for operationalizing OH in the context of Ahmedabad [20,79]. Globally, it has been highlighted that a key challenge for promoting sustainable ISCs is lacking political commitment, competition between bureaucratic agencies, different governance structures across sectors, and lacking a common understanding of collaboration across actors [80,81]. Similar challenges for establishing sustainable collaborations were identified in this study for the context of Ahmedabad: lack of interest, lack of resources, lack of political commitment, and lack of guidelines. To establish successful ISC, effective communication and advocacy among the actors for both levels are required. Furthermore, to tackle the issue of low interest for ISC, structured joint training programs (especially for the provider level actors), documentation of success case stories around the country, and evidence on cost–benefit-ratios could help in promoting ISC in the local context. Additionally, guidance documents need to be developed jointly among the actors to establish a framework for ISC in the context of zoonotic disease prevention and control.

Limitations

It is important to note that the study was undertaken in one city of India and that the generalizability of the findings to any other part of the country might be constrained as cities of India have different governance structures. However, the approach used in this study could be utilized in any context for exploring OH actors. There are certain limitations of the study. First, this study conducted the health system network survey with a cross-sectional design; however, a longitudinal design might have provided better insights into the dynamics of the relationships during different situations. Especially the considerable time since the outbreak in 2017 might have induced recall bias. Second, this particular study did not capture the viewpoint of the community leaders and other potential actors at the community level, the interactions were captured based on the responses of the administrative and provider actors. Thus, it is recommended to consider the perception of leaders and other actors in the community in such a network analysis for improving operational policies. Third, this study did not include the governance process of interaction among the actors within the respective system,

which might be of importance as the policy or guidelines and working culture is distinctly different in the human and the animal health system.

5. Conclusions

This study identified the presence and analyzed the interaction of the OH actors in the context of Ahmedabad, India, who are directly or indirectly involved in zoonotic disease prevention and management. The actors at the district level who act as 'context setters' over the 'players' and 'subjects' at the city level were found to be the drivers for collaboration. The collaboration strength, in the form of network density, decreases between outbreak and non-outbreak situations. With minimal ISC at the provider level and in the absence of community workers of the animal health system, the physicians and veterinarians recommended strengthening the ISC at the community level by vertical programs and top-down directives. Some of the major challenges that have been identified in this study were the lack of interest for ISC, low perception of any advantages of ISC, and lack of political commitment to ISC. The hitherto minimal involvement of the private and non-governmental actors needs to be enhanced. As most of the actors are relying on the top-down directives, the necessary policy/guidelines on zoonoses prevention with a focus on the OH approach and ISC are recommended to be developed. Keeping the differential governance structure and power rivalry in mind, one idea could be a One Health Task Force of Ahmedabad (OHTFA) with representative actors from the administrative, provider, and community level across the OH domains (human health, animal health, environment) and also including private actors. The design, duties, and powers, working modus, and acceptance such a OHTFA would have to be the objectives of a further study. The last conclusion concerns the lowest level of public action: the presence of community actors from the human health system should be considered as an advantage for awareness-raising on zoonosis in the local context.

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Availability of Data and Materials: Data from this study will be available at the Center for Development Research (ZEF), Bonn, Germany, after the completion of this study. Researchers who meet the criteria for access to confidential data are encouraged to approach Timo Falkenberg, Coordinator Fortschrittskolleg 'One Health', Center for Development Research (ZEF), Bonn, Genscherallee 3, 53113 Bonn, Germany. Email: falkenberg@uni-bonn.de.

References

1. Vesterinen, H.M.; Dutcher, T.V.; Errecaborde, K.M.; Mahero, M.W.; Macy, K.W.; Prasarnphanich, O.-O.; Kassenborg, H.; Yulizar, E.; Fauzi, R.P.; Budayanti, N.S.; et al. Strengthening multi-sectoral collaboration on critical health issues: One health systems mapping and analysis resource toolkit (OH-SMART) for operationalizing One Health. *PLoS ONE* **2019**, *14*, e0219197. [CrossRef] [PubMed]
2. Queenan, K. Roadmap to a One Health agenda 2030. *CAB Rev. Perspect Agric. Vet. Sci. Nutr. Nat. Resour.* **2017**, *12*. [CrossRef]
3. Dhiman, R.; Tiwari, A. Emergence of zoonotic diseases in India: A systematic review. *Med Rep. Case Stud.* **2018**, *3*, 3. [CrossRef]
4. Chatterjee, P.; Kakkar, M.; Chaturvedi, S. Integrating one health in national health policies of developing countries: India's lost opportunities. *Infect. Dis. Poverty* **2016**, *5*, 87. [CrossRef] [PubMed]

5. McKenzie, J.S.; Dahal, R.; Kakkar, M.; Debnath, N.; Rahman, M.; Dorjee, S.; Naeem, K.; Wijayathilaka, T.; Sharma, B.K.; Maidanwal, N.; et al. One Health research and training and government support for One Health in South Asia. *Infect. Ecol. Epidemiol.* **2016**, *6*, 33842. [CrossRef]
6. Baum, S.E.; Machalaba, C.; Daszak, P.; Salerno, R.H.; Karesh, W.B. Evaluating one health: Are we demonstrating effectiveness? *One Health* **2017**, *3*, 5–10. [CrossRef]
7. Galaz, V.; Leach, M.; Scoones, I.; Christina, S. The Political Economy of One Health Research and Policy. 2015. Available online: https://steps-centre.org/wp-content/uploads/One-Health-wp3.pdf (accessed on 14 June 2020).
8. Deliberto, T.J.; Nolte, D.L.; Clay, W. Integrative approaches to disease control: The value of international collaborations. In Proceedings of the Compendium of the OIE Global Conference on Wildlife, Paris, France, 23–25 February 2011; p. 7.
9. Gongal, G. One Health approach in the South East Asia region: Opportunities and challenges. *Curr. Top. Microbiol. Immunol.* **2013**, *366*, 113. [CrossRef]
10. Dahal, R.; Upadhyay, A.; Ewald, B. One Health in South Asia and its challenges in implementation from stakeholder perspective. *Vet. Rec.* **2017**, *181*, 626. [CrossRef]
11. EClinicalMedicine. Emerging zoonoses: A one health challenge. *EClinicalMedicine* **2020**, *19*, 100300. [CrossRef]
12. FAO-OIE-WHO. Taking a Multisectoral One Health Approach: A Tripartite Guide to Addressing Zoonotic Diseases in Countries. 2019. Available online: http://www.fao.org/3/ca2942en/ca2942en.pdf (accessed on 2 January 2020).
13. Sekar, N.; Shah, N.K.; Abbas, S.S.; Kakkar, M. Research options for controlling zoonotic disease in India, 2010–2015. *PLoS ONE* **2011**, *6*, e17120. [CrossRef]
14. Chatterjee, P.; Bhaumik, S.; Chauhan, A.S.; Kakkar, M. Protocol for developing a database of zoonotic disease research in India (DoZooRI). *BMJ Open* **2017**, *7*, e017825. [CrossRef] [PubMed]
15. Varma, G.B.S.N.P. India needs "One Health" policy to eradicate zoonotic diseases. *Nat. India* **2014**, *10*. [CrossRef]
16. John, T.J.; Dandona, L.; Sharma, V.P.; Kakkar, M. Continuing challenge of infectious diseases in India. *Lancet* **2011**, *377*, 252–269. [CrossRef]
17. Hyder, A.; Syed, S.; Puvanachandra, P.; Bloom, G.; Sundaram, S.; Mahmood, S.; Iqbal, M.; Hongwen, Z.; Ravichandran, N.; Oladepo, O.; et al. Stakeholder analysis for health research: Case studies from low—And middle-income countries. *Public Health* **2010**, *124*, 159–166. [CrossRef] [PubMed]
18. Kurian, A.; Dandapat, P.; Jacob, S.; Francis, J. Ranking of zoonotic diseases using composite index method: An illustration in Indian context. *Indian J. Anim. Sci.* **2014**, *84*, 357–363.
19. World Organization for Animal Health (OIE). Animal health and biodiversity: Preparing for the future. In Proceedings of the OIE Global Conference on Wildlife, Paris, France, 23–25 February 2011.
20. Lee, K.; Brumme, Z.L. Operationalizing the One Health approach: The global governance challenges. *Health Policy Plan.* **2013**, *28*, 778–785. [CrossRef]
21. Abimbola, S.; Negin, J.; Jan, S.; Martiniuk, A. Towards people-centred health systems: A multi-level framework for analysing primary health care governance in low-and middle-income countries. *Health Policy Plan.* **2014**, *29*, 29–39. [CrossRef]
22. Abimbola, S.; Negin, J.; Martiniuk, A.L.; Jan, S. Institutional analysis of health system governance. *Inst. Anal. Health Syst. Gov.* **2017**, *32*, 1337–1344. [CrossRef]
23. Horwath, J.; Morrison, T. Collaboration, integration and change in children's services: Critical issues and key ingredients. *Child Abus. Negl.* **2007**, *31*, 55–69. [CrossRef]
24. Shigayeva, A.; Atun, R.; McKee, M.; Coker, R. Health systems, communicable diseases and integration. *Health Policy Plan.* **2010**, *25*, 4–20. [CrossRef]
25. Axelsson, R.; Axelsson, S.B. Integration and collaboration in public health—A conceptual framework. *Int. J. Health Plan. Manag.* **2006**, *21*, 75–88. [CrossRef] [PubMed]
26. Jackson, M.C.; Sambo, L.G. Health systems research and critical systems thinking: The case for partnership. *Syst. Res. Behav. Sci.* **2020**, *37*, 3–22. [CrossRef]
27. Siddiqi, S.; Masud, T.I.; Nishtar, S.; Peters, D.H.; Sabri, B.; Bile, K.M.; Jama, M.A. Framework for assessing governance of the health system in developing countries: Gateway to good governance. *Health Policy* **2009**, *90*, 13–25. [CrossRef] [PubMed]

28. National Centre for Disease Control (NCDC), Division of Zoonotic Diseases Programmes (DZDP). Directorate General of Health Services, Ministry of Health & Family Welfare, Government of India. 2019. Available online: https://ncdc.gov.in/index1.php?lang=1&level=1&sublinkid=105&lid=56 (accessed on 12 February 2020).
29. National Animal Disease Control Programme, Department of Animal Husbandry and Dairying. Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. 2019. Available online: http://dahd.nic.in/ (accessed on 12 February 2020).
30. Gandhi, S.; Dave, P.; Patel, G.; Khatri, H.; Shah, N.; Mishra, U. An epidemiological investigation of a multisource outbreak of crimean-Congo hemorrhagic fever in Gujarat. *J. Commun. Dis.* **2011**, *43*, 161–167.
31. The Times of India. Swine flu in Ahmedabad: 408 new cases and 10 deaths in September 2018. Times of India, 26 September 2018. Available online: https://timesofindia.indiatimes.com/city/ahmedabad/408-swine-flu-cases-10-deaths-this-september/articleshow/65956967.cms (accessed on 15 January 2020).
32. Integrated Disease Surveillance Program (IDSP). Bird flu scare: Foresters order autopsies of birds in Ahmedabad, Gujarat. Times of India, 3 January 2017. Available online: https://timesofindia.indiatimes.com/city/ahmedabad/bird-flu-scare-foresters-order-autopsies-of-birds/articleshow/56300935.cms (accessed on 16 January 2020).
33. Achievements of Ahmedabad Municipal Corporation. Available online: https://ahmedabadcity.gov.in/portal/jsp/Static_pages/amc_awards.jsp (accessed on 12 February 2020).
34. Gupta, I.; Bhatia, M. The Indian health care system. Institute of Economics Growth and London School of Economics. 2013. Available online: https://www.commonwealthfund.org/international-health-policy-center/countries/india (accessed on 20 March 2020).
35. Ahmedabad Municipal Corporation. Ahmedabad City. Available online: https://ahmedabadcity.gov.in/portal/jsp/Static_pages/about_us.jsp (accessed on 2 January 2018).
36. Yasobant, S.; Bruchhausen, W.; Saxena, D.; Falkenberg, T. Convergence model for effectual prevention and control of zoonotic diseases: A health system study on "One Health" approach in Ahmedabad, India. *Health Res. Policy Syst.* **2018**, *16*, 124. [CrossRef]
37. Asokan, G.V.; Asokan, V.; Fedorowicz, Z.; Tharyan, P. Use of a systems approach and evidence-based One Health for zoonoses research. *J. Evid. Based Med.* **2011**, *4*, 62–65. [CrossRef]
38. Luke, D.A.; Harris, J.K. Network analysis in public health: History, methods, and applications. *Annu. Rev. Public Health* **2007**, *28*, 69–93. [CrossRef]
39. Young, D.; Borland, R.; Coghill, K. An actor-network theory analysis of policy innovation for smoke-free places: Understanding change in complex systems. *Am. J. Public Health* **2010**, *100*, 1208–1217. [CrossRef]
40. *ATLAS.ti, version 8 [Computer Software]*; ATLAS.ti Scientific Software Development GmbH: Berlin, Germany, 2017.
41. Varvasovszky, Z.; Brugha, R. How to do (or not to do) A stakeholder analysis. *Health Policy Plan.* **2000**, *15*, 338–345. [CrossRef]
42. Bryson, J.M. What to do when Stakeholders matter. *Public Manag. Rev.* **2004**, *6*, 21–53. [CrossRef]
43. Borgatti, S.P.; Everett, M.G.; Freeman, L. *Ucinet for Windows: Software for Social Network Analysis (UCINET version 6) [Computer Software]*; Analytic Technologies: Lexington, KY, USA, 2002.
44. *R version 3.4.1. [Computer Software]*; A language and environment for statistical computing; R Core Team: New Zealand, 2017.
45. Pelletier, D.; Gervais, S.; Hafeez-ur-Rehman, H.; Sanou, D.; Tumwine, J. Boundary-spanning actors in complex adaptive governance systems: The case of multisectoral nutrition. *Int. J. Health Plan. Manag.* **2018**, *33*, e293–e319. [CrossRef] [PubMed]
46. Bednarek, A.T.; Wyborn, C.; Cvitanovic, C.; Meyer, R.; Colvin, R.M.; Addison, P.F.E.; Close, S.L.; Curran, K.; Farooque, M.; Goldman, E.; et al. Boundary spanning at the science–policy interface: The practitioners' perspectives. *Sustain. Sci.* **2018**, *13*, 1175–1183. [CrossRef] [PubMed]
47. Dotson David, V. Boundary-spanning actors in urban 4-H: An action research case study. *J. High. Educ. Outreach Engag.* **2014**, *18*, 104, ISSN:1534.
48. Burris, S.; Hancock, T.; Lin, V.; Herzog, A. Emerging strategies for healthy urban governance. *J. Urban Health* **2007**, *84*, 154–163. [CrossRef] [PubMed]
49. Plochg, T.; Delnoij, D.M.J.; Hogervorst, W.V.G.; van Dijk, P.; Belleman, S.; Klazinga, N.S. Local health systems in 21st century: Who cares?—An exploratory study on health system governance in Amsterdam. *Eur. J. Public Health* **2006**, *16*, 559–564. [CrossRef]

50. Rao, S.; Rasheed Sulaiman, V.; Natchimuthu, K.; Ramkumar, S.; Sasidhar, P.; Gandhi, R. Improvement of veterinary services delivery in India. *Rev. Sci. Tech. Off. Int.* **2015**, *34*. [CrossRef]
51. Rao, K.D.; Bhatnagar, A.; Berman, P. So many, yet few: Human resources for health in India. *Hum. Resour. Health* **2012**, *10*, 19. [CrossRef]
52. Murphy, S.C.; Negron, M.E.; Pieracci, E.G.; Deressa, A.; Bekele, W.; Regassa, F.; Wassie, B.A.; Afera, B.; Hajito, K.W.; Walelign, E.; et al. One Health collaborations for zoonotic disease control in Ethiopia. *Revue Scientifique Technique* **2019**, *38*, 51–60. [CrossRef]
53. British Veterinary Association. One Health: Collaboration on all levels is key, concludes joint meeting. *Vet. Rec.* **2014**, *174*, 644. [CrossRef]
54. Thadani, K.B. Public private partnership in the health sector: Boon or Bane. *Procedia Soc. Behav. Sci.* **2014**, *157*, 307–316. [CrossRef]
55. Das, A. Public-private partnerships for providing healthcare services. *Indian J. Med Ethics* **2007**, *4*, 174–175. [CrossRef] [PubMed]
56. Bhat, R. Issues in health: Public-private partnership. *Econ. Polit. Wkly.* **2000**, *35*, 4706–4716. [CrossRef]
57. Yadav, V.; Kumar, S.; Balasubramaniam, S.; Srivastava, A.; Pallipamula, S.; Memon, P.; Singh, D.; Bhargava, S.; Sunil, G.A.; Sood, B.; et al. Facilitators and barriers to participation of private sector health facilities in government-led schemes for maternity services in India: A qualitative study. *BMJ Open* **2017**, *7*, e017092. [CrossRef] [PubMed]
58. Spencer, J.; McRobie, E.; Dar, O.; Rahman-Shepherd, A.; Hasan, N.; Hanefeld, J.; Khan, M. Is the current surge in political and financial attention to One Health solidifying or splintering the movement? *BMJ Glob. Health.* **2019**, *4*, e001102. [CrossRef] [PubMed]
59. Söderlund, N.; Mendoza-Arana, P.; Goudge, J. *The New Public/Private Mix in Health: Exploring the Changing Landscape*; Alliance for Health Policy and Systems Research: Geneva, Switzerland, 2003.
60. Johnston, L.M.; Finegood, D.T. Cross-sector partnerships and public health: Challenges and opportunities for addressing obesity and noncommunicable diseases through engagement with the private sector. *Annu. Rev. Public Health* **2015**, *36*, 255–271. [CrossRef] [PubMed]
61. Kuruvilla, S.; Hinton, R.; Boerma, T.; Bunney, R.; Casamitjana, N.; Cortez, R.; Fracassi, P.; Franz-Vasdeki, J.; Helldén, D.; McManus, J.; et al. Business not as usual: How multisectoral collaboration can promote transformative change for health and sustainable development. *BMJ (Online)* **2018**, *363*. [CrossRef]
62. Willis, C.D.; Greene, J.K.; Abramowicz, A.; Riley, B.L. Strengthening the evidence and action on multi-sectoral partnerships in public health: An action research initiative. Health promotion and chronic disease prevention in Canada. *Res. Policy Pract.* **2016**, *36*, 101–111. [CrossRef]
63. USAID-SPIRNG. *Operationalizing Multi-Sectoral Coordination and Collaboration for Improved Nutrition: Recommendations from an in-Depth Assessment of Three Countries' Experiences*; Feed the Future: Washington, DC, USA, 2016.
64. Degeling, C.; Johnson, J.; Kerridge, I.; Wilson, A.; Ward, M.; Stewart, C.; Gilbert, G. Implementing a One Health approach to emerging infectious disease: Reflections on the socio-political, ethical and legal dimensions. *BMC Public Health* **2015**, *15*, 1307. [CrossRef]
65. Institute of Medicine, US Committee. *Guidance for Establishing Standards of Care for Use in Disaster Situations*; Altevogt, B.M., Stroud, C., Hanson, S.L., Hanfling, D., Gostin, L.O., Eds.; National Academies Press: Washington, DC, USA, 2009; ISBN 978-0-309-14430-8.
66. Menon, V.C. India—National disaster and epidemic preparedness. *Int. J. Infect. Dis.* **2016**, *45*, 12. [CrossRef]
67. Mazet, J.A.K.; Uhart, M.M.; Keyyu, J.D. Stakeholders in One Health. *Revue Scientifique Technique* **2014**, *33*, 443–452. [CrossRef]
68. Plianbangchang, S. International leadership for the control of disease outbreaks relating to "One Health". *J. Health Res.* **2018**, *32*, 106–111. [CrossRef]
69. Stephen, C.; Stemshorn, B. Leadership, governance and partnerships are essential One Health competencies. *One Health* **2016**, *2*, 161–163. [CrossRef] [PubMed]
70. Hueston, W.D.; van Klink, E.G.M.; Rwego, I.B. One Health Leadership and Policy. In *Beyond One Health*; John Wiley & Sons: Hoboken, NJ, USA, 2018; pp. 267–278.
71. Eussen, B.G.M.; Schaveling, J.; Dragt, M.J.; Blomme, R.J. Stimulating collaboration between human and veterinary health care professionals. *BMC Vet. Res.* **2017**, *13*, 174. [CrossRef] [PubMed]

72. De Giusti, M.; Barbato, D.; Lia, L.; Colamesta, V.; Lombardi, A.M.; Cacchio, D.; Villari, P.; La Torre, G. Collaboration between human and veterinary medicine as a tool to solve public health problems. *Lancet Planet. Health* **2019**, *3*, e64–e65. [CrossRef]
73. Speare, R.; Mendez, D.; Judd, J.; Reid, S.; Tzipori, S.; Massey, P.D. Willingness to consult a veterinarian on physician's advice for zoonotic diseases: A formal role for veterinarians in medicine? *PLoS ONE* **2015**, *10*, e0131406. [CrossRef]
74. Shanko, K.; Kemal, J.; Kenea, D. A Review on confronting zoonoses: The role of veterinarian and physician. *J. Vet. Sci. Technol.* **2014**, *6*, 1–7. [CrossRef]
75. Matthiessen, P.W.; Sansone, R.A.; Meier, B.P.; Gaither, G.A.; Shrader, J. Zoonotic diseases and at-risk patients: A survey of veterinarians and physicians. *AIDS* **2003**, *17*, 1404–1406. [CrossRef] [PubMed]
76. Hill, W.A.; Petty, G.C.; Erwin, P.C.; Souza, M.J. A survey of Tennessee veterinarian and physician attitudes, knowledge, and practices regarding zoonoses prevention among animal owners with HIV infection or AIDS. *J. Am. Vet. Med. Assoc.* **2012**, *240*, 1432–1440. [CrossRef]
77. Courtenay, M.; Sweeney, J.; Zielinska, P.; Brown Blake, S.; La Ragione, R. One Health: An opportunity for an interprofessional approach to healthcare. *J. Interprof. Care* **2015**, *29*, 641–642. [CrossRef]
78. Berrian, A.M.; Smith, M.H.; van Rooyen, J.; Martínez-López, B.; Plank, M.N.; Smith, W.A.; Conrad, P.A. A community-based One Health education program for disease risk mitigation at the human-animal interface. *One Health* **2018**, *5*, 9–20. [CrossRef]
79. Conrad, P.A.; Meek, L.A.; Dumit, J. Operationalizing a One Health approach to global health challenges. *Comp. Immunol. Microbiol. Infect. Dis.* **2013**, *36*, 211–216. [CrossRef] [PubMed]
80. Kriegner, S.; Ottersen, T.; Røttingen, J.A.; Gopinathan, U. Promoting intersectoral collaboration through the evaluations of public health interventions: Insights from key informants in 6 European countries. *Int. J Health Policy Manag.* **2020**, *2020*, 1–10. [CrossRef] [PubMed]
81. Bennett, S.; Glandon, D.; Rasanathan, K. Governing multisectoral action for health in low-income and middle-income countries: Unpacking the problem and rising to the challenge. *BMJ Global Health* **2018**, *3*, e000880. [CrossRef] [PubMed]

2.7. Publication 7

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Systemic factors for enhancing intersectional collaboration for the operationalization of One Health: A case study in India

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Abstract

Background: The One Health approach is one of the greatest movements so far in controlling zoonotic diseases at the global level. However, the operationalization of this One Health approach is unclear for local health systems with their respective targets. In this scenario, the empirical study of intersectoral collaboration between the human and animal health systems provides an opportunity to investigate the appropriate strategies and its enabling factors at the local health system level. Thus, this study documented and validated the innovative strategies for intersectoral collaboration with a focus on effectual prevention and control of zoonotic diseases with its enabling factors for a city in western India, Ahmedabad.

Methods: This case study was conducted in three phases, phase-I (qualitative data collection i.e. vignette interview), phase-II (quantitative data collection through modified policy Delphi), and phase-III (participatory workshop). The vignette data were handled for content analysis and the Delphi data, as like other quantitative data, for descriptive statistics. The participatory workshop adapts the computerized Sensitivity Model® developed by Vester to analyze the dynamics of the health system.

Result: Out of the possible 36 strategies, this study validated the top 15 essential (must have) and 5 preferred (should have) strategies for the study area. For operationalization of the One Health approach, the enabling factors that were identified through the system approach are *micro-level factors* at the individual level (trust, leadership, motivation, knowledge), *meso-level factors* at the organizational level (human resource, capacity building, shared vision, decision-making capacity, laboratory capacity, surveillance), *macro-level factors* at the system level (coordinated

roles, relationships, common platform) and *external factors* at outside of the system (guidelines/policies, community participation, a specific budget, political will, smart technology).

Discussion: This study reveals that the micro-level factors at the individual level are potential levers of the health system. More attention to them could be enormously beneficial for the operationalization of the One Health approach. This study recommends the bottom-up exploration as part of the systems approach for individual health systems during the operationalization. The identified enabling factors for the operationalization should be accounted for in formulating the future One Health policies.

Keywords: Intersectoral collaboration, One Health, Operationalization, Health System, India

1. Introduction

The recurrent (re-) emerging of zoonotic diseases bring about the momentum for action on the One Health (OH) concept that encourages an interdisciplinary, transdisciplinary, and intersectoral approach to tackle disease risks at the interface of humans and animals with the environment (1–3). OH is an emerging concept; still, an amorphous entity with a state of flux, as the OH and its operationalization is facilitated by some bridging factors and is impeded by barrier factors (4,5). The operationalization of OH involves multiple challenges such as lack of policies/guidelines on information and/or resource sharing, biased funding, and imbalanced participation across different sectors (6–8). To-date OH implementation is recognized as highly politically driven (4) with its top-down approach (9,10) with few community-driven initiatives (11,12). However, this top-down approach has its disadvantages in the policy process such as effectiveness to acceptability, local adaptation, dynamics of changes, etc. (13). In response to the perceived weakness of the top-down perspective, the bottom-up approach (14) provides a platform to analyze the multitude of actors, who interact at the operational (local) level on a particular issue (or perhaps, better yet: the problem solving) (15–18), which might contribute an opportunity towards the sustainable operationalization of One Health.

In the absence of a global criterion, intersectoral collaboration (ISC) is one of the key aims for the operationalization of OH (8,19–21). Few ISC strategies have been

evinced in African (5,22), Arctic (23), American (24), Asian (25–27), European (28) and Oceanian (29) countries; however, it has been suggested to develop strategies concerning the health system structure and its dynamics. To date, there is no such national One Health policy or guideline in India, thus an effort on the development of strategies and its enabling factors for a better operationalization can provide essential evidence for operationalization of OH. Considering the complexity of the Indian health system, the principles of system thinking, where the system and its respective context is viewed as a complex of interrelated and interdependent parts, provides an opportunity to address the above gap (30,31). The system thinking also is being recommended for health system strengthening by World Health Organization (WHO), even without a OH ambition (32), which indicates the need of a system approach to tackle health challenges, as evinced in the literature (33–35). Within the health system, systems thinking is helping in addressing the complex health challenges, by empowering tests of new ideas in the respective systems (30). With the principles of the complex adaptive system thinking process, this study does not intend to provide an 'easy answer' for an ideal ISC for the OH approach. However, it provides an abundant way to consider about and cultivate different possible solutions in a context that avoids the 'common unintended mishaps' resulting from enforcing linear "expert solutions" (36). To address this gap, this study adopts the bottom-up approach with the principles of system thinking. This case study aims (1) to document and validate the innovative strategies for ISC with a focus on OH operationalization in the prevention and control of zoonoses and (2) to document the enabling factors to boost the ISC between the human and animal health systems through a mixed-method approach.

2. Materials and methods

2.1. Study design

This case study was conducted in three phases from July to October 2019. In phase-I, qualitative data through vignette interviews were collected, followed by quantitative data collection through a modified policy Delphi method in phase-II. Phase-III collected information through a participatory workshop. This case study is part of a larger health system study executed in India i.e. RICOHA (Research to explore Intersectoral collaboration for One Health approach) study. The detailed RICOHA study methodology is described elsewhere (37).

2.2. Study sampling

Mixed sampling was applied in this study. For phase-I, purposive sampling was used to select the key actors at the local, state, and national levels. A total of 8 actors (experts at the state/national level from both the human and the animal health systems) were interviewed after their consent of participation. Out of 8 actors, there were 2 from the local level (1 human health, 1 animal health), 2 from the district level (1 human health, 1 animal health), 2 from the state level (1 human health, 1 animal health), 2 from the national level (1 human health, 1 animal health). The sample for phase-II was drawn from a larger sample of experts. The experts included researchers, academia, policymakers, and health managers, irrespective of their level of professional experience, working at the local, state, or national level. Initially, a large volume of experts (n=297) was approached, only one-third provided consent for participating in the policy Delphi survey (even after two reminders). In the end, 23 experts (9 from the local and 14 from the state/national) participated in the survey (10 from animal health and 13 from human health). For phase-III, purposive sampling was adapted through a facilitated consultative process to recruit the stakeholders from the local health system level. Both the government and the private institutions working in the domain of the human and animal health systems were identified. The appropriate individuals for the workshop were nominated by the respective departments. This process was carried out two months before the actual date of the workshop. Among others, the participants were: epidemic officer, medial officer of health, surveillance officer from the human health system, zoo veterinarian, superintendent of cattle nuisance control department, foot and mouth disease laboratory director, animal husbandry department director, lead private practitioner and environmental specialist.

2.3. Data collection and analysis

In phase-I information was collected through Vignette interviews. This method has so far been used both in clinical (38) and public health settings (39) to solve complex issues. In simpler terms, the vignette technique is a method that can provoke and synthesize perceptions or opinions from the respondents (40). A semi-structured vignette interview guide, hypothesizing the innovative convergence strategies among the health system actors, was administered through face-to-face interviews with the sampled stakeholders. Interviews were conducted at the date and time convenient to participants. The interviews were recorded after the duly consent of the participant and

verbatim notes were also taken during the interview. The vignette responses were handled like other qualitative data. The content analysis (inductive) was used to gather proposed strategies from the transcripts. The findings were reported by using the 'Consolidated Criteria for Reporting Qualitative Research (41) utilizing the software ATLAS.ti version 8 (42).

All the codes (in the form of strategies) derived from the phase-I analysis were clustered into themes and presented in the phase-II. In this phase, information was collected through the policy Delphi technique (developed at the RAND Corporation in the 1950s (43)) with health system experts. Through this process, we have identified a wide range of validated options and solutions to the respective strategies (44,45). An online platform i.e. Survey Monkey software (46) was used to develop the survey and potential health system experts were invited via email for participation. The health system experts were asked to rank the importance of each item on a Likert scale (1-4) from 1: somewhat preferable, 2: very much preferable, 3: somewhat essential, and 4: very much essential. They have been explained the difference between the criteria 'essential' and 'preferable'. If the presence of a strategy is 'must' within the system to uphold the resilience of the system, then the strategy is considered as 'essential'; whereas strategies that make the system better but without which the system could also function, are considered as 'preferable'. There was a high non-response rate in the first round (of about two-third) and the second round (of about half). The Likert score was utilized to categorize the strategies into "essential" (must have) or "preferable" (should have) strategies. The cut-off value was set at the level of 60%, i.e. if 60% of actors agreed to a strategy being either essential or preferred then that strategy is considered under the respective category.

For Phase-III; a computerized Sensitivity Model® developed by Vester was adapted in a one-day participatory workshop. This software has its foundation in cybernetics and dealing with the complex system in an interconnected approach (47). This model facilitates the consensus-building process, based on the fuzzy logic reasoning, among participants for a particular issue (48,49). This follows a flexible and iterative process with consensus building at a certain level (with repeated deliberation) and thus minimizes the personal importance of the participant. This stemmed into a comprehensive, deterministic, and aggregated outcome at the end of the participatory workshop. The outcome of this participatory workshop had provided a comprehensive

description of factors' interactions with their interlinkages in the health system. The participatory workshop was conducted in a step-wise manner as per the Vester model. First, the boundaries of the health system, system factors, and representativeness through system viewpoints were discussed and the criteria matrix was developed. Then, the system factor interlinkages, and their role in the system were allocated, which resulted in the consensus matrix.

A participatory discussion about the health system issues pertaining to OH (especially for zoonoses prevention and control in the local context) was initiated to engage the participants, which was guided by the facilitation process. The main focus was to summarize problems and specially to understand the sub-systems (such as human and animal health, public and private within the larger system. Some of the discussions were also about the levels of the health system involved, with an emphasis on the power relations at the national, state, district, corporation, and operational level. Lead questions like: What are the factors?; How does the system function with or without these factors?; What could be done?, facilitated the process of engagement. From this iterative discussion process, a set of factors with their characteristics was collected and presented for open discussion.

The criteria matrix was developed by assigning a criterion to each factor as fully, partly or not applicable. The values for each criterion were assigned as 1, 0.5, or 0, respectively. All system factors were checked for completeness (assessed by all the 18 criteria) from multiple perspectives. The key components of the system were covered by the seven levels of consideration with three entities, four aspects of the dynamics and four types of factor's relation to the system resulted in the 18 criteria to weight the factors. The total score of each factor after weighing was compared with each other and the distribution was discussed from the system viewpoint.

To develop the consensus effect matrix, two representative groups of participants were formed along with one facilitator for guiding the discussions and amending any methodological error. As the main aim was to understand the factor's strength of connection and interaction with all other components of the system, a scale of disproportionally strong (3), medium (2), weak (1) connection, or no connection (0) was used. The focus of this scale was only on strength of interaction, not the direction. The numbered entered is the one on which the group agreed after a certain amount

of thought and discussion. Then, the results of the two groups were compiled, debated, discussed and the final score for each pair of factors was agreed upon, forming the final consensus “effect matrix”.

The sum of horizontal rows from the matrix was calculated as the active sum for each factor *i* (AS*i*) i.e., how strongly a factor affects the rest of the system. Similarly, the sum of the vertical columns calculated the passive sum for each factor *i* (PS*i*) i.e. how susceptible a factor is to changes in the system and how it would react to them. In summary, the total effect of a given factor was expressed by the AS*i*, whereas the PS*i* was expressed as the total effect of the system on a given factor. To derive the P-value, the AS*i* and PS*i* were multiplied, and to derive the Q-value, the AS*i* and PS*i* were divided.

Based on the P-value (interconnectedness) and the Q-value (impact strength), all the factors were assigned a role in the system. A factor was called ‘critical’ when the P-value was high, i.e. factor could influence others in the system and is highly interconnected. The reverse, low P-value, was called ‘buffering’ (47). With help of the Vester system model, these values were plotted (x-axis: PS & y-axis: AS, P-values from the bottom-left to the top-right and Q-values from the bottom-right to top-left) and used for the visualization of each factor. The role of each factor within the system was synthesized based on the location of the factor i.e. active (top left), reactive (bottom right), critical (top right), and buffering (bottom left).

3. Results

3.1. Thematic OH strategies derived from the Vignette (Phase-I)

The content analysis indicated 36 different strategies that are categorized into the themes such as legal or policies, clinical aspects including disease-specific ones, collaboration at the managerial level, collaborations at the provider level, collaborations at the community level, the inclusion of private actors.

3.2. ISC strategies for the operationalization of OH (Phase-II)

Out of 36 different strategies, the top 15 validated ‘must-have’ i.e. essential strategies and the top 5 validated ‘should have’ i.e. preferred strategies based on the outcome of the policy Delphi process are presented in table 1.

3.3. Enabling factors for strengthening ISC and OH operationalization (Phase-III)

The workshop participants defined 18 factors encompassing micro-level factors (at the individual level), meso-level factors (at the organizational level), macro-level factors (at the system level), and external factors (beyond the boundary of the system) aspects to fulfill the above mentioned 15 essential strategies for the case of Ahmedabad, India (Table 2). The boundary refers to the local health system comprising human and animal health as controlled by the municipal governance. The set of factors synthesized during the first step of the workshop offers an accumulated and comprehensive perspective about the operationalization of the OH with a focus on zoonoses prevention and control. As described in the methods, the system boundaries for the OH was defined as per the participating stakeholders. The set of factors from a health system viewpoint was confirmed during the deliberation and discussion phase of the workshop and cross-checked during the further steps of the workshop.

Figure 1 presents the final consensus effect-matrix (summary of all the system variables with their AS and PS values) after the deliberation of two sub-groups. A high AS value, as attributed to the factor *'adequate knowledge (4)*', signifies the high influence on the other factors of the system, whereas a low AS value, e.g. '*community participation (17)*', signifies low influence and requires an extensive change to influence the system. Similarly, a high PS value, e.g. '*strengthening surveillance system (10)*', is influenced significantly by the other factors of the system, whereas a low PS value, e.g. '*motivation for teamwork (3)*', indicates that extreme system changes are necessary to affect the factors.

The systematic role of the factors was calculated (P-value and Q-value) and the system role was assigned based on those values (as described in the method section). Figure 2 represents a geometric visualization and interpretation of each factor within the system, based on the P-value, Q-value, AS, and PS values. The role of each factor could be ascertained from the respective position in the system as shown in figure 2.

All the factors are classified according to their character or systemic role into four categories, passive, active, critical, and buffering. Table 3 represents the systemic role of the factors based on P- and Q-value. Based on the Q value, the factors are classified as either active or passive role i.e. factors having a large quotient Q value (e.g. Building

trust=2.67), meaning that they have a great impact on the system as they influence the system directly if the changes are considered as with 'active'. On the other side, they cannot be steered or changed by other factors in the system. If the quotient is small, the factors are called 'passive' (e.g. Coordinating roles=0.60), characterized by reactive nature as they are influenced by many factors in the system. Similarly, based on the P-value the factors are assigned as either critical or buffering roles. The large product value indicates that they not only influence many other factors but ate at the same time influenced by many of them (e.g. Strengthening surveillance system=1120). The factors with smaller product value indicate that they do not influence nor are influenced by others (e.g. Community participation=208). Intervention on these factors is decided based on their role in the system and with the P- and Q-value. The factors with high P- and Q-values are suitable as leverage factors such as '*Leadership quality (1)*, they have a salient position within the system, whereas factors with low P- and Q-value like '*Community participation (17)*' are likely to be less important for this specific system functioning. However, the factors with high P-value and a low Q-value should not be necessarily less considered because it is strongly interwoven and has a buffering function in the system. Further, the systemic role of each factor is considered with its combined effect from active-passive and critical-buffering such as active- slightly critical, highly-active-slightly-critical.

3.3.1. Potential leverages of the health system (Active roles)

Five factors have active roles with different ranges (highly active, active, slightly active) in the system i.e. a micro-level factor from the individual level, i.e. '*Building trust (2)*', and a meso-level factor from the system level, i.e. '*Relationship among actors (12)*', were observed as highly active. The other 3 factors having active role were micro-level factors i.e. '*Leadership quality (1)*', '*Motivation for teamwork (3)*' was active, and '*Adequate knowledge (4)*' was slightly active. This indicates that these have the strongest leverage on the system and also impact several other factors. However, the systemic effect was observed in combination with the role of critical-buffering. As the factor 2,3 and 12 belong to slightly critical indicating that these factors influenced least by other factors; whereas factor 1 belongs to critical and factor 4 belongs to highly critical i.e. influenced by other factors are maximum.

For example, 'T*rust with actors (2)*' affects all other factors except smart technology, because of its highly active role, whereas least influenced by leadership quality,

adequate knowledge, and shared vision, because of its slightly critical role. In contrast, another example could for the factor adequate knowledge, which could influence most of the other factors except the specific budget head, because of its active role and influenced by all the factors except motivation for teamwork, because of its highly critical role.

With these combined roles, the factor 1 should be carefully observed, especially if modified in order to give the development a new direction, factor 2 and 12 effects could be canalized if interventions are made here, factor 3 considered as steering lever, it should not be untouched by the repercussions of its interventions, therefore, it should be kept under control even after its use as a lever and factor 4 considered with hard-hitting effect. All these 5 factors are ideal to be considered for the intervention as most of the factors are micro-level factors at the individual level.

3.3.2. Strong catalysts of the health system (Critical roles)

There were 8 factors with a highly critical role, 4 factors with critical and 4 factors with a slightly critical role observed. Out of 8 highly critical, factors 10, 5, 6, 7, 14 have same time neutral role also indicating their strong influence on most of the other factors and influenced highly by other factors within the system. Out of 4 with the critical role, factor 15, 16 have a similar neutral role also. Therefore, these 7 factors with a critical and neutral effects are described here. The remaining factors with a critical role have a secondary effect of either active or passive, thus they are considered in the respective sections accordingly. This is because each factor having one role in the dimension of active to passive and another role in the dimension of critical to buffering.

An example of a meso-level factor from the organization level, is '*Adequate human resources (5)*', which has an extremely critical role in the system. This is implied by the fact that, it could provoke system changes, both positively and negatively, which could lead to system instability. By intervening here uncontrolled amplifying or tipping could hardly be avoided, because, this factor highly influences capacity development, developing laboratory capacities, and strengthening the surveillance system. The factor itself is influenced by external factors such as political will and specific budget. Therefore, this factor needs to be tackled with extreme caution and should only be used as an initial ignition in extremely frozen systems. Nevertheless, the existing

human resource should be mobilized to develop the ISC rather than addressing the addition of human resources to the system.

The observation indicates that factor 6 is influencing the other meso-level and macro-level factors, while factor 7 is influencing the external factors only. By intervening with factor 10, the effect will be similar to the other meso-level factors, however, as it is influenced by most of the external factors it might require extensive resources during the intervention, thus it is suggested to consider it at the later phase of the operationalization. The three external factors, i.e. factor 14,15, and 16 are very much influenced by the other micro-level and meso-level factors, therefore it is essential to be careful while addressing these factors during the operationalization process.. Thus, interventions on these factors will lead to the improvement of the development of ISC, however, the absence will not make the process impossible. Although these three external factors are important and their intervention may cause trouble in the existing system, due to its equally strong activity and reaction, it has been suggested (as per the outcome of the sensitivity model) that if not intended to give a strong initial impact it has to be targeted at a later phase of ISC development.

3.3.3. Ideal factors to monitor the health system development (Reactive roles)

There were 4 factors i.e. two meso-level factors from the organizational level, i.e. '*Improving decision-making (8)*' and '*Improving laboratory capacity (9)*', and two macro-level factors from the system level, i.e. '*Coordinating roles (11)*' and '*Common platform (13)*', were observed under this reactive or passive role. Out of these 4 critical roles, factor 8 has a critical role, factor 9 and 12 have slightly critical and factor 13 as a highly critical role. As a combined effect, these factors were influenced by many other factors in the system with minimal influence capacity to other factors. Only factor 13 with its highly critical role could influence most of the factors with minimal strength, while other factors have a weak influencing capacity to other factors in the system.

For example, the factor '*Common platform or networking (13)*' is influenced by most of the factors, because of its critical role and could able to influence to some of the factors like smart technology, motivation for teamwork, adequate knowledge, coordinating roles with its highly critical role. In contrast to the previous example, the factor '*Improving laboratory capacity (9)*' is influenced by most of the ether factors, whereas it could not influence any other factor with its slightly critical role.

Effective intervention with factor 8 suggests that it can inflame considerable changes in the system, but can also get unmanageable by strong repercussions from the system. The role of factor 9, suggests that it can enflame moderate changes in the system, however, it is more influenced by the effects of the other factors from each level of the system. As intervention at this factor might require extensive resources, it should be entertained at the later phase of ISC development. The role of factor 11 and 13 implies that it can incite profound changes in the system, but its effect can be slightly reinforced or weakened. These two factors are highly influenced by the micro-level factors, thus, intervening in the micro-level factor could bring some changes to these factors during the operationalization.

3.3.4. Important factors to stabilize the health system (Neutral and buffering roles)

The role of the two external factors, i.e. '*Community participation (17)*' and '*Smart technology (18)*', are considered as important system stabilizers. Factor 17 is slightly-reactive and weakly buffering, which is contributing to the self-regulation of the system without being an indicator. The neutral factor 18 has little effect on steering the system, although it is well fitted for self-regulation. These two factors are least influenced by any other factors of the system and have minimal influence on other factors within the system. Thus, intervention on these two factors during the OH operationalization is not very beneficial for the development of ISC.

3.4. The intervention of enabling factors for the identified OH strategies

Considering the enabling factors and their systemic role with their impact, the validated OH strategies could be achieved in two ways. One is by intervening all factors (except buffer) and thus achieving indirectly the OH strategies, other is directly achieving OH strategies individually as per the priority. As seen in Table 1, each OH strategies have their factors and it has found that factor 18 with its highest frequency, required for most of the strategy. However, in the systemic role factors 18 observed with the neutral role and signifying its presence with no effect, indicating that without factor 18 also the respective strategies could be achieved. In contrast, micro-level factors like factor 3 which is a leverage for the system with its active role, which is only required to fulfill few strategies and another micro-level factor i.e. factor 4, which also has an active role is essential for achieving most of the OH strategies. This points out that intervening

the factors with the active role is necessary as per the Vester sensitivity model, however, the factors with the least frequency could be ignored for the intervention.

4. Discussion

This paper ascertains individual factors (as active factors) are more imperative as compared to the political/external, economic, or system-network factors for the operationalization process OH. As mentioned in the literature (50), the individual factors that support successful ISC for OH operationalization, are education, training, prior experience, and existing relationships, whereas this study adds more in the perspective of managerial enablers, such as trust, leadership, and motivation along with subject knowledge. Similarly, the organizational factors already mentioned in literature are organizational structures, culture, human resources, and communication, whereas in addition, this study highlights capacity building, shared vision/objectives, and decision-making capacity along with adequate human resources. Evidence also indicates the network factors such as network structures, relationships, leadership, management, available and accessible resources, political environment, whereas this study adds as further factors: the coordinated roles and a common platform including the relationships with actors. Also, there are certain external and political factors such as structured guidelines/policy, a specific budget, strengthening laboratory and surveillance system, the inclusion of smart technology, and last but not least community participation and political will. In some countries, where the One Health approach has been initiated, the key factors that have been discussed were political will, resources, context, common goals, strong governance, routine coordination/communication, strong sectoral systems (5,16,17,51,52).

A cross-case analysis by Rubin et al. suggests that OH operationalization entails team-building challenges (53), and this study supports this by emphasizing individual factors as active factors that assist in successful team building activities. Thus, a successful One Health approach will require team-building skills as fundamental core competencies. In the same line, system thinking also urges transformational leadership as an essential and prime strategy for health system strengthening (54,55). Similarly, in the literature, it has been documented that systemic or adaptive leadership as one of the prime necessity for any organizational cultural model(56). An interpretive study by Wong et al. identified systemic factors for ISC as structures, funding models, regulatory policies, power relations, harmonized information, and communication

infrastructure, targeted professional education, formal systems leaders as collaborative champions (57), which also became evident in our findings. Another review argues that, for effective implementation, lessons learned and 'best practice' must be led by regional stakeholders drawn from a variety of disciplines(58); that means the local actors are more influential in OH operationalization. The factors that have emerged for operationalizing OH from the local stakeholders were based on their experience and expertise in the respective sectors. ISC is rarely without complications; however, drawing shreds of evidence from the local actors with the identified strategies and enabling factors will smoothen the operationalization process of OH.

This case study is unique of its kind to reveal the importance of the local stakeholders and the bottom-up approach, strategies that are more appropriate to the concerned health system at the operational level. On the one hand, external factors like political will and a specific budget, are important influencers for the operationalization of OH. On the other hand, the micro-level factors at the individual level like trust, leadership, and motivation, are essential drivers at the grass-root level. This system approach analysis strongly recommends that the OH operationalization at the grass-root level could be initiated with innerving the factors with active role, i.e. most of the micro-level factors, except the motivation for the teamwork, identified in the study. Additionally, addressing the other macro-level factors with an active role in the system, i.e. instituting relationships among actors, will also enhance this operationalization process. As most of the external factors are found as critical or neutral, the immediate intervention should not target these factors. In the longer term, once the micro, meso, and macro-level factors are strengthened and stabilized, addressing the external factors is recommended. As the meso-level factors are highly influenced by either micro or external factors, it is recommended to address the micro-level factors during the initial phase as these are found to have an active role in the system. In addition, most of the micro-level factors could be intervened with minimal cost and thus supportive to be addressed in the preliminary phase of operationalization. While in general, the collectivistic leaderships in healthcare have demonstrated a positive impact according to recent implementation health research (59,60), the special requirements of OH operationalization additionally endorse the strengthening of collaborative, transformational conflict management and leadership development across OH actors (61). This case study unfolds the importance of the system approach

in identifying the need for the local health system. Although this case study emphasizes the local health system for the operationalization of OH, similar kinds of research are recommended to understand the scenarios for the regional, national, and global needs. The future OH policies should prioritize balance between the subject knowledge development and the leadership competencies among the OH actors, which becomes a prime for the OH operationalization. This bottom-up approach provides new insight into the ISC development and indicates the importance of the micro-level factors at the individual level over the other enabling factors for the OH operationalization. Thus, the bottom-up approach remained an utmost important exploration way in the operational research especially for the local health system. This approach could be of highly beneficial to develop strategies, where there is an absence of the policy.

5. Conclusion

The operationalization of collaborative preventive strategies of OH relies on the full adhesion to necessary micro-level factors at the individual level followed by the macro- and meso-level factors. The willingness of actors to embark on this resource-consuming collaborative strategy depends on the relationship among staff and the trust with other sectors followed by leadership quality and staff motivation. Additionally, external factors, such as structured guidelines and political will, are needed but not vital as micro-level factors to initiate the ISC. This study provides great insight into the type of enabling factors, which could be actively addressed through adequate intervention without affecting the resilience of the health system during the operationalization process. The system approach through a bottom-top exploration is highly essential to understand the local health system and its enabling factors during the ISC development as part of OH operationalization.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

All authors contributed equally to the development of this study. Conceptualization, SY, WB, DS & TF; Methodology, SY, WB & TF; Software, SY; Validation, DS & TF.; Formal Analysis, SY; Investigation, SY & DS; Resources, WB, DS & TF; Data Curation, SY & DS; Writing – Original Draft Preparation, SY; Writing – Review & Editing, WB, DS & TF.; Visualization, SY &TF; Supervision, WB, DS & TF; Project Administration, SY; Funding Acquisition, TF. All authors approved the final draft.

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Ethics approval

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 the Indian Institute of Public Health Gandhinagar, India.

Data Availability Statement

All relevant data that supports the findings of this study are within the manuscript.

References

1. Degeling C, Johnson J, Kerridge I, Wilson A, Ward M, Stewart C, Gilbert G. Implementing a One Health approach to emerging infectious disease: reflections on the socio-political, ethical and legal dimensions. BMC Public Health (2015) 15:1307. doi:10.1186/s12889-015-2617-1
2. Mazet JAK, Clifford DL, Coppolillo PB, Deolalikar AB, Erickson JD, Kazwala RR. A “One Health” Approach to Address Emerging Zoonoses: The HALI Project in Tanzania. PLoS Med (2009) 6:e1000190. doi:10.1371/journal.pmed.1000190
3. 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) 23: doi:10.3201/eid2313.170418
4. Lee K, Brumme ZL. Operationalizing the One Health approach: The global governance challenges. Health Policy Plan (2013) 28:778–785. doi:10.1093/heapol/czs127
5. Okello AL, Bardosh K, Smith J, Welburn SC. One Health: Past Successes and Future Challenges in Three African Contexts. PLoS Negl Trop Dis (2014) 8: doi:10.1371/journal.pntd.0002884
6. Bardosh KL, Scoones JC, Grace D, Kalema-Zikusoka G, Jones KE, De Balogh K, Waltner-Toews D, Bett B, Welburn SC, Mumford E, et al. Engaging research with policy and action: What are the challenges of responding to zoonotic disease in Africa? Philos Trans R Soc B Biol Sci (2017) 372:20160172. doi:10.1098/rstb.2016.0172
7. Schurer JM, Mosites E, Li C, Meschke S, Rabinowitz P. Community-based surveillance of zoonotic parasites in a ‘One Health’ world: A systematic review. One Heal (2016) 2:166–174. doi:10.1016/j.onehlt.2016.11.002
8. Vesterinen HM, Dutcher T V., Errecaborde KM, Mahero MW, Macy KW, Prasarnphanich O-O, Kassenborg H, Yulizar E, Fauzi RP, Budayanti NS, et al. Strengthening multi-sectoral collaboration on critical health issues: One Health Systems Mapping and Analysis Resource Toolkit (OH-SMART) for operationalizing One Health. PLoS One (2019) 14:e0219197. doi:10.1371/journal.pone.0219197
9. Mbabu M, Njeru I, File S, Osoro E, Kiambi S, Bitek A, Ithondeka P, Kairu-Wanyoike S, Sharif S, Gogstad E, et al. Establishing a One Health office in Kenya. Pan Afr Med J (2014) 19:106. doi:10.11604/pamj.2014.19.106.4588

10. Kayunze KA, Kiwara A, Lyamuya E, Kambarage DM, Rushton J, Coker R, Kock R. Practice of One Health approaches: Bridges and barriers in Tanzania. Onderstepoort J Vet Res (2014) 81:E1-8. doi:10.4102/ojvr.v81i2.733

11. HORN . One Health Regional Network for the Horn of Africa . (2020) Available at: http://onehealthhorn.net/ [Accessed October 29, 2020]

12. HEAL . One Health Units for Humans, Environment, Animals and Livelihoods (HEAL). (2019) Available at: https://cgspace.cgiar.org/handle/10568/106514 [Accessed October 29, 2020]

13. Sabatier PA. Top-Down and Bottom-Up Approaches to Implementation Research: A Critical Analysis and Suggested Synthesis. J Public Policy (1986) 6:21–48. doi:10.1017/S0143814X00003846

14. Austvoll-Dahlgren A. Bottom-up approach to successful implementation of pharmaceutical policy. Expert Rev Pharmacoeconomics Outcomes Res (2009) 9:193–195. doi:10.1586/ERP.09.11

15. Koontz TM, Newig J. From Planning to Implementation: Top-Down and Bottom-Up Approaches for Collaborative Watershed Management. Policy Stud J (2014) 42:416–442. doi:10.1111/psj.12067

16. Rüegg SR, Nielsen LR, Buttigieg SC, Santa M, Aragrande M, Canali M, Ehlinger T, Chantziaras I, Boriani E, Radeski M, et al. A Systems Approach to Evaluate One Health Initiatives. Front Vet Sci (2018) 5:23. doi:10.3389/fvets.2018.00023

17. Rüegg SR, Buttigieg SC, Goutard FL, Binot A, Morand S, Thys S, Keune H. Editorial: Concepts and Experiences in Framing, Integration and Evaluation of One Health and EcoHealth. Front Vet Sci (2019) 6:155. doi:10.3389/fvets.2019.00155

18. Hitziger M, Aragrande M, Berezowski JA, Canali M, Del Rio Vilas V, Hoffmann S, Igrejas G, Keune H, Lux A, Bruce M, et al. EVOlvINC: Evaluating knowledge integration capacity in multistakeholder governance. Ecol Soc (2019) 24:18. doi:10.5751/ES-10935-240236

19. Osoro E, Mbabu M, Njeru I, Kairu-Wanyoike S, Muturi M, Kiambi S, Bitek A, Njenga K. Implementing one health intersectoral collaboration at country level. in Session 4 (OIE Conference). Operationalisation of dog transmitted rabbies elimination through prevention at the source, 24–25. Available at: http://www.oie.int/fr/RABIES2015/abstracts/Session_4.3_Osoro_One_Health_abstracts.pdf [Accessed January 16, 2018]

20. Bridges DR, Davidson RA, Odegard PS, Maki I V, Tomkowiak J. Interprofessional collaboration: three best practice models of interprofessional education. Med Educ Online (2011) 16: doi:10.3402/meo.v16i0.6035

21. Amuguni HJ, Mazan M, Kibuuka R. Producing Interdisciplinary Competent Professionals: Integrating One Health Core Competencies into the Veterinary Curriculum at the University of Rwanda. J Vet Med Educ (2017) 44:649–659. doi:10.3138/jvme.0815-133R

22. Rwego IB, Babalobi OO, Musotsi P, Nzietchueng S, Tiambo CK, Kabasa JD, Naigaga I, Kalema-Zikusoka G, Pelican K. One Health capacity building in sub-Saharan Africa. Infect Ecol Epidemiol (2016) 6:34032. doi:10.3402/iee.v6.34032

23. Ruscio BA, Brubaker M, Glasser J, Hueston W, Hennessy TW. One Health – a strategy for resilience in a changing arctic. Int J Circumpolar Health (2015) 74:27913. doi:10.3402/ijch.v74.27913

24. Stroud C, Kaplan B, Logan JE, Gray GC. One Health training, research, and outreach in North America. Infect Ecol Epidemiol (2016) 6: doi:10.3402/IEE.V6.33680

25. Dahal R, Upadhyay A, Ewald B. One Health in South Asia and its challenges in implementation from stakeholder perspective. Vet Rec (2017) doi:10.1136/vr.104189

26. McKenzie JS, Dahal R, Kakkar M, Debnath N, Rahman M, Dorjee S, Naeem K, Wijayathilaka T, Sharma BK, Maidanwal N, et al. One Health research and training and government support for One Health in South Asia. Infect Ecol Epidemiol (2016) 6: doi:10.3402/IEE.V6.33842

27. Wu J, Liu L, Wang G, Lu J. One Health in China. Infect Ecol Epidemiol (2016) 6:33843. doi:10.3402/iee.v6.33843

28. Sikkema R, Koopmans M. One Health training and research activities in Western Europe. Infect Ecol Epidemiol (2016) 6: doi:10.3402/IEE.V6.33703

29. Reid SA, McKenzie J, Woldeyohannes SM. One Health research and training in Australia and New Zealand. Infect Ecol Epidemiol (2016) 6: doi:10.3402/IEE.V6.33799

30. Atun R. Health systems, systems thinking and innovation. Health Policy Plan (2012) 27:iv4–iv8. doi:10.1093/heapol/czs088

31. Koskinen KU. “Systemic View and Systems Thinking,” in Knowledge Production in Organizations (Heidelberg: Springer International Publishing), 13–30. doi:10.1007/978-3-319-00104-3_3

32. Savigny D de, Adam T. Systems thinking for health systems strengthening. (2009). Available at: http://apps.who.int/iris/bitstream/10665/44204/1/9789241563895_eng.pdf

33. Pfeiffer DU. From risk analysis to risk governance - Adapting to an ever more complex future. Vet Ital (2014) 50:169–176. doi:10.12834/VetIt.313.1220.3

34. Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, De Souza Dias BF, Ezeh A, Frumkin H, Gong P, Head P, et al. Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation-Lancet Commission on planetary health. Lancet (2015) 386:1973–2028. doi:10.1016/S0140-6736(15)60901-1

35. World Health Organization and Secretariat of the Convention on Biological Diversity . Connecting Global Priorities: Biodiversity and Human Health: A State of Knowledge Review. (2015). Available at: https://www.cbd.int/health/SOK-biodiversity-en.pdf [Accessed October 29, 2020]

36. Sturmberg JP. “We Need a Systemic Approach for the Redesign of Health Systems,” in Health System Redesign (Springer International Publishing), 1–18. doi:10.1007/978-3-319-64605-3_1

37. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. Convergence model for effectual prevention and control of zoonotic diseases: a health system study on “One

Health" approach in Ahmedabad, India. Heal Res policy Syst (2018) 16:124. doi:10.1186/s12961-018-0398-6

38. Evans SC, Roberts MC, Keeley JW, Blossom JB, Amaro CM, Garcia AM, Stough CO, Canter KS, Robles R, Reed GM. Vignette methodologies for studying clinicians' decision-making: Validity, utility, and application in ICD-11 field studies. Int J Clin Heal Psychol (2015) 15:160–170. doi:10.1016/J.IJCHP.2014.12.001

39. Jackson M, Harrison P, Swinburn B, Lawrence M. Using a Qualitative Vignette to Explore a Complex Public Health Issue. Qual Health Res (2015) 25:1395–1409. doi:10.1177/1049732315570119

40. Finch J. The Vignette Technique in Survey Research. Sociology (1987) 21:105–114. doi:10.1177/0038038587021001008

41. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care (2007) 19:349–357. doi:10.1093/intqhc/mzm042

42. ATLAS.ti Development Team. ATLAS.ti [Computer Software]. (1999)

43. Helmer-Hirschberg O. Analysis of the Future: The Delphi Method. RAND Pap (1967)3558. Available at: https://www.rand.org/pubs/papers/P3558.html [Accessed May 2, 2018]

44. Turoff M. The design of a policy Delphi. Technol Forecast Soc Change (1970) 2:149–171. doi:10.1016/0040-1625(70)90161-7

45. de Meyrick J. The Delphi method and health research. Health Educ (2003) 103:7–16. doi:10.1108/09654280310459112

46. Finley R. Survey Monkey: An online survey tool. (1999) Available at: www.surveymonkey.com

47. Vester F. The art of interconnected thinkging : ideas and tools for a new approach to tackling complexity. MCB Pub. House (2012).

48. Chan SL, Huang SL. A systems approach for the development of a sustainable community - The application of the sensitivity model (SM). J Environ Manage (2004) 72:133–147. doi:10.1016/j.jenvman.2004.04.003

49. Sims J, Aboelata MJ. A System of Prevention: Applying a Systems Approach to Public Health. Health Promot Pract (2019) 20:476–482. doi:10.1177/1524839919849025

50. Errecaborde KM, Macy KW, Pekol A, Perez S, O'Brien MK, Allen I, Contadini F, Lee JY, Mumford E, Bender JB, et al. Factors that enable effective One Health collaborations - A scoping review of the literature. PLoS One (2019) 14:e0224660. doi:10.1371/journal.pone.0224660

51. FAO-OIE-WHO . Taking a Multisectoral One Health Approach : A Tripartite Guide to Addressing Zoonotic Diseases in Countries. Geneva (2019). Available at: http://www.fao.org/3/ca2942en/ca2942en.pdf [Accessed March 24, 2020]

52. Lakwo T, Ukety T, Bakajika D, Tukahebwa E, Awaca P, Amazigo U. "Cross-border collaboration in onchocerciasis elimination in Uganda: progress, challenges and

opportunities from 2008 to 2013." Global Health (2018) 14:16. doi:10.1186/s12992-018-0333-1

53. Rubin C, Dunham B, Sleeman J. "Making One Health a Reality—Crossing Bureaucratic Boundaries," in One Health (American Society of Microbiology), 269–283. doi:10.1128/microbiolspec.OH-0016-2012

54. Swanson RC, Cattaneo A, Bradley E, Chunharas S, Atun R, Abbas KM, Katsaliaki K, Mustafee N, Meier BM, Best A. Rethinking health systems strengthening: key systems thinking tools and strategies for transformational change. Health Policy Plan (2012) 27:54–61. doi:10.1093/heapol/czs090

55. Tozan Y, Ompad DC. Complexity and dynamism from an urban health perspective: a rationale for a system dynamics approach. J Urban Health (2015) 92:490–501. doi:10.1007/s11524-015-9963-2

56. Laloux's F. Reinventing organizations. (2018). Available at: https://www.reinventingorganizations.com/ [Accessed October 29, 2020]

57. Wong ST, MacDonald M, Martin-Misener R, Meagher-Stewart D, O'Mara L, Valaitis RK. What systemic factors contribute to collaboration between primary care and public health sectors? An interpretive descriptive study. BMC Health Serv Res (2017) 17: doi:10.1186/s12913-017-2730-1

58. Okello AL, Gibbs EPJ, Vandersmissen A, Welburn SC. One Health and the neglected zoonoses: turning rhetoric into reality. Vet Rec (2011) 169:281–285. doi:10.1136/vr.d5378

59. De Brún A, O'Donovan R, McAuliffe E. Interventions to develop collectivistic leadership in healthcare settings: A systematic review. BMC Health Serv Res (2019) 19:72. doi:10.1186/s12913-019-3883-x

60. Gifford WA, Squires JE, Angus DE, Ashley LA, Brosseau L, Craik JM, Domecq MC, Egan M, Holyoke P, Juergensen L, et al. Managerial leadership for research use in nursing and allied health care professions: A systematic review. Implement Sci (2018) 13:127. doi:10.1186/s13012-018-0817-7

61. Plianbangchang S. International leadership for the control of disease outbreaks relating to "One Health." J Heal Res (2018) 32:106–111. doi:10.1108/JHR-12-2017-011

Table 1. Top fifteen 'essential' strategies and top five 'preferred' strategies validated through modified policy Delphi process for the operationalization of One Health in the prevention and control of zoonotic diseases in Ahmedabad, India

Essential One Health strategies	1. Cross-sectoral information and data sharing is recommended within the human and animal health system with an emphasis on the joint data analysis and an early alert system for zoonoses (1,2,3,4,6,7,10,11,13,14,18) 2. Public health act or clinical establishment act for all the clinics (human/animal) in the city emphasizing on reporting diagnosed conditions to the public health system (4,6,7,9,10,14,18) 3. Strengthening the local capacity of laboratories for screening and diagnosis of the zoonotic diseases (6,9,15,16) 4. Developing guidelines for disposal of all the dead animals irrespective of disease condition for the city (1,4,6,11,12,15) 5. Enhancing and strengthening the prophylactic vaccination of all the types of animals especially for rabies prevention (1,2,5,6,7,8,10,11,14,15,16,17,18) 6. Promoting better hygiene and preventive practices among the community especially for flu prevention (1,4,5,6,7,11,14,17,18) 7. Resource sharing with the human/animal health system for improving service delivery and establishing surveillance (1,2,3,5,6,7,8,11,12,13,14,16,18) 8. Reporting pattern for prioritized zoonotic conditions should be established and regular monitoring of the same is recommended (4,5,6,9,10,11,14,16,17,18) 9. Sharing of knowledge among the medical and the veterinary profession through a common platform including the joint training programs (1,4,7,13,14,16,18) 10. A common One Health clinical body that is answerable for every situation related to zoonoses management and its prevention (1,4,5,6,7,8,11,13,14,15,16,18) 11. Developing Informed Education and Communication (IEC) materials for zoonoses prevention across the clinical setting of both the system to educate their respective patients (4,13,16,17,18) 12. Cross-communication among the frontline workers at the grass-root level and cross-sectoral information sharing with appropriate officials for any abnormal occurrence (4,5,16,17,18) 13. Sensitization of community along with knowledge and awareness on prevention and control of zoonoses (4,5,6,11,14,16,17,18) 14. Formulation of One Health community cell at the grass-root level with help of frontline health workers and community members (4,5,6,11,14,16,17,18) 15. Financial incentive packages for the inclusion of private providers into the public health delivery system and for reporting the symptoms and/or diagnosed zoonotic conditions to the system (4,6,8,9,10,11,14,16,18)
Preferred One Health strategies	1. Urban zoonoses and/or One Health committee, like at the district and state level, should be developed for the city level (1,2,3,4,5,6,7,8,11,12,13,14,15,16) 2. The city should develop animal treatment centers and hostel facilities where stray animals can be inspected and vaccinated regularly (4,5,6,11,14,16) 3. In the clinical and primary healthcare setting, a detailed history taking for a provisional diagnosis of zoonotic conditions should be emphasized (4,6,8,13) 4. Financial incentives to the animal handlers to report any disease or any abnormal condition(s) of their animals to the public health system (4,10,17) 5. Enhancing collaboration among professional bodies like the Indian Medical Association, Indian Veterinary Association, etc. (1,6,7,13)

( ) indicates the serial number of factors (see table 2) responsible for the respective strategy

Table 2. Factors for operationalization of One Health in the prevention and control of zoonotic diseases in Ahmedabad, India, extracted from the system workshop during September 2019

Context	Factors	Description
Micro-level factors (Individual level)	Leadership quality (1)	Each individual within their sector should take the lead as per their expertise
	Building trust (2)	Trust among the sectors need to be facilitated for collaborative work
	Motivation for teamwork (3)	Actors should have motivation towards working as a team
	Adequate knowledge (4)	Adequate knowledge of zoonotic conditions for early detection and experiences
Meso-level factors (Organizational level)	Adequate human resources (5)	Multidisciplinary team 'One Health Cell' consisting of a representative from a different sector or dedicated human resource within each department for OH
	Capacity building (6)	Appropriate inter-professional education needs to be targeted towards the medical and veterinary education and other clinical experiences for the health workers
	Shared vision and objectives (7)	Departmental visions need to be shared with other sectors to form a comprehensive agenda
	Improving decision-making capacity (8)	Capacity building to take an appropriate decision during the health emergencies and other relevant conditions
	Improving laboratory capacity (9)	Availability of screening and diagnosing zoonotic conditions
	Strengthening surveillance system (10)	The current surveillance system needs to be strengthened. Individual systems should also effort to capture the symptoms from the animals and do a prediction of disease transmission.
Macro-level factors (System level)	Coordinating roles (11)	Specific coordinating responsibilities of actors at a different level
	Relationships among actors (12)	A good relationship among staff members should be there irrespective of hierarchy within the respective department
	Common platform (13)	A common platform is necessary to share the knowledge, experiences and could act as a bridge
External factors (beyond the system boundary level)	Structured guidelines/policy (14)	Guidelines on roles and responsibilities of each actor including the type of activities
	Political will (15)	Both urban and rural governance systems need to work collaboratively. The political commitments need to be enforced with the current system.
	Specific budget head (16)	Budget head for specific One Health activities
	Community participation (17)	Community engagement and participation is essential for promoting disease awareness
	Smart technology (18)	Both the system should be able to use smart technologies to share the data, information at any point of time

Table 3. Systemic role of the factors based on the P-Value and Q-Value extracted from the workshop during September 2019

Active-Passive	Q-Value	Critical-Buffering	P-Value
Highly active		**Highly critical**	
(2) Building trust	2.67	(10) Strengthening surveillance system	1120
(12) Relationship among actors	2.50		
Active		(5) Adequate human resources	1116
(3) Motivation for teamwork	1.67	(6) Capacity building	884
(1) Leadership quality	1.67	(13) Common platform	805
Slightly active		(7) Shared vision and objectives	800
(4) Adequate knowledge	1.43	(4) Adequate knowledge	759
Neutral		(14) Structured guidelines/policy	750
(18) Smart technology	1.21	(11) Coordinating roles	735
(16) Specific budget head	1.13	**Critical**	
(15) Political will	1.04	(15) Political will	600
(10) Strengthening surveillance system	0.91	(16) Specific budget head	598
		(1) Leadership quality	540
(5) Adequate human resources	0.86	(8) Improving decision-making capacity	522
(14) Structured guidelines/policy	0.83		
(17) Community participation	0.81	**Slightly critical**	
(7) Shared vision and objectives	0.78	(9) Improving laboratory capacity	400
(6) Capacity building	0.76	(2) Building trust	384
Slightly passive		(3) Motivation for teamwork	375
(13) Common platform	0.66	(12) Relationship among actors	360
(9) Improving laboratory capacity	0.64	**Neutral**	
		(18) Smart technology	238
(8) Improving decision-making capacity	0.62	**Slightly buffering**	
		(17) Community participation	208
(11) Coordinating roles	0.60		

Q-Value= ASi/PSi; P-value=$ASi*PSi$

Q-value ranges: highly active (Q > 2,25), active (1,60 < Q > 2,25), moderately active (1,30 < Q > 1,60), neutral (0,75 < Q > 1,30), moderately reactive (0,60 < Q > 0,75), reactive (0,45 < Q > 0,60), highly reactive (Q < 0,45)

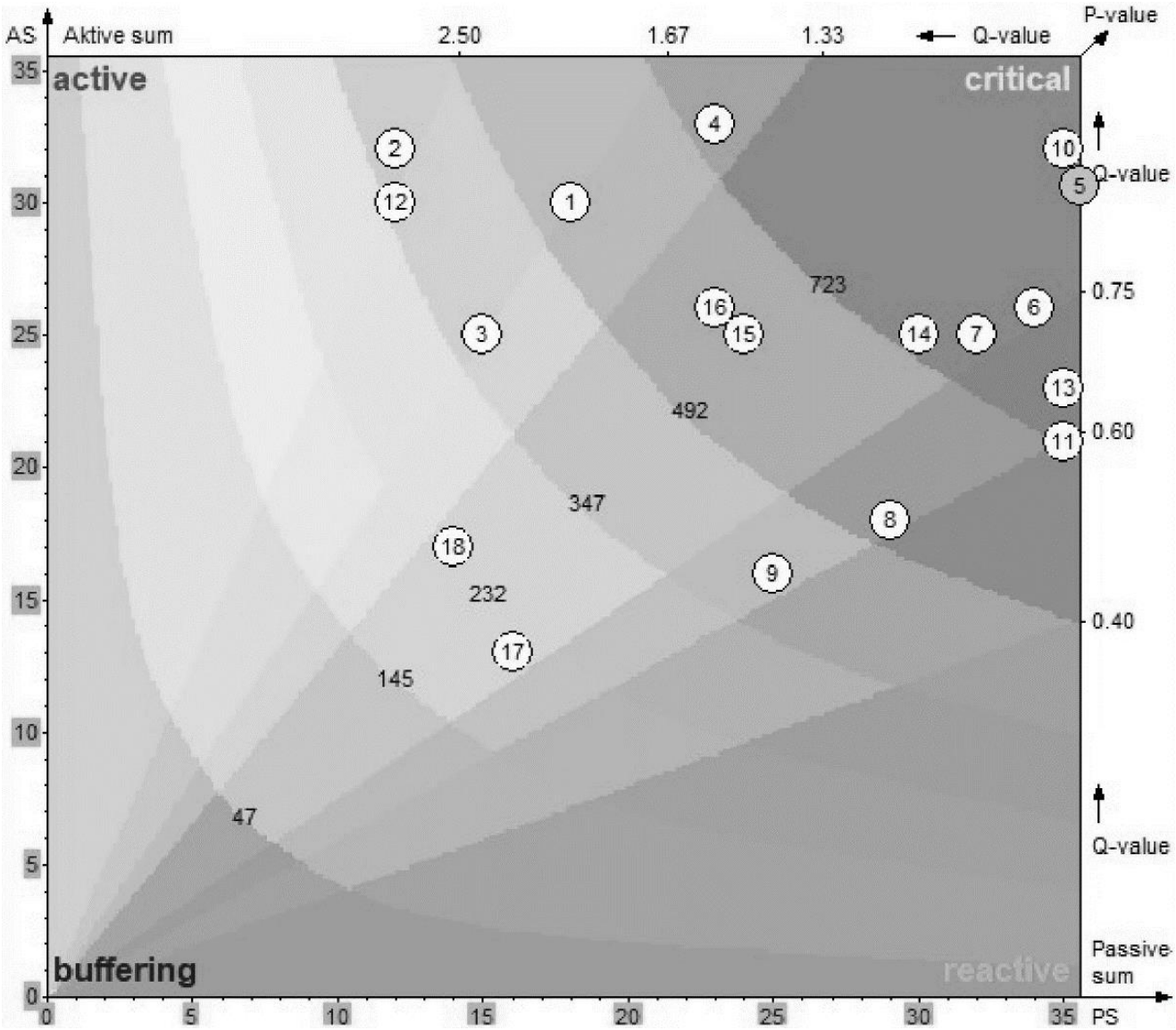
P-value ranges: highly critical (P > 2,5a), critical (1,70a < P > 2,5a), moderately critical (1,20a < P > 1,70a), neutral (0,80a < P > 1,20a), moderately buffering (0,51a < P > 0,80a), buffering (0,16a < P > 0,50a), and highly buffering (P < 0,16a); where a= (n-1), n = number of factors.

Figure 1. Consensus effect-matrix representing the strength of the direct effects among factors extracted from the system workshop for the operationalization of One Health during September 2019

Influence by ↓ to →		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	AS	P
1	Leadership quality	X	2	2	2	3	3	2	3	0	1	3	1	2	2	3	0	1	0	30	540
2	Building trust	2	X	2	2	2	2	3	2	2	2	3	2	3	2	1	0	2	0	32	384
3	Motivation for teamwork	2	1	X	0	2	3	2	2	0	2	3	2	3	1	0	0	2	0	25	375
4	Adequate knowledge	1	2	2	X	2	3	3	2	3	2	2	1	2	3	2	0	2	1	33	759
5	Adequate human resources	2	0	1	2	X	3	2	2	3	3	2	0	2	2	1	3	1	2	31	1116
6	Capacity building	1	1	0	2	2	X	2	3	2	2	3	1	2	1	1	1	1	1	26	884
7	Shared vision and objectives	1	2	0	1	2	2	X	1	2	1	2	1	3	3	3	1	0	0	25	800
8	Improving decision-making	1	1	0	1	1	1	1	X	0	1	1	2	1	3	2	2	0	0	18	522
9	Improving laboratory capacity	0	0	0	1	2	1	1	1	X	2	0	0	2	2	1	2	0	1	16	400
10	Strengthening surveillance sys	1	0	0	1	3	2	2	2	3	X	3	0	2	2	2	3	3	3	32	1120
11	Coordinating roles	2	1	2	1	2	1	3	1	0	1	X	1	1	1	1	1	1	1	21	735
12	Relationships among actors	3	1	2	2	2	3	2	3	0	3	3	X	2	2	0	0	2	0	30	360
13	Common platform	1	1	2	2	2	1	1	1	0	1	2	1	X	1	2	2	0	3	23	805
14	Structured guidelines/policy	0	0	0	1	2	2	2	3	2	2	2	0	2	X	3	3	1	0	25	750
15	Political will	0	0	0	1	3	1	3	1	3	3	1	0	3	3	X	3	0	0	25	600
16	Specific budget head	1	0	0	1	3	3	2	1	3	3	1	0	2	2	2	X	0	2	26	598
17	Community participation	0	0	2	1	2	1	1	0	0	3	2	0	1	0	0	0	X	0	13	208
18	Smart technology	0	0	0	2	1	2	0	1	2	3	2	0	2	0	0	2	0	X	17	238
	PS	18	12	15	23	36	34	32	29	25	35	35	12	35	30	24	23	16	14	448	
	Qx100	167	267	167	143	86	76	78	62	64	91	60	250	66	83	104	113	81	121		

Foot Note: 0=Negligible effect (empty cells), 1=under-proportional effect, 2=proportional effect, 3=over-proportional effect. AS=Active Sum, PS=Passive Sum, P=P-value, Q=Q-value(36)

Figure 2. Diagram representing the systemic roles of the factors of validated OH strategies in the Ahmedabad, India, extracted from the workshop during September 2019



Foot Note: AS: Active Sum; PS: Passive Sum; Numbers in the circle indicates the serial number of the factors: Leadership quality (1), Building trust (2), Motivation for teamwork (3), Adequate knowledge (4), Adequate human resources (5), Capacity building (6), Shared vision and objectives (7), Improving decision-making capacity (8), Improving laboratory capacity (9), Strengthening surveillance system (10), Coordinating roles (11), Relationship among actors (12), Common platform (13), Structured guidelines/policy (14), Political will (15), Specific budget head (16), Community participation (17), Smart technology (18)

3. Discussion

3.1. OH actors in the health system of Ahmedabad, India

The RICOHA study has explored the actors at three levels of the health system, i.e., administrative, provider, and community, from the human and the animal health system. As discussed in 'Publication 6', in addition to the city actors, there were top authorities from the district/state/nation have an integral role in decision-making for the prevention and control of zoonoses in Ahmedabad, India. The ISCs (coordination) eventuated only during the outbreak as instructed by the top authorities, which then decreased to the communication among the administrative actors in the non-outbreak situation. Similar to the other cities of India [97,98], the capacity of the animal health system of Ahmedabad is limited only to the cattle nuisance control along with the basic emergency animal care with a lack of skilled human resources. This might be one of the potential reasons why this study documented low network cohesion during non-outbreak situations compared to the outbreak situations at the administrative level. Although in the literature, the interaction among the administrative actors from both the system happens not only during health emergencies/disaster situations [99,100] but also during routine work [72], this research documented the interdependency of the city actors near the district/state actors, due to lack of human resources.

In the Indian public health system, the inter-dependency for HRH across the governance level has been documented [101]. This indicates the need for ISC, not only across the system (i.e., human-animal-environment) but also across the different governance levels. Another key finding from this research was the negligence of considering the private and non-governmental actors as part of the public health system. Although more than half of healthcare services are catered by private providers [102], this study documented minimal involvement of private actors with the governmental actors in the zoonoses prevention and control activities. With a lack of skilled human resources in the animal health system, the presence of these actors needs to be considered as an advantage in the local context.

At the provider level, ISC was found to be very low, especially at the interface between physicians and veterinarians, irrespective of the health emergencies. As pointed out in the result of 'Publication 6', the low awareness about zoonoses and lack of collaborative work experience might be the potential reasons for low ISC at this level.

As suggested in the literature, the collaboration between physician-veterinarian exists for managing [103] and controlling [104] zoonoses, or for joint clinical services for minimizing the risks [105–107]. As per the findings of this study in the local setting, this type of ISC is far away to visualize at the provider level. At the provider level, ISC was considered as a burden, and clinicians recommended task shifting to the community level.

In contrast, at the community level, this study found no such actor from the animal health system except the private veterinarian offering the need-based healthcare services (as discussed in 'Publication 4'). Although there is a lack of studies indicating the importance of community-level actors in disease prevention or risk mitigation at the human-animal interface [108], the evidence suggests the importance of the community health workers (CHW) in preventive and primary care in diverse domains of public health [109,110]. In the absence of a community actor from the animal health system, this study explored the possibility of task extension of the existing actors of the human health system as a potential OH activist. As discussed in 'Publication 4', the female health workers, i.e., Accredited Social Health Activists (ASHAs), are the most accepted CHWs with profound contact by the surveyed households. However, the low motivation and the demand for additional financial incentives becoming the major challenges to consider ASHAs as OHAs (as discussed in 'Publication 5'). The actors identified and listed in this research have direct or indirect involvement in the prevention and control of prioritized zoonotic diseases for Ahmedabad (Publication 3), i.e., rabies, brucellosis, avian influenza, and swine flu.

On the one hand, the low awareness level in the community (as found in the 'Publication 4') about the prioritized zoonoses and on the other hand, the lack of community actors from the animal health system ('Publication 4') making the local health system much more challenging. In literature, CHWs are contributing significantly to improve health security and community-level resilience in low and middle-income countries (LMICs) [111]. Considering the principles of the PCHS [81], this research urged to promote ASHAs as OHAs with suitable health promotion strategies in Ahmedabad, India.

3.2. ISC operationalization for OH implementation: Challenges and way forward

Overall, there is low interest for ISC at the provider level and a low acknowledgment of the advantages of ISC at the administrative level. ISC is instead considered as a burden and would not be implemented unless instructed by the top authorities. There is not yet an understanding of OH in the study area, but the identified actors across the local health system of different health system levels would provide a preliminary platform for an eventual OH implementation. As pointed out by Degeling *et al.* about the political-legal issues in the OH decision-making process [20], the current research identified the guidelines/policies for ISC as external factors that lie outside of the system in addition to the community participation, specific budget, political will, smart technology. As discussed in 'Publication 7', the prime enablers for enhancing ISC are micro factors at the individual level, i.e., trust, leadership, motivation, knowledge, which are grossly lacking in the study setting. As evinced the low awareness about the zoonoses at the community level (Publication 4&5) and the provider level (Publication 6), the knowledge of zoonoses promotion becomes one of the prime recommendations for the study setting.

Currently, the ISC ranges from communication to coordination, as shown in Figure 2. To progress towards the next level of convergence, the trust and motivation of actors at all levels of the health system are essential. Studies by Errecaborde *et al.* [112] and Rubin *et al.* [113] have emphasized the importance of individual factors like trust, the motivation of the actors for the OH implementation process. However, in the health system of Ahmedabad, the meso-level factors at the organizational level, i.e., human resource, capacity building, shared vision, decision-making capacity, are found to be equally essential to vitalize the ISC at the provider level. By intervening these meso-level factors, issues like lack of skilled human resources in the animal health system, the low motivation of ASHAs, the inter-dependency issues of the city and district administrative actors could be addressed. Some of the challenges that have been identified in this study as dissimilarity in the information flow and/or disease-reporting pattern could be tackled through the identified macro-level factors at the system level i.e. developing a common platform, enhancing the coordinated roles as pointed out in the 'Publication 7'. These types of factors, such as the individual, organizational, and network factors, are also narrated in a scoping review [112]. Addressing all the

enabling factors as identified in the study (Publication 7) at a single point of time would require additional financial resources, human resources for the awareness promotion, structured top-down directives. Thus, it is recommended to address the micro factors first, aiming at the system strengthening, as it would not involve financial burden, and then move towards addressing structural and external factors targeting the system changes. As the OH implementation across the globe have documented various enablers and barriers [35,36,114,115], and some are more important than others due to the local context [116]; the identified enablers and barriers (Publication 7) need to be considered for strengthening the ISC operationalization in the health system of Ahmedabad. As suggested in the literature, ISC operationalization without any complications is rare [35,36,114,115,117,118]; thus, continuous monitoring and evaluation strategies during implementation is recommended. In the literature, it is highlighted that limited resources at the city level [119–121] might lead to the negligence of the ISC activities and thus overlooking the burden of zoonoses. Given these circumstances and the reach presence of the private actors need to consider as an advantage for the local setting. As recommended in 'Publication 6', initiatives like a public-private partnership (PPP) are encouraged for OH implementation in Ahmedabad. The PPP strategies have shown huge advantages in different dimensions of public health in the study setting, as well as at the national level [122,123]. The learnings from the existing PPP strategies would be beneficial if replicated at the provider level to engage the private veterinarian in the zoonoses prevention and control activities in addition to involving non-governmental actors in the decision-making process.

3.3. ISC as a continuum process: Enhancing the convergence

The ISC operationalization, as part of the OH implementation, is being acknowledged as a continuum process. As documented in this study, ISC ranged from communication to coordination during non-outbreak and outbreak situations, respectively. The coordinated activities during the outbreak situation are a kind of solution-based collaboration, as discussed in 'Publication 2', where the desired actors do coordinated action until the problem continues. Although this type of coordinated activity was immensely helpful in controlling the past outbreaks, the concern arises on how better we might have prevented the outbreaks through ISCs during the non-outbreak situation. In such a case, the next step on the ladder of ISC, i.e., continuous

collaboration and coadunation, needs to be emphasized and promoted among the actors. In the literature, it is highlighted how and what type of ISCs strategies have been implemented in different public health domains in achieving the next step of the ladder with a joint determination of common goals [124,125]; there is a lack of evidence in the OH domains. Although in 'Publication 2', we have recommended a mixed ISC for India, i.e., a combination of level-based along with the third-party based collaboration, considering the situation of the Ahmedabad health system, a third party based collaboration is recommended. The level-based collaboration could be envisaged at a longer-term by addressing the structural and organizational changes. To develop a third-party based collaboration in the health system of Ahmedabad, the identified micro factors at the individual level (Publication 7) could help in motivating the current workforce for OH. The issues as suggested in the literature like involving all potential actors in the planning phase [126], minimizing the professional conflicts [127], tackling moral dilemmas [32], and minimizing the gap between policy visions and implementation efforts [128], are essential to be considered during OH implementation. Also, the current attitude of the top-down directive needs to be redirected towards enabling local innovation and meeting the needs of the people through addressing the identified enablers in the study setting for a people-centred health system.

Undoubtedly, the study setting is at the introductory level of the ISC process of convergence, thus to move ahead, it is essential to repeat the five-step process of exploration for each new common goal. The five-steps process of ISC exploration as part of the operationalization, recommended from the RICOHA are- (a) prioritizing the goals (either for the disease control or for the risk mitigation), (b) identifying all the potential and relevant actors (stakeholders and/or institutions) responsible for the prioritized goals, (c) understanding the current network cohesion among the identified actors as well as their interest in the newly prioritized goal(s) and influence on the other actors, (d) decision-making process on the key strategies for the operationalization, (e) identifying enablers and barrier factors within the network for operationalization.

With the lack of evidence for the local setting, the RICOHA study attempted to determine which zoonoses need to be prioritized for collaboration as the first step of the ISC, as discussed in 'Publication 3' [91]. Similarly, this has been done for different

purposes, such as to provide guidelines for resource allocation to enhance surveillance in Kenya [129], or to identify the most critical zoonotic diseases that should be jointly addressed in Tanzania [130], Uganda [131], Ethiopia [132]. Therefore, the purpose of ISC could differ as per the targeted goals, and that should be mutually decided as per the need of the study setting. These five-step processes of ISC exploration could be replicated to any other setting for OH implementation processes.

ISC, as one of the key strategies for the implementation of OH, has been documented across the globe [133]. In similar ways, ISC has also been the key to the prevention and control of vector-borne diseases [134,135], noncommunicable diseases [136,137]. However, the range of sectors involved as part of OH implementation depends on the need of the local setting or the goal of the actors [10,34,114,138]. Thus the ISC strategies identified in this research (as pointed in 'Publication 7') might facilitate the OH implementation process in Ahmedabad. For example, from 'Publication 7', a common platform for knowledge sharing or the joint training programs or developing OH clinical body between the interface of the physician and veterinarian remained of utmost importance. Although in our review (Publication 2), we failed to conclude on how much ISC is required for an effective OH implementation, it is essential to measure the ISC in different situations to understand its impact. Therefore, it is crucial to note here that future reviews should focus on quantified ISCs and their effects on disease control and/or risk mitigation.

3.4. RICOHA study contributions: Unfolding recognition

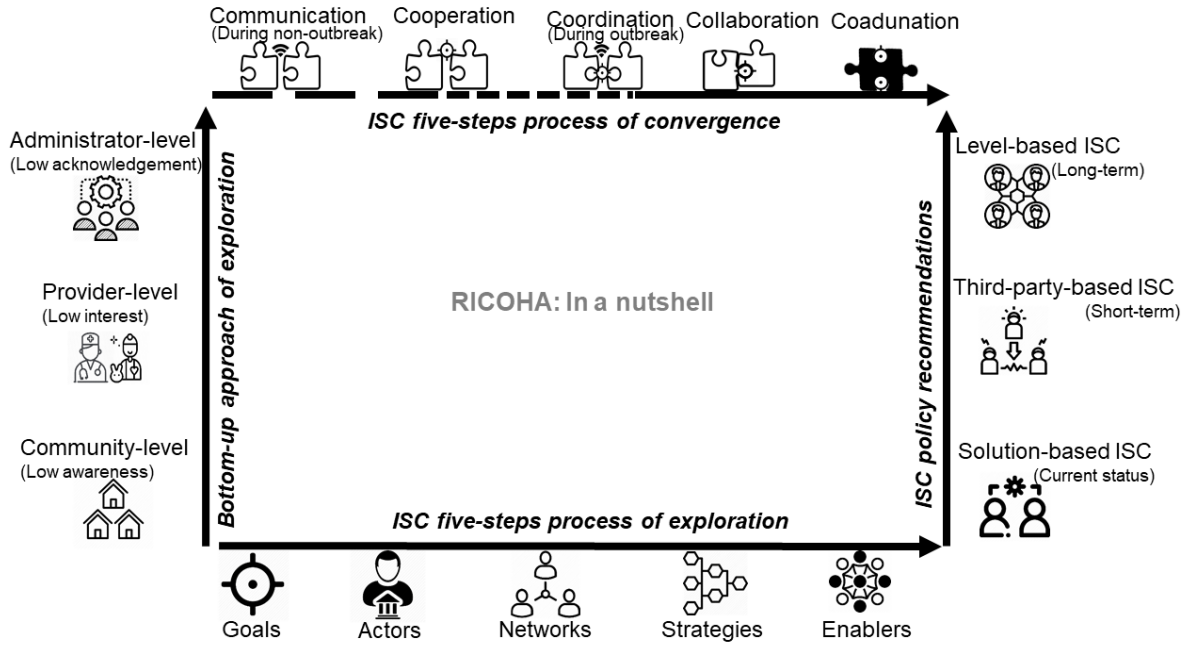
This health system study has a two-layered contribution, i.e., a conceptual and an empirical. As there was a lack of information on the OH implementation, especially in LMICs, this study added value in generating the preliminary scenario and potential options for ISC operationalization for the case of Ahmedabad, India. Conceptually, this study developed the process of exploring the ISC operationalization for a study setting where there is no concept of OH so far. The five-step process of ISC exploration as part of the operationalization discussed in the RICOHA study could be replicated in any other setting to tackle different purposes in the domain of OH. Also, in the study setting, this five-step process could be repeated over time, and the findings from this study could act as baseline information for future monitoring and evaluations.

Further, the advantages of investigations from the lens of the bottom-up approach in the context of HPSR made an empirical contribution. First, the importance of the community and people as per PCHS was captured, and second, when there is a lack of evidence on the zoonotic disease awareness and perceptions about the health systems, it remained an important task to understand the community scenario rather than understanding the apex governance level. Thus, the community level was explored first, followed by the provider level and the administrative level. While other HPSR studies in the same study setting benefited from top-down exploration[139] in the presence of a defined policy, the RICOHA study benefited through the bottom-up approach in the absence of a defined OH policy. This might result in formulating the people-centered and need-based policy on OH in the near future. This bottom-up approach in the HPSR could also be referenced to any other issues in public health, where pre-defined policy is absent or to understand the need of people, which would ultimately lead to change in the current policies. With increasing the health system complexity [83], this bottom-up approach exploration of the health system helped to understand the local context and the realities.

3.5. Beyond zoonotic diseases: Learnings from RICOHA

In an increasingly complex and dynamic health system, a single actor and/or institution has no adequate knowledge or capacity to tackle efficiently and effectively the future emerging and re-emerging diseases [140,141]. Thus, exploring ISC enables a better understanding of the local situation, including its potential actors, capacities, and networks, as studied in the RICOHA. Although RICOHA studied ISC pertaining to the prevention and control of the selected zoonotic diseases, it has enormous potential to replicate a similar process in the other dimensions of OH. The same exercise could be scaled up (a) to any other spatial scale (within India or outside), (b) to any other complex issues of OH approach (such as mitigation of antimicrobial resistance or food safety), (c) to any other lenses of the health system (i.e., to the state, regional, national level), (d) to any other discipline of public health (where multiple sectors are required to address a common issue or challenge).

Figure 2. Summarized findings of RICOHA study indicating the current scenario and the way forward



3.6. Limitations and Recommendations

One of the limitations of the RICOHA study is that it has primarily explored the two systems only, i.e., the human and the animal health systems. Therefore, future studies should focus on exploring the other systems relevant to OH. As this research recommends ASHAs to become OHAs in the absence of any community actors from the animal health system, this might have been different vary if any other systems were included in the exploration. However, the reach of eventual community actors other than the human and animal health systems also needs to be tested for their potentials in disease control and awareness about zoonoses. The health system interventional trial studies are recommended to find out the most potential OHAs from all other systems. Secondly, this study represents a cross-sectional study, and there might be recall bias while enquiring about the potential actors that have collaborated in the last outbreak. This might be better captured through longitudinal data collection over time. This might have allowed us to understand the dynamic changes of the health system and the real-time interaction of actors. Thirdly, the implementation phase of this operationalization process was beyond the scope due to the time constraint; therefore, future studies should implement strategies that have been developed by RICOHA and evaluate its effectiveness over time. Despite these

limitations, the RICOHA is the first of its kind in India, targeting the exploration of ISC in a local health system, concluded with the following policy and research recommendations:

Short-term policy recommendations

- Develop a third-party based ISC for prevention and control of zoonotic disease; for example, a One Health Task Force of Ahmedabad (OHTFA) consisting of representative actors from the different levels of the health system, including district/state actors.
- Establish a common platform across the different health system levels for zoonoses knowledge sharing, promotion of the advantages of ISC, and training for addressing the identified micro factors (e.g. leadership, trust, motivation).
- The presence of the private and non-governmental actors needs to be considered as an advantage and needs to be integrated into zoonoses prevention and control activities by building public-private partnerships.
- Conduct structured training programs for the prioritized zoonotic diseases (rabies, brucellosis, and influenza) at the different levels of the health system.
- Sustain vertical collaborations between the administrative actors of the city and the district/state level during non-outbreak situations.
- Establish a combined OH clinical body and reporting system at the provider level for diagnosis, treatment, and prevention of zoonoses.
- Train ASHAs on zoonoses prevention and deploy them for awareness promotion in the community.

Long-term policy recommendations

- Developing level based collaborations.
- Increase the scope of the Cattle Nuisance Control Department (the current animal health cell of the AMC) towards zoonotic disease control and risk mitigation by recruiting more animal health professionals and extending the animal health clinics across the city.
- At the administrative level, coadunation processes for joint resource sharing for risk mitigation need to be developed.
- At the provider level, initiate the cross-referral mechanism between the physicians and veterinarians.

- At the community level, promote ASHAs to One Health Activists (OHA) with appropriate financial incentive packages.

Research recommendation(s)

- Understanding the network cohesion and nodes of actor interactions for all OH sectors in the national, state, or local context.
- Assess the power dynamics between the actors across the OH sectors within the local health system.
- Use the bottom-up approach in health system research in the absence of a defined policy or to develop people-centered health policies.

4. References

1. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, et al. Global trends in emerging infectious diseases. Nature [Internet]. 2008 Feb 21 [cited 2018 Jan 1];451(7181):990–3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18288193

2. Gebreyes WA, Dupouy-Camet J, Newport MJ, Oliveira CJB, 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 [Internet]. 2014 [cited 2018 Mar 8];8(11):e3257. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25393303

3. FAO-OIE-WHO . Taking a Multisectoral One Health Approach : A Tripartite Guide to Addressing Zoonotic Diseases in Countries [Internet]. Geneva; 2019 [cited 2020 Mar 24]. Available from: http://www.fao.org/3/ca2942en/ca2942en.pdf

4. Rabozzi G, Bonizzi L, Crespi E, Somaruga C, Sokooti M, Tabibi R, et al. Emerging zoonoses: The “one health approach.” Vol. 3, Safety and Health at Work. Elsevier Science B.V.; 2012. p. 77–83.

5. Destoumieux-Garzón D, Mavingui P, Boetsch G, Boissier J, Darriet F, Duboz P, et al. The one health concept: 10 years old and a long road ahead. Vol. 5, Frontiers in Veterinary Science. Frontiers Media S.A.; 2018. p. 14.

6. Atlas RM. One Health: Its Origins and Future. In: Mackenzie J, Jeggo M, Daszak P, Richt J, editors. One Health: The Human-Animal-Environment Interfaces in Emerging Infectious Diseases [Internet]. Springer International Publishing; 2012 [cited 2020 Jun 22]. p. 1–13. Available from: https://www.springer.com/de/book/9783642368882

7. 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 [Internet]. 2017;23(13). Available from: https://doi.org/10.3201/eid2313.170418

8. Bidaisee S, Macpherson CNL. Zoonoses and one health: a review of the literature. J Parasitol Res [Internet]. 2014;2014:874345. Available from: https://doi.org/10.1155/2014/874345

9. Mazet JAK, Clifford DL, Coppolillo PB, Deolalikar AB, Erickson JD, Kazwala RR. A “One Health” Approach to Address Emerging Zoonoses: The HALI Project in Tanzania. PLoS Med [Internet]. 2009 Dec 15 [cited 2017 Dec 5];6(12):e1000190. Available from: http://dx.plos.org/10.1371/journal.pmed.1000190

10. Vandersmissen A, Welburn SC. Current initiatives in One Health: consolidating the One Health Global Network. Rev Sci Tech. 2014;33(2):421–32.

11. 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 [Internet]. 2011;101(3–4):148–56. Available from:

https://doi.org/10.1016/j.prevetmed

12. Tarazona AM, Ceballos MC, Broom DM. Human Relationships with Domestic and Other Animals: One Health, One Welfare, One Biology. Animals [Internet]. 2019 Dec 24 [cited 2020 Jun 22];10(1):43. Available from: https://www.mdpi.com/2076-2615/10/1/43

13. Centers for Disease Control and Prevention . One Health Basics [Internet]. U.S. Department of Health & Human Services. 2019 [cited 2020 Jul 14]. p. 1–8. Available from: https://www.cdc.gov/onehealth/basics/index.html

14. One Health Commission . What is One Health?: Definitions of One Health [Internet]. 2019 [cited 2020 Jul 14]. p. 1–7. Available from: https://www.onehealthcommission.org/en/why_one_health/what_is_one_health/

15. One Health Global Network. What is One Health? [Internet]. OHGN. 2011 [cited 2018 Jun 4]. Available from: http://www.onehealthglobal.net/what-is-one-health/

16. American Veterinary Medical Association. One Health : A New Professional Imperative [Internet]. One Health Initiative Task Force; 2008. Available from: https://www.avma.org/KB/Resources/Reports/Documents/onehealth_final.pdf

17. World Health Organization . What is “One Health”? [Internet]. WHO. 2017 [cited 2020 Jul 14]. p. 1. Available from: https://www.who.int/news-room/q-a-detail/one-health

18. World Organisation for Animal Health . One Health “at a glance” [Internet]. OIE. 2019 [cited 2020 Jul 14]. p. 1–2. Available from: https://www.oie.int/en/for-the-media/onehealth/

19. Food and Agriculture Organisation of the United Nations. What is One Health? [Internet]. FAO. 2019 [cited 2020 Jul 14]. p. 1. Available from: http://www.fao.org/asiapacific/perspectives/one-health/en/

20. Degeling C, Johnson J, Kerridge I, Wilson A, Ward M, Stewart C, et al. Implementing a One Health approach to emerging infectious disease: reflections on the socio-political, ethical and legal dimensions. BMC Public Health [Internet]. 2015;15:1307. Available from: https://doi.org/10.1186/s12889-015-2617-1

21. 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 [Internet]. 2017 Dec [cited 2018 Nov 20];23(13). Available from: http://www.ncbi.nlm.nih.gov/pubmed/29155664

22. Murphy SC, Negron ME, Pieracci EG, Deressa A, Bekele W, Regassa F, et al. One Health collaborations for zoonotic disease control in Ethiopia. Rev Sci Tech [Internet]. 2019 May 1 [cited 2020 Jul 16];38(1):51–60. Available from: https://experts.umn.edu/en/publications/one-health-collaborations-for-zoonotic-disease-control-in-ethiopi

23. Meseko CA, Egbetade AO, Fagbo S. Ebola virus disease control in West

Africa: An ecological, one health approach [Internet]. Vol. 21, Pan African Medical Journal. African Field Epidemiology Network; 2015 [cited 2020 Jul 14]. Available from: https://pubmed.ncbi.nlm.nih.gov/26401200/

24. Zumla A, Dar O, Kock R, Muturi M, Ntoumi F, Kaleebu P, et al. Taking forward a 'One Health' approach for turning the tide against the Middle East respiratory syndrome coronavirus and other zoonotic pathogens with epidemic potential [Internet]. Vol. 47, International Journal of Infectious Diseases. Elsevier B.V.; 2016 [cited 2020 Jul 14]. p. 5–9. Available from: http://dx.doi.org/10.1016/j.ijid.2016.06.012

25. Gibbs EPJ. The evolution of one health: A decade of progress and challenges for the future. Vet Rec. 2014 Jan 25;174(4):85–91.

26. Stephen C, Artsob H, Bowie WR, Drebot M, Fraser E, Leighton T, et al. Perspectives on Emerging Zoonotic Disease Research and Capacity Building in Canada. Can J Infect Dis Med Microbiol [Internet]. 2004;15(6):339–44. Available from: https://doi.org/10.1155/2004/238126

27. Anholt RM, Stephen C, Copes R. Strategies for Collaboration in the Interdisciplinary Field of Emerging Zoonotic Diseases. Vol. 59, Zoonoses and Public Health. Zoonoses Public Health; 2012. p. 229–40.

28. Paternoster G, Babo Martins S, Mattivi A, Cagarelli R, Angelini P, Bellini R, et al. Economics of One Health: Costs and benefits of integrated West Nile virus surveillance in Emilia-Romagna. Riddle MS, editor. PLoS One [Internet]. 2017 Nov 27 [cited 2020 Apr 18];12(11):e0188156. Available from: https://dx.plos.org/10.1371/journal.pone.0188156

29. Häsler B, Gilbert W, Jones BA, Pfeiffer DU, Rushton J, Otte MJ. The Economic Value of One Health in Relation to the Mitigation of Zoonotic Disease Risks. In: One Health: The Human-Animal-Environment Interfaces in Emerging Infectious Diseases [Internet]. Nature Publishing Group; 2012 [cited 2020 Jun 25]. p. 127–51. Available from: /pmc/articles/PMC7120618/?report=abstract

30. Bruchhausen W. Emerging Global Health Approaches at the Human-Animal Interface: Conceptual and Historical Issues of One Health. In: Yasobant S, Saxena D, editors. Global Applications of One Health Practice and Care. USA: IGI Global; 2019. p. 1–32.

31. Le Gall FG, Plante CA, Berthe FCJ, Bouley T, Seifman RM, Karesh WB, et al. Operational framework for strengthening human, animal and environmental public health systems at their interface [Internet]. 2018 [cited 2018 Mar 13]. p. 1–170. Available from: http://documents.worldbank.org/curated/en/703711517234402168/Operational-framework-for-strengthening-human-animal-and-environmental-public-health-systems-at-their-interface

32. van Herten J, Bovenkerk B, Verweij M. One Health as a moral dilemma: Towards a socially responsible zoonotic disease control. Zoonoses Public Health [Internet]. 2019 Feb 1 [cited 2020 Apr 18];66(1):26–34. Available from: http://doi.wiley.com/10.1111/zph.12536

33. Baum SE, Machalaba C, Daszak P, Salerno RH, Karesh WB. Evaluating one

health: Are we demonstrating effectiveness? One Heal (Amsterdam, Netherlands) [Internet]. 2017;3:5–10. Available from: https://doi.org/10.1016/j.onehlt.2016.10.004

34. Osoro E, Mbabu M, Njeru I, Kairu-Wanyoike S, Muturi M, Kiambi S, et al. Implementing one health intersectoral collaboration at country level. In: Session 4 (OIE Conference) Operationalisation of dog transmitted rabbies elimination through prevention at the source [Internet]. 2010 [cited 2018 Jan 16]. p. 24–5. Available from: http://www.oie.int/fr/RABIES2015/abstracts/Session_4.3_Osoro_One_Health_abstracts.pdf

35. Conrad PA, Meek LA, Dumit J. Operationalizing a One Health approach to global health challenges. Comp Immunol Microbiol Infect Dis [Internet]. 2013 May;36(3):211–6. Available from: https://doi.org/10.1016/j.cimid.2013.03.006

36. Lee K, Brumme ZL. Operationalizing the One Health approach: the global governance challenges. Health Policy Plan [Internet]. 2013 Oct 1 [cited 2017 Mar 6];28(7):778–85. Available from: https://academic.oup.com/heapol/article-lookup/doi/10.1093/heapol/czs127

37. Kakkar M, Hossain S, Abbas SS. One Health: a perspective from the human health sector. Rev Sci Tech. 2014;33(2):407–12.

38. Dente MG, Riccardo F, Bolici F, Colella NA, Jovanovic V, Drakulovic M, et al. Implementation of the One Health approach to fight arbovirus infections in the Mediterranean and Black Sea Region: Assessing integrated surveillance in Serbia, Tunisia and Georgia. Zoonoses Public Health [Internet]. 2019 Feb 5 [cited 2019 Apr 7];zph.12562. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30724030

39. Thomson AM, Perry JL. Collaboration Processes: Inside the Black Box. Public Adm Rev. 2006;66(1):20–32.

40. Kim SS, Avula R, Ved R, Kohli N, Singh K, Van Den Bold M, et al. Understanding the role of intersectoral convergence in the delivery of essential maternal and child nutrition interventions in Odisha, India: A qualitative study. BMC Public Health [Internet]. 2017 Feb 2 [cited 2020 Mar 12];17(1):161. Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-017-4088-z

41. Tangcharoensathien V, Srisookwatana O, Pinprateep P, Posayanonda T, Patcharanarumol W. Multisectoral actions for health: Challenges and opportunities in complex policy environments. Vol. 6, International Journal of Health Policy and Management. Kerman University of Medical Sciences; 2017. p. 359–63.

42. de Leeuw E. Engagement of Sectors Other than Health in Integrated Health Governance, Policy, and Action. Annu Rev Public Health. 2017 Mar 20;38(1):329–49.

43. Bennett S, Glandon D, Rasanathan K. Governing multisectoral action for health in low-income and middle-income countries: unpacking the problem and rising to the challenge. BMJ Glob Heal [Internet]. 2018 Oct 10 [cited 2019 Aug

11];3(Suppl 4):e000880. Available from: http://gh.bmj.com/lookup/doi/10.1136/bmjgh-2018-000880

44. Gajda R. Utilizing Collaboration Theory to Evaluate Strategic Alliances. Am J Eval [Internet]. 2004 Mar 24 [cited 2020 Apr 30];25(1):65–77. Available from: http://journals.sagepub.com/doi/10.1177/109821400402500105

45. Woulfe J, Oliver TR, Zahner SJ, Siemering KQ. Multisector partnerships in population health improvement. Prev Chronic Dis [Internet]. 2010 [cited 2018 Jan 18];7(6):A119. Available from: http://www.cdc.gov/pcd/issues/nov/10_0104.htm.

46. World Health Organization. Health Promotion Glossary [Internet]. Geneva; 1998. Available from: https://www.who.int/healthpromotion/about/HPR Glossary 1998.pdf

47. World Health Organization ., Public Health Agency of Canada . An Analysis of 18 Country Case Studies Health Equity Through Intersectoral Action [Internet]. Geneva; 2008 [cited 2020 Jun 25]. Available from: https://www.who.int/social_determinants/resources/health_equity_isa_2008_en.pdf

48. Peters DH. The application of systems thinking in health: why use systems thinking? Heal Res Policy Syst [Internet]. 2014 Dec 26 [cited 2018 Feb 28];12(1):51. Available from: http://health-policy-systems.biomedcentral.com/articles/10.1186/1478-4505-12-51

49. Leischow SJ, Best A, Trochim WM, Clark PI, Gallagher RS, Marcus SE, et al. Systems thinking to improve the public's health. Am J Prev Med [Internet]. 2008 Aug [cited 2018 Feb 28];35(2 Suppl):S196-203. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18619400

50. Salway S, Green J. Towards a critical complex systems approach to public health [Internet]. Vol. 27, Critical Public Health. Routledge; 2017 [cited 2020 Jul 16]. p. 523–4. Available from: https://www.tandfonline.com/doi/abs/10.1080/09581596.2017.1368249

51. Rüegg SR, Nielsen LR, Buttigieg SC, Santa M, Aragrande M, Canali M, et al. A Systems Approach to Evaluate One Health Initiatives. Front Vet Sci [Internet]. 2018 Mar 9 [cited 2020 Jul 16];5(MAR):23. Available from: http://journal.frontiersin.org/article/10.3389/fvets.2018.00023/full

52. Carey G, Malbon E, Carey N, Joyce A, Crammond B, Carey A. Systems science and systems thinking for public health: A systematic review of the field [Internet]. Vol. 5, BMJ Open. BMJ Publishing Group; 2015 [cited 2020 Jul 16]. p. 9002. Available from: http://bmjopen.bmj.com/

53. Thomas CW, Corso L, Monroe JA. The value of the system in public health services and systems research [Internet]. Vol. 105, American Journal of Public Health. American Public Health Association Inc.; 2015 [cited 2020 Jun 26]. p. S147–9. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4355686/

54. Sims J, Aboelata MJ. A System of Prevention: Applying a Systems Approach to Public Health. Health Promot Pract [Internet]. 2019 Jul 12 [cited 2020 Mar

10];20(4):476–82. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31081376

55. Sheikh K, Gilson L, Agyepong IA, Hanson K, Ssengooba F, Bennett S. Building the field of health policy and systems research: Framing the questions. PLoS Med [Internet]. 2011 Aug [cited 2020 Jun 23];8(8). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3156683/

56. Abimbola S, Negin J, Martiniuk AL, Jan S. Institutional analysis of health system governance. Health Policy Plan [Internet]. 2017 [cited 2020 Feb 4];32(9):1337–44. Available from: https://academic.oup.com/heapol/article-abstract/32/9/1337/3952584

57. Atun R. Health systems, systems thinking and innovation. Health Policy Plan [Internet]. 2012 Oct 1 [cited 2018 Feb 28];27(suppl 4):iv4–8. Available from: https://academic.oup.com/heapol/article-lookup/doi/10.1093/heapol/czs088

58. Koskinen KU. Systemic View and Systems Thinking. In: Knowledge Production in Organizations [Internet]. Heidelberg: Springer International Publishing; 2013 [cited 2018 May 29]. p. 13–30. Available from: http://link.springer.com/10.1007/978-3-319-00104-3_3

59. Rasanathan K, Bennett S, Atkins V, Beschel R, Carrasquilla G, Charles J, et al. Governing multisectoral action for health in low- and middle-income countries. PLoS Med. 2017;14(4).

60. Tangcharoensathien V, Srisookwatana O, Pinprateep P, Posayanonda T, Patcharanarumol W. Multisectoral Actions for Health: Challenges and Opportunities in Complex Policy Environments. Int J Heal policy Manag [Internet]. 2017 May 16 [cited 2018 Nov 20];6(7):359–63. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28812831

61. Levinson FJ, Balarajan Y, Marini A. Addressing malnutrition multisectorally: What have we learned from recent international experience? [Internet]. New York; 2013 Aug [cited 2020 Mar 12]. Available from: http://www.mdgfund.org/sites/default/files/Addressing malnutrition multisectorally-FINAL-submitted.pdf

62. Jindai K, McLellan RT, Takakura S, Noda H, Miyake K. Nippon AMR One Health Report: the first step towards multisectoral collaboration. Lancet Infect Dis [Internet]. 2018 Nov [cited 2019 Apr 7];18(11):1179–80. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1473309918305668

63. Bordier M, Binot A, Pauchard Q, Nguyen DT, Trung TN, Fortané N, et al. Antibiotic resistance in Vietnam: moving towards a One Health surveillance system. BMC Public Health [Internet]. 2018 Dec 24 [cited 2019 Apr 7];18(1):1136. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-6022-4

64. Karimuribo ED, Sayalel K, Beda E, Short N, Wambura P, Mboera LG, et al. Towards One Health disease surveillance: The Southern African Centre for Infectious Disease Surveillance approach. Onderstepoort J Vet Res [Internet]. 2012 Jun 20 [cited 2019 Apr 20];79(2):7. Available from:

https://ojvr.org/index.php/ojvr/article/view/454/565

65. Babo Martins S, Rushton J, Stark K. Economics of zoonoses surveillance in a 'One Health' context: an assessment of Campylobacter surveillance in Switzerland. Epidemiol Infect [Internet]. 2017 Apr 23 [cited 2019 Apr 7];145(06):1148–58. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28112074

66. Zheng Z, Lu Y, Short KR, Lu J. One health insights to prevent the next HxNy viral outbreak: learning from the epidemiology of H7N9. BMC Infect Dis [Internet]. 2019 Dec 11 [cited 2019 Apr 7];19(1):138. Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-019-3752-6

67. Morton J. The innovation trajectory of Sleeping sickness control in Uganda: Research knowledge in its context [Internet]. California; 2010 [cited 2019 Apr 20]. Report No.: 08. Available from: https://assets.publishing.service.gov.uk/media/57a08b29e5274a31e00009f4/riu10discuss08ssickcntrl-ug.pdf

68. Mbabu M, Njeru I, File S, Osoro E, Kiambi S, Bitek A, et al. Establishing a One Health office in Kenya. Pan Afr Med J [Internet]. 2014 [cited 2019 Apr 7];19:106. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25722779

69. Batsukh Z, Tsolmon B, Otgonbaatar D, Undraa B, Dolgorkhand A, Ariuntuya O. One Health in Mongolia. In 2012 [cited 2019 Apr 8]. p. 123–37. Available from: http://link.springer.com/10.1007/82_2012_253

70. One Health Bangladesh Secretariat. Strategic framework for One Health approach to infectious diseases in Bangladesh [Internet]. Bangladesh; 2012 [cited 2018 Jan 26]. Available from: http://www.iedcr.gov.bd/pdf/files/One Health/Strategic_framework_for_One_Health_Bangladesh-26 Jan.pdf

71. Sabatier PA. Top-Down and Bottom-Up Approaches to Implementation Research: A Critical Analysis and Suggested Synthesis. J Public Policy. 1986;6(1):21–48.

72. Mazet JAK, Uhart MM, Keyyu JD. Stakeholders in One Health. Rev Sci Tech. 2014;33(2):443–52.

73. Falzon LC, Alumasa L, Amanya F, Kang'ethe E, Kariuki S, Momanyi K, et al. One Health in Action: Operational Aspects of an Integrated Surveillance System for Zoonoses in Western Kenya. Front Vet Sci [Internet]. 2019 Jul 31 [cited 2020 Aug 25];6:252. Available from: https://www.frontiersin.org/article/10.3389/fvets.2019.00252/full

74. Osterhaus ADME, Vanlangendonck C, Barbeschi M, Bruschke CJM, Christensen R, Daszak P, et al. Make science evolve into a One Health approach to improve health and security: a white paper. One Heal Outlook [Internet]. 2020 Dec 17 [cited 2020 Jul 24];2(1):6. Available from: https://onehealthoutlook.biomedcentral.com/articles/10.1186/s42522-019-0009-7

75. Viswanathan M, Duncan R, Grigortsuk M, Sreekumar A. A Bottom-Up Approach to Understanding Low-Income Patients: Implications for Health-Related Policy. J Law, Med Ethics [Internet]. 2018 Sep 18 [cited 2020 Jul

20];46(3):658–64. Available from: http://journals.sagepub.com/doi/10.1177/1073110518804220

76. Laaser U, Dorey S, Nurse J. A plea for global health action bottom-up. Front Public Heal [Internet]. 2016 Oct 31 [cited 2020 Jul 20];4(OCT):1. Available from: www.frontiersin.org

77. Bengoa R. Transforming health care: an approach to system-wide implementation. Int J Integr Care [Internet]. 2013 Sep 25 [cited 2020 Jul 20];13(3). Available from: /pmc/articles/PMC3812354/?report=abstract

78. Matland RE. Synthesizing the Implementation Literature: The Ambiguity-Conflict Model of Policy Implementation [Internet]. Vol. 5, Journal of Public Administration Research and Theory: J-PART. Oxford University PressPublic Management Research Association; [cited 2020 Mar 12]. p. 145–74. Available from: https://www.jstor.org/stable/1181674

79. Hjern B. Implementation Research: The Link Gone Missing [Internet]. Vol. 2, Journal of Public Policy. Cambridge University Press; [cited 2020 Mar 12]. p. 301–8. Available from: https://www.jstor.org/stable/3998186

80. Sheikh K, Ranson MK, Gilson L. Explorations on people centredness in health systems. Health Policy Plan [Internet]. 2014 [cited 2020 Jul 22];29(Suppl 2):ii1–5. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4202918/

81. Sturmberg JP, Njoroge A. People-centred health systems, a bottom-up approach: where theory meets empery. J Eval Clin Pract [Internet]. 2017 Apr 8 [cited 2020 Jul 21];23(2):467–73. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/jep.12540

82. Min B, Allen-Scott LK, Buntain B. Transdisciplinary research for complex One Health issues: A scoping review of key concepts. Prev Vet Med. 2013 Nov 1;112(3–4):222–9.

83. Kannampallil TG, Schauer GF, Cohen T, Patel VL. Considering complexity in healthcare systems. J Biomed Inform. 2011 Dec 1;44(6):943–7.

84. Ricketts TC. Geography and Disparities in Health care. In: Swift EK, editor. Institute of Medicine (US) Committee on Guidance for Designing a National Healthcare Disparities Report [Internet]. National Academies Press (US); 2002 [cited 2020 Jul 20]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK221045/

85. Kovačić L, Jakšić Ž. Healthcare as a System: Elements, Boundaries, Levels. In: Management in Healthcare practice: A handbook for teachers, researchers and health professionals. 2008. p. 1–9.

86. Ahluwalia IJ. Urban governance in India. J Urban Aff [Internet]. 2019 Jan 2 [cited 2020 Jun 30];41(1):83–102. Available from: https://www.tandfonline.com/doi/full/10.1080/07352166.2016.1271614

87. Balarajan Y, Selvaraj S, Subramanian S V. Health care and equity in India. Lancet [Internet]. 2011 Feb 5 [cited 2014 Nov 3];377(9764):505–15. Available from:

http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3093249&tool=pmcentrez&rendertype=abstract

88. Chokshi M, Patil B, Khanna R, Neogi SB, Sharma J, Paul VK, et al. Health systems in India [Internet]. Vol. 36, Journal of Perinatology. Nature Publishing Group; 2016 [cited 2020 Jun 30]. p. S9–12. Available from: /pmc/articles/PMC5144115/?report=abstract

89. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. Convergence model for effectual prevention and control of zoonotic diseases: a health system study on “One Health” approach in Ahmedabad, India. Heal Res policy Syst [Internet]. 2018 Dec 19 [cited 2019 Jan 18];16(1):124. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30567599

90. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. One health collaboration for a resilient health system in India: Learnings from global initiatives. One Health [Internet]. 2019 Dec 1 [cited 2019 Jul 31];8:100096. Available from: https://www.sciencedirect.com/science/article/pii/S2352771419300011

91. Yasobant S, Saxena D, Bruchhausen W, Memon FZ, Falkenberg T. Multi-sectoral prioritization of zoonotic diseases: One health perspective from Ahmedabad, India. Samy AM, editor. PLoS One [Internet]. 2019 Jul 30 [cited 2019 Aug 20];14(7):e0220152. Available from: http://dx.plos.org/10.1371/journal.pone.0220152

92. Rist CL, Arriola CS, Rubin C. Prioritizing zoonoses: a proposed one health tool for collaborative decision-making. PLoS One [Internet]. 2014;9(10):e109986. Available from: https://doi.org/10.1371/journal.pone.0109986

93. Yasobant S, Bruchhausen W, Saxena D, Memon FZ, Falkenberg T. Health system contact and awareness of zoonotic diseases: Can it serve as One Health entry point in the urban community of Ahmedabad, India. Yale J Biol Med. 2020;Accepted.

94. Yasobant S, Bruchhausen W, Saxena D, Memon FZ, Falkenberg T. Who could be One Health Activist at the community level: A case for India? Hum Resour Health [Internet]. 2020;19(13):1–11. Available from: https://human-resources-health.biomedcentral.com/articles/10.1186/s12960-021-00558-3

95. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. ‘One Health’ actors in multifaceted health systems: An operational case for India. Healthcare. 2020;8(387):1–19.

96. Yasobant S, Bruchhausen W, Saxena D, Falkenberg T. Systemic factors for enhancing intersectional collaboration for the operationalization of One Health: A case for India. Heal Res Policy Syst. 2020;Under review.

97. Ghatak S, Singh BB. Veterinary public health in India: current status and future needs. Rev Sci Tech. 2015;34(3):713–27.

98. Rao S, Rasheed Sulaiman V, Natchimuthu K, Ramkumar S, Sasidhar P, Gandhi R. Improvement of veterinary services delivery in India. Rev Sci Tech Off Int Epiz. 2015;34(3).

99. Institute of Medicine US Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations. Guidance for Establishing Crisis Standards of Care for Use in Disaster Situations [Internet]. Altevogt BM, Stroud C, Hanson SL, Hanfling D, Gostin LO, editors. National Academies Press (US); 2012 [cited 2020 May 27]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK219958/

100. Menon VC. India - National disaster and epidemic preparedness. Int J Infect Dis. 2016 Apr 1;45:12.

101. Rao KD, Bhatnagar A, Berman P. So many, yet few: Human resources for health in India. Hum Resour Health [Internet]. 2012 Aug 13 [cited 2020 May 27];10(1):19. Available from: https://human-resources-health.biomedcentral.com/articles/10.1186/1478-4491-10-19

102. Sengupta A, Nundy S. The private health sector in India: Is burgeoning, but at the cost of public health care. Br Med J [Internet]. 2005 Nov 19 [cited 2020 Aug 5];331(7526):1157–8. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1285083/

103. Speare R, Mendez D, Judd J, Reid S, Tzipori S, Massey PD. Willingness to Consult a Veterinarian on Physician's Advice for Zoonotic Diseases: A Formal Role for Veterinarians in Medicine? PLoS One [Internet]. 2015;10(8):e0131406. Available from: https://doi.org/10.1371/journal.pone.0131406

104. Shanko K, Kemal J, Kenea D. A Review on Confronting Zoonoses: The Role of Veterinarian and Physician. J Vet Sci Technol [Internet]. 2014;06(02):1–7. Available from: https://doi.org/10.4172/2157-7579.1000221

105. Matthiessen PW, Sansone RA, Meier BP, Gaither GA, Shrader J. Zoonotic diseases and at-risk patients: a survey of veterinarians and physicians. AIDS [Internet]. 2003;17(9):1404–6. Available from: https://doi.org/10.1097/01.aids.0000072668.21517.92

106. Hill WA, Petty GC, Erwin PC, Souza MJ. A survey of Tennessee veterinarian and physician attitudes, knowledge, and practices regarding zoonoses prevention among animal owners with HIV infection or AIDS. J Am Vet Med Assoc. 2012 Jun 15;240(12):1432–40.

107. Courtenay M, Sweeney J, Zielinska P, Brown Blake S, La Ragione R. One Health: An opportunity for an interprofessional approach to healthcare. J Interprof Care. 2015 Nov 3;29(6):641–2.

108. Berrian AM, Smith MH, van Rooyen J, Martínez-López B, Plank MN, Smith WA, et al. A community-based One Health education program for disease risk mitigation at the human-animal interface. One Heal (Amsterdam, Netherlands) [Internet]. 2018 Jun [cited 2019 Jul 17];5:9–20. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29270459

109. Sharma N, Harris E, Lloyd J, Mistry SK, Harris M. Community health workers involvement in preventative care in primary healthcare: A systematic scoping review [Internet]. Vol. 9, BMJ Open. BMJ Publishing Group; 2019 [cited 2020 Jul 3]. p. e031666. Available from:

https://bmjopen.bmj.com/content/9/12/e031666

110. Scott K, Beckham SW, Gross M, Pariyo G, Rao KD, Cometto G, et al. What do we know about community-based health worker programs? A systematic review of existing reviews on community health workers [Internet]. Vol. 16, Human Resources for Health. BioMed Central Ltd.; 2018 [cited 2020 Jul 3]. p. 39. Available from: https://human-resources-health.biomedcentral.com/articles/10.1186/s12960-018-0304-x

111. Boyce MR, Katz R. Community Health Workers and Pandemic Preparedness: Current and Prospective Roles. Front Public Heal. 2019 Mar;7(MAR):62.

112. 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. Oren E, editor. PLoS One [Internet]. 2019 Dec 4 [cited 2020 Mar 23];14(12):e0224660. Available from: https://dx.plos.org/10.1371/journal.pone.0224660

113. Rubin C, Dunham B, Sleeman J. Making One Health a Reality—Crossing Bureaucratic Boundaries. In: One Health [Internet]. American Society of Microbiology; 2014 [cited 2018 May 21]. p. 269–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26082124

114. Nyatanyi T, Wilkes M, McDermott H, Nzietchueng S, Gafarasi I, Mudakikwa A, et al. Implementing one health as an integrated approach to health in Rwanda. BMJ Glob Heal [Internet]. 2017 Feb 1 [cited 2020 Jul 1];2(1):121. Available from: http://gh.bmj.com/

115. Ribeiro C dos S, Burgwal LHM van de, Regeer BJ. Overcoming challenges for designing and implementing the One Health approach: A systematic review of the literature. One Heal. 2019 Jun 1;7:100085.

116. Danaher A. Reducing Health Inequities: Enablers and Barriers to Inter-sectoral Collaboration [Internet]. Toronto; 2011 Jun [cited 2020 Jul 21]. Available from: https://www.wellesleyinstitute.com/wp-content/uploads/2012/09/Reducing-Health-Inequities-Enablers-and-Barriers-to-Intersectoral-Collaboration.pdf

117. Ruscio BA, Brubaker M, Glasser J, Hueston W, Hennessy TW. One Health – a strategy for resilience in a changing arctic. Int J Circumpolar Health [Internet]. 2015 Jan 31 [cited 2020 Mar 24];74(1):27913. Available from: https://www.tandfonline.com/doi/full/10.3402/ijch.v74.27913

118. Okello AL, Bardosh K, Smith J, Welburn SC. One Health: Past Successes and Future Challenges in Three African Contexts. PLoS Negl Trop Dis. 2014;8(5).

119. Sciences) "Small Cities and Towns in Global Era: Emerging Changes and Perspectives" (Seminar) (2011 : Tata Institute of Social. Small cities and towns in global era : emerging changes and perspectives. Jaipur : : Rawat Publications, ; 2013.

120. Burris S, Hancock T, Lin V, Herzog A. Emerging strategies for healthy urban governance. J Urban Health [Internet]. 2007;84(3 Suppl):i154-63. Available from: https://doi.org/10.1007/s11524-007-9174-6

121. Plochg T, Delnoij DMJ, Hogervorst WVG, van Dijk P, Belleman S, Klazinga

NS. Local health systems in 21st century: who cares?—an exploratory study on health system governance in Amsterdam. Eur J Public Health [Internet]. 2006;16(5):559–64. Available from: https://doi.org/10.1093/eurpub/ckl010

122. Thadani KB. Public Private Partnership in the Health Sector: Boon or Bane. Procedia - Soc Behav Sci. 2014 Nov 27;157:307–16.

123. Raman AV, Björkman JW. Public-Private Partnerships in Healthcare. In: The Palgrave International Handbook of Healthcare Policy and Governance [Internet]. Palgrave Macmillan UK; 2015 [cited 2020 Jul 23]. p. 376–92. Available from: https://link.springer.com/chapter/10.1057/9781137384935_23

124. Okeyo I, Lehmann U, Schneider H. The impact of differing frames on early stages of intersectoral collaboration: The case of the First 1000 Days Initiative in the Western Cape Province. Heal Res Policy Syst [Internet]. 2020 Jan 9 [cited 2020 Jul 21];18(1):3. Available from: https://health-policy-systems.biomedcentral.com/articles/10.1186/s12961-019-0508-0

125. Brooke-Sumner C, Lund C, Petersen I. Bridging the gap: Investigating challenges and way forward for intersectoral provision of psychosocial rehabilitation in South Africa. Int J Ment Health Syst [Internet]. 2016 Mar 9 [cited 2020 Jul 21];10(1):21. Available from: /pmc/articles/PMC4784432/?report=abstract

126. Mlozi MRS, Rumisha SF, Mlacha T, Bwana VM, Shayo EH, Mayala BK, et al. Challenges and opportunities for implementing an intersectoral approach in malaria control in Tanzania. Tanzan J Health Res [Internet]. 2015 [cited 2020 Jul 21];17(1):1–16. Available from: https://doi.org/10.4314/thrb.v17i1

127. Bochatay N, Bajwa NM, Cullati S, Muller-Juge V, Blondon KS, Junod Perron N, et al. A Multilevel Analysis of Professional Conflicts in Health Care Teams: Insight for Future Training. Acad Med [Internet]. 2017 Nov 1 [cited 2020 Jul 21];92(11):S84–92. Available from: http://journals.lww.com/00001888-201711001-00014

128. Kousgaard MB, Scheele CE, Vrangbæk K. Inter-sectoral collaboration in municipal health centres: A multi-site qualitative study of supporting organizational elements and individual drivers. Int J Integr Care [Internet]. 2019 Jun 21 [cited 2020 Jul 21];19(2). Available from: https://doi.org/10.5334/ijic.4196

129. Munyua P, Bitek A, Osoro E, Pieracci EG, Muema J, Mwatondo A, et al. Prioritization of Zoonotic Diseases in Kenya, 2015. Markotter W, editor. PLoS One [Internet]. 2016 Aug 24 [cited 2018 Nov 20];11(8):e0161576.

130. Center for Disease Control and Prevention. One Health Zoonotic Disease Prioritization for Multisectoral Engagement in Tanzania [Internet]. Dar es Salaam, Tanzania; 2017 [cited 2018 Nov 20]. Available from: https://www.cdc.gov/onehealth/pdfs/tanzania-report-508.pdf

131. Sekamatte M, Krishnasamy V, Bulage L, Kihembo C, Nantima N, Monje F, et al. Multisectoral prioritization of zoonotic diseases in Uganda, 2017: A One Health perspective. Kuhn JH, editor. PLoS One [Internet]. 2018 May 1 [cited 2018 Nov 20];13(5):e0196799. Available from:

http://dx.plos.org/10.1371/journal.pone.0196799

132. Pieracci EG, Hall AJ, Gharpure R, Haile A, Walelign E, Deressa A, et al. Prioritizing zoonotic diseases in Ethiopia using a one health approach. One Heal [Internet]. 2016 Dec 1 [cited 2018 Nov 20];2:131–5. Available from: https://www.sciencedirect.com/science/article/pii/S2352771416300155

133. British Veterinary Association B. One Health: collaboration on all levels is key, concludes joint meeting. Vet Rec [Internet]. 2014 Jun 28 [cited 2018 Feb 23];174(26):644. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24970622

134. Herdiana H, Sari JFK, Whittaker M. Intersectoral collaboration for the prevention and control of vector borne diseases to support the implementation of a global strategy: A systematic review. PLoS One [Internet]. 2018 [cited 2020 Jul 2];13(10). Available from: /pmc/articles/PMC6179246/?report=abstract

135. Naing C, Whittaker MA, Tanner M. Inter-sectoral approaches for the prevention and control of malaria among the mobile and migrant populations: A scoping review. Malar J [Internet]. 2018 Nov 16 [cited 2020 Jul 2];17(430):1–17. Available from: https://malariajournal.biomedcentral.com/articles/10.1186/s12936-018-2562-4

136. World Health Organization. Noncommunicable diseases prevention and control in the South-eastern Europe Health Network: An analysis of intersectoral collaboration [Internet]. Copenhagen; 2012 [cited 2020 Jul 2]. Available from: https://www.euro.who.int/__data/assets/pdf_file/0009/164457/e96502.pdf

137. Li XM, Rasooly A, Peng B, Jianwang, Xiong SY. An analysis on intersectional collaboration on non-communicable chronic disease prevention and control in China: A cross-sectional survey on main officials of community health service institutions. BMC Health Serv Res [Internet]. 2017 Nov 10 [cited 2020 Jul 2];17(1). Available from: /pmc/articles/PMC5681825/?report=abstract

138. Dahal R, Upadhyay A, Ewald B. One Health in South Asia and its challenges in implementation from stakeholder perspective. Vol. 181, Veterinary Record. British Veterinary Association; 2017. p. 626.

139. Sidney K, De Costa A, Diwan V, Mavalankar D V., Smith H. An evaluation of two large scale demand side financing programs for maternal health in India: The MATIND study protocol. BMC Public Health [Internet]. 2012 Dec 27 [cited 2020 Jul 22];12(1):699. Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-12-699

140. Provan KG, Kenis P. Modes of network governance: Structure, management, and effectiveness. J Public Adm Res Theory. 2008 Apr;18(2):229–52.

141. Kapucu N. Interorganizational coordination in dynamic context: Networks in emergency response management. Connections [Internet]. 2005 [cited 2020 Jul 7];26(2):33–48. Available from: https://www.scopus.com/record/display.uri?eid=2-s2.0-34548455487&origin=inward&txGid=436189d2cde1f7a15d636f8a916db03d

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6. Appendices

6.1. Annexure-I (Additional publications)

Yasobant S, Bruchhausen W, Saxena D. Applications of Systems Thinking for Health System Research: A One Health perspective. SAGE Research Methods Cases: Medicine and Health. 2020: SAGE, UK. doi. 10.4135/9781529730739

Perez A, Yasobant S, Bruchhausen W, Bender K, Falkenberg T. Intersectoral collaboration shaping One Health in the policy agenda: A comparative analysis of Ghana and India. 2021; Under review.

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6.2. Annexure-II (Consent form)

INDIAN INSTITUTE OF PUBLIC HEALTH GANDHINAGAR

Participation Information Sheet and Informed Consent Form

zef Center for Development Research University of Bonn

I am Sandul Yasobant, part of a research team carrying out a survey of possible collaboration strategies for one health. I conduct this research as doctoral researcher at the Center for Development Research (ZEF), University of Bonn, Germany in collaboration with Indian Institute of Public Health Gandhinagar (IIPHG), India.

This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take the time to explain. If you have questions later, you can ask me directly.

The study examines the importance of inter-sectoral collaboration between human & animal health system for prevention & control of zoonotic diseases in Ahmedabad city, India. The study aims to understand how the actors within human & animal health system are interacting currently and how the convergence can be enhanced among these actors, for effective prevention and control of zoonotic diseases by investigating the complexity of human and animal health system in reference to one health approach in Ahmedabad city, India.

We would like to ask you a set of questions for this study. The type of information we seek includes how you have collaborated with human or animal health system for control of zoonotic diseases during out-breaks as well as non-out-break sessions in last year.

We value your opinion on the questions we will be asking. We require about half an hour of your time to complete the survey.

There is no direct benefit to all the participants through this study; however, the result of the study will facilitate developing one health policy and will improve the collaboration strategies between human & animal health system for better prevention of zoonotic diseases.

Your participation will be highly appreciated. Your answers will help to provide information to use in planning for better convergence strategies between human & animal health system to enhance the one health approach.

Your participation in this research is completely voluntary. You are free to withdraw your consent and discontinue answering these questions at any time. I will give you an opportunity at the end of the interview/discussion to review your remarks, and you can ask to modify or remove portions of those, if you do not agree with my notes or if I did not understand you correctly.

This study is conducted pseudo anonymously. That means that any information that may lead to you will be partially anonymized. Thus, a researcher who uses the data will never be able to identify you, except with your explicit permission. This is strictly demanded by national and international law, and ZEF/ University of Bonn will never infringe that law!

The information/ data gained from your answers will be pseudo anonymized and will be used for the purpose of research. In any scientific publication, also the data will be pseudo anonymized. You allow ZEF to potentially make a second survey round in order to generate panel data. Should ZEF seek to do this, the new interviewer would get only your name from me. The new interviewer would have to prove his identity to you, using an authorization signed by me. The data will not be given to any other third party without anonymization.

If you have any questions, you can ask them now or later. If you feel you have been treated unfairly, or you have questions or concerns, you may contact:

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INFORMED CONSENT

The above statement has been read to me (or I have read it myself) and its meaning has been explained by the research staff. I agree to take part in this research. I understand that I am free to discontinue participation at any time if I so choose and that the research staff/contact person will answer any questions that arise during the course of the survey.

☐ Yes, I agree to participate.

☐ No, I do not wish to participate.

Name of the participant:

Signature of Participant **Date:**

Signature by the researcher: **Date:**

6.3. Annexure-III (Data collection tools)

Table 1. Overview of tools for data collection under RICOHA project

Objective	Tools
I. To determine which zoonoses need to be prioritized for collaboration among the actors of the human and the animal health system	*Form-1:* One Health Zoonotic Disease Prioritization (OHZDP) Tool
II. To document the health system contact and its effect on the awareness level of zoonotic diseases	*Form-2.1:* Basic Household details *Form-2.2:* Animal Health details *Form-2.3:* Human health system contact details *Form-2.4:* Animal health system contact details *Form-2.5:* Awareness about prioritized zoonotic diseases (Form-2.5.1: Awareness about rabies, Form 2.5.2: Awareness about brucellosis, Form 2.5.3: Awareness about influenza)
III. To understand the motivation to become an OH activist at the community level	*Form-3.1:* Awareness about prioritized zoonotic diseases and work performance of the community health workers *Form-3.2:* Semi-structured interview guide for community healthcare workers
IV: To identify, categorize OH actors and examine the strength of the health system network for implementation of OH with a focus on prevention and control of zoonotic diseases	*Form-4.1:* Semi-structured interview guide for identifying actors *Form-4.2:* Documenting the health system network at the administrative level *Form-4.3:* Documenting the health system network at the provider level
V. To document and validate the innovative strategies for ISC with a focus on OH implementation in the prevention and control of zoonoses and to document the enabling factors to boost the ISC between the human and animal health systems	*Form-5.1:* Interview guide for Vignette study *Form-5.2:* Policy Delphi tool for validation of key strategies *Form-5.3:* Semi-structured tool for the participatory system workshop

Note: Kinldy seek permissions before using these tools

Form-1: One Health Zoonotic Disease Prioritization (OHZDP) Tool

[NB: Adapted from Center for Disease Control (CDC, USA) and modified for Ahmedabad, India with aim to determine which zoonoses will receive high concern for collaboration between the human health and the animal health system in Ahmedabad, Gujarat]

Step	Type of Work	Objective
Pre-Workshop	Desktop Review	Review of zoonotic diseases in context of Ahmedabad, Gujarat and India
Pre-workshop	Individual	Informal discussion with experts
Step-1	Individual	Selection of potential zoonotic diseases that need to be considered for prioritization
Step-2	Individual	Selection of criteria, under which each disease need to be evaluated further
Step-3	Group	Deciding questions for each criteria
Step-4	Group	Ranking of criteria using the Analytic Hierarchy Process
Step-5	Group	Ranking of the diseases using decision tree analysis

Step-1: Deciding zoonotic diseases: OHZDP Tool

Instruction

Below given is the list of zoonotic diseases that have been identified through expert interview, literature review and group work prior to the workshop. Select the zoonotic diseases that you consider an important public health concern for Ahmedabad, Gujarat.

Zoonotic diseases	**Mark as 'X' against zoonotic disease that you would like to consider for further prioritization process**
Japanese Encephalitis	
Dengue	
Chikungunya	
Crimean-Congo hemorrhagic fever	
Rabies	
Chandipura virus encephalitis	
Kyasanur Forest Disease	
Avian Influenza (H5N1)	
Pandemic Flu	
Swine Flu (H1N1)	
Buffalopox Virus	
Nipah virus	
Ganjam Virus Disease	
Bhanja virus	
Leptospirosis	
Plague	
Anthrax	
Brucellosis	
Tuberculosis	
Toxoplasmosis	
Q Fever	
Lyme disease	
Food borne	
Vibrio cholera	
Listeria monocytogenes	
Campylobacter spp	
Enterohemorrhagic Escherichia coli	
Cysticercosis	
Helminths	
Babesiosis	
Other (Please specify)	

Step-2: Deciding Criteria: OHZDP Tool

Instruction

*Below given criteria have been summarized as per the U.S. Centers for Disease Control and Prevention's (CDC) One Health Zoonotic Disease Prioritization (OHZDP) Tool. Among the **eight** listed criteria, kindly choose **five** most important criteria, that you feel should be considered for prioritization of zoonotic diseases.*

Criteria	**Mark as 'X' against 5 criteria only**
Severity of Disease in Humans (HD)	
Burden of animal disease (AD)	
Availability of interventions (IN)	
Existing inter-sectoral collaboration (IC)	
Prevention and Control strategy (PC)	
Potential for Epidemic and/or Pandemic (EP)	
Social-Economic Impact (SE)	
Bioterrorism Potential (BP)	

Step-3: Deciding questions: OHZDP Tool

Instruction

[All the participants need to develop certain questions under each criteria.]

Criteria	Abbre-viation	Question	Answers			
Severity of Disease in Humans	HD	Is the disease causes morbidity and/or mortality among humans?	0. No	1. Yes		
Prevention and Control strategy	PC	Is there an effective control strategy in both humans and animals in Ahmedabad?	0. None	1. Either	2. Both	
Potential for Epidemic and/or Pandemic	EP	Has the disease caused an epidemic in humans or animals in the last 10 years in Ahmedabad?	0. None	1. Either	2. Both	
Burden of animal disease	AD	Is the disease considered as burden for animals?	0. Disease not present, loss of production no or unknown or OIE not reportable	1. Disease not present, loss of production yes or unknown but OIE reportable	2. Disease present, loss of production no or unknown or OIE not reportable	3. Disease present, loss of productio n yes or unknown but OIE reportable
Existing inter-sectoral collaboration	IC	Is there any inter-sectoral collaboration existing among human and animal health system in Ahmedabad?	0. No	1. Yes		

Step-4: Ranking Criteria: OHZDP Tool

Instruction

The below mentioned is a pairwise comparison scale developed by Saaty et al. used for filling up the below matrix. We intend to create a comparison matrix of the criteria involved in the decision, therefore please fill the empty boxes with help of given example.

Saaty's pairwise comparison scale

Verbal judgment	**Numeric value**
Extremely important	**9**
	8
Very Strongly more important	**7**
	6
Strongly more important	**5**
	4
Moderately more important	**3**
	2
Equally important	**1**

For example, if in daily life we say that an apple A is twice as big as apple B (A/B = 2), this implies that apple B is half the size of apple A (B/A = 1/2).

Rank the criteria

Criteria					
	1.00				
		1.00			
			1.00		
				1.00	
					1.00

Step-5: Ranking diseases: OHZDP Tool

Instructions

Answer the above-mentioned questions (from step-3) for each selected diseases, which are finalized for the prioritization an score the appropriate number under each criteria.

Zoonotic Disease	**Initial Scores**				
	HD	**EP**	**PC**	**AD**	**IC**
Dengue					
Rabies					
Swine Flu (H1N1)					
Tuberculosis					
Chikungunya					
Avian Influenza (H5N1)					
Food Borne					
Brucellosis					
Crimean-Congo Hemorrhagic Fever (CCHF)					
Leptospirosis					
Vibrio Cholera					
Japanese Encephalitis					
Plague					
Anthrax					

Form-2.1: Basic Household details

[NB: This form need to be filled for each sampled HH]

Section-1.1: Basic information			
Unique HH ID			
Zone		**Ward**	
Name			
Address			
Mobile Number		**GPS**	

Section-1.2: Socio-demographic details					
1	Age in years	☐☐	2	Gender	1. Male 2. Female
3	Highest education completed	1. Illiterate 2. Able to read and write 3. Primary education 4. Secondary education 5. Higher secondary education 6. Graduate or above-	4	Occupation	1. Farmer/Agriculture- 2. Livestock dependant 3. Daily labourer 4. Public/Private employed 5. Housewife 6. Other (specify)_____
5	Marital Status	1. Married 2. Single 3. Widowed 4. Separated	6	Religion	1. Hindu 2. Muslim 3. Christian 4. Other (specify)- ____
7	Caste	1. SC/ST 2. OBC 3. General 4. Other(specify) _____ 99. Do not know	8	Do you have a BPL ration card?	0. No 1. Yes 99. Do not know
9	Total HH Members	☐☐	1. Children (0-5 yrs.) 2. Adolescent (6-17 yrs.) 3. Adult (18 yrs. or above)		☐☐ ☐☐ ☐☐
10	What is the approximate HH monthly income?		☐☐☐☐☐☐ (Ask in INR)		
11	Since how many years you live in this community?		☐☐		
Section- 1.3: Health seeking behavior					

Section-1.4: Gateway questions			
12	How many times in a day you wash your hands with soap/solution?	☐☐	
13	When do you usually prefer to wash your hands?	1. After toileting 2. After coming from outside 3. Before cooking 4. Before having food 5. After touching to any animals 6. After each household work 7. Other (Specify) _____	
14	When is the last time you visited your doctor?	☐☐ month	
15	Where do you prefer to go for seeking health services in case of general infection?	1. Public Health facility 2. Private hospital/Clinics 3. Pharmacy Store 4.Traditional Medicine Clinics/Hospitals- 5. Traditional healers 6. Other (Specify)_____	
16	Why you prefer the particular provider?	1. Near to my resident/Ease of geographic access 2. No waiting time/ Hassle free services- 3. Lower Consultation fee/ Affordable 4. Better quality of care 5. Other (specify)_____	*Multiple answers allowed*
17	What is your preferred mode of getting health awareness and/or education?	1. Mass media(TV/Newspaper/ Brochures)- 2. Through health workers 3. Relative/ Neighbors 4. Any other (specify) _____	*Multiple answer allowed*
18	Have you or any of your HH members been sick?	0. No 1. Yes, Within last 15 days 2. Yes, Within last 1 month 3. Yes, Within last 1 year 99. Do not know	If yes, then fill the below details or else switch to section-1.4

Family member(s)	**Last 15 days**		**Last 01 month**		**Last 01 year**	
	Dx	**Rx**	**Dx**	**Rx**	**Dx**	**Rx**
19. Children (0-5 yrs.)						
20. Adolescent (6-17 yrs.)						
21. Adult (18-59 yrs.)						
22. Aged (60+ or above)						

Instructions

Dx: Name the disease or symptoms (Open-ended)

Rx: Ask for either any treatment sought for the same or not? Please mention the below codes- 1.No treatment, 2.Public health facility, 3.Private clinic/hospital, 4.Traditional healer, 5.From the ASHA/FHW, 6.Pharmaceutical stores, 7.Any other (specify)

23	Do you keep any animals?	0. No 1. Yes	If yes, then fill the Form-2.2
24	During last one year, any of human health personnel visited to you at your doorstep?	0. No 1. Yes 99. Do not know	If yes, then fill the Form-2.3
25	During last one year, any of animal health personnel visited to you at your doorstep?	0. No 1. Yes 99. Do not know	If yes, then fill the Form-2.4
26	Do you know some diseases transmitted between animals and humans?	0. No 1. Yes 99. Do not know	*Irrespective of the response, ask about below three diseases*
27	Have you heard about rabies?	0. No 1. Yes 99. Do not know	If yes, then fill the Form-2.5.1
28	Have you heard about Brucellosis?	0. No 1. Yes 99. Do not know	If yes, then fill the Form-2.5.2
29	Have you heard about flu?	0. No 1. Yes 99. Do not know	If yes, then fill the Form-2.5.3

Form-2.2: Animal Health details

[NB: This form need to be filled for each sampled HH having animals]

Unique HH ID_____

Section-1: Details of Animals				
1	How many animals do you keep?	☐☐☐	1. _____ 2. _____ 3. _____	☐☐ ☐☐ ☐☐
2	Since, how many years are you keeping animals?	☐☐ Years		
3	Where do your animals live?	1. Inside the home 2. Within the compound 3. Just out of the compound 4. Far from home 5. On the road (no specific shield) 6. Others (specify)_____		
4	Have your animals ever been vaccinated in last 1 year?	0. No 1. Yes 99. Do not know		
5	If, yes, then for which disease?			*Write for all vaccination*
6	Where do you prefer to go for seeking animal health services?	1. Govt. veterinary hospital 2. Private hospital/Clinics 3. Pharmacy Store 4. Traditional healers 5. Seek services at door step 6. Other (Specify) _____		
7	Why you prefer the particular provider?	1. Near to my resident/Ease of geographic access 2. No waiting time/ Hassle free services- 3. Lower Consultation fee/ Affordable 4. Better quality of care		*Multiple answers allowed*
8	When is the last time you call your doctor or took your animal to doctor?	☐☐ month		
9	Have any animal been sick?	0. No 1. Yes, Within last 15 days 2. Yes, Within last 1 month 3. Yes, Within last 1 year		*If No, then tool is completed*

Section-2: General health seeking behavior for the animal						
Type of Animal	**Last 15 days**		**Last 01 month**		**Last 01 year**	
	Dx	**Rx**	**Dx**	**Rx**	**Dx**	**Rx**
10.						
11.						

Instructions: **Dx:** Name the disease or symptoms (Open ended).
Rx: Ask for either any treatment sought for the same or not? Please mention the below codes-
1. No treatment, 2.Public Veterinary Hospital, 3.Private Veterinary Clinic, 4.Traditional healer, 5.Home care remedies, 6.Slaughtered for human consumption, 7.Immediately sold, 8.Immediately killed, 9.Nothing done, 10.Have no idea, 11.Any other (specify)

Form-2.3: Human health system contact details

Unique HH ID_____

Section-1: Health system contact details			
1	Can you please tell us the key person who has visited and which type of services provided to you in last 1 year?	1. AWW _____ 2. ASHA_____ 3. MPHW/FHW_____ 4. Sanitary Inspector/Entomologist _____ 5. Pharmacist_____ 6. Govt. Doctor_____ 7. Pvt. Doctor_____ 8. Other (Specify) _____	
2	How frequently the key person shared preventive health messages with you?	1. During every visit 2. During some visits 3. Only once 4. Never	
3	Have you received any preventive messages pertaining to diseases spread between animals and humans?	0. No 1. Yes 99. Do not know	
4	Do you contact the key person from the health system prior to visiting to any health facility?	1. Always 2. Sometimes 3. Rarely 4. Never	
5	Do the key person understand your problems and suggest you as per your satisfaction?	1. Always 2. Sometimes 3. Rarely 4. Never	
6	Is the key person able to refer you to the right place as per your problem/need?	1. Always 2. Sometimes 3. Rarely 4. Never	
7	Is the key person able to enroll you or your family into the relevant public health schemes, as per the eligibility?	1. Always 2. Sometimes 3. Rarely 4. Never	
8	How much you satisfied on the service provided by the key person?	1. Very satisfied 2. Moderately satisfied 3. Slightly satisfied 4. Not satisfied	

Form-2.4: Animal health system contact details

Unique HH ID_____

Section-1: Health system contact details			
1	Can you please tell us the person who has visited and which type of services provided to you in last 1 year?	1. Livestock Inspector _____ 2. Representative from Vet. Clinic_____ 3. Govt. Veterinarian _____ 4. Pvt. Veterinarian _____ 5. Other (Specify) _____	
2	How frequently the key person shared preventive health messages with you?	1. During every visit 2. During some visits 3. Only once 4. Never	
3	Have you received any preventive messages pertaining to diseases spread between animals and humans?	0. No 1. Yes 99. Do not know	
4	Do you contact the key person from the health system prior to visiting to any health facility?	1. Always 2. Sometimes 3. Rarely 4. Never	
5	Do the key person understand your problems and suggest you as per your satisfaction?	1. Always 2. Sometimes 3. Rarely 4. Never	
6	Is the key person able to refer you to the right place as per your problem/need?	1. Always 2. Sometimes 3. Rarely 4. Never	
7	Is the key person able to enroll you or your family into the relevant public health schemes, as per the eligibility?	1. Always 2. Sometimes 3. Rarely 4. Never	
8	How much you satisfied on the service provided by the key person?	1. Very satisfied 2. Moderately satisfied 3. Slightly satisfied 4. Not satisfied	

Form-2.5.1: Awareness about rabies

Unique HH ID_____

<table>
<tr><th colspan="4">Section-1: Awareness about rabies</th></tr>
<tr><td>1</td><td>Have you or any HH member been bitten by a dog ever?</td><td>0. No
1. Yes
99. Don’t know</td><td></td></tr>
<tr><td>2</td><td>If yes, then who and how often?</td><td>1. _____
2. _____
3. _____</td><td></td></tr>
<tr><td>3</td><td>Are you aware about animals that transmit rabies?</td><td><table><tr><th>Animals</th><th>Yes</th><th>No</th></tr><tr><td>Dog</td><td></td><td></td></tr><tr><td>Cat</td><td></td><td></td></tr><tr><td>Monkey</td><td></td><td></td></tr></table></td><td>If other, specify</td></tr>
<tr><td>4</td><td>Do you know how the rabies is transmitted?</td><td><table><tr><th></th><th>Yes</th><th>No</th></tr><tr><td>Bites</td><td></td><td></td></tr><tr><td>Scratches</td><td></td><td></td></tr><tr><td>Licks</td><td></td><td></td></tr></table></td><td>If other, specify</td></tr>
<tr><td>5</td><td>Are you aware about the symptoms of human rabies</td><td>1. Fear of water
2. All of sudden darkness
3. Memory issue
4. Behaving like a dog
5. Death
6. Any other (specify) _____
99. Do not know</td><td>Do not probe</td></tr>
<tr><td>6</td><td>If a person is bitten by a dog, then what should be done?</td><td>1. Seek medical attention
2. Wash the wounds with water
3. Tie a cloth around the wound
4. Apply turmeric or other powders
99. Don’t know</td><td>Multiple answers allowed</td></tr>
<tr><td>7</td><td>Are you aware about the availability of anti-rabies vaccine?</td><td>0. No
1. Yes, at the public health facilities
2. Yes, at the private health facilities</td><td></td></tr>
<tr><td>8</td><td>Are you aware about a health facility for treatment of animal bites</td><td>0. No
1. Yes, at the public health facilities
2. Yes, at the private health facilities</td><td></td></tr>
<tr><td>9</td><td>Are stray dogs a problem in your community?</td><td>0. No
1. Yes</td><td></td></tr>
<tr><td>10</td><td>Do you report dog bites?</td><td>0. No
1. Yes
99. Don’t know</td><td>If yes, then ask Q-11</td></tr>
<tr><td>11</td><td>If yes, to whom you have reported a case of dog bite?</td><td>1. Human healthcare provider while visiting for treatment
2. Animal health care provider
3. Municipal Corporation/ any govt. authority
99. Do not know</td><td></td></tr>
</table>

Form-2.5.2: Awareness about brucellosis

Unique HH ID_____

<table>
<tr><th colspan="4">Section-1: Awareness about brucellosis</th></tr>
<tr><td>1</td><td>Do you know how brucellosis is transmitted?</td><td>1. Raw Milk
2. Uncooked animal food
3. Dirty Water
4. Through skin wound
5. Any other (specify)
_____
99. Do not know</td><td></td></tr>
<tr><td>2</td><td>Have you or any of HH member ever suffered from brucellosis?</td><td>0. No
1. Yes
2. I don’t remember</td><td></td></tr>
<tr><td>3</td><td>If yes, then who and how many times?</td><td></td><td></td></tr>
<tr><td>4</td><td>Do you know symptoms of brucellosis?</td><td>1. Fever and/or diarrhea
2. Joint and/or muscle pain
3. Loss of appetite
5. Headache
6. Night sweat
7. Fatigue and/or malaise and/or nausea
8. Blurred vision
9. Any other
(specify)_____
99. Do not know</td><td></td></tr>
<tr><td>5</td><td>If a person is affected by brucellosis then what should be done?</td><td>1. Cannot be cured
2. Visit to the public health facility
3. Consult a private doctor
4. Consult to a traditional healer
5. Consult to a Veterinarian
6. Visit to the nearest medicine store
7. Other (Specify)_____</td><td></td></tr>
<tr><td>6</td><td>Are you aware about the availability of brucellosis vaccine?</td><td>0. No
1. Yes (Specify) _____</td><td></td></tr>
<tr><td>7</td><td>In your family, how they prefer to consume milk?</td><td><table><tr><th></th><th>Raw milk</th><th>Boiled Milk</th></tr><tr><td>Children</td><td></td><td></td></tr><tr><td>Adolescent</td><td></td><td></td></tr><tr><td>Adult</td><td></td><td></td></tr><tr><td>Aged (60+)</td><td></td><td></td></tr></table></td><td></td></tr>
</table>

Form-2.5.3: Awareness about influenza

Unique HH ID_____

Section-1: Awareness about influenza			
1	Do you know how the flu is transmitted?	1. Through touching 2. Through sneezing and/or coughing 3. Through face to face talk 4. Through hand shaking 5. Through eating pig meat/ poultry meat 6. Through direct contact with 7. Through food and water 8. Any other (specify) _____ 99. Do not know	
2	Can you please name the common symptoms of the flu?	1. Fever 2. Cough 3. Cold 4. Body ache 5. Headache 6. Breathlessness 7. Vomiting 8. Loose stools 9. Any other (specify) _____ 99. Do not know	
3	Do you know how the transmission of the Swine flu can be prevented?	1. Wearing mask 2. Covering nose or mouth while sneezing 3. Reducing contact to the crowded places 4. Washing hands regularly 5. Vaccination 6. By Ayurveda/ Homeopathic treatment 7. Killing pigs 99. Do not know	
4	Do you know how the transmission of the Bird flu can be prevented?	1. Surfaces in contact with the poultry should be cleaned 2. Not eating sick and dead poultry 3. Washing hands with soap and water after poultry handling 4. Eating properly cooked meat and eggs 5. Keeping poultry coops far away from the house 6. Proper disposal of poultry droppings and litter 7. Avoid direct contact with birds and poultry 99. Do not know	

5	Where will you go if you develop symptoms of flu?	1. Public health facility 2. Consult a private doctor 3. Home remedies 4. Consult a traditional healer 5. Go to medicine stores 6. Any other (specify)_____ 7. Do not go anywhere	
6	Do you know about the availability of flu vaccine?	0. No 1. Yes	
7	Have you ever received the flu vaccine?	0. No 1. Yes	
8	If yes, then.	1. When:_____ 2. How many times:_____ 3. Why:_____	
9	If no, then why?	1. Low risk of getting the flu 2. I am taking all precautions 3. Unaware of vaccine 4. Access issue 5. Cost of vaccine 6. Any other (specify)_____	

Form-3.1: Awareness about prioritized zoonotic diseases and work performance of the community health workers

[Administer this tool for the sampled healthcare workers (ASHA and/or MSI/SI]

Section-1.1: Basic information			
UID			
Name			
UHC		**Zone** **Ward**	
Mobile		**GPS**	

Section-1.2: Professional details			
No.	**Questions**	**Answers**	**Instructions**
1	Completed age (in years)		
3	Highest educational qualification	1. Primary 2. Secondary 3. High School 4. Intermediate 5. Graduation or Higher	
4	Total years of experience in health work (in years)		
5	Marital status	1. Married 2. Single 3. Divorced 4. Separated	
6	Average time spent per week (In hrs.)		
7	Average monthly incentives (INR)		
8	Catering population assigned to you		

Section 2: Documenting knowledge & practices on prevention of Zoonoses			
No.	**Questions**	**Answers**	**Instruction**
1	Have you ever had any training on Zoonoses?	0. No 1. Yes	
2	If yes, name of training program, when & duration.		
3	Have you attended any health campaigns on zoonosis prevention?	0. No 1. Yes	
4	If you came across a case of dog bite, what you do?	0. Do not do anything 1. Counsel for ARV 2. Refer to UHC/ ARC 3. Inform to FHS/MO 4. Other _____	
5	If you came across about cough, fever, then what you do?	0. Do not do anything 1. Give basic medicines 2. Refer to UHC 3. Inform to FHS/MO 4. Other _____	
6	Are you aware of the National Rabies Control Program?	0. No 1. Yes	
7	Are you aware of the National Brucellosis Control Program?	0. No 1. Yes	
8	Are you aware of the influenza vaccine?	0. No 1. Yes	
9	Are you aware of the Anti-Rabies vaccination?	0. No 1. Yes	
10	What are the symptoms of human rabies?	0. Do not Know 1. Fear of water 2. All of sudden darkness ever 4. Memory issue 5. Behaving like a dog 6. Death 7. Any other (specify)_____	
11	What are the symptoms of brucellosis?	0. Do not Know 1. Fever and/or diarrhea 2. Joint and/or muscle pain 3. Loss of appetite 4. Chills 5. Headache	

		6. Night sweat 7. Fatigue and/or malaise and/or nausea 8. Blurred vision 9. Any other (specify) _____	
12	Can you please name the common symptoms of the flu?	0. Do not Know 1. Fever 2. Cough 3. Cold 4. Body ache 5. Headache 6. Breathlessness - 7. Vomiting 8. Loose stools 9. Any other (specify) _____	
13	How can the transmission of Swine flu be prevented?	0. Do not know 1. Wearing mask 2. Covering nose or mouth while sneezing 3. Reducing contact to the crowded places 4. Washing hands regularly 5. Vaccination 6. By Ayurveda/ Homeopathic treatment 7. By killing pigs 8. Any other (specify) _____	
14	How can the transmission of Bird flu be prevented?	0. Do not know 1. Surfaces in contact with the poultry should be cleaned 2. Not eating sick and dead poultry 3. Washing hands with soap and water after poultry handling 4. Eating properly cooked meat and eggs 5. Keeping poultry coops far away from the house 6. Proper disposal of poultry droppings and litter 7. Avoid direct contact with birds and poultry 8. Any other (specify) _____	
15	Are you currently involved in any zoonoses prevention activities? If yes specify	0. None 1. Rabies/ Dog bite control 2. Brucellosis control 3. Swine flu control 4. Bird flu control 5. All of them	Multiple answers allowed

Section-3: Details on the convergence			
No.	**Questions**	**Answers**	**Instructions**
1	Have you shared your responsibility with any other staff? With whom?	0. Anganwadi Worker 1. Lab technicians 2. Pharmacists 3. Persons in your rank 4. Doctor's 5. Superiors/administrative 6. Other (specify) _____	
2	If yes please record, Reason for sharing and its frequency		
3	Have you ever been involved in any joint activity with the animal husbandry department?	0. Never 1. Yes, Once only 2. Yes, few times 3. Yes, many times	
4	If yes, can you specify the reasons	0. Disease that needed assistance from medical doctor/Veterinarian 1. Instructed by upper level authorities 2. Sending weekly/monthly reports 3. Other (specify) _____	Multiple answers allowed
5	Do you get any special activity during any outbreak?	0. No 1. Yes	
6	If yes, then from whom and what type?		
7	Do you work with any frontline worker from other departments?	0. No 1. Yes	
8	If yes, please name the front line worker and department.		
9	Will you accept any additional activities beyond your current duties?	0. No 1. Yes	
10	If, yes, what will motivate you to accept the same?	0. Financial incentives 1. Challenging activity 2. Support from colleague 3. Other _____	
11	If no, why not?	0. Already over loaded with work 1. Low incentives 2. Other _____	

Section-4: Measuring the current level of motivation

[Scale adapted from a motivation construct developed by Tripathy JP et al., which was adapted originally from Bennet et al.]

Category	Description of item	Score (1-4)
General Motivation	I feel motivated to work hard	
	Only do this job to get paid	
	I do this job as it provides long-term security for me	
Burnout	*I feel emotionally drained at the end of the day	
	*Sometimes when I get up in the morning, I dread having to face another day at work	
Job satisfaction	Overall, I am very satisfied with my job	
	I am satisfied with my colleagues in my work	
	I am satisfied with my supervisor	
Intrinsic job satisfaction	I am satisfied with the health services being provided	
	I feel that the services being provided by me are	
	I get ample opportunities for career and skill	
Organization commitment	I am proud to be working for this health facility	
	I feel very committed to this health facility	
	This health facility really inspires me to do my very best on the job	
Conscientiousness and self-efficacy	I can rely on my colleagues at work	
	I always complete my tasks efficiently and correctly	
	Do things that need doing without being asked or told	
Timeliness	I am punctual about coming to work	
	*I am often absent from work	
	It is not a problem if I sometimes come late for work/on leave	
Personal issues	*I suffer from health related problems due to the work	
	*I feel difficulty in doing field activities	
	*My work affects my duties towards my family	

Section-5: Exploring on enabling factors for convergence

How much do you think each of the following elements is necessary for the convergence between the human and the animal health system for effective prevention & control of zoonotic diseases (One Health approach) in Ahmedabad city?

Factors	**Very unnecessary**	**Somewhat unnecessary**	**Neutral**	**Somewhat necessary**	**Very necessary**
Coordinating roles	①	②	③	④	⑤
Close relationships among staff members	①	②	③	④	⑤
Knowledge and expertise	①	②	③	④	⑤
Social skills of individuals	①	②	③	④	⑤
Trust in other departments	①	②	③	④	⑤
Shared vision and objectives	①	②	③	④	⑤
Sufficient resources (time, personnel, budget)	①	②	③	④	⑤
Conflict resolution between departments	①	②	③	④	⑤
Successful experiences/cases of collaboration	①	②	③	④	⑤
Institutional supports	①	②	③	④	⑤
Leadership of each department	①	②	③	④	⑤
Legal ground (ordinance, plans, orders)	①	②	③	④	⑤

Form-3.2: Semi-structured interview guide for community healthcare workers

[Willingness to be a One Health Activists for prevention and control of zoonoses]

1. Introduction and brief about RICOHA project (with aim & objective), Consents
2. Role and responsibilities of urban ASHAs [Prompt: Day-to-day routine work, any special work on programs]
3. Factors influencing ASHA's performance in delivering healthcare services [Prompt: incentives, selection process, training, infrastructure and institutions, gender and tradition and geographical terrain]
4. Any change in role/additive work during outbreaks/ epidemics.
5. Any experience on working for zoonoses prevention (Prompt: For Rabies, Swine Flu, Bird Flu, Brucellosis)
6. Any experiences on working with other sectors (other than the health department)
7. Willingness to work with other departments such as Animal Husbandry, Agriculture.
8. Factors that will motivate you to work as a Brigadier between health and other sector?
9. Any other suggestion

Form-4.1: Semi-structured interview guide for identifying actors

Topic: General and personal information

1. Presentation of the research and agreement for interview.
2. Can you please tell us about your role and your department structure?
3. Can you please specify about the activities that your department do for the prevention and control of zoonotic diseases in Ahmedabad? *(Probe: Awareness, Vaccination, Surveillance)*

Topic: During the outbreak conditions

4. Can you please tell us about your department role during an outbreak of zoonotic diseases in Ahmedabad? *(Probe: Especially in Rabies, Brucellosis, Influenza control)*

5. Who are the stakeholders that you have collaborated during the outbreak of zoonotic diseases? *(Probe: Especially in Rabies, Brucellosis, Influenza control, Ask for both the system)*

Topic: During the non-outbreak conditions

6. Who are the important stakeholders (in your view) for prevention & control of zoonotic diseases? *(Probe: Human Health system and Veterinary & Animal Husbandry System)*

    - Ask for Rabies prevention
    - Ask for Brucellosis prevention
    - Ask for Influenza prevention

7. Who are the stakeholders that you do interaction/collaboration for prevention of zoonotic diseases?
   (Probe: Within the human and/or animal health system. Ask for disease specific also)

8. If you are not interacting/collaborating with any of the stakeholders, then whom do you think that an important stakeholders you want to collaborate for prevention of zoonotic diseases *(Probe: Disease specific, for both the system)*

9. Can you explain briefly and assess using a scale of Low, Medium, High,
    - What do you think about the interest of the following stakeholders in prevention & control of zoonotic diseases?
    - What do you think about the influence of the following stakeholders on prevention & control of zoonotic diseases?

Instruction

Please put a '√' against your answer

Stakeholder	Interest			Influence		
	High (3)	**Medium (2)**	**Low (1)**	**High (3)**	**Medium (2)**	**Low (1)**
AMC, Health Dept.						
AMC, Cattle Nuisance Dept.						
AH & Vet Dept., Dist. Panchayat						
Forest & Envt. Dept., Dist. Panchayat						
Surveillance- Human (IDSP)						
Surveillance- Animal (NADRS)						
Laboratory- Human						
Laboratory-Animal						
Physician/ Doctors						
Veterinarians						
Community Healthcare workers						
Livestock Inspectors						
Professional bodies						
NGOs/ Civil societies						
General public						
Any other (Specify)						
Any other (Specify)						
Any other (Specify)						
Any other (Specify)						

Form-4.2: Documenting the health system network at the administrative level

[Administer to all managerial/administrative stakeholders from both the human and the animal health system]

Section-1.1: Basic information			
UID			
Name			
Department		**Designation**	
Mobile		**GPS**	

Section-1.2: Professional details			
No.	**Questions**	**Answers**	**Instructions**
1	Completed age (in years)		
2	Gender	0. Male 1. Female	
3	Highest educational qualification	0. Bachelor (MBBS/BVMS) 1. Master (MD/MVM) 2. Higher degree (DM/DVM) 3. Other (specify)_____	
5	Total years of professional experience (in years)		
6	Experience in the current position (in years)		
7	Sector in which you work	0. Health-AMC 1. Cattle Nuisance & Control 2. H&FW-Dist. Panchayat 3. Animal Husbandry-Dist. Panchayat	
8	Are you aware of any professional organization for CME/ to enhance your skill of work	0. No 1. Yes	
9	If yes, name the professional body.		
10	Do you like to be shown in the One Health stakeholder map of Ahmedabad city?	0. No 1. Yes	

Section-2: Collaboration details			
No.	**Questions**	**Answers**	**Instruction**
1	Which of the zoonoses are currently reported in the system?	0. Dog bite & Rabies 1. Brucellosis 2. Swine Flu 3. Bird Flu 4. None of the Above 5. Do not know	Multiple answers allowed
2	Which other zoonoses can be reported in the existing system?		
3	Have you ever collaborated with any other experts for zoonoses control?	0. Never collaborated 1. Collaborated with Human health expert 2. Collaborated with Animal health experts 3. Collabrated with Wildlife experts	
4	If yes, can you specify the reasons for collaboration.	0. Disease that needed assistance from medical doctor/Veterinarian 1. Instructed by upper level authorities 2. Common budgetary provision 3. Sending weekly/monthly reports 4. Other (specify) _____	Multiple answers allowed
5	If No, can you specify the reasons for lack of collaboration	0. Do not know 1. No policy statement 2. No networking partners 3. Lack of knowledge/resource 4. Not required 5. Other (Sepcify) _____	Multiple answers allowed
6	In your opinion who can act as bridge between the human and animal health system for zoonoses control?	0. Managers at AMC 1. Surveillance actors 2. Medical Officer/Veterinarian 3. MPHW/FHW/FHS/SI 4. ASHA/AWW 5. LSI/Para Vets 6. Any other _____	
7	Have you ever been part of any joint activity with the human/ the animal health system or vice-versa?	0. No 1. Yes	Prompt for below mentioned activities

Type	*Outbreak management*	*Combined healthcare delivery/services*	*Advocacy activities (campaigns/ promotion)*	*Resource sharing (finance, staff)*	*Administrative (Meetings)*	*Any other*
Details						

Section-3: Exploring on enabling factors for convergence

How much do you think each of the following elements is necessary for the convergence between the human and the animal health system for effective prevention & control of zoonotic diseases (One Health approach) in Ahmedabad city?

Factors	**Very unnecessary**	**Somewhat unnecessary**	**Neutral**	**Somewhat necessary**	**Very necessary**
Coordinating roles	①	②	③	④	⑤
Close relationships among staff members between dept.	①	②	③	④	⑤
Knowledge and expertise	①	②	③	④	⑤
Social skills of individuals	①	②	③	④	⑤
Trust in other departments	①	②	③	④	⑤
Shared vision and objectives	①	②	③	④	⑤
Sufficient resources (time, personnel, budget)	①	②	③	④	⑤
Conflict resolution between departments	①	②	③	④	⑤
Successful experiences/cases of collaboration	①	②	③	④	⑤
Institutional supports	①	②	③	④	⑤
Leadership of each department	①	②	③	④	⑤
Legal ground (ordinance, plans, orders)	①	②	③	④	⑤

Section-4: Details on the strength of convergence

Who is your point of contact with the human and the animal health system or vice-versa? Rate them based on the working relation (T: Type) and how frequently you are collaboratively working in difference scenarios (F: Frequency)?

Type/ Frequency	Rabies Control	Brucellosis Control	H1N1 Control	H5N1 Control	During outbreak	During epidemic	During non-epidemic
Actor-1:							
T							
F							
Actor-2:							
T							
F							
Actor-3:							
T							
F							
Actor-4:							
T							
F							
Actor-5:							
T							
F							
Actor-6:							
T							
F							
Actor-7:							
T							
F							

Type: 1. Not linked (Do not work together), 2. Communication (share information only), 3. Cooperation (Work together informally to achieve common goals), 4. Collaboration (Work together as a formal team with specific responsibilities), 5. Fully linked (Work together as a formal team, mutually plan & share staff or resources to accomplish goals)
Frequency: 1. Daily, 2. Weekly, 3. Monthly, 4. Quarterly, 5. Yearly, 6. No contact

Form-4.3: Documenting the health system network at the administrative level

[Administer to all the Veterinarians, Physicians practicing infectious disease, Medical Officers]

Section-1.1: Basic information			
UID			
Name			
Department		**Designation**	
Mobile		**GPS**	

Section-1.2: Professional details			
No.	**Questions**	**Answers**	**Instructions**
1	Completed age (in years)		
2	Gender	0. Male 1. Female	
3	Highest educational qualification	0. Bachelor (MBBS/BVMS) 1. Master (MD/MVM) 2. Higher degree (DM/DVM) 3. Other (specify)_____	
5	Total years of professional experience (in years)		
6	Experience in the current position (in years)		
7	Sector in which you work	0. Government 1. Private 2. Trust/Civil society 3. Other (specify)_____	
8	Are you a member of any professional organizations?	0. No 1. Yes	
9	If yes, name the professional body.		
10	Do you like to be shown in the One Health stakeholder map of Ahmedabad city?	0. No 1. Yes	

Section-2: Collaboration details						
No.	**Questions**		**Answers**			**Instructions**
1	Which of the zoonoses are currently reported in the system?		0. Dog bite & Rabies 1. Brucellosis 2. Swine Flu 3. Bird Flu 4. None of the Above 5. Do not know			Multiple answers allowed
2	Which other zoonoses can be reported in the existing system?					
3	Have you ever collaborated with any other experts for zoonoses control?		0. Never collaborated 1. Collaborated with Human health expert 2. Collaborated with Animal health experts 3. Collabrated with Wildlife experts			
4	If yes, can you specify the reasons for collaboration.		0. Disease that needed assistance from medical doctor/Veterinarian 1. Instructed by upper level authorities 2. Common budgetary provision 3. Sending weekly/monthly reports 4. Other (specify) _____			Multiple answers allowed
5	If No, can you specify the reasons for lack of collaboration.		0. Do not know 1. No policy statement 2. No networking partners 3. Lack of knowledge/resource 4. Not required 5. Other (Sepcify) _____			Multiple answers allowed
6	In your opinion who can act as bridge between the human and animal health system for zoonoses control?		0. Managers at AMC 1. Surveillance actors 2. Medical Officer/Veterinarian 3. MPHW/FHW/FHS/SI 4. ASHA/AWW 5. Any other _____			
7	Have you ever been part of any joint activity with the human/ the animal health system or vice-versa?		0. No 1. Yes			Prompt for below mentioned activities
Type of activity	*Outbreak management*	*Combined healthcare delivery/services*	*Advocacy activities (campaigns/ promotion)*	*Resource sharing (finance, staff)*	*Administrative (Meetings)*	*Any other*
Details of activity						

Section-3: Documenting practices on prevention of Zoonoses			
No.	**Questions**	**Answers**	**Instructions**
1	Since obtaining your highest qualification, have you attended any training on zoonosis?	0. No 1. Yes	
2	If yes, name of training program, duration and when?		
3	Have you attended any health campaigns on zoonosis prevention?	0. No 1. Yes 2. Don't know	
4	Are you aware about the pre-prophylaxis for rabies control?	0. No 1. Yes 2. Don't know	
5	If yes, then please specify the dose, interval and site of vaccine?	Human: Animal:	
6	What is the post-exposure prophylaxis for rabies control followed at your clinic/center?	Human: Animal:	
7	What do you do to the rabid animal after bite?	0. Do not do anything 1. Inform the animal husbandry authority 2. Keep on for observation 3. Advice to kill the animal 4. Any Other_____	
8	Are you aware about the National Rabies Control Program?	0. No 1. Yes 2. Don't know	
9	Are you aware about the National Brucellosis Control Program?	0. No 1. Yes 2. Don't know	
10	Are you aware about the vaccination against Brucellosis?	0. Don't know 1. Only for humans 2. Only for animals 3. Both for humans & animals	
11	If yes, then have you ever suggested to your client for brucella vaccine for their animals?	Human: Animal:	
12	Are you aware about the influenza vaccine?	0. Don't know 1. Only for humans 2. Only for animals 3. Both for humans & animals	

13	If yes, then please specify the dose, interval and site of vaccine?	Human: Animal:	
14	How can the transmission of Swine flu be prevented?	0. Do not know 1. Through medication Oseltamivir/ Tamiflu 2. Wearing mask 3. Covering nose or mouth while sneezing 4. Reducing contact to the crowded places 5. Washing hands regularly 6. Vaccination 7. By Ayurveda/ Homeopathic treatment 8. By killing pigs 9. Any other (specify) _____	Multiple answers allowed
15	How can the transmission of Bird flu be prevented?	0. Do not know 1. Through medication Oseltamivir/ Tamiflu 2. Surfaces in contact with the poultry should be cleaned 3. Not eating sick and dead poultry 4. Washing hands with soap and water after poultry handling 5. Eating properly cooked meat and eggs 6. Keeping poultry coops far away from the house 7. Proper disposal of poultry droppings and litter 8. Avoid direct contact with birds and poultry 9. Any other (specify) _____	Multiple answers allowed
16	Have you ever referred any of the zoonotic patients/animals to other experts like Physician/ Veterinarians for their exposure assessment/ screening?	0. No 1. Yes, sometimes 2. Yes, always 3. Other (specify)_____	
17	Did any clients ask you about animal exposure & risk of zoonotic diseases?	0. No 1. Yes, sometimes 2. Yes, always 3. Other (specify) _____	
18	Which Govt. agency would you first notify if you came across with		

	an unusual infectious disease among patients/animals & How?		
19	Which Govt. agency would you first notify if the companion person of sick animal/livestock patient had an unusual infections & How?		
20	In your opinion who can act as bridge between the human and animal health system for zoonoses control?	0. Managers at AMC 1. Surveillance actors 2. Medical Officer/Veterinarian 3. MPHW/FHW/FHS/SI 4. ASHA/AWW 5. LSI/Para Vets 6. Any other _____	

Section-4: Exploring on enabling factors for convergence

How much do you think each of the following elements is necessary for the convergence between the human and the animal health system for effective

Factors	**Very unnecessary**	**Somewhat unnecessary**	**Neutral**	**Somewhat necessary**	**Very necessary**
Coordinating roles	①	②	③	④	⑤
Close relationships among staff members between dept.	①	②	③	④	⑤
Knowledge and expertise	①	②	③	④	⑤
Social skills of individuals	①	②	③	④	⑤
Trust in other departments	①	②	③	④	⑤
Shared vision and objectives	①	②	③	④	⑤
Sufficient resources (time, personnel, budget)	①	②	③	④	⑤
Conflict resolution between departments	①	②	③	④	⑤
Successful experiences/cases of collaboration	①	②	③	④	⑤
Institutional supports	①	②	③	④	⑤
Leadership of each department	①	②	③	④	⑤
Legal ground (ordinance, plans, orders)	①	②	③	④	⑤

Section-5: Details on the strength of convergence

prevention & control of zoonotic diseases (One Health approach) in Ahmedabad city?

Who is your point of contact with the human and the animal health system or vice-versa? Rate them based on the working relation (T: Type) and how frequently are you collaboratively work in difference scenarios (F: Frequency)?

Type/ Frequency	Rabies Control	Brucellosis Control	H1N1 Control	H5N1 Control	During outbreak	During epidemic	During non-epidemic
Actor-1:							
T							
F							
Actor-2:							
T							
F							
Actor-3:							
T							
F							
Actor-4:							
T							
F							
Actor-5:							
T							
F							
Actor-6:							
T							
F							
Actor-7:							
T							
F							

Type: 1. Not linked (Do not work together), 2. Communication (share information only), 3. Cooperation (Work together informally to achieve common goals), 4. Collaboration (Work together as a formal team with specific responsibilities), 5. Fully linked (Work together as a formal team, mutually plan & share staff or resources to accomplish goals)
Frequency: 1. Daily, 2. Weekly, 3. Monthly, 4. Quarterly, 5. Yearly, 6. No contact

Form-5.1: Interview guide for Vignette study

[To develop the innovative convergence strategies for effective prevention and control of zoonotic diseases]

Topic: General and personal information

1. Introduction of the research and agreement for interview.

2. What is your experience in prevention & control of zoonotic diseases?

Topic: Convergence pattern

[Brief about the importance of One Health Collaboration]

3. In your opinion, when the actors from the human and the animal health system should collaborate for effectual prevention and control of zoonoses?

4. If we consider the three-tier health system of India, in your opinion, where the convergence of actors from the human and the animal health system need to be focused? [Prompt: Entry points for collaboration]

5. In your view, how could the collaboration between the human and the animal health system be strengthened? [Prompt: Strategies for collaboration (early detection, combined health services), Ways to engage private actors]

6. In your opinion, what should be the ideal reporting pattern for early detection of zoonotic diseases among key actors of the human & the animal health system?

7. In your opinion, what should be the ideal roles & responsibilities of the following actors with reference to the collaboration?

    a. Actors at the community level
    b. Actors at the clinical level
    c. Actors at the managerial level

8. What need to be done further for strengthening the collaboration between various actors?

[Prompt: Consider for disease specific i.e. Rabies, Brucellosis, Influenza (H1N1, H5N1) and at different levels of health system]

Any further suggestions!

Form-5.2: Policy Delphi tool for validation of key strategies

[Online survey through Survey monkey]

Section-1: Basic information			
UID			
Name			
Department		**Designation**	
Mobile		**GPS**	
Completed age (in years)			
Gender			
Highest educational qualification			
Total years of experience (in years)			

Section-2: Key strategies on effectual prevention and control of zoonotic diseases in Ahmedabad, India				
Strategies	**Some what preferable**	**Very much preferable**	**Some what essential**	**Very much essential**
Legal strategies or policies				
Public health act or clinical establishment act for all the clinics in the state emphasizing reporting any conditions to the public health system	①	②	③	④
Guidelines for disposal of all dead animals irrespective of the disease condition	①	②	③	④
Development of joint guidelines (clinical/preventive) for each prioritized zoonotic diseases	①	②	③	④
Urban city should have animal treatment centers, hostel facility where stray animals can be inspected and vaccinated is recommended	①	②	③	④
Bi-directional and cross-flow of information is recommended with respective departments	①	②	③	④
Zoonoses committee at district and state should act as the prime platform for One Health and similar zoonoses committee is encouraged at the urban setting too.	①	②	③	④
Provision of Animal Health Card/Passport for animals and compelling to use while buying/selling any animals	①	②	③	④
Clinical aspects or disease-specific				

Strengthening the capacity of laboratories for screening and diagnosing zoonotic conditions	①	②	③	④
Prophylactic vaccination of animals for rabies prevention	①	②	③	④
Capacity development for differential diagnosis of brucellosis as an ultimate prevention strategy	①	②	③	④
Promoting good hygiene for flu prevention	①	②	③	④
Collaboration at the managerial level				
Resource sharing (especially Human resources) within each department to initiate the One Health approach	①	②	③	④
Regular data sharing and joint-data analysis	①	②	③	④
Information flowing from various departments to a single platform for early prediction of emerging diseases	①	②	③	④
Regular joint meetings among the program planners, even though there is no epidemic or out-break	①	②	③	④
Reporting pattern for prioritized zoonotic conditions to be established and regular monitoring of the same is essential	①	②	③	④
Professional bodies like IMA, GVC should initiate collaborative activities	①	②	③	④
Collaboration at the provider level				
Sharing of knowledge among Medical doctor and Veterinarians through a common platform	①	②	③	④
A common One Health clinical body that is answerable for every queries related to zoonoses and assist in the clinical practice.	①	②	③	④
The IEC materials should be with Medical doctors as well as Veterinarians to educate their patients	①	②	③	④
Social media like WhatsApp group of different clinical groups should be merged together for early alert system	①	②	③	④
There is a need to improve the early alert system about zoonoses much prior to the outbreak across the professionals	①	②	③	④
Joint training on Zoonoses for medical doctors and veterinarians	①	②	③	④

A detailed history taking for provisionally diagnosis of zoonotic conditions at primary care setting	①	②	③	④
There should be a system of cross-referral of cases between medical doctor and veterinarian for respective risk assessment	①	②	③	④
Symptom based early diagnosis capacity need to be developed among medical doctors and veterinarians	①	②	③	④
Collaboration at the community level				
One Health committee at the grass root level could be formulated with the help of the frontline workers along with the community representative	①	②	③	④
The frontline workers should communicate each other at the grass root level and also should inform both officials for any abnormal occurrence	①	②	③	④
Sensitization of community along with knowledge and awareness on prevention and control of zoonoses	①	②	③	④
Financial incentives to the animal handlers to report any disease or any abnormal condition of their animals to the system	①	②	③	④
Community awareness by the grass root healthcare workers	①	②	③	④
Inclusion of private actors				
Financial incentive package to private providers for reporting a zoonosis to the public health system	①	②	③	④
There should be no financial incentive for the private actors to report any zoonotic diseases, it should be by law	①	②	③	④
Dairy personnel could be trained further to improve the scope of symptom based disease detection among the animals	①	②	③	④
Sensitization and promotion of ethical practices among private providers as essential to bring them to the health system	①	②	③	④
Social media of private actors should be integrated with the public health actors, to be a potential platform to exchange the knowledge and early detection of zoonoses	①	②	③	④

Form-5.3: Semi-structured tool for the participatory system workshop

[To develop the innovative convergence strategies for effective prevention and control of zoonotic diseases]

Step-1: System description

Here, system is defined as the health system of the Ahmedabad city, which comprises both the human and animal health sub-systems. This also comprises of the public and the private actors from both the system.

Step-2: Defining variables

Please suggest further factors that you think would be considered while developing One Health inter-sectoral collaboration

Step-3: Criteria assignments (Criteria Matrix)

To verify their completeness (from a "systems" viewpoint), all indicators were crosschecked against the fixed criteria. These criteria define the indicators' representativeness, physical quality, dynamics, and entropy. The possible fitting scores are:

- Fully applicable (dark ● circle; 1)
- Partially applicable (open ○ circle; 0.5)
- No relevance (empty; 0)

The values for each domain are summed up and compared amongst one another, seeking a balanced coverage of all systemic aspects.

Criteria	Description
Spheres of Life	
Economy	Activities (What they do?)capital production, tax receipts, debts, shareholder value
Population	Participants (Who are they all?) Number, structure and dynamics, working people, age structure
Space utilization	Space (What happens where?) Use of space, land development, residential structure
Human ecology	Mood (How do people feel?) Human ecology, social structure, quality of life, security, education, state of health
Natural balance	Natural balance (How does resources budget work?) Consumption of raw materials, energy, water, soil sealing, influence on climate
Infrastructure	Internal processed (What channels of communication are there?) Transport and access roads, tele communications, traffic and supply
Rules & Laws	Internal order (How is this regulated?) Local government, taxes, measures, ordinances and legislations, planning procedure
Physical Category	
Matter	Variable having a primarily material character (E.g. Buildings, raw materials, people, animals, plants, vehicles)

Energy	Variables having a primarily energy-related character (E.g. Power consumption, Workers, Energy carriers, financial strengths)
Information	Variables having a primarily information-related and communication-related character (E.g. Media, decisions, explication, exchange of information, orders, perception, acceptance)
Dynamic Category	
Flow quantity	Variables expressing primarily flows of matter, energy or information within the system (E.g. Power consumption, traffic, commuters, instructions)
Structure quantity	Variables serving to determine structure rather than flow (E.g. Green spaces, population densities, traffic network, accessibility, hierarchy)
Temporal dynamics	Variables that at the same location change at a given time or that possess a temporal dynamics (E.g. Seasonal activity, election meetings, climate factors, transport timetables, tax checking)
Spatial dynamics	Variables that at a given time differ from location to location (E.g. Traffic revenue, industrial effluent, nature-conservation area)
System relationship	
Opens the system through inputs	Variables that open the system through influences from outside (E.g. precipitation, dumping, imports, tourism)
Opens the system through outputs	Variables that open the system through influences from inside (E.g. Waste water, commuters leaving the city, exports)
Can be influenced from inside	Variables that can be controlled by decision-making processes coming from within the system under consideration. Among other things these are a measure of the system's self-sufficiency
Can be influenced from outside	Variables that are subject to decision-making processes taking place outside the system under consideration. Among other things these are a measure of the system's dependence

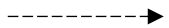
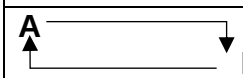
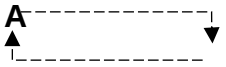
Step-4: Matrix of Consensus (Impact Matrix)

Strength of connections should be assigned values between 0 to 3.

- **3 (Disproportionally strong connection):** If A changes only a little, B changes a lot
- **2 (Medium strength, more or less proportional connections):** If A changes a lot in order to achieve a more or less equally big change in B
- **1 (Weak connections):** If a marked change in A brings about only a weak change in B
- **0 (No connections):** No effect at all , a very weak effect or an effect occurring only after a lengthy delay

	F1	F2	F3	F4	F5
F1					
F2					
F3					
F4					
F5					

Step-5: Effect System (Feedback loop)

Feedback Loop	Relations
	A continuous arrow stands for a link in the same direction
	A dotted arrow stands for a link in the reverse direction
	Two continuous arrows indicate that two variables mutually reinforce each other in the same direction
	Two dotted arrows indicate that two variables reverse connections and are harnessed together