ZOONOSES - A DOUBLE EDGED WEAPON

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Received: 02-05-2016 Accepted: 20-08-2016

Zoonotic infections are an ever-growing public health hazard, which lay burden on both medical and veterinary professions and more importantly on the economy and trade of the country. Zoonoses occur throughout the world transcending the natural boundaries. Zoonoses act as a double edged weapon, one by causing serious and fatal diseases in human being and other by undermining the animal health and productivity, thereby producing great financial losses to the animal industries.

Recently the occurrence of zoonoses is increasing widely throughout the world, which requires attention of the scientific community as well as the public in order to undertake control measures. The world is becoming a global community, the public health event in one geographic region or nation often affects the health and economy beyond that region, sometimes even globally. Zoonoses not only affect developing or transition countries which generally have poor public health systems but also the industrialized countries with high health standards as was the case with the Bovine Spongiform Encephalopathy(BSE) crisis in Europe.

Zoonoses is a Greek word derived from the words 'zoon' means animal and 'noses' means diseases. The term "zoonosis" was first coined by Rudolf Virchow, a German physician-scientist who is probably better known as the "Father of Modern Pathology" because of his elucidation of the cellular nature of disease. Since his pronouncement of the word over a century ago, more than eight hundred zoonoses have been recognized and studied. In 1959, the Joint Expert committee of WHO and FAO has defined zoonoses as "those diseases and infections which are naturally transmitted between vertebrate animals and man" (WHO, 1959).

Most zoonotic pathogens can infect more than one host species, including humans. Calvin W. Schwabe, widely known as the "Father of Veterinary Epidemiology" advocated the concept of "One Medicine" to capture the interrelatedness between animal and human health and the medical realities of preventing and controlling zoonotic diseases (Schwabe, 1984).

Zoonoses are among the most frequent and dreaded risk to which mankind is exposed. Out of 1,415 pathogens known to infect humans, 61% are zoonotic. Over 800 pathogens have been identified as zoonoses (Taylor *et al*., 2001, Woolhouse and Gowtage, 2005). The main hotspots of Zoonoses identified are: Nigeria, Ethiopia, Tanzania, Togo and India (ILRI, 2012). Man is dependent on animals either for livelihood (livestock rearing) or for companionship (pets), so he is in continuous interaction with animals and thus he contract zoonoses as wide variety of animals including domestic, domiciliated

and wild animals acts as reservoirs of zoonotic agents. Human exposure to infection mainly depends on the lifestyle and occupation. Most of the developing countries have an agricultural dependent economy with >70% of the small land holders who are rearing livestock are at risk of exposure. As a part of occupation, veterinarians are in continuous association with the animals and thus form a major risk group.

Zoonoses can be either endemic in human population or enzootic in animal population with frequent cross-species transmission. Recently an increasing trend in emerging zoonoses across the globe can be noticed as the world is facing challenges like new variants of organisms (Influenza) or the organisms which were previously susceptible to antibiotics but now attaining multidrug resistance (Multidrug-resistant strains of *Mycobacterium tuberculosis*, Methicillin Resistant *Staphylococcus aureus*). Most of the emerging zoonoses are viral in origin and originate in wild animal hosts. Such zoonotic pathogens are responsible for majority of the new human disease threats and a number of recent international epidemics.

The WHO/FAO/OIE joint consultation on emerging zoonotic diseases held in Geneva on 3-5 May 2004, defined an emerging zoonosis as "a zoonosis that is newly recognized or newly evolved or that has occurred previously but showing an increase in incidence or expansion in geographical area, host or vector range". The concept of emerging infectious diseases appeared in late 1980s and 1990s, when major outbreaks of Bovine Spongiform Encephalopathy (BSE), Avian influenza, Nipah viral infection and Severe Acute Respiratory Syndrome (SARS) occurred across the globe. Over 30 new infectious agents have been detected worldwide in the past three decades; 75% of these are of zoonotic origin (Jones *et al*., 2008).

Modes of Transmission of Zoonotic agents

Different modes of transmission of zoonotic diseases are summarised below.

Classification of Zoonoses

Zoonoses can be classified in a number of ways: based on etiological agent as Bacterial, Viral, Rickettsial, Chlamydial, Mycotic and Parasitic zoonoses. Based on transmission cycle, zoonoses can be classified as 'Direct zoonoses' which are perpetuated in a single vertebrate species (Example: Rabies, Anthrax, Tuberculosis), 'Cyclozoonoses' requiring two or more vertebrate species to complete the transmission cycle (Obligatory cyclozoonoses - Man is a must for completion of lifecycle Example: *Taeniasolium*, Non obligatory zoonoses- Man is accidentally involved in transmission cycle Example: Hydatidosis), 'Metazoonoses' in which both vertebrate and invertebrate species are involved (Example: Plague, Clonorchiasis, Paragonimiasis) and 'Saprozoonoses' that are transmitted via in-animate substance (Example: Histoplasmosis, Cutaneous Larval Migrans). Diseases of domestic or wild animals infecting humans are called anthrapozoonoses. When humans infect other animals; it is called reverse zoonosis or zooanthroponoses. Recent examples include methicillin-resistant *Staphylococcus aureus, Influenza A* virus, *Cryptosporidium parvum* and *Ascaris lumbricoides* (Messenger *et al*., 2014).

Table 1. Different modes of transmission(Pal, 2005)

Mode of transmission		**Examples**
Direct	Contact	Brucellosis, Leptospirosis, Anthrax, Foot and Mouth Disease, Cow pox, Dermatophytosis
Indirect	Transplacental/Vertical	Toxoplasmosis
	Soil	Larva migrans (cutaneous and visceral), Anthrax, Tetanus
	Bite or scratches	Rabies, Cat scratch disease
	Droplet infection	New castle disease, Tuberculosis
	Vector	
	Mechanical	Amoebiasis, Cholera
	Biological	Malaria, Trypanosomiasis, KFD
	Vehicle	
	Blood	Hepatitis B virus , Listeriosis
	Water	Hepatitis A virus , Leptospirosis
	Meat	Salmonellosis, Sarcocystosis, Diphyllobothriosis, Taeniasis
	Milk	Tuberculosis, Brucellosis
	Egg	Salmonellosis, Campylobacteriosis
	Tissue / organ	Listeriosis, Rabies
	Fomite	
	Fomite borne	Anthrax, FMD

Amphixenoses are ubiquitous diseases for which man as well as vertebrate animals act as hosts (Staphylococcosis, Streptococcosis) (Park, 2015 and Sherikar *et al*., 2011)

Epidemiology and economic impact of zoonoses

In low income countries, established and emerging zoonoses make up 26 % of the DALYs (Disability-adjusted life year) lost to infectious disease and 10 % of the total DALYs lost. In contrast, in high income countries it represent < 1 % of DALYs lost to infectious disease and only 0.02 % of the total disease burden (Grace *et al*., 2012). Every year 2.3 billion human infections occur in developing countries from zoonotic diseases, resulting in mortality to the tune of 2.2 million (ILRI, 2012). Over the previous decade, the impact of the emergence of zoonotic diseases like that of BSE, SARS and Influenza A (H1N1, H5N1) have been estimated to be over $20

billion USD in terms of direct economic losses and another $200 billion USD in indirect losses (World Bank, 2012).

Infectious diseases, of which many are zoonoses, remain a concern to all countries which impose a significant burden on economies and public health. Economic impact exists beyond the cost of control, including direct decrease in household income due to reduction in livestock/ product sales and consumption impacts occur due to reduced food security, increased household vulnerability where livestock is used as a risk-coping mechanism and affects the household wealth which influences savings and gender equality (Birol *et al.,* 2010).

The global burden of Rabies dis-proportionately affects Asia, which experiences more than half of global human rabies deaths and approximately 65% of livestock losses and performs more than 90% of post exposure prophylaxis (PEP). Africa is second to Asia in terms of human deaths and livestock losses. Currently over 69,000 rabies deaths occur per year in Africa and Asia (Shwiff *et al.*, 2013).

The incidence of human Tuberculosis due to *Mycobacterium bovis* varies considerably among the countries depending on the prevalence of the disease in cattle, socio-economic conditions, consumer habits and food hygiene practices. In developed countries, *M. bovis* generally accounts for an insignificant share of total tuberculosis cases in humans as in case of USA (less than 2% of total TB cases). The incidence of zoonotic Tuberculosis in developing countries is heterogeneously distributed and the livestock producing rural populations are mostly affected by *M. bovis* infections (Michel *et al*., 2010).

The overall burden of Brucellosis in animal and human populations in low-income countries of tropical Asia and Africa is large. The fact is that, human brucellosis is even more under-reported than animal brucellosis and thus global DALY burden for Brucellosis is yet to be identified (McDermott *et al*., 2013).

Avian influenza strain H5N1 wreaked havoc and spread panic when it first appeared in Hong Kong in 1997. The disease has been reported from many South-East Asian countries including India, Pakistan, Bangladesh, China, Japan and Taiwan (Kumar *et al.,* 2015). The World Bank estimates that an avian flu pandemic could result in a two per cent loss of the World's Gross Domestic Product (GDP) and cost the world economy US$ 800 billion in the space of one year (World Bank, 2012). Japanese encephalitis is endemic in India and many countries of Asia including China and Japan. The total number of cases reported in Asia is estimated to be 30,000 - 50,000 per year (Kumar *et al*., 2015).

Middle East Respiratory Syndrome (MERS) is a viral respiratory disease caused by a novel corona virus (MERS-CoV) that was first identified in Saudi Arabia in 2012. Globally, since September 2012, WHO has been notified of 1195 laboratory-confirmed cases of MERS-CoV infection, including 448 related deaths (WHO, 2015b).

As 2014 progressed, the world has learned a great deal from the largest and longest Ebola outbreak in the history, and these lessons have shaped a more strategic approach going forward. The health crisis snowballed into a humanitarian, social, economic and security crisis shaking the West and Central African countries. As on 30th March 2016, out of 28610 suspected

cases of Ebola in these countries, 15221 were laboratory confirmed cases and 11308 were dead (WHO, 2016).

Billions of people are at risk and millions fall ill every year, many die as a result of consuming unsafe food. Of the approximately 600 million cases of illness caused by the 31 foodborne hazards recognized, infectious agents that cause diarrhoeal diseases accounted for the vast majority (550 million), in particular *Norovirus* (120 million cases) and *Campylobacter* spp. (96 million cases) (WHO, 2015a).

Most parasitic zoonoses are neglected diseases which cause a considerable burden on the health of human and livestock. Cystic echinococcosis cause a persistently

Table 2. DALY (Disability-adjusted life year) lost due to various Zoonoses

<table>
<tr><th>Disease</th><th colspan="2">DALY lost (in millions)</th></tr>
<tr><td>Global burden of food borne disease (WHO, 2015a)</td><td colspan="2">*S. enterica* - 4.0 million, Campylobacteriosis, ETEC (enterotoxigenic *Escherichia coli),* Shigellosis - 1to 3 million each
Taeniasolium infection – 2.8 million
Paragonimiasis – 1.0 million
Trichinellosis – 550</td></tr>
<tr><td rowspan="2">Global burden of Vector borne zoonoses (Institute of medicine, 2008)</td><td colspan="2">DALY lost (in millions)</td></tr>
<tr><td>Mosquito-borne infections
Malaria - 46.5
Lymphatic filariasis – 5.8
Dengue – 0.62
Japanese encephalitis -0.71</td><td>Others
Onchocercosis – 0.48
Leishmaniasis – 2.1
African trypanosomiasis – 1.5
Chagas disease – 0.67</td></tr>
<tr><td>Cutaneous Leishmaniasis (Karimkhani *et al*., 2016)</td><td colspan="2">0·58 per 100 000 people (globally)</td></tr>
<tr><td>Neurocysticercosis in India (Singh *et al*., 2014)</td><td colspan="2">2.10 million</td></tr>
<tr><td>Rabies in Africa and Asia (WHO, 2010)</td><td colspan="2">1.83 million</td></tr>
<tr><td>Global burdens of Cystic and Alveolar Echinococcosis (WHO, 2010)</td><td colspan="2">1.5 million</td></tr>
<tr><td>Congenital toxoplasmosis in Netherlands (WHO, 2010)</td><td colspan="2">2300/ annum</td></tr>
<tr><td>Diarrhoeal diseases (globally) (WHO, 2010)</td><td colspan="2">59 million</td></tr>
</table>

Table 3. Economic losses due to zoonotic diseases (World Bank, 2012)

Disease	Location	Period	Total loss (US$ millions)
BSE	UK	1988 - 1996	935/year
Nipah virus	Malaysia	1999	400
SARS	East Asia	2003	78,000
SARS	Globally	2003	1,20,000
HPAI	East Asia	2003 - 2006	8,000
Rabies	Asia, Africa	Annually	590
Porcine cysticercosis / Taeniasis	India	Annually	150

high burden in many parts of world, of which China alone accounts for 40% of total burden with 350,000 individuals being infected (Budke *et al*., 2006). *Taeniasolium,* a cause of neurocysticercosis attributable to 30% of epilepsy cases, has a global distribution and is endemic in low income areas like Latin America, China, South East Asia and sub-Saharan Africa. Due to increased popularity of eating raw or undercooked fish, nearly 9 to 20 million people are infected with the parasite *Diphyllobothrium latum* leading to human Diphyllobothriosis. Over 20 million people are suffering from Paragonimiasis world-wide through eating raw or undercooked crabs, crayfish or shrimp. The true burden of human Schistosomiasis is substantially higher and is currently estimated to be approximately 70 million DALYs annually (Torgerson and Macpherson, 2011). Human cases of Trichinellosis have been documented in 55 countries and 10,000 cases occur annually with 0.2% of these cases being fatal.

Zoonotic protozoan parasites including *Cryptosporidium*, *Giardia* and *Blastocystis* spp. cause a significant proportion of the global burden. In low and middle income countries, about 200 million people have symptomatic Giardiasis with around 500,000 new cases reported each year. Visceral Leishmaniasis (VL) is caused by *Leishmania donovani* in the Old World and *L. infantum* in both the Old and New Worlds. The global burden is approximately two million DALYs per annum, about 90% of CL cases occur in only seven countries (Afghanistan, Algeria, Saudi Arabia, Syria, Iran, Brazil and Peru) whereas, 90% of VL cases occur in rural and suburban areas of five countries (Bangladesh, India, Nepal, Sudan and Brazil) (Torgerson and Macpherson, 2011). Globally, Toxoplasmosis is considered to be the third leading cause of death attributable to foodborne illness (WHO, 2010). Human African Trypanosomiasis (HAT) has resulted in 1.34 million DALYs loss in 2000 and 1.54 million in 2002.

India, A Hotspot for Zoonoses

India, having the second largest human population and one of the world's greatest densities of tropical livestock, possesses a favourable environment for the transmission of both known and novel diseases between animals and human being. Poorer section of the community which lacks basic needs for survival and follow poor hygiene are at greater risk. Slum areas of various Indian cities regularly

experience the outbreaks of many endemic bacterial infections like Leptospirosis, Salmonellosis and Brucellosis, and Viral diseases like Dengue and Japanese Encephalitis. Apart from the huge burden of the exhaustive list of neglected zoonotic diseases in the country, India is threatened by the emerging diseases such as Hanta virus infection, Kyasanur Forest Disease, Nipah Viral Encephalitis and Crimean Congo Haemorrhagic Fever. Besides this, rickettsial infections like Scrub typhus is also endemic and is an important challenge for India (Dubal *et al*., 2014).

The zoonoses like – Bovine Tuberculosis, Anthrax, Brucellosis and Cysticercosis are primarily occupational diseases affecting livestock keepers, veterinarians and those who process animal products such as tanners, butchers and wool sorters. The general public are exposed to zoonoses through consumption of livestock products like unpasteurized milk (TB, Brucellosis etc.), poor quality meat (Cysticercosis, Sarcocystosis, Trichinellosis etc.) and companionship with pets (Dogs - Rabies, Tape worm infections; Pet birds - Chlamydial infections; Cats-Toxoplasmosis, Cat scratch disease). Vector borne diseases like Japanese Encephalitis (JE), Dengue, West Nile fever, KFD and Rift Valley fever are also spreading to much wider areas.

The annual incidence of human rabies in India was estimated to be 20,565 or about two per 100,000 population. The majority of the victims were male unvaccinated adults from rural areas. The main animals responsible for bites were dogs (96.2%), most of which were stray (Sudarshan *et al*., 2007). India has been featured among the 22 high TB burden countries and has accounted for an estimated one quarter (26%) of all TB cases worldwide (Sharma and Mohan, 2013). The burden of zoonotic TB, although holding a significant proportion is still not estimated. In India, Brucellosis in livestock is responsible for a median loss of US $ 3.4 billion. These losses are additional to the economic and social consequences of the disease in humans (Singh *et al.*, 2015).

In India, there had been fatal outbreaks of Plague in 1994 (876 cases) and in 2002 in Maharashtra and Shimla, respectively. The National Centre for Disease Control (NCDC) has identified four sylvatic foci in India; the tri junction of Karnataka, Andhra Pradesh and Tamil Nadu, later in Beed belt of Maharashtra, Rohru in Himachal Pradesh and Uttarakhand (Dubal *et al*., 2014).

Leptospirosis is known to be a major endemic zoonotic disease in India since the early 20th century. Most outbreaks of Leptospirosis in India are reported from the coastal regions of Gujarat, Maharashtra, West Bengal, Orissa, Kerala, Tamil Nadu, Karnataka and the Andaman Islands. Highest rates occur during October to November which coincides with the monsoon season in these parts. The eco-epidemiological settings in which Leptospiral transmission occurs can be broadly categorized as urban, rural, recreation associated and disaster sequel (Himani *et al*., 2013).

Visceral Leishmaniasis (VL), a vector-borne disease, locally known as Kala-Azar in India, predominantly targets the poorest of the poor, has been endemic in India since ancient times. *Leishmania donovani* parasites are the causal agents of Visceral Leishmaniasis, transmitted to

humans by the female phlebotomine sand fly (*Phlebotomus argentipes*). From 1987 through 2011, a total of 6,70,897 Kala-Azar cases were reported officially from Bihar alone (Bhunia *et al*., 2013).

A total annual median loss of Rs. 11.47 billion (approx. US $ 212.35 million) has been reported due to Cysticercosis in India. Human hydatidosis related losses were estimated to be Rs. 472.72 million (approx. US $ 8.75 million) but are likely to be an under-estimate due to under-reporting of the disease in the country (Singh *et al*., 2014)

Japanese Encephalitis (JE) was first detected in India in 1955 from Tamil Nadu. The longest and most severe epidemic of JE occurred in 2005 in Uttar Pradesh, India in which 5,737 persons were affected and 1,344 persons died (Dubal *et al*., 2014). The Nipah virus is closely related to Hendra virus and outbreak of Nipah virus infection has been noticed in Siliguri, West Bengal in 2001(Dubal *et al*., 2014). Crimean–Congo Haemorrhagic Fever (CCHF) and Kyasanur Forest Disease (KFD) are the two major tick- borne viral diseases present in India. KFD was first identified in 1957 in India with estimated incidence 400 - 500 cases per year. The epidemic period begins in November or December and peaks from January to April, then declines by May and June. Between 2003 and March 2012, there were 3263 reported human cases, out of these 823 were laboratory confirmed (Mourya *et al*., 2014). The CCHF virus was first detected in Gujarat in January 2011. Out of 198 human samples tested, 19 samples were tested positive by real-time PCR (RT- PCR) (Mourya *et al*., 2014).

Zoonotic burden in Kerala

In Kerala, the rapidly increasing migrant workforce from relatively poorer states of India, rapid urbanization and its consequent stress on public health, unsolved issues of urban waste disposal has led to re-emergence of many communicable diseases like Malaria and emergence of many zoonotic diseases like Lyme disease, Scrub typhus and Kyasanur Forest Disease (Sukumaran and Pradeepkumar, 2015). Conventional zoonotic infections such as Anthrax and Brucellosis still remain as potential threat for human health. Rabies continues to cause major concern from mortality point of view, as well as major drainer of state's budget every year. Leptospirosis has remained major burden among the communicable diseases for the past 10 years and the annual incidence ranged from 2 to 7 per 100,000 population. Having a large section of its people working in various agriculture and animal rearing occupations, the state has all risk factors for propagation of Leptospirosis. Japanese Encephalitis appeared as an epidemic in 2011 in two of the southern districts in Kerala. Lyme disease was reported for the first time in India, from Wayanad district in Kerala (Sukumaran and Pradeepkumar, 2015). The migratory bird-pig-domestic birds-human interface being a well-knit network in the state is most suitable for all new variants of influenza virus evolution.

Factors responsible for Emergence of zoonoses

Transmission of pathogens into human populations from other species is a natural product of man's relation with animals and the environment.

Table 4. Factors responsible for emergence/re-emergence of infectious diseases

Factors	Causes	
Socio – economic and population related	Urbanization and technological expansion	Increase in urban / peri-urban population (e.g., Dengue, Malaria infections), increase in encroachment into wild life (e.g., KFD, Lyme disease), settlement coalescence (e.g., Influenza), rapid long distance travel (e.g., SARS pandemic in 2003), technological and industrial globalization (e.g., BSE), break down in public health measures due to natural or anthropogenic activities (e.g., Cholera outbreak)
	Ecological alteration	**Deforestation** Human - wildlife interface (e.g., Lyme disease, Yellow fever, KFD): direct contact with vector/reservoirs of pathogens biodiversity loss, decrease in natural pathogen regulation capacity and imbalance in predator-prey relationship, illegal wildlife hunting and transport, spillover of infection, feral reservoir species. **Agricultural intensification** Water diversion / irrigation canals / dams (e.g., Schistosomiasis), agro-chemicals accumulation (e.g., antibiotics / pesticides residues)
Host associated	Factors associated with immune system of hosts (e.g., HIV), occupational hazards (e.g., Brucellosis), xeno-transplantation (e.g., Rabies from corneal transplant), drug abuse and indiscriminate use of antibiotics, improper hygiene practices, leisure time activities, nosocomial/iatrogenic infections, unconventional eating habits (e.g., *E. coli* O157: H7), biological warfare	
Pathogen associated	Antigenic shift, antigenic drift, microbial evolution, host switching and dynamics	
Environment associated	Climate change, natural disasters, vegetative index	
Public health related	War or other anthropogenic destructive activities Lack of political will for implementation of control/surveillance measures	

Tackling Zoonoses: A one-health approach

Zoonotic diseases pose both major health threats and complex scientific and policy challenges, to which the social, cultural, and political norms and values are essential to address successful control outcomes (Leach and Scoones, 2013). Many-a-times, zoonoses are misdiagnosed and under reported resulting in inaccuracy in DALY estimation (WHO, 2010). There is an urgent need to strengthen the screening and diagnostic facilities of diseases and the reporting systems for notification of outbreaks.

The primary range of interventions given by the World Health Organisation to be made in order to control zoonoses mainly comprises of

1) Human/Public Health intervention: Preventive chemotherapy (Taeniasis), preventive immunization (Rabies, Leptospirosis), clinical management of cases and health education.

2) Animal/Veterinary Public Health intervention: Quarantine, early diagnosis, treatment and control of diseases in animals (Cysticercosis, Trypanosomiasis), preventive immunization (Anthrax, Rabies, Leptospirosis), host control / population management (Rodent - Leptospirosis, Dog-Rabies), test and slaughter of reactors (Bovine TB, Brucellosis), hygienic animal husbandry practices, effective meat inspection and assuring food security and safety.

3)Vector control: Environmental measures, chemical control, biological measures and genetic manipulation of vectors

4) Environmental interventions: Improve environment sanitation (Leptospirosis, Dengue, Malaria, Japanese Encephalitis), community led sanitation programme (Cysticercosis) and upgrading hygiene at food processing environment (WHO, 2010).

Currently, our surveillance systems often lack the ability to monitor the human–animal interface for emergence of zoonotic pathogens. Identifying and ultimately addressing emergent cross species infections will require a ‘‘One Health’’ approach in which resources from public health, veterinary, environmental and human health function need to be part of an integrative system. National and regional public health sectors should give priority to surveillance systems and enhanced diagnostics regarding emerging pathogens.

The closer collaborations are needed among veterinarians, physicians, and public health professionals in three areas: individual health, population health and comparative medicine research. Since physicians and veterinarians would be the key professionals to recognize and report outbreaks, enhanced communications among hospital epidemiologists, veterinarians, and local public health officials would not only help to expedite a local response, but also help to identify whether unusual diseases or outbreaks involving animals and humans were related or separate events. In the research setting, collaboration between physicians and veterinarians in comparative medicine would improve our understanding of zoonotic agent-host interactions. The inter-sectoral collaboration helps to understand the ecological interactions and climate change impacts, which can facilitate a clearer in sight of ecological perspectives to provide foresight into the appropriateness of interventions and contribute to effective

management solutions in an ever-changing environment (Patz and Hahn, 2012).

The organisations such as Roadmap to Combat Zoonoses in India (RCZI), National Centre for Disease Control (NCDC) and National Institute of Veterinary Epidemioloy and Disease Informatics (NIVEDI) are ensuring joint capacity building for strengthening a consolidated and collaborative response to zoonoses in India. Roadmap to Combat Zoonoses in India (RCZI) initiative was launched in June, 2008 with the vision of supporting and promoting integrated zoonotic disease prevention and control. The RCZI has been set up under the aegis of the Public Health Foundation of India (PHFI) and is the only standalone initiative on zoonoses in the country that mobilises a range of inter-sectoral partners working in the human, veterinary and wildlife health sectors. It modelled itself around the 'One World, One Health' concept which is a worldwide strategy for expanding interdisciplinary collaborations and communications in all aspects of health care for humans, animals and the environment. Various 'Priority zoonoses' have been identified and importance is given for research in endemic and neglected zoonoses (rabies, leptospirosis and brucellosis) than emerging infections for the Indian population.

CONCLUSION

Zoonotic diseases impose a "double whammy" on society by affecting both people and animals. In a developing country like India, zoonoses poses a real challenge. India is double burdened with endemic and emerging zoonoses. In order to combat this, solid inter-sectoral collaboration and coordination among sectors *viz*., veterinary, medical and public health departments is of paramount importance together with the establishment of timely information exchange on disease occurrence, early effective epidemiological surveillance and early warning system operation. Thus Virchow's one medicine and Schwabe's one health concept are more relevant in order to combat zoonoses in the present scenario.

As the Ebola epidemic has shown, capacities to detect emerging and epidemic-prone diseases early and mount an adequate response need to be an integral part of a well-functioning health system. Identification of national centres for diagnosis and their capacity building should be given at most priority. Establishment of area specific (geographical as well as discipline wise) diagnostic laboratories is necessary. Educating the public about source of infection, mode of transmission and preventive measures also aid in this process. The risk related to emerging and re-emerging zoonoses can be reduced by an increased collaboration between animal health stakeholders and human health authorities at local, national, regional and international levels. Thus, it is the need of the hour to initiate effective surveillance, prompt disease diagnosis and control programmes fostering the concept of 'One world - One Health - One medicine' through an interdisciplinary approach, with the sole aim to provide optimum health for people, animals, plants and our environment.

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