



# Infection Ecology & Epidemiology

ISSN: (Print) 2000-8686 (Online) Journal homepage: <http://www.tandfonline.com/loi/ziee20>

## One Health research and training and government support for One Health in South Asia

Joanna S. McKenzie, Rojan Dahal, Manish Kakkar, Nitish Debnath, Mahmudur Rahman, Sithar Dorjee, Khalid Naeem, Tikiri Wijayathilaka, Barun Kumar Sharma, Nasir Maidanwal, Asmatullah Halimi, Eunmi Kim, Pranab Chatterjee & Brecht Devleesschauwer

To cite this article: Joanna S. McKenzie, Rojan Dahal, Manish Kakkar, Nitish Debnath, Mahmudur Rahman, Sithar Dorjee, Khalid Naeem, Tikiri Wijayathilaka, Barun Kumar Sharma, Nasir Maidanwal, Asmatullah Halimi, Eunmi Kim, Pranab Chatterjee & Brecht Devleesschauwer (2016) One Health research and training and government support for One Health in South Asia, *Infection Ecology & Epidemiology*, 6:1, 33842, DOI: [10.3402/iee.v6.33842](https://doi.org/10.3402/iee.v6.33842)

To link to this article: <https://doi.org/10.3402/iee.v6.33842>



© 2016 Joanna S. McKenzie et al.



Published online: 29 Nov 2016.



[Submit your article to this journal](#)



Article views: 501



[View related articles](#)



[View Crossmark data](#)



Citing articles: 2 [View citing articles](#)

REVIEW ARTICLE

# One Health research and training and government support for One Health in South Asia

Joanna S. McKenzie, PhD<sup>1\*</sup>, Rojan Dahal, MPH<sup>2</sup>,  
Manish Kakkar, MPH<sup>3</sup>, Nitish Debnath, PhD<sup>4</sup>, Mahmudur Rahman, PhD<sup>5</sup>,  
Sithar Dorjee, PhD<sup>6</sup>, Khalid Naeem, PhD<sup>7</sup>, Tikiri Wijayathilaka, MVM<sup>8</sup>,  
Barun Kumar Sharma, MVM<sup>9</sup>, Nasir Moidanwal, MPH<sup>10</sup>,  
Asmatullah Halimi, MVM<sup>10</sup>, Eunmi Kim, PhD<sup>1</sup>, Pranab Chatterjee, MBBS<sup>3</sup>  
and Brecht Devleeschauwer, PhD<sup>11</sup>

<sup>1</sup>International Development Group, Institute of Veterinary Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand; <sup>2</sup>Ministry of Health, Kathmandu, Nepal; <sup>3</sup>Public Health Foundation of India, Delhi, India; <sup>4</sup>United Nations Food and Agriculture Organisation, Dhaka, Bangladesh; <sup>5</sup>Institute of Epidemiology Disease Control and Research, Directorate General of Health Services, Ministry of Health and Family Welfare, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh; <sup>6</sup>Bhutan Agriculture and Food Regulation Authority, Thimpu, Bhutan; <sup>7</sup>Animal Sciences Institute, Pakistan Agriculture Research Centre, Islamabad, Pakistan; <sup>8</sup>Department of Animal Production and Health, Peradeniya, Sri Lanka; <sup>9</sup>Ministry of Livestock Development, Kathmandu, Nepal; <sup>10</sup>Health Protection Research Organisation, Kabul, Afghanistan; <sup>11</sup>Department of Public Health and Surveillance, Scientific Institute of Public Health (WIV-ISP), Brussels, Belgium

**Introduction:** Considerable advocacy, funding, training, and technical support have been provided to South Asian countries to strengthen One Health (OH) collaborative approaches for controlling diseases with global human pandemic potential since the early 2000s. It is essential that the OH approach continues to be strengthened given South Asia is a hot spot for emerging and endemic zoonotic diseases. The objectives of this article are to describe OH research and training and capacity building activities and the important developments in government support for OH in these countries to identify current achievements and gaps.

**Materials and methods:** A landscape analysis of OH research, training, and government support in South Asia was generated by searching peer-reviewed and grey literature for OH research publications and reports, a questionnaire survey of people potentially engaged in OH research in South Asia and the authors' professional networks.

**Results:** Only a small proportion of zoonotic disease research conducted in South Asia can be described as truly OH, with a significant lack of OH policy-relevant research. A small number of multisectoral OH research and OH capacity building programmes were conducted in the region. The governments of Bangladesh and Bhutan have established operational OH strategies, with variable progress institutionalising OH in other countries. Identified gaps were a lack of useful scientific information and of a collaborative culture for formulating and implementing integrated zoonotic disease control policies and the need for ongoing support for transdisciplinary OH research and policy-relevant capacity building programmes.

**Discussion:** Overall we found a very small number of truly OH research and capacity building programmes in South Asia. Even though significant progress has been made in institutionalising OH in some South Asian countries, further behavioural, attitudinal, and institutional changes are required to strengthen OH research and training and implementation of sustainably effective integrated zoonotic disease control policies.

**Keywords:** *One Health; zoonoses; South Asia; research; training; policy*

\*Correspondence to: Joanna S. McKenzie, International Development Group, Institute of Veterinary Animal and Biomedical Science, Massey University, Private Bag 11-222, Palmerston North 4442, New Zealand, Email: [j.s.mckenzie@massey.ac.nz](mailto:j.s.mckenzie@massey.ac.nz)

Received: 16 October 2016; Revised: 26 October 2016; Accepted: 27 October 2016; Published: 29 November 2016

**C**ollaborative One Health (OH) approaches that integrate the formulation, funding, implementation, and governance of control policies involving human, animal, and wildlife populations are required to

more effectively control endemic zoonotic diseases and to detect and manage emerging zoonotic diseases (1). This is especially important in South Asia, which is a hot spot for endemic and emerging infectious zoonotic diseases (2, 3).

Major neglected endemic zoonotic diseases, such as rabies, continue to impact human and animal health in South Asia, with a disproportionate effect on poor and marginalised communities (4–6).

The occurrence of potential global human pandemics in the early 2000s was the driver for major international advocacy and funding to strengthen collaboration between the human health, domestic animal health, and wildlife health sectors in an OH approach (7, 8). Supported by advocacy, expertise, and funding from international agencies, governments in South Asia formulated and implemented multidisciplinary collaborative frameworks and operational programmes to combat outbreaks of zoonotic diseases with pandemic potential, such as highly pathogenic avian influenza (HPAI, H5N1). There has been a lesser effort to support research and policy development for managing endemic zoonotic diseases, despite evidence of the high impact of these diseases (6). The challenge is to extend the OH approach from disease issues of global concern to endemic or neglected zoonoses of national and regional concern (9), which in itself is likely to strengthen the ability to detect newly emerging diseases (10).

Some governments in South Asia have made significant progress with institutionalising a collaborative OH mechanism. However, policies for managing endemic diseases in the region are largely *ad hoc* (11, 12). Zoonotic disease research is also largely *ad hoc*, and a large proportion of the research focuses on the development of vaccines, therapeutics, and diagnostic tests rather than evidence for policy formulation and implementation (13, 14). There is a need for policy-relevant research, generating evidence of zoonotic disease impacts, and of the effectiveness and economic value of OH approaches (15, 16), in addition to stakeholder perspectives to formulate sustainable policies for zoonotic disease control. Ideally, OH research should involve the integrated analysis and interpretation of data on human and animal health and their environments such that the research ‘leads to insights that would not be visible without inter-sectoral collaboration, such as impacts of multi-host infections on humans, animal and ecosystem health and economics’ (17). Truly transdisciplinary research, the hallmark of OH or EcoHealth approaches, involves multidisciplinary teams addressing OH research questions within a common conceptual framework (18).

The investment in people through education and training is essential to build a workforce trained in effective multidisciplinary collaboration to formulate and implement sustainable endemic zoonotic disease control policies and to build capacity for detecting and managing emerging zoonotic diseases (7, 19). In addition to strengthening technical expertise for research and policy formulation, studying within a collaborative framework builds relationships and respect for the roles and expertise of professionals in different sectors that are an essential component of collaboration.

A range of OH research and training programmes have been implemented in the South Asian region since the outbreak of zoonotic diseases with a pandemic potential in the early 2000s, such as HPAI (H5N1) and Severe acute respiratory syndrome (SARS). The objectives of this article are to describe OH research and training and capacity building activities in South Asia in recent years and to describe the important developments in government support for OH in these countries. This will contribute to understanding the achievements and identifying the gaps where resources can be targeted to strengthen collaborative OH research, training, and advocacy to build an ‘enabling environment’ to move towards more effective integrated management of endemic and emerging zoonotic diseases in South Asia.

## Methods

Data and information on OH research projects, OH training and capacity building programmes, and government support for OH in South Asian countries were collected through a range of different approaches to generate a ‘landscape analysis’ of OH in the South Asian region. The major focus of this analysis was on the eight member states of the South Asian Association for Regional Cooperation (SAARC), notably: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Data on OH research were collected through searching peer-reviewed and grey literature, a questionnaire survey of people potentially engaged in OH research in South Asia, and personal contact with key people identified through the authors’ professional networks.

An initial search for peer-reviewed publications on individual zoonotic diseases by a country in South Asia provided information on the volume of research associated with each disease in each country. The search was conducted in all databases in Web of Science (WoS) for publications within a 20-year period from 1996 to 2016, to capture the period of the early HPAI outbreaks that were a major driver for global investment in an OH approach. The search terms for zoonotic diseases by country included key words that captured the range of names by which a disease is described in the literature and the country name. The total number of publications returned in each search was considered a reflection of the most commonly researched zoonotic diseases in each country.

A second search was conducted to specifically identify publications on OH research in South Asia, using the keywords ‘One Health’ and ‘South Asia’ plus ‘One Health’ and individual country names. As not all publications on OH research included the term ‘One Health’, a second set of searches was conducted using the term ‘humans and livestock’ or ‘humans and animals’ or ‘livestock and humans’ or ‘animals and humans’ or ‘humans and their animals’ or ‘humans and their livestock’ or ‘livestock and children’ and country name for each of the South Asian

countries. The papers were then reviewed to identify those that represented OH research as defined in the following two ways:

1. A multidisciplinary study on a health-related topic, involving people from two or more disciplines, including human health, domestic animal health, wildlife health, ecological, environmental, sociological, entomological and other. Multidisciplinary was ascertained from the author affiliations in published papers.
2. A multidisciplinary, multi-study research programme on a health-related topic. The programme includes individual studies that may involve researchers from only one discipline and/or data collection from either human or animal populations, but the studies are designed in an integrated way within the programme so that the results of each study can be interpreted together and contribute to designing integrated approaches to zoonotic disease control.

A questionnaire was distributed to 115 professionals who were potentially working in OH-related areas in the South Asia region using the Hubnet platform ([www.hubnet.org.nz/](http://www.hubnet.org.nz/)) to collect information on OH research, training, and challenges in implementing an OH approach in South Asian countries. OH research was defined as above, and OH training was defined as 'Training, education or capacity building activities and programmes that involved people from two or more disciplines related to human health, domestic animal health, wildlife health or environmental health'. Training was separated into short-term training such as short courses, workshops, and seminars of less than 1 month; long-term training programmes of 1 month or more; and university undergraduate or postgraduate education.

Additional information on OH training was collected by a Google search using the terms '[Country name]' and 'One Health'. Such a broad search was found to produce the most comprehensive information on OH activities in the South Asian countries. Results were reviewed, and activities that were defined as training were collated. Further information was obtained through the authors' professional networks.

Government support for OH in each country was identified through the authors' knowledge of government initiatives and collection of further details through OH networks in each country.

## Results

In addition to the database searches, information was available through a total of 61 completed questionnaires, ranging from 4 to 17 per country, and additional contacts through professional networks.

### *OH research*

The number of peer-reviewed publications on zoonotic diseases associated with each country identified through the WoS searches for the period 1996 and 2016 is shown in Table 1. The publications were not checked to exclude duplicates and remove papers that did not relate to the disease and country in the search terms, and hence, these numbers over-estimate the actual number of publications. However, given similar errors occur across all search terms, the relativity of the numbers is likely to be reasonably accurate. India is clearly associated with the greatest number of zoonotic disease publications, with fewest from the Maldives. The highest number of publications was associated with visceral leishmaniasis and the lowest number with Q fever.

A total of 41 peer-reviewed publications from South Asia included the term OH in the title or body of the text, of which 26 correctly related to OH in South Asia. An additional 11 papers representing OH research were identified through the search terms that included humans and animals and a further five through personal communications. Overall, a total of 42 published papers were identified as relating to OH, 34 of which represented OH field studies or zoonotic disease reviews that referred to human and domestic animal or wildlife health and the remaining eight represented commentary or perspectives on OH (Table 2).

The number of identified OH research programmes per country ranged from three (Pakistan) to seven (Bangladesh), with the exception of the Maldives, for which no OH research programmes were identified (Table 3). The vast majority of the identified programmes were aimed at studying specific endemic or emerging zoonotic diseases while few programmes were aimed at evaluating information of value for OH disease control programmes and policies. A wide variety of national and international institutes contributed to these programmes, while funding was mainly from multilateral (European Union (EU), World Bank, World Health Organization (WHO)) or bilateral (Canada, Japan, Netherlands, UK, USA) development cooperations, with the exception of certain Indian OH research programmes funded by the Indian Council of Medical Research.

### *OH training*

Details of the major OH training and education programmes conducted in the seven countries are shown in Table 4. Massey University has implemented the largest OH training programme in the South Asia region, with an alumnus of 90 Master's degree and Postgraduate Certificate in Science graduates in the seven South Asian countries, and a wider group of approximately 2,000 people who participated in applied epidemiology training programmes. Other significant OH training and capacity building programmes are Relief International's

**Table 1.** Number of publications by zoonotic disease and country identified through searching all databases in Web of Science for the period 1996–2016

Search term	India	Bangladesh	Pakistan	Nepal	Sri Lanka	Afghanistan	Bhutan	Maldives	TOTAL
'Visceral leishmaniasis' or kala-azar	1,311	294	55	339	46	52	8	1	2,106
'Japanese encephalitis'	658	40	28	88	54	2	2	1	873
'rabies'	548	51	58	39	84	18	17	3	818
'Cutaneous leishmaniasis'	292	35	158	43	73	162	2	0	765
'Brucell*' or Brucellosis	504	60	81	13	7	14	0	0	679
'Avian influenza' or H5N1 or H7N9 or H5N6 or H9N2 or 'highly pathogenic avian influenza' or HPAI	262	158	192	24	7	14	8	1	666
'Leptospirosis' or 'Weil's disease'	508	15	11	12	78	3	0	2	629
'Porcine cysticercosis' or 'neurocysticercosis' or 'Taenia solium'	505	3	2	50	1	0	3	1	565
'Echinococcosis' or 'hydatid disease' or 'hydatidosis' or 'echinococcal disease'	437	15	62	25	1	12	0	0	552
'Plague' or <i>Yersinia pestis</i>	364	64	72	20	7	18	5	1	551
'Toxoplasma**'	292	16	56	21	15	4	0	0	404
'Nipah virus' or 'Nipah encephalitis'	94	225	1	1	3	0	1	1	326
'Tsutsugamushi' or 'Scrub typhus'	256	2	2	6	29	1	0	4	300
'Crimean Congo Haemorrhagic fever' or 'Crimean Congo Hemorrhagic fever' or 'CCHF'	57	0	120	0	0	43	1	0	221
'Anthrax' or 'Hide porter's disease'	125	33	11	3	2	23	1	0	198
'Bovine tuberculosis'	48	7	25	1	2	0	0	0	83
'Q fever' or <i>Coxiella burnetii</i>	25	5	2	2	3	19	1	1	58
Total	6,286	1,023	936	687	412	385	49	16	9,794

programme implemented in three countries, the Indian PERIMILK programme, plus the US National Academies of Sciences-funded fellowship programme, and the US Centres for Disease Control and Prevention (CDC)-supported Field Epidemiology and Laboratory Training Program in Pakistan. A large number of OH

short courses and workshops have been conducted in all countries, in particular under avian influenza control programmes.

Three postgraduate degrees that have an OH focus are offered by universities in Bangladesh (Chittagong), India (Kerala), and Sri Lanka (Peradeniya). While a number of

**Table 2.** Peer-reviewed papers categorised into One Health studies, One Health zoonotic disease reviews, and One Health commentary or perspectives, by country in South Asia, identified through a search of all databases in Web of Science

Country <sup>a</sup>	OH studies <sup>b</sup>	References	OH zoonotic disease reviews	References	OH commentary, perspectives	References
Afghanistan	2	(20, 21)	0		0	
Bangladesh	4	(22–25)	2	(26, 27)	2	(28, 29)
Bhutan	2	(30, 31)	0		0	
India	5	(32–36)	5	(11, 4, 37–39)	5	(40–44)
Nepal	2	(45, 46)	3	(47–49)	0	
Pakistan	4	(50–53)	1	(54)	0	
Sri Lanka	4	(55–58)	0		0	
South Asia			0		1	(19)

<sup>a</sup>No OH publications were identified from the Maldives.

<sup>b</sup>Includes studies conducted on both human and animal populations and studies conducted by multidisciplinary teams as determined from the author affiliations.

Table 3. One Health research programmes in South Asia

Project/programme title	National/partner institution	International partner	Funder	Diseases	References
<b>Afghanistan</b>					
Assessment of programmes and policies on One Health in Afghanistan	HPRO	None	Relief International (EU – One Health in Asia Program)	OH	N/A
Knowledge, attitude, and practices of health-care providers in Afghanistan with respect to diagnosing and treating zoonoses	HPRO; Afghanistan National Public Health Institute (ANPHI); GDAH&P	Massey University	EU (One Health in Asia Program)	Brucellosis and Q fever	<a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a>
Zoonotic and transmissible diseases in livestock that potentially threaten unique wildlife species in the trans-boundary area between Afghanistan, Pakistan, and Tajikistan (2012)	GDAH&P	Wildlife Conservation Society (WCS); University of Veterinary and Animal Sciences, Lahore, Pakistan	American Association for the Advancement of Science (AAAS); USAID	Foot and mouth disease, glanders, brucellosis, bovine tuberculosis, Q fever, toxoplasmosis and bluetongue	N/A
CCHF in livestock, camels, and wildlife	GDAH&P, Ministry of Public Health (MOPH)	Food and Agriculture Organization of the United Nations (FAO); World Health Organization (WHO); Relief International	N/A	CCHF in camels, livestock and wildlife	N/A
<b>Bangladesh</b>					
OH research programme on emerging zoonoses in the poultry farming and trading system in Bangladesh under the Zoonoses and Emerging Livestock Systems (ZELS) programme	CVASU; FAO Bangladesh; DLS, Bangladesh; IEDCR; BLRI	Royal Veterinary College (RVC) and the London School of Health and Tropical Medicine (LSH&TM)	Department for International Development (DFID)	Avian Influenza	<a href="http://www.rvc.ac.uk/research/research-centres-and-facilities/veterinary-epidemiology-economics-and-public-health/projects/controlling-and-monitoring-emerging-zoonoses-in-the-poultry-farming-and-trading-system-in-bangladesh-an-interplay-between-pathogens-people-policy">www.rvc.ac.uk/research/research-centres-and-facilities/veterinary-epidemiology-economics-and-public-health/projects/controlling-and-monitoring-emerging-zoonoses-in-the-poultry-farming-and-trading-system-in-bangladesh-an-interplay-between-pathogens-people-policy</a>
Investigation of date palm sap collectors' practices, ecological factors, and seroprevalence of antibodies to Nipah virus	IEDCR, CVASU, Bangladesh Forest Department	Massey University; Australian Animal Health Laboratory and	EU (One Health in Asia Program)	Nipah Virus	<a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a>

Table 3 (Continued)

Project/programme title	National/partner institution	International partner	Funder	Diseases	References
Biosecurity practices and the movement and contact patterns of commercial layer, commercial broiler, and backyard poultry	IEDCR, DLS, BLRI	Massey University	EU (One Health in Asia Program)	Avian Influenza	<a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a>
Improving food safety in Bangladesh	FAO, Directorate of General Health Services	N/A	Government of the Kingdom of Netherland	Foodborne illness	<a href="http://www.fao.org/in-action/food-safety-bangladesh/background/en/">www.fao.org/in-action/food-safety-bangladesh/background/en/</a>
Surveillance to detect and prevent the spillover of pathogens of pandemic potential in Bangladesh (PREDICT)	International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, Bangladesh); IEDCR; Bangladesh Forest Department; DLS; CVASU	University of California, Davis, USA	USAID	Multiple	<a href="http://www.vetmed.ucdavis.edu/ohi/predict">www.vetmed.ucdavis.edu/ohi/predict</a>
Multidisciplinary Nipah research programme	IEDCR	ICDDR, Bangladesh; EcoHealth Alliance; CDC, University of Wisconsin and other groups	Multiple sources	Nipah	N/A
<b>Bhutan</b>					
Seroprevalence of leptospirosis in cattle and humans	The National Centre for Animal Health (NCAH) and Royal Centre for Disease Control	WHO SEARO	SEARO	Leptospirosis	<a href="http://www.phls.gov.bt/web/risk-based-surveillance-of-leptospirosis-in-domestic-animal-human-interface-in-bhutan/">www.phls.gov.bt/web/risk-based-surveillance-of-leptospirosis-in-domestic-animal-human-interface-in-bhutan/</a>
An evaluation of the effectiveness of OH collaboration in managing zoonotic diseases in Bhutan	Ministry of Health, Ministry of Agriculture and Forest, Royal Government of Bhutan	Massey University	AHIF/World Bank	OH collaboration	<a href="http://www.onehealthnetwork.asia/sites/bhutan-oh-evaluation-project">www.onehealthnetwork.asia/sites/bhutan-oh-evaluation-project</a>
Ecology of dog populations and human PEP usage – contributing towards rabies control policy in Bhutan	Ministry of Health, Ministry of Agriculture and Forest, Royal Government of Bhutan	Massey University	AHIF/World Bank	Rabies	<a href="http://www.onehealthnetwork.asia/sites/bhutan-rabies-project">www.onehealthnetwork.asia/sites/bhutan-rabies-project</a>
Descriptive epidemiology and risk factors for scrub typhus; zoonotic pathogens in rodents	Ministry of Health, Ministry of Agriculture and Forest, Royal Government of Bhutan	Massey University	EU (One Health in Asia Program)	Scrub typhus	<a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a>
KAP studies of clinicians' PEP usage in high and low rabies-risk areas of Bhutan relating to rabies control policy	Ministry of Health, Ministry of Agriculture and Forest, Royal Government of Bhutan	Massey University	EU (One Health in Asia Program)	Rabies	<a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a>

Table 3 (Continued)

Project/programme title	National/partner institution	International partner	Funder	Diseases	References
<b>India</b>					
Supporting and promoting integrated zoonotic disease prevention and control through a One Health approach	Road Map to Combat zoonotic Diseases, Public Health Foundation of India	N/A	N/A	Priority zoonotic diseases	<a href="http://www.zoonoses.phfi.org/">www.zoonoses.phfi.org/</a>
PERIMILK: Research Initiative on Peri-Urban Human-Animal-Environment Interface in India	Public Health Foundation, India	International Livestock Research Institute(ILRI)	IDRC, Canada	Multiple zoonotic pathogens, aflatoxins, pesticide residues, antibiotic resistance	<a href="http://www.perimilk.phfi.org/zoonoses-and-food-safety/">www.perimilk.phfi.org/zoonoses-and-food-safety/</a>
Multicentre study on Crohn's disease in India (2015–2018)	Multiple human and animal health institutions	N/A	ICMR	Crohn's disease	<a href="http://www.dhr.gov.in/res_projects/2015-16.pdf">www.dhr.gov.in/res_projects/2015-16.pdf</a>
Microbiological and clinical evaluation of neurobrucellosis involving human and multiple domestic animal species (2014–2016)	The Indian Council of Agricultural Research (ICAR)- National Institute of Veterinary Epidemiology and Disease Informatics (ICAR-NIVEDI)	N/A	ICMR	Neurobrucellosis	N/A
<b>Nepal</b>					
Zoonosis Control Project	Ministry of Agriculture Development (MOAD); Ministry of Health (MOH), Government of Nepal	N/A	World Bank	Priority zoonotic diseases	World Bank. 2014. <i>Nepal – Zoonoses Control Project</i> . Washington, DC: World Bank Group. <a href="http://www.documents.worldbank.org/curated/en/203131468059704553/Nepal-Zoonoses-Control-Project">www.documents.worldbank.org/curated/en/203131468059704553/Nepal-Zoonoses-Control-Project</a>
Zoonotic risk factors for leptospirosis in Kaski District, Nepal	DAH, DLS; EDCD, DOHS; Regional Veterinary Laboratory, Pokhara; District Public Health Office, Pokhara; Heifer Project International; Child Health and Environment Safe Society; Walter Reed / AFRIMS Research Unit Nepal (WARUN)	Massey University	World Bank/AHIF	Leptospirosis	<a href="http://www.onehealthnetwork.asia/sites/nepal-leptospirosis-project">www.onehealthnetwork.asia/sites/nepal-leptospirosis-project</a>
Contact networks and biosecurity practices associated with brucellosis transmission in cattle and buffalo and JE transmission in pigs	National Zoonoses and Food Hygiene Research Centre (NZFHRC); DLS; DOHS	Massey University	EU (One Health in Asia Program)	Brucellosis and Japanese encephalitis (JE)	<a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a>



Table 3 (Continued)

Project/programme title	National/partner institution	International partner	Funder	Diseases	References
Emerging Pandemic Threat Program (PREDICT)	Center for Molecular Dynamics Nepal (CMDN); Department of National Parks and Wildlife Conservation; DAH, DLS; EDCD, DOHS	University of California-Davis	USAID	Pathogen discovery in wildlife species; interface between humans, livestock and wildlife	<a href="http://www.vetmed.ucdavis.edu/ohi/predict">www.vetmed.ucdavis.edu/ohi/predict</a>
One Health Asia Program – Fighting zoonosis in Afghanistan, Bangladesh, and Nepal	Asia Network for Sustainable Agriculture and Bio Resource (ANSAB); Agriculture and Forestry University (AFU), Rampur, Nepal; DOHS; DLS	Relief International	N/A	Antibiotic resistance	N/A
<b>Pakistan</b>					
Seroprevalence and risk factors for brucellosis and CCHF in people and their livestock	National Agricultural Research Centre (NARC); National Institute of Health (NIH), Department of Health (DOH); Livestock and Dairy Development (L&DD) of Khyber Pakhtunkhwa (KPK) and Baluchistan provinces	Massey University	AHIF/WB	Brucellosis and CCHF	<a href="http://www.onehealthnetwork.asia/sites/pakistan-cCHF-project">www.onehealthnetwork.asia/sites/pakistan-cCHF-project</a>
Surveillance for brucellosis, CCHF, and avian influenza in 37 districts of Pakistan (FELTP-human and animal disease)	National Zoonoses and Surveillance Research Unit (NaZSRU), NARC	National Institute for Health	US government	Brucellosis, CCHF and avian influenza	<a href="http://www.agingportfolio.org/projects/search/?pid=1638508&amp;fyear=&amp;countries_ids=162&amp;countries=Pakistan&amp;aging=1&amp;noparent=1&amp;site=1">www.agingportfolio.org/projects/search/?pid=1638508&amp;fyear=&amp;countries_ids=162&amp;countries=Pakistan&amp;aging=1&amp;noparent=1&amp;site=1</a>
Zoonotic influenza and salmonellosis surveillance under Agriculture Linkage Program (2012–2016)	National Reference Laboratory for Poultry Diseases, NARC; Federal and Provincial laboratories	N/A	USA government	Influenza, salmonellosis	<a href="http://www.alp.gov.pk/about.html">www.alp.gov.pk/about.html</a>
<b>Sri Lanka</b>					
Studies on leptospirosis in humans and animals in Sri Lanka	University of Peradeniya	Hokkaido University	N/A	Leptospirosis	(59–61)
OH study of leptospirosis	Faculty of Medicine and Allied Sciences, Rajarata University, Sri Lanka	University of California, San Diego, USA; Universidad Peruana Cayetano Heredia, Peru	US National Institute of Health	Leptospirosis	N/A

Table 3 (Continued)

Project/programme title	National/partner institution	International partner	Funder	Diseases	References
Wildlife human health net project building research capacity in wildlife and human health through producing knowledge on wildlife diseases, mobilising multisector capacity for safeguarding wildlife and public health, and sustaining local livelihoods	Department of Wildlife Conservation, Wildlife Department; Department of Animal Production and Health (DAPH); Faculty of Veterinary Medicine, University of Peradeniya	Canadian Cooperative Wildlife Health Centre of Saskatchewan University and Canadian Centre for Coastal Health	IDRC, Canada	Wildlife diseases	<a href="http://www.idrc.ca/en/project/building-research-excellence-wildlife-and-human-health-sri-lanka">www.idrc.ca/en/project/building-research-excellence-wildlife-and-human-health-sri-lanka</a>
OH research into owned and Free roaming dog populations, leptospirosis in humans and animals, systematic review of policy-relevant brucellosis data	Epidemiology Unit, Ministry of Health; Department of Animal Health, Ministry of Agriculture	Massey University	WB/AHIF	Rabies, leptospirosis, brucellosis	<a href="http://www.onehealthnetwork.asia/sites/sri-lanka-leptospirosis-project">www.onehealthnetwork.asia/sites/sri-lanka-leptospirosis-project</a> <a href="http://www.onehealthnetwork.asia/sites/sri-lanka-rabies-project">www.onehealthnetwork.asia/sites/sri-lanka-rabies-project</a> <a href="http://www.onehealthnetwork.asia/sites/sri-lanka-brucellosis-project">www.onehealthnetwork.asia/sites/sri-lanka-brucellosis-project</a>

N/A: Not available.

HPRO, Health Protection Research Organisation; GDAH&P, General Directorate of Animal Health and Production; USAID, United States Agency for International Development; CCHF, Congo haemorrhagic fever; CVASU, Chittagong Veterinary and Animal Sciences University; DLS, Department of Livestock Services; IEDCR, Institute of Epidemiology, Disease Control and Research; BLRI, Bangladesh Livestock Research Institute; SEARO, South East Asian Regional Office; AHIF, Avian and Human Influenza Facility; ICMR, Indian Council of Medical Research; DAH, Directorate of Animal Health; EDCCD, Epidemiology and Disease Control Division; DOHS, Department of Health Services; PEP, post-exposure prophylaxis; IDRC, International Development Research Centre.

Table 4. One Health training programmes by country in South Asia identified through a Google search and the authors' networks

Programme title	National institutions and partners	International partners	Funder	Programme description	Reference
<b>Afghanistan</b>					
OH Master's education and applied epidemiology training	Ministry of Public Health; Ministry of Agriculture, Irrigation and Livestock; Health Protection Research Organisation (HPRO)	Massey University	World Bank/AHIF and EU	Massey University provided OH Master's degree education for 3 public health professionals (2010–2011) and applied epidemiology training through CIPs on brucellosis and Q fever involving 28 people (2012–2013), funded by the AHIF/World Bank. A second cohort of 3 public health, 2 domestic animal health, and 1 wildlife health professional is undertaking the 2-year OH Epidemiology Fellowship (2014–2016) including Master's degree, CIPs, economic evaluation of zoonotic disease control policies, and development of a national language scenario-based training programme in zoonotic disease outbreak investigation, funded by the EU.	Integrating Education and Actin for One Health in South Asia <a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a> Epidemiology Fellowship <a href="http://www.onehealthnetwork.asia/ohfep">www.onehealthnetwork.asia/ohfep</a>
One Health Asia Program- Fighting Zoonosis in Afghanistan, Bangladesh and Nepal	Afghanistan Bu Ali Rehabilitation and Aid Network	Relief International	EU	Providing training to CHWs and community-based organisations in recognition and reporting of zoonotic diseases in Mohmand Dara, Lal pur and Goshta districts, bordering Pakistan.	N/A
<b>Bangladesh</b>					
OH Master's education and applied epidemiology training	IEDCR; DLS; CVASU	Massey University	AHIF/WB and EU	OH Master's education for 5 human and 7 animal health professionals (2010–2011) and applied epidemiology training through CIPs on anthrax and rabies PEP treatment involving ~1,500 people (2012–2013), funded by the World Bank/AHIF. A second cohort of 2 public health, 2 domestic animal, and 2 wildlife veterinarians is undertaking a 2-year OH Epidemiology Fellowship (2014–2016 as described above under Afghanistan.	Integrating Education and Actin for One Health in South Asia <a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a> Epidemiology Fellowship <a href="http://www.onehealthnetwork.asia/ohfep">www.onehealthnetwork.asia/ohfep</a>
One Health Asia Program- Fighting Zoonosis in Afghanistan, Bangladesh and Nepal	None	Relief International	EU	Providing training to CHWs and community-based organisations in recognition and reporting of zoonotic diseases in Sirajganj, Pabna, and Lalmonirhat districts.	<a href="http://www.ri.org/programs/one-health-asia-program-bangladesh">www.ri.org/programs/one-health-asia-program-bangladesh</a>
FETP	IEDCR	CDC	CDC	In 2011, CDC designated Bangladesh as a CDC Global Disease Detection (GDD) Center for enhancing global health security for rapid detection and response to emerging and re-emerging infectious diseases and hosts the 2-year intensive FETP program.	<a href="http://www.iedcr.org/index.php?option=com_content&amp;view=article&amp;id=141:fetpbmain&amp;catid=24:fetpb">www.iedcr.org/index.php?option=com_content&amp;view=article&amp;id=141:fetpbmain&amp;catid=24:fetpb</a>

Table 4 (Continued)

Programme title	National institutions and partners	International partners	Funder	Programme description	Reference
OH MSc	CVASU			CVASU will establish a One Health Institute in 2017 which will include an OH MSc programme providing postgraduate veterinary and medical OH education.	N/A
<b>Bhutan</b>					
OH Master's education and applied epidemiology training	Department of Livestock; Department of Public Health; Bhutan Agriculture and Food Regulation Agency	Massey University	World Bank/AHIF and EU	Applied epidemiology training through CIPs evaluating OH collaboration and rabies-related dog population studies involving 60 people (2012–2013), funded by the AHIF/World Bank. A second cohort of 3 public health, 2 domestic animal health, and 1 wildlife health professional is undertaking the 2-year OH Epidemiology Fellowship (2014–2016) as described under Afghanistan and Bangladesh above.	Integrating Education and Actin for One Health in South Asia <a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a> Epidemiology Fellowship <a href="http://www.onehealthnetwork.asia/ohefp">www.onehealthnetwork.asia/ohefp</a>
<b>India</b>					
Postgraduate Diploma and a Postgraduate Certificate in OH	Kerala Veterinary and Animal Sciences University	N/A	N/A	Kerala Veterinary and Animal Sciences University established a Centre for OH Education, Advocacy, Research and Training (COHEART) in February 2014 and offers a Postgraduate Diploma and a Postgraduate Certificate in OH.	<a href="http://www.coheart.ac.in/">www.coheart.ac.in/</a>
India Research Initiative on Peri-Urban Human-Animal Environment Interface (PERIMILK study)	Public Health Foundation, India	International Livestock Research Institute	IDRC, Canada	PERIMILK is a research capacity building programme that awards 8–10 Master's and 1–2 PhD fellowships for OH research. The project aims to generate a stronger evidence-based cross-sector policy and local capacity for integrating public health, animal/livestock health, urban planning, local food production, and social development in selected peri-urban sites in India.	<a href="http://www.perimilk.phfi.org/zoonoses-and-food-safety/">www.perimilk.phfi.org/zoonoses-and-food-safety/</a>
OH Master's education and applied epidemiology training	Ministry of Agriculture and Farmers Welfare; Ministry of Health and Family Welfare	Massey University	World Bank/AHIF	Provided OH Master's education and applied epidemiology training to 8 human health and 13 animal health professionals in India in 2010–2012.	<a href="http://www.onehealthnetwork.asia/node/313">www.onehealthnetwork.asia/node/313</a>

Table 4 (Continued)

Programme title	National institutions and partners	International partners	Funder	Programme description	Reference
<b>Nepal</b>					
OH Master's education and applied epidemiology training	MOH; MOAD; Ministry of Livestock Development (MOLD); NZFHRC; AFU, Rampur, Chitwan	Massey University	World Bank/AHIF and EU	OH Master's education for 5 human and 7 animal health professionals (2010–2011) and applied epidemiology training through CIP on leptospirosis involving 40 people (2012–2013), funded by the World Bank/AHIF. A second cohort of 2 public health, 2 domestic animal, and 2 wildlife veterinarians is undertaking a 2-year OH Epidemiology Fellowship (2014–2016) as described above under Afghanistan.	Integrating Education and Actin for One Health in South Asia <a href="http://www.onehealthnetwork.asia/node/596">www.onehealthnetwork.asia/node/596</a> Epidemiology Fellowship <a href="http://www.onehealthnetwork.asia/ohfp">www.onehealthnetwork.asia/ohfp</a>
One Health Asia Program- Fighting Zoonosis in Afghanistan, Bangladesh and Nepal	ANSAB, Relief International Nepal, AFU; DLS; DOHS	N/A	EU	Relief International, in partnership with ANSAB has trained 90 CHWs to facilitate early detection, reporting and control of zoonosis in coordination with District Health Office and Veterinary Offices. It is currently implemented in Chitwan, Rupendehi, and Banke districts. Collaborated with Agriculture & Forest University, Chitwan to develop zoonoses information resource centre and conducting research on zoonotic diseases.	N/A
Emerging Pandemic Threat Program- PREDICT	CMDN; MOH; MOLD; Dept of National Parks and Wildlife Conservation; Patan Academy of Health Sciences	University of California, Davis, USA; FAO	USAID	PREDICT trained 21 veterinary doctors, ecologists, laboratory personnel, and managers to enhance expertise in field surveillance, biosafety, animal capture and handling, laboratory diagnostics, and information management in Nepal.	<a href="http://www.vetmed.ucdavis.edu/ohi/predict">www.vetmed.ucdavis.edu/ohi/predict</a>
<b>Pakistan</b>					
OH Master's education and applied epidemiology training	Ministry of Health; Ministry of Agriculture; National Agricultural Research Centre (NARC); National Institute of Health (NIH)	Massey University	World Bank/AHIF	OH Master's education for 3 human and 5 animal health professionals (2010–2011) and applied epidemiology training through CIP on brucellosis and CCHF involving 40 people (2012–2013), funded by the World Bank/AHIF.	<a href="http://www.onehealthnetwork.asia/node/313">www.onehealthnetwork.asia/node/313</a>

Table 4 (Continued)

Programme title	National institutions and partners	International partners	Funder	Programme description	Reference
Pakistan – US Science and Technology Cooperation Program	Higher Education Commission, Pakistan	N/A	National Academies of Sciences (NAS) USA	Six fellowships have been provided for early to mid-career professionals from medical and veterinary faculties to undertake a 12-month OH research programme involving 5 months working at an affiliated mentor's institution and the following 5 months continuing their research in Pakistan	<a href="http://www.sites.nationalacademies.org/PGA/pakistan/index.htm">www.sites.nationalacademies.org/PGA/pakistan/index.htm</a>
The CDC-Pakistan Field Epidemiology and Laboratory Training Program (FELTP) program	Ministry of Health; Ministry of Agriculture; NIH; NARC	N/A	USAID	On the job training to strengthen the capacity for the detection of zoonotic diseases involving the NIH, NARC, provincial Department of Health, departments and provincial L&DD departments through the FELTP.	<a href="http://www.cdc.gov/globalhealth/security/stories/disease-detectives-pakistan.html">www.cdc.gov/globalhealth/security/stories/disease-detectives-pakistan.html</a>
<b>Sri Lanka</b>					
OH Master's education and applied epidemiology training	Ministry of Public Health and Ministry of Agriculture, Irrigation and Livestock	Massey University	World Bank/AHIF	OH Master's education for 11 human and 10 animal health professionals (2010–2011) and applied epidemiology training through CIP on leptospirosis, rabies, and brucellosis involving 190 people (2012–2013).	<a href="http://www.onehealthnetwork.asia/node/313">www.onehealthnetwork.asia/node/313</a>
OH research and training activities	University of Peradeniya, Sri Lanka	University of California, Davis; Massey University	N/A	University of Peradeniya is actively engaged in OH research and training activities in collaboration with University of California, Davis, and the university is engaged in a veterinary education twinning programme with Massey University of New Zealand.	N/A
Postgraduate Diploma and Master's degree in Applied Epidemiology	University of Peradeniya, Sri Lanka	N/A	N/A	The degree has an OH focus. It was started with assistance of the AHIF/WB project to provide educational opportunities in Sri Lanka for veterinary and medical professionals to undertake a Master's degree in epidemiology and is now self-sustaining.	<a href="http://www.pgis.lk/appepi.php">www.pgis.lk/appepi.php</a>

AHIF, Avian and Human Influenza Facility; EU, European Union; CIP, Collaborative Investigation Projects; CHWs, Community Health Workers; IEDCR, Institute of Epidemiology Disease Control and Research; DLS, Department of Livestock Services; CVASU, Chittagong Veterinary and Animal Sciences University; FETP, Field Epidemiology Training Programs; MOH, Ministry of Health; AFU, Agriculture and Forestry University; ANSAB, Asia Network for Sustainable Agriculture and Bio Resource; USAID, United States Agency for International Development.

universities offer an MSc in epidemiology, we restricted reporting to those with a reported OH focus.

### **South Asian regional OH activities**

Following the outbreaks of HPAI (H5N1), the WHO, the Food and Agriculture Organization of the United Nations (FAO), and the World Organisation for Animal Health (OIE) established a tri-partite relationship in SAARC and Association of Southeast Asian Nations (ASEAN) countries under the Asia Pacific Strategy for Emerging Diseases, funded by the EU. The tri-partite defined collaborative mechanisms for disease surveillance and outbreak management (62). While there have been many challenges to integrating the activities of the three large international organisations in the region, the tri-partite has facilitated inter-sectoral relationships and awareness of OH approaches through annual regional meetings on multisectoral collaboration for the prevention and control of zoonoses since 2010.

Each of the three organisations individually contributes to strengthening OH in the region. The WHO South East Asian Regional Office is supporting the development of a regionally integrated rabies control programme. Changes to the WHO's International Health Regulations are a driver for the human health sector to report on zoonotic diseases. FAO's Regional Support Unit for SAARC is the only sub-regional institution and coordination mechanism in South Asia dealing with animal health, and OH components are incorporated where possible. OIE supports the strengthening of veterinary services, predominantly through the Performance of Veterinary Services tool ([www.oie.int/support-to-oie-members/pvs-evaluations/oie-pvs-tool/](http://www.oie.int/support-to-oie-members/pvs-evaluations/oie-pvs-tool/)).

Massey University implemented a regional OH capacity building programme to strengthen epidemiology and health risk management skills through integrated OH Master's education and applied epidemiology training, funded by the Avian and Human Influenza Facility (AHIF), administered by the World Bank from 2010 to 2013 ([www.onehealthnetwork.asia/node/313](http://www.onehealthnetwork.asia/node/313)). Under the programme, an OH Hub was established in six countries, led by the two government institutions responsible for human and animal health in each country, providing a networking and communication platform for individuals from government, non-government, university institutions, professional bodies, and international organisations working in OH-related areas. The OH Network – South Asia was established in Hubnet, a web-based communication and collaborative system developed by the Massey University, with a current membership of 249 professionals working in OH-related areas in South Asia. A national OH symposium was supported in each country, culminating with a regional OH symposium (Paro, Bhutan December 2013) during which nine regional resolutions were formulated to strengthen OH in the region ([www.onehealthnetwork.asia/node/492](http://www.onehealthnetwork.asia/node/492)).

The One Health Association of South Asia is a second regional OH network facilitated by the EcoHealth Alliance with the mission of facilitating communication and cooperation among scientific and government agencies in member countries through meetings, workshops, research, and information exchange (63).

Other programmes are implemented in multiple countries in the region but not operating as full regional programmes. A second Massey University capacity building programme involving 24 human health, domestic animal health, and wildlife health professionals from Afghanistan, Bangladesh, Bhutan, and Nepal was implemented from September 2014 to October 2016, funded by the EU. Relief International's 'Fighting Zoonoses in Afghanistan, Bangladesh and Nepal' programme ([www.devex.com/jobs/one-health-training-capacity-building-consultant-afghanistan-bangladesh-or-nepal-373076](http://www.devex.com/jobs/one-health-training-capacity-building-consultant-afghanistan-bangladesh-or-nepal-373076)) was also funded by the EU, to reduce the incidence of zoonoses and alleviate their impact through community awareness, capacity building, and institutionalisation of OH. The United States Agency for International Development (USAID) funded PREDICT programme led by the University of California, Davis is implemented in Nepal, Bangladesh, and India with the aim of developing an early warning system to detect, track, and predict the emergence of new zoonotic pathogens in animals that could pose a threat to human health ([www.vetmed.ucdavis.edu/ohi/predict](http://www.vetmed.ucdavis.edu/ohi/predict)). The CDC is implementing both 3-month and 2-year Field Epidemiology Training Programs for public health and laboratory personnel in Pakistan, India, and Bangladesh, which include public health and animal health professionals. FAO is implementing Field Epidemiology Training Programs programmes for veterinarians in multiple countries.

### **Government support for OH in South Asia**

#### **Afghanistan**

A number of international organisations have worked to facilitate collaboration through the signing of memoranda of understanding between the government institutes and general directorates responsible for human and animal health in Afghanistan. However, to date these have not resulted in sustainable collaboration once the supporting donor-funded projects ended. In May 2012, a National Zoonotic Disease Committee was established with the support of FAO and WHO. In 2013, Massey University facilitated the establishment of an OH Hub with focal points from the Afghanistan National Public Health Institute and the General Directorate of Animal Health and Production. However, neither organisation has remained active. Massey University, Health Protection Research Organisation, and Relief International are supporting collaboration in OH research through evaluation of zoonotic disease control policies and investigation of zoonotic disease outbreaks under the current EU-funded

OH in South Asia programme. The dependence on donor-funded programmes and political instability create a challenging environment for establishing sustainable collaboration to manage zoonotic diseases in Afghanistan.

#### Bangladesh

Multisectoral committees were formed at all tiers of the government to manage HPAI (H5N1) in the early 2000s. Subsequently, the human and animal health sectors have continued to collaborate in controlling anthrax outbreaks, progressive implementation of a rabies control strategy, and containment of antimicrobial resistance. Bangladesh developed a Strategic Framework for OH Approach to Infectious Diseases in 2012 which was later endorsed by the Ministry of Health & Family Welfare, the Ministry of Fisheries and Livestock, and the Ministry of Environment and Forests, with the support of FAO, WHO, and the United Nations Children's Fund ([www.iedcr.org/pdf/files/One%20Health/Strategic\\_framework\\_for\\_One\\_Health\\_Bangladesh-26%20Jan.pdf](http://www.iedcr.org/pdf/files/One%20Health/Strategic_framework_for_One_Health_Bangladesh-26%20Jan.pdf)). The Strategic Framework 'provides direction for prevention, early warning and control of emerging, re-emerging, and high impact infectious diseases at the human–animal–ecosystem interface in Bangladesh'. Significant progress has been made in implementing the strategy, with the establishment of an Inter-Ministerial Steering Committee and an OH Secretariat in June 2016. The Secretary of Health is the initial chair of the Steering Committee which will be rotated every 3 years. The OH Secretariat initially comprising one officer seconded from the health, livestock, and forest sectors will be located at the Institute of Epidemiology Disease Control and Research, with support from the USAID Preparedness and Response project, FAO and CDC.

'OH Bangladesh' is the major professional OH network in Bangladesh, inaugurated in 2008. The National Co-ordination Committee, formed under this organisation, arranges monthly meetings and an annual international OH conference in Bangladesh. The OH Hub, Bangladesh, established in 2013, with focal points from the Institute of Epidemiology Disease Control and Research and the Department of Livestock Services and a membership of 44 ([www.onehealthnetwork.asia/sites/bangladeshonehealthhub](http://www.onehealthnetwork.asia/sites/bangladeshonehealthhub)), is integrated with and supports the OH Bangladesh organisation.

#### Bhutan

An extremely successful collaboration between the human and animal health authorities has responded to stamp out avian influenza outbreaks, forming a strong platform for the subsequent development of OH initiatives. The Ministry of Health and the Ministry of Agriculture and Forests in Bhutan have developed and approved an OH Strategic Plan 2016–2020, which is pending approval of the Cabinet of Ministers. The plan is a 5-year strategic document that will guide all sectors and agencies involved

in the preparedness and prevention of zoonoses and other public health risks through an OH approach.

The Department of Public Health, the Department of Livestock, and Bhutan Agriculture and Food Regulatory Authority have jointly developed guidelines for the prevention and control of zoonotic diseases, namely, National Influenza Pandemic Preparedness and Response Plan for H5N1 and H7N9, National Rabies Prevention and Control Plans in Animals (2016), National Guidelines for Rabies Prophylaxis in Humans (2012), Guidelines for Preparedness, Surveillance, Control of Anthrax in Humans and Animals in Bhutan (2013). All these guidelines emphasise effective and timely communication of suspected or confirmed outbreaks, and collaboration among the aforementioned departments and other relevant sectors from central to field levels.

#### India

A number of government-led initiatives established inter-sectoral platforms in response to the threat of potential pandemic diseases such as HPAI (H5N1) and SARS. An Inter-Ministerial Task Force and a Joint Monitoring Group were established in 2004 to facilitate collaborative multisectoral management of HPAI (H5N1) (64). A National Standing Committee on Zoonoses was constituted by the Indian government in 2005 and headed by the Director of Health Services to recommend policies, operational research, and inter-sectoral collaboration on the control of zoonoses in the country (44). In 2010, the CDC and the National Center for Disease Control in India signed a memorandum of understanding for the establishment of the India Global Disease Detection Regional Center to strengthen the Epidemic Intelligence Service of India, supporting emerging disease surveillance, improving preparedness and response to outbreaks, strengthening laboratory safety and bio safety, and improving zoonotic disease investigation and control (U.S. India Bilateral Cooperation on Public Health and Research, U.S. Department of State. Retrieved from [www.state.gov/r/pa/prs/ps/2012/06/192275.htm](http://www.state.gov/r/pa/prs/ps/2012/06/192275.htm)). While these initiatives have responded to potential pandemic threats, they have not yet resulted in institutionalising an OH approach that supports the implementation of coordinated OH research programmes that contribute to the formulation and implementation of effective integrated policies for controlling zoonotic diseases.

#### Maldives

There was no evidence of OH activities in the Maldives, which has a small livestock population and veterinary services provided by Sri Lanka.

#### Nepal

The Department of Livestock Services and the Department of Health Services have collaborated to control HPAI (H5N1), Japanese encephalitis, and rabies, producing



rabies vaccine for human use since 1986. A multisectoral task force was formed under the leadership of the public health authority in response to the threat of SARS in 2001. The animal and public health sectors developed an integrated National Avian Influenza Strategic Plan, approved by the Council of Ministers in 2006, involving the Ministry of Home Affairs, Ministry of Federal Affairs and Local Development, relevant stakeholders and external development partners including United Nations agencies.

Both aforementioned departments are working towards the institutionalisation of OH by developing an 'OH Strategic Framework for Nepal' with support from other development partners including FAO. The Directorate of Animal Health has initiated the establishment of 75 district-level OH hubs, providing a single platform to discuss OH issues at district level. The OH Hub, Nepal, was established in 2013 with the Directorate of Animal Health and the Epidemiology and Disease Control Department as focal points, with support from Massey University.

#### Pakistan

Pakistan demonstrated an exemplary collaboration between the Ministry of Health and the Ministry of Livestock to control an outbreak of HPAI (H5N1) in 2008 following identification of the first human avian influenza case in Pakistan in November 2007 (65). A similar collaboration was implemented to manage H1N1 (swine flu) from 2010 to 2012. However, in 'peace time', especially after the devolution phenomenon, there has not been strong governmental support nor inter-provincial efforts for expanding OH in Pakistan. The adoption of International Health Regulations by Pakistan in 2016 provides an opportunity for the revival of better coordination between federal and provincial governments to address the issue of zoonoses under an OH approach. However, strong political will is required to activate such joint efforts to better handle the public health issues in this part of the world.

#### Sri Lanka

A joint technical committee for avian influenza was established under the Avian Influenza Preparedness and Response programme in Sri Lanka in 2008 ([www.epid.gov.lk/web/attachments/article/180/Background on AI& PI.pdf](http://www.epid.gov.lk/web/attachments/article/180/Background%20on%20AI%20PI.pdf)), co-chaired by the Director General of the Department of Animal Production and Health of the Ministry of Rural Economic Affairs and the Director General of Health Services, Ministry of Health. While Sri Lanka did not experience any outbreaks of HPAI (H5N1), this joint technical committee is still functioning well, meeting every month at the Ministry of Health. Two further joint technical committees have recently been established for rabies and for stray dog population control, respectively hosted by the Ministry of Health and the Ministry of Local Government and Provincial

Council. Both committees include members from the Ministry of Health, the Ministry of Rural Economic Affairs, and the Ministry of Provincial Councils and Local Government.

While an OH culture has not yet strongly formed at an institutional level, collaboration in zoonotic disease control arises as a result of the personal relationships between professionals in the human health, domestic animal health, and wildlife health sectors that have developed through the OH activities described above.

## Discussion

It is a challenge to present a comprehensive picture of OH in South Asia, given the diversity of multiple countries and cultures, the multiple national institutions, and the multiple international institutions that are involved to varying extents with OH-related activities. Nevertheless, by integrating information from multiple sources, we were able to generate the first-ever landscape analysis of OH research, training, and government support in this very diverse region.

### OH research

Comparison of the peer-reviewed publications on zoonotic disease research with those that specifically relate to OH studies indicates that only a very small proportion of *ad hoc* research can be defined as truly multidisciplinary OH research. A similar situation was identified with respect to rabies research in India, despite efforts of the Roadmap to Combat Zoonoses in India to provide strategic direction for multidisciplinary zoonotic disease research through a strategic research agenda (4). While most animal health institutions in South Asia conduct zoonotic disease research, a large proportion of which estimates disease prevalence in animal populations, very few public health institutions conduct zoonotic disease research. As a result, there is a significant lack of reliable information on the burden of zoonotic diseases in human populations, despite evidence that the impact of some zoonoses is higher than that of malaria, and comparable to that of HIV/AIDS (47). Reliable estimates of zoonotic disease burdens in humans as well as in animals are important for formulating effective zoonotic disease control policies. There is a major need for well-coordinated and well-designed zoonotic disease research programmes, integrated within an OH framework to produce information of value in both human and animal populations for the development of effective integrated OH disease control policies.

To date, the most effective OH research appeared to be conducted within larger multidisciplinary, multi-collaborator, multi-year research programmes, such as the PERIMILK programme in India and the Zoonoses and Emerging Livestock Systems programme in Bangladesh. Such large-scale programmes that provide a suitable

framework for integrated OH research require considerable resourcing and effective management and leadership to integrate the multidisciplinary inputs necessary to produce information of value for zoonotic disease control policy. While these programmes have been supported by international funding sources, national organisations such as the Indian Council of Medical Research and the Indian Council of Agricultural Research have the potential to fund such multidisciplinary multi-study programmes. The OH strategies developed in Bangladesh and Bhutan provide the framework for collaborative leadership and coordinated funding and implementation of integrated OH research programmes in their countries. However, there is a clear need for ongoing national and international support to build OH research capacity through the implementation of integrated OH research programmes that are supported by education and training to strengthen these initiatives in South Asia. Most importantly, there is a need to develop sustainable research platforms within the region that can keep functioning beyond the lifespan of a single project and for continued advocacy for the OH approach to policy.

### **OH training**

Only a small number of truly integrated OH capacity building programmes have been implemented within the South Asia region, involving long-term education and training of health professionals from multiple sectors. Postgraduate OH education programmes are beginning to be offered within the region, notably the Centre for OH Education, Advocacy, Research and Training programme at Kerala University in India, the Masters of Applied Epidemiology in Sri Lanka, and the proposed OH Institute and associated OH-focused MSc at Chittagong Veterinary and Animal Sciences University in Bangladesh. The challenge is to create an OH education programme that is well-balanced and therefore attractive to both human health and animal health professionals.

Joint education of professionals from different sectors is an effective way of building understanding and trust between disciplines, breaking down the barriers and misconceptions between the medical and veterinary professions. Effective OH training and education should facilitate participants towards a transdisciplinary conceptual framework that draws together disciplinary-specific theories, concepts, and approaches to address common problems. Participants' experience in Massey University's capacity-building programmes has shown that learning together in a joint postgraduate degree programme and working together in applied epidemiology projects and policy evaluation build understanding and relationships, which lay the foundation for implementing OH research and sustainable policies for managing emerging and endemic zoonotic diseases.

### **Government support for OH**

Formulation and implementation of policies for collaborative integrated control of zoonotic diseases in human and animal populations is strongly dependent on the formation of a government-led OH strategy and institutionalisation of OH. Formal collaborative mechanisms were established in all South Asian countries in the mid-2000s to manage emerging disease threats such as HPAI (H5N1), H1N1, and SARS. However, sustainability of these collaborations for managing endemic zoonoses in 'peace time' has been very variable. Some countries have made significant progress towards building a strong OH network and institutionalising OH, while in other countries collaboration occurs as a result of individual advocates and where it is supported by donor funding. Bangladesh is the leading South Asian country with its One Health Strategic Framework signed by the three responsible Ministers in 2012 and is making steady progress implementing the strategy, with the establishment of an Inter-Ministerial Steering Committee for One Health and a One Health Secretariat in June 2016. The government of Bhutan is also making good progress towards a government-led Strategic Framework for One Health, with a strategic document signed by the relevant ministers and awaiting approval of the Cabinet of Ministers. While Nepal has not yet developed a national OH strategy, the establishment of district-level OH hubs serving as a single platform for issues associated with zoonotic disease control is a significant development. Some inter-sectoral collaboration occurs in Sri Lanka and Pakistan, and the collaborative networks, while largely dormant are activated and meet as and when required, but collaboration is not yet supported by a national government-led strategy. In India, the Public Health Foundation India leads initiatives and advocacy for an integrated OH approach to research and policy formulation for controlling zoonotic diseases. While national multisectoral committees have been established in India, these have not yet translated into effective collaborative research or policy formulation. In the absence of any governmental structure to support OH, collaboration in Afghanistan is still very *ad hoc* and largely dependent on donor-led advocacy and support.

### **Conclusion**

Substantial behavioural, attitudinal, and institutional changes are required to support effective OH research and training and the formulation and implementation of integrated zoonotic disease control policies. Significant progress has been made in some countries of South Asia in the 15 years since the early outbreaks of HPAI (H5N1). It is important that national and international agencies continue supporting this progress, in particular through integrated OH zoonotic disease research and education programmes that bring together professionals

from different sectors over a sufficiently long period to build relationships, understanding, and respect for the roles and expertise of professionals in different sectors, generating a transdisciplinary conceptual framework to address common problems.

## Acknowledgements

We gratefully acknowledge all those who have provided information that has contributed to the OH landscape represented in this article.

## Conflict of interest and funding

The authors have not received any funding or benefits from industry or elsewhere to conduct this study.

## References

- Zinsstag J, Schelling E, Waltner-Toews D, Whittaker M, Tanner M. Theoretical issues of One Health. In: Zinsstag J, et al. eds. *One Health: the theory and practice of integrated health approaches*. Wallingford, UK: CAB International; 2015, pp. 16–25.
- Grace D, Mutua F, Ochungo P, Kruska R, Jones K, Brierley L, et al. Mapping of poverty and likely zoonoses hotspots, in Zoonoses Project 4. Report to Department for International Development, UK. *International Livestock Research Institute*; 2012, p. 119. Available from: [https://cgspace.cgiar.org/bitstream/handle/10568/21161/ZooMap\\_July2012\\_final.pdf](https://cgspace.cgiar.org/bitstream/handle/10568/21161/ZooMap_July2012_final.pdf) [cited 17 October 2016].
- Mackey TK, Liang BA, Cuomo R, Hafen R, Brouwer KC, Lee DE. Emerging and reemerging neglected tropical diseases: a review of key characteristics, risk factors, and the policy and innovation environment. *Clin Microbiol Rev* 2014; 27: 949–79.
- Kakkar M, Abbas SS, Hossain SS. One Health: a perspective from the human health sector. *Revue Scientifique Et Technique-Office International Des Epizooties* 2014; 33: 407–412.
- Lobo DA, Velayudhan R, Chatterjee P, Kohli H, Hotez PJ. The neglected tropical diseases of India and South Asia: review of their prevalence, distribution, and control or elimination. *PLoS Negl Trop Dis* 2011; 5: e1222.
- WHO (2015). The control of neglected zoonotic diseases. From advocacy to action. Report of the fourth international meeting held at WHO headquarters. Geneva, Switzerland. p. 48. Available from: [http://www.who.int/neglected\\_diseases/ISBN9789241508568\\_ok.pdf](http://www.who.int/neglected_diseases/ISBN9789241508568_ok.pdf) [cited 17 October 2016].
- Gibbs EPJ. The evolution of One Health: a decade of progress and challenges for the future. *Vet Rec* 2014; 174: 85–91.
- Horby PW, Pfeiffer D, Oshitani H. Prospects for emerging infections in East and Southeast Asia 10 years after severe acute respiratory syndrome. *Emerg Infect Dis* 2013; 19: 853–60.
- Welburn SC, Beange I, Ducrotoy MJ, Okello AL. The neglected zoonoses – the case for integrated control and advocacy. *Clin Microbiol Infect* 2015; 21: 433–43.
- Halliday J, Daborn C, Auty H, Mtema Z, Lembo T, Bronsvooort BM, et al. Bringing together emerging and endemic zoonoses surveillance: shared challenges and a common solution. *Philos Trans R Soc Lond B Biol Sci* 2012; 367: 2872–80.
- Sekar N, Shah NK, Abbas SS, Kakkar M. Research options for controlling zoonotic disease in India, 2010–2015. *PLoS One* 2011; 6: e17120.
- WHO (2012). Research priorities for zoonoses and marginalized infections. Technical Report of the TDR Disease Reference Group on zoonoses and marginalized infectious diseases of poverty. Geneva, Switzerland: World Health Organization. p. 136.
- Abbas SS, Kakkar M. Research & policy disconnect: The case of rabies research in India. *Indian J Med Res* 2013; 138: 560–1.
- Galaz V, Leach M, Scoones I, Stein C. The political economy of One Health research and policy. STEPS Working Paper 81. Brighton: STEPS Centre; 2015, p. 46.
- Grace D. The business case for One Health. *Onderstepoort J Vet Res* 2014; 81: E1–6.
- Rabinowitz PM, Kock R, Kachani M, Kunkel R, Thomas J, Gilbert J, et al. Toward proof of concept of a one health approach to disease prediction and control. *Emerg Infect Dis* 2013; 19: e130265.
- Schelling E, Hattendorf J. One Health study designs. In: J. Zinsstag, et al. eds. *One Health: the theory and practice of integrated health approaches*. Wallingford, UK: CAB International; 2015, pp. 107–21.
- Choi BC, Pak AW. Multidisciplinarity, interdisciplinarity, and transdisciplinarity in health research, services, education and policy: 3. Discipline, inter-discipline distance, and selection of discipline. *Clin Invest Med* 2008; 31: E41–8.
- Vink WD, McKenzie JS, Cogger N, Borman B, Muellner P. Building a foundation for ‘One Health’: an education strategy for enhancing and sustaining national and regional capacity in endemic and emerging zoonotic disease management. *Curr Top Microbiol Immunol* 2013; 366: 185–205.
- Akbarian Z, Ziyi G, Schauwers W, Noormal B, Saeed I, Qanee AH, et al. Brucellosis and *Coxiella burnetii* infection in householders and their animals in secure villages in Herat province, Afghanistan: a cross-sectional study. *PLoS Negl Trop Dis* 2015; 9: e0004112.
- Mustafa ML, Ayazi E, Mohareb E, Yingst S, Zayed A, Rossi CA, et al. Crimean-Congo hemorrhagic fever, Afghanistan, 2009. *Emerg Infect Dis* 2011; 17: 1940–1.
- Hahn MB, Epstein JH, Gurley ES, Islam MS, Luby SP, Daszak P, et al. Roosting behaviour and habitat selection of *Pteropus giganteus* reveal potential links to Nipah virus epidemiology. *J Appl Ecol* 2014; 51: 376–87.
- Islam MS, Hossain MJ, Mikolon A, Parveen S, Khan MSU, Haider N, et al. Risk practices for animal and human anthrax in Bangladesh: an exploratory study. *Infect Ecol Epidemiol* 2013; 3: 21356.
- Roess AA, Winch PJ, Akhter A, Afroz D, Ali NA, Shah R, et al. Household animal and human medicine use and animal husbandry practices in rural Bangladesh: risk factors for emerging zoonotic disease and antibiotic resistance. *Zoonoses Public Health* 2015; 62: 569–78.
- Nahar N, Uddin M, Gurley ES, Khan MSU, Hossain MJ, Sultana R, et al. Pig illnesses and epidemics: a qualitative study on perceptions and practices of pig raisers in Bangladesh. *Vet Ital* 2012; 48: 157–65.
- Hayman DTS, Gurley ES, Pulliam JRC, Field HE. The application of One Health approaches to Henipavirus research. *Curr Top Microbiol Immunol* 2013; 365: 155–70.
- Islam MA, Khatun MM, Werre SR, Sriranganathan N, Boyle SM. A review of Brucella seroprevalence among humans and animals in Bangladesh with special emphasis on epidemiology, risk factors and control opportunities. *Vet Microbiol* 2013; 166: 317–26.
- Rahman MM, Rahman MH. Innovating veterinary public health challenges of Bangladesh to integrate the concept of ‘one world, one health’. *Sci J Rev* 2012; 1: 111–29.
- International Centre for Diarrhoeal Disease Research, Bangladesh. Improving human health through a One Health approach in Bangladesh. HSB (Health Sci Bull) 2011; 9: 17–20.
- Wangchuk S, Pelden S, Dorji T, Tenzin S, Thapa B, Zangmo S, et al. Crimean-Congo hemorrhagic fever virus IgG in goats, Bhutan. *Emerg Infect Dis* 2016; 22: 919–20.

31. Thapa NK, Tenzin, Wangdi K, Dorji T, Migma, Dorjee J, et al. Investigation and control of anthrax outbreak at the human-animal interface, Bhutan, 2010. *Emerg Infect Dis* 2014; 20: 1524–6.
32. Abbas SS, Venkataramanan V, Pathak G, Kakkar M. Rabies control initiative in Tamil Nadu, India: a test case for the 'One Health' approach. *Int Health* 2011; 3: 231–9.
33. Schmidt WP, Boisson S, Routray P, Bell M, Cameron M, Torondel B, et al. Exposure to cows is not associated with diarrhoea or impaired child growth in rural Odisha, India: a cohort study. *Epidemiol Infect* 2016; 144: 53–63.
34. Lundborg CS, Vishal D, Ashish P, Purohit MR, Harshada S, Megha S, et al. Protocol: a 'One health' two year follow-up, mixed methods study on antibiotic resistance, focusing children under 5 and their environment in rural India. *BMC Public Health* 2015; 15: 1321.
35. Koteeswaran A. Seroprevalence of leptospirosis in man and animals in Tamilnadu. *Indian J Med Microbiol* 2006; 24: 329–31.
36. Masthi NRR, Narayana DHA, Praveen K, Gangaboraiah, Ashwin B. Epidemiology and prevention of animal bite and human rabies in a rural community – one health experiment. *Asian Pac J Trop Dis* 2014; 4(Suppl 1): S486–90.
37. Singh BB, Gajadhar AA. Role of India's wildlife in the emergence and re-emergence of zoonotic pathogens, risk factors and public health implications. *Acta Trop* 2014; 138: 67–77.
38. Asokan GV, Asokan V, Tharyan P. One health national programme across species on zoonoses: a call to the developing world. *Infect Ecol Epidemiol* 2011; 1: 8293.
39. Chatterjee S, Riaz H. Rabies: beware of the dog. *BMJ* 2013; 347: f5912.
40. Ghatak S, Singh BB. Veterinary public health in India: current status and future needs. *Rev Sci Tech* 2015; 34: 713–27.
41. Utpal D. Genesis of 'Veterinary Public Health' and route to 'One Health'. *Intas Polivet* 2015; 16: 182–6.
42. Kakkar M, Abbas SS, Hossain SS. One Health: a perspective from the human health sector. *Rev Sci Tech* 2014; 33: 407–12.
43. Singh BB, Ghatak S, Banga HS, Gill JPS, Singh B. Veterinary urban hygiene: a challenge for India. *Rev Sci Tech* 2013; 32: 645–56.
44. Vergis J, Das DP, Suryawanshi RD, Mamta N, Pankaj D, Deepthi V, et al. One health approach: veterinary perspectives in global and Indian context. *Adv Anim Vet Sci* 2014; 2(4 Suppl): 11–16.
45. Paudel S, Mikota SK, Nakajima C, Gairhe KP, Maharjan B, Thapa J, et al. Molecular characterization of *Mycobacterium tuberculosis* isolates from elephants of Nepal. *Tuberculosis* 2014; 94: 287–92.
46. Pandey G, Dhakal S, Sadaula A, Subedi S, Pandey K, Dhakal I, et al. Status of tuberculosis in bovine animals raised by tuberculosis infected patients in Western Chitwan, Nepal. *Int J Infect Microbiol* 2012; 1: 49–53.
47. Devleeschauwer B, Ale A, Torgerson P, Praet N, de Noordhout CM, Pandey BD, et al. The burden of arasitic zoonoses in Nepal: a systematic review. *PLoS Negl Trop Dis* 2014; 8: e2634.
48. Devleeschauwer B, Aryal A, Sharma BK, Ale A, Declercq A, Deprez S, et al. Epidemiology, impact and control of rabies in Nepal: a systematic review. *PLoS Negl Trop Dis* 2016; 10: e0004461.
49. Baylis M, Barker CM, Caminade C, Joshi BR, Pant GR, Rayamajhi A, et al. Emergence or improved detection of Japanese encephalitis virus in the Himalayan highlands? *Trans R Soc Trop Med Hyg* 2016; 110: 209–11.
50. Hussain I, Arshad MI, Mahmood MS, Akhtar M. Seroprevalence of brucellosis in human, cattle, and buffalo populations in Pakistan. *Turk J Vet Anim Sci* 2008; 32: 315–18.
51. Rowland M, Durrani N, Kenward M, Mohammed N, Urahman H, Hewitt S. Control of malaria in Pakistan by applying delta-methrin insecticide to cattle: a community-randomised trial. *Lancet* 2001; 357: 1837–41.
52. Franco AO, Gomes MGM, Rowland M, Coleman PG, Davies CR. Controlling malaria using livestock-based interventions: a One Health approach. *PLoS One* 2014; 9: e101699.
53. Latif AA, Tanveer A, Maqbool A, Siddiqi N, Kyaw-Tanner M, Traub RJ. Morphological and molecular characterisation of *Echinococcus granulosus* in livestock and humans in Punjab, Pakistan. *Vet Parasitol* 2010; 170: 44–9.
54. Leblebicioglu H, Sunbul M, Memish ZA, Al-Tawfiq JA, Bodur H, Ozkul A, et al. Consensus report: preventive measures for Crimean-Congo hemorrhagic fever during Eid-al-Adha festival. *Int J Infect Dis* 2015; 38: 9–15.
55. Haesler B, Hiby E, Gilbert W, Obeyesekere N, Bennani H, Rushton J. A One Health framework for the evaluation of rabies control programmes: a case study from Colombo City, Sri Lanka. *PLoS Negl Trop Dis* 2014; 8: e3270.
56. Karunanayake D, Matsumoto T, Wimalaratne O, Nanayakkara S, Perera D, Nishizono A, et al. Twelve years of rabies surveillance in Sri Lanka, 1999–2010. *PLoS Negl Trop Dis* 2014; 8: e3205.
57. Liyanaarachchi DR, Rajakaruna RS, Dikkumbura AW, Rajapakse RPVJ. Ticks infesting wild and domestic animals and humans of Sri Lanka with new host records. *Acta Trop* 2015; 142: 64–70.
58. Ahmed K, Wimalaratne O, Dahal N, Khawplod P, Nanayakkara S, Rinzin K, et al. Evaluation of a monoclonal antibody-based rapid immunochromatographic test for direct detection of rabies virus in the brain of humans and animals. *Am J Trop Med Hyg* 2012; 86: 736–40.
59. Gamage CD, Amarasekera J, Palihawadana P, Samaraweera S, Mendis D, Janakan N, et al. Analysis of hospital-based sentinel surveillance data on leptospirosis in Sri Lanka, 2005–2008. *Jpn J Infect Dis* 2012; 65: 157–61.
60. Gamage CD, Koizumi N, Muto M, Nwafor-Okoli C, Kurukurusuriya S, Rajapakse J, et al. Prevalence and carrier status of leptospirosis in smallholder dairy cattle and peridomestic rodents in Kandy, Sri Lanka. *Vector Borne Zoonotic Dis* 2011; 11: 1041–7.
61. Gamage CD, Koizumi N, Perera AKC, Muto M, Nwafor-Okoli C, Ranasinghe S, et al. Carrier status of leptospirosis among cattle in Sri Lanka: a zoonotic threat to public health. *Transbound Emerg Dis* 2014; 61: 91–6.
62. Anonymous (2008). *Zoonotic diseases: a guide to establishing collaboration between animal and human health sectors at the country level*. Geneva, Switzerland: World Health Organization. p. 20.
63. Aguirre A, Daszak P. One Health Alliance of South Asia (OHASA): Predicting and preventing the next emerging disease on the Indian subcontinent – sponsored by the Rockefeller Foundation. *Ecohealth* 2011; 7: S104.
64. Dawra S. *Bird flu: diagnosis and treatment*. Delhi, India: Biotech Books; 2006, p. 200.
65. Karamat KA, Khattak FH, Mahmood B. Avian influenza and program guidelines for its prevention and control in Pakistan. Undated, p. 12. Available from: [http://www.pc.gov.pk/useful\\_links/Papers/Avain\\_influenza\\_new.pdf](http://www.pc.gov.pk/useful_links/Papers/Avain_influenza_new.pdf) [cited 17 October 2016].