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Review Article

One World, One Health - Veterinary Perspectives

Kuldeep Dhama[1], Sandip Chakraborty[2*], Sanjay Kapoor[3], Ruchi Tiwari[4], Amit Kumar[5], Rajib Deb[6], S. Rajagunalan[7], Rajendra Singh[8], Kranti Vora[9], Senthilkumar Natesan[10]

[1,8]Division of Pathology, [7]Division of Veterinary Public Health, Indian Veterinary Research Institute, Izatnagar, Bareilly (U.P.)– 243122; [2]Animal Resources Development Department, Pandit Nehru Complex, Agartala, Tripura – 799006; [3]Department of Veterinary Microbiology, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana- 125004; [4,5]Department of Veterinary Microbiology and Immunology, Uttar Pradesh Pandit Deen Dayal Upadhayay Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (DUVASU), Mathura (U.P.) – 281001; [6]Division of Animal Genetics and Breeding, Project Directorate on Cattle, Indian Council of Agricultural Research, Grass farm Road, Meerut, Uttar Pradesh-250001; [9]Indian Institute of Public Health, Gandhinagar Sardhar Patel institute of Economic and Social Research, Drive-in Road, Ahmedabad, Gujarat; [10]Institute of Science, Nirma University, Sarkej- Gandhinagar Highway, Ahmedabad 380009, Gujarat, India.
*Corresponding author: sandipchakraborty53@yahoo.com

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ABSTRACT

Multidisciplinary efforts at global, national and local levels are required for creating One Health for the benefit of our planet, mankind and animals. A plethora of emerging global issues viz., international trade and travel, global warming, rapid population growth, ecotourism, food safety concerns, continuous increase in migration of people from rural to urban areas, and changes in traditional livestock rearing practices to meet the demand of higher animal protein production leading to increased risk of emergence and re-emergence of several zoonotic diseases, and all these factors affect human health. Wrong diagnosis and misdiagnosis causing thousands of deaths everyday worldwide have increased the agony and certainly, require one health approach globally. Increased antimicrobial resistance, extreme variability of RNA viruses, involvement of domestic and migratory birds and wildlife in disease transmission have made the scenario of the spread of zoonotic diseases more complicated than ever before. Moreover, cross-border diseases make the health concept more critical as they cause major economic shutdowns across the countries. These issues have created an urge to control emerging and zoonotic diseases at global, national and regional level at a quicker pace than ever before. Joint venture via a collaborative approach from experts of various fields, laboratories and countries certainly seeks attention for One Health to maintain the global integrity. Regional and local networking systems of various international organizations should make use of the highly sensitive and specific methods, both molecular and serological, including cost effective and pen-side diagnostic methods, to detect pathogens at the earliest. Dearth of antiviral drugs, increased antimicrobial resistance among zoonotic organisms, and inadequate compensation during adoption of stamping out policies have created crisis with respect to disease control and preventive measures. This requires heightened biosecurity measures, disease surveillance and monitoring activities, in addition to judicious vaccination. In this regard, developmental vaccinology, generating a variety of new generation vaccines, and advanced delivery systems require special mention. This review deals with all these aspects, which will be beneficial to create One World, One Health concept.

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INTRODUCTION

One Health requires multidisciplinary efforts at global, national and local levels, for the sake of our planet, mankind and animals. It was initiated at the American Veterinary Medical Association (AVMA) Annual Convention (2007) as launched by the American Medical Association along with AVMA and the Centers for Disease Control and Prevention (CDC). One health concept is governed by a great deal of interest as well as resources. To a certain level it is due to the greater popularity attained by the term population health. Successes up to a certain extent to provide understanding of socioeconomic gradients in health status at depth even though achieved, it has not yet led to sufficient development of corresponding policies that can effectively reduce the inequalities in health (Glouberman and Millar, 2003; Tsui *et al.*, 2010). Recent decades of modernization and industrialization, along with adoption of policies like liberalization and globalization, the characteristics of human demographics have been affected considerably (Nolen and Kahler, 2007). Increase in international trade and travel, global climate change, habitat destruction, ecotourism, changes in ecosystem and biodiversity have resulted in exposure of humans as well as animals to new pathogens to which they were never exposed, requiring proper veterinary attention (Morse, 1995; Taylor *et al.*, 2001; Patz *et al.*, 2005; Rogers and Randolph, 2006; Myers and Patz, 2009; Osburn *et al.*, 2009; Pawaiya *et al.*, 2009; Bloom, 2011; Dhama *et al.*, 2012a; Mahima *et al.*, 2012; Dhama *et al.*, 2013a). Besides the preceding situations, certain other circumstances like civil unrest, political instability, communal

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riots, etc have also led to the uneven demographic changes in human population in most of the developing countries.

Certainly, global warming is unequivocal, and is primarily caused by increasing concentrations of greenhouse gases produced by deforestation and burning of fossil fuels (Battisti and Naylor, 2009; Knight *et al*., 2009; United Nations Framework Convention on Climate Change, 2011). Rapid population growth has several impacts which may be immediate or short-lived, comprising of poverty, lower living conditions or older populations living longer during the period of stagnant birth rates (Wittemyer *et al*., 2008). Research and health education when combined with social marketing as well as community development, along with legislative and public policy approaches are prerequisites to determine healthy lifestyle of people (Mc Keown, 1972; The Maclean's Health Report, 1999).

There is a continuous increase in migration of people from rural to urban/peri-urban areas; also there has been a considerably increase in human population along with increase in consumption of animal proteins, which has necessitated changes in traditional livestock rearing/production systems to meet the demands. In addition, budgetary restrictions in developing countries especially in the last two decades have led to a decline in the quality of public services provided. All these changes constitute important risk factors for maintaining and developing diseases in such population resulting in the emergence and re-emergence of diseases, including zoonoses (Taylor *et al*., 2001; Patz *et al*., 2005; Rogers and Randolph, 2006; Myers and Patz, 2009; Bloom, 2011; Dhama *et al*., 2012a,b). Some of the zoonotic diseases that seem to attract less public awareness viz. brucellosis, rabies, cysticercosis and hydatidosis are re-emerging in some regions nowadays (Jones *et al*., 2008; Kumar *et al*., 2009). Again, vector-borne zoonoses form the most complex group of infectious diseases that are difficult to prevent and control due to difficulty in predicting the habits of the vectors; striking diseases are West Nile, Lyme disease, plague (caused by *Yersinia pestis*) tick transmitted diseases caused by rickettsiales like Rocky mountain spotted fever, Ehrlichiosis and anaplasmosis, Q fever and mosquito-borne diseases such as dengue and chikungunya, all having fatal outcome, responsible for sufferings of millions in US, Africa and Asia (U.S General Accounting Office, 2000; Kahn *et al*., 2007; Wolfe *et al*., 2007). It is also indicative that avian influenza (H5N1) viruses are now being transmitted between migratory/wild birds and may pose a threat to poultry and human health (Webster *et al*., 1992; Dhama *et al*., 2005; Sengupta *et al*., 2007; Dhama *et al*., 2008a; Dhama *et al*., 2012 a,b,c; Ahmed *et al*., 2012; Sakoda *et al*., 2012; Dhama *et al*., 2012b)

EMERGING AND RE-EMERGING ZOONOSES

The urgent need of various partnerships and collaboration lies in the critical difference in response to emergence and re-emergence of zoonotic diseases that illustrate a new dependency, governed by the complexity of human-animal relationships, including wildlife (Garrett, 1994; Dazak *et al*., 2000; Bengis *et al*., 2004; Zinsstag *et al*., 2007; Zinsstag *et al*., 2008; Jones *et al*., 2008; Cascio *et al*., 2011).

New infection evolving due to change of an existing pathogen or spread of a known infection to a new geographic area or population, and diagnosing infection caused by an agent previously unrecognized, all contribute to the occurrence of emerging disease. Zoonotic diseases are those that animals use to transmit/ birds to humans under natural conditions (Office des International Epizootics, 2004). Out of 1415 species of pathogens in human, 868 (61%) are zoonotically important. The prevalence of infectious diseases have increased in last three decades with 175 pathogens causing emerging diseases with most of them [132 (75%)] to be of zoonotic nature (Statistics Division, United Nations, 2003; World Health Organization, 2009; Osburn *et al*., 2009; Dhama *et al*., 2012a). Surveillance data between public health and animal health organizations indicate an ever increasing emergence of zoonotic diseases caused by pathogens resistant to antimicrobial substances viz., tuberculosis, campylobacteriosis, salmonellosis, *E. coli* and *Staphylococcus aureus* infections (Cosivi *et al*., 1998; Eberhart-Philips, 2000; Gupta, 2001; Hamburg *et al*., 2003; Verma *et al*., 2007; Dhama *et al*., 2011; Kumar *et al*., 2012).

Emerging and re-emerging diseases involve numerous mechanisms. Particularly, RNA viruses show extreme variations that act as a key factor for population of quasi-species to cross species barrier. Evolution of viruses is much quicker as they use mechanisms like point mutation and deletion; recombination and re-assortment along with acquisition of cellular genes. Also, the increase in widespread antimicrobial resistance among zoonotic bacteria limits the use of antibiotic treatments in animals. Emerging diseases may be the outcome of involvement of invasive/migratory species or release of foreign species accidentally in a new environment. Also, recent infectious disease events (Severe Acute Respiratory Syndrome / SARS; avian influenza, H1N1; swine origin influenza virus H1N1, SOIV-H1N1) have uncovered vulnerabilities of the global health community in its preparedness and response to diseases emerging on the human-animal interface (Slingenbergh *et al*., 2004; Dhama *et al*., 2005; Amonsin *et al*., 2008; Pawaiya *et al*., 2009; Ali *et al*., 2012; Dhama *et al*., 2012a; Dhama *et al*., 2012b).

Poultry meat is the major source of animal protein worldwide. So people need to work or live with birds daily, exposing themselves to numerous microorganisms having the potential of zoonotic disease like Avian Influenza (AI), tuberculosis, salmonellosis, campylobacteriosis, colibacillosis and chlamydiosis. In addition, listeriosis, Newcastle disease (ND), eastern equine encephalitis (EEE), West Nile virus, cryptosporidiosis, erysipelas, clostridial infections, arizonosis, cryptococcosis, histoplasmosis and allergic alveolitis also contribute to human infections (Leslie, 2000; Saif, 2003; Dhama *et al*., 2005; Dhama *et al*., 2008a; Dhama *et al*., 2011; Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, 2010; Grunkemeyer, 2011; Dhama *et al*., 2012c; Tiwari and Dhama, 2012).

WILDLIFE AND EMERGING/RE-EMERGING ZOONOTIC DISEASES

Wildlife acts as a potential but unknown reservoir for diseases that emerge or re-emerge possessing zoonotic threat and include vector-borne viral diseases (75%) (Taylor *et al*., 2001) viz., Hendra and Nipah viruses, Menangle, West Nile virus, Monkey pox (Dazak *et al*., 2000; Centers for Disease Control and Prevention, 2003; Bengis *et al*., 2004; Daszak *et al*., 2004, King, 2004; Dhama *et al*., 2010; Chakraborty, 2012). This ultimately poses threat to biodiversity, and human and animal health. Leading causes for the occurrence of the zoonosis from wildlife pool are:

a) Growth of human population exponentially and invasion of wildlife habitats. For example, vampire bat rabies has re-emerged in people living in Amazon basin due to deforestation caused by human activities for the progress of civilization (Schneider *et al*., 2005); natural foci of Kyasanur Forest disease (KFD) i.e. adult tick *Haemaphysalis spinigera*

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(of cattle) flare up due to deforestation and agricultural development (Varma, 2001).

b) Changes in agricultural practices like domestication of species of wild animals leading to reemerging zoonoses such as bovine tuberculosis in deer populations kept in captivity (Wilson, 2002) and brucellosis in wild boar (Godfroid *et al*., 2005). During 1998–1999, removal of forests and expansion of non-industrial pig farming along with production of fruiting trees has led to Nipah virus outbreak in Malaysia (Daszak *et al*., 2001).

c) Rabies can spread due to movement of wild animals for example repopulation of hunting pens with raccoons trapped in endemic zones of the Southern United States have led to introduction of the disease during 1970s in the mid-Atlantic states (Woodford and Rossiter, 1993); Crested hawk eagles carried a highly pathogenic avian influenza A H5N1 virus in Europe (Van Borm *et al*., 2005).

d) Ecotourism also plays crucial role e.g. *Rickettsia africae* (causes African tick bite fever) (Jensenius *et al*., 2004); Cercopithecine herpes virus-1 (herpes B virus) (Huff and Barry, 2003).

e) Petting zoos and exotic birds have been linked to several zoonotic outbreaks viz., *Escherichia coli* O157:H7 and Salmonellae as well as ricketsialles like *Coxiella burnetii* (Bender and Shulman, 2004).

IMPACT OF TRANSBOUNDARY DISEASES ON ONE HEALTH

Transboundary diseases include the epidemic diseases of highly contagious nature, which can spread very rapidly, irrespective of national borders, and are of much serious socio-economic and possibly public health concerns. These are the emerging and re-emerging diseases which can cross borders between animals (domestic and wildlife) and human, and thus threaten both livestock and human health. This is another reason to combine all the latest research on economically important infectious animal diseases worldwide. No country whether rich or poor is immune from the risk of these disease, especially South Asian countries, which have been identified as a global 'hotspot' for emergence of infectious diseases of animal origin. The conditions that encourage the emergence of disease may be different, but the challenge of managing disease spread is almost the same for a given disease condition (National Research Council, 2005; Dhama *et al*., 2012a). Improvement of health of man, animal and environment through One Health concept with special reference to control of emerging and zoonotic diseases at national, regional and global level becomes more critical with increased emergence of infectious diseases (Karesh *et al*., 2005). Also, as these diseases can cross the animals-human-environment interface, studying in detail about the disease in one host species or environment alone may not be applicable for others; more researches are required on this area (Foreign Agriculture Service, 2003; Wolfe *et al*., 2005).

BIOTERRORISM

One Health concept plays a crucial role in case of growing threats like bioterrorism (comprising of 80% self-replicating zoonotic pathogens). Biological agents are organisms or toxins produced by organisms (natural), which when used deliberately against humans, animals or crops, can cause illnesses even in a small concentration, in contrast to chemical agents, which are man-made (Block, 2001). They can be spread through the air, through water, or in food and are resistant to current medicines. The botulinum toxin produced by *Clostridium botulinum*, and ricin extracted from the castor seeds are amongst the most potent toxins. The lethality of many toxins is much more than several lethal chemical agents. The 50% lethal dose (LD_{50}) of VX, most lethal chemical agent is ~15,000 times more than that of botulinum toxin. The political, religious or other ideological factors may motivate the terrorists to use these biological agents, as the detection of these agents is not easy due to the time lapse between their use and the production of illnesses. The threat of person to person spread is present in some bioterrorism agents, like the smallpox virus, which is not present in other agents like anthrax. During the past few years, the threat of bioterrorism has evoked widespread concern and brain-storming putting additional responsibilities on governmental agencies to ensure biosecurity. Bio-surveillance is the detection of disease outbreaks in real-time in which data from different sources, various places and categories are collected and analysed. It can be effectively applied in the fight against bioterrorism (Wagner *et al*., 2006). Pioneer work conducted in US has lead to the deployment of the first automated bioterrorism detection system, called RODS (Real-Time Outbreak Disease Surveillance), which can detect a probable bioterrorism event within the shortest possible time. The RODS system has now been replicated in all the States of the USA. The Global Emerging Infections Surveillance and Response System along with many other programmes have been put in place by the Defence department of USA for worldwide bio-surveillance. Similarly, surveillance for any bioterrorism event/activity is not done at country level, but on the continent-wide scale in the Europe. Therefore, the "One World, One Health" has an important role to play in the fight against the bioterrorism at the global level. The CDC has classified the bioterrorism agents into three categories, depending on ease of spread and severity of illness or death they cause.

a) **Category A:** Organisms or toxins such as Anthrax (*Bacillus anthracis*); Plague (*Yersinia pestis*); Tularemia (*Francisella tularensis*); Viral Hemorrhagic Fever Viruses (Ebola, Marburg, Lassa, Machupo) that pose the highest risk to the public and national security are included in this category. The easy person to person spread or transition results in high death rates and have the potential for major public health impact causing panic and social disruption, thus requires special public health preparedness.

b) **Category B:** These agents are the second highest priority as they are moderately easy to spread resulting in moderate illness rates and low death rates, and require enhanced disease monitoring.

c) **Category C:** Emerging pathogens that could be engineered for mass spread in the future are included in the C category, whose acquisition, production and dissemination is easier. They have potential for high morbidity and mortality rates and posses the ability to cause pronounced health impact.

THE ONE HEALTH APPROACH

Death of thousands of children and adults everyday worldwide due to underdiagnosed diseases arising at human-animal-environment interface, explosive human population growth, and environmental changes have created the urgent need for a One Health approach on a global basis (Taylor *et al*., 2001). One health approach requires the complex field of endeavor utilizing individual, organizational and cultural interventions, leading to improved morbidity patterns and health care use, behavior of defined populations (Kindig and Stoddart, 2003; Howe and Christopher, 2004).

The animal and human health can be improved and enhanced within 'One Health' concept using innovative partnerships, collaborations, and research/surveillance/control

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programmes. The novel advances in diagnostics and therapeutics need to be explored to their full potentials to safeguard health of humans as well as their companion animals (Schmitt and Henderson, 2005; Belák, 2007; Bollo, 2007; Ratcliff *et al*., 2007; Bergquist, R. 2011; Deb and Chakraborty, 2012; Dhama *et al*., 2012 a,d; Dhama *et al*., 2013b). The concept of 'One World One Health', put forward during a conference of the Wildlife Conservation Society, 2004, helps in building the cooperative momentum to control and defeat emerging and reemerging diseases at the interface between man, animal and ecosystem (Ahmed *et al*., 2010). The foundation of One Health is a flexible global governance model. Therefore, existing resources are mobilized and smoothly redirected to respond to emerging issues, without any requirement for the creation of new norms or new institutions. Classical examples in this regard include deaths of wild and captive birds leading up to the West Nile human (confused for St. Louis encephalitis virus) outbreaks, monkey pox (confused for smallpox virus) in prairie dogs from West African rodents, or deaths of apes in the Congo forest due to Ebola epidemic. Until the discovery of horseshoe bats as the real hosts, the civet cat was initially wrongly thought to be the reservoir for SARS. Similarly, in the year 1998, in Malaysia, pigs were originally considered as hosts for Nipah virus, which are now found out to be intermediary hosts, while the actual hosts were fruit bats. The spill-over from wildlife reservoir to livestock and human is also represented by the Hendra virus that has killed both horses and human beings in Australia. Again, in this case also the fruit bats were found to be the reservoir hosts. Whole-hearted cooperation between public health and animal health services will be required for prompt and effective control of well-known emerging and re-emerging diseases as and when they occur, or else their control will be hard and difficult, resulting in disastrous consequences and great economical losses. This type of situation was seen in the past in bovine spongiform encephalopathy (BSE) [or Variant Creutzfeldt-Jakob disease (vCJD)] and is now observed in the case with Q-fever in the Netherlands; or in a recent outbreak of rabies in racoons in New York City (FAO, 2010; FAO-OIE-WHO, 2010a).

The One Health approach can also be viewed in a different context away from the zoonotic diseases and human-animal interface, wherein global concerted efforts are directed to prevent, control and if possible, to eradicate the diseases from planet earth. This has been shown for the smallpox in human and rinderpest in bovines. A resolution put forth in 1958 by the Soviet Union for global eradication of smallpox was adopted by WHO, later on sponsored by many countries, had eradicated smallpox within ten years. Forty four countries were still reporting the disease during that time. The Smallpox Eradication Program (SEP), started in some of the poorest countries, was successful even under situations where health services were minimal. It was observed that every single individual needs not be vaccinated for the removal of disease. Improved technology also made delivering the vaccine more efficient leading to declaration of freedom from smallpox by many more new countries. The last naturally-occurring case of smallpox in the world was observed in October, 1977 in Somalia. However, smallpox last two victims were observed in 1978 in Birmingham, England, who tragically contracted the smallpox virus escaped from a research lab. The certification of the eradication of smallpox in 1979 by a global commission was officially accepted by the 33rd World Health Assembly in 1980 (Fenner *et al*., 1988; FAO, 2010).

The Global Rinderpest Eradication Programme (GREP) including many different regional campaigns such as Pan African Rinderpest Campaign (PARC), West Asia Rinderpest Eradication Campaign (WAREC), South Asia Rinderpest Eradication Campaign (SAREC), and India's National Programme for Rinderpest Eradication (NPRE) were involved in prevention and control of rinderpest. These regional campaigns incorporated common features in their campaigns along with the use of three OIE pathways and a common vaccine strain (Rweyemamu and Cheneau, 1995, Taylor et al., 1995; FAO-OIE-WHO, 2010a; The World Bank, 2010). These combined efforts have produced results to eradicate Rinderpest, the first one of veterinary importance to be eradicated. The decades-long, worldwide collective field activities to eradicate the disease were stopped in October 2010, by the United Nations Food and Agriculture Organization. In May 2011, the World Organization for Animal Health (OIE) announced the free status of the last eight countries not yet recognized, and announced freedom from the disease in a total of 198 countries. In August 2011, the United Nations declared rinderpest has been fully eradicated, making it only the second disease in history to be fully wiped out, the one being the smallpox. These two examples encourage the application of combined, concerted and simultaneous efforts and resources at the global level to achieve the One Health concept for human and animal diseases.

CLINICIANS AND ONE HEALTH PRACTICE

The human health and animal health practitioners should understand the concept of One Health, appreciate the complexities of the spread of zoonotic diseases between human and animals, and apply the One Health knowledge in their clinical practice. When human and animal health professionals collaborate and communicate can work for the benefit of human and animal health and this can be recognized through practicing One Health. Human health clinicians can better understand the contribution of household pets in the spread of zoonotic diseases and animal allergies in human by the interaction with a veterinarian, which would help in the diagnosis and prevention of infectious diseases and allergies. Geographical information System (GIS) based display of data on the detection of zoonotic diseases in human and animals in a given geographical area would help to alert the clinicians as well as public health specialists in the diagnosis and prevention of the disease. Practicing One Health is also important in the diagnosis and prevention of diseases associated with occupational health hazards.

JOINT VENTURE - SEEKS ATTENTION FOR ONE HEALTH

Collaborative efforts of veterinary and human medicine, environmental, wildlife and public health, result in establishing or identifying Centers of Excellence for Education, Research and Training, thereby lead to the success of the One Health approach. A collaborative approach from experts of various fields, laboratories and countries will be helpful with division of labor and creating the Centers of Excellence (Osburn *et al*., 2009). Regional consultations of government officials, agricultural and conservation scientists, entomologists, epidemiologists, anthropologists, microbiologists and nutritionists, economists and educators, engineers, hydrologists, physicians, public health professionals, sociologists, and veterinarians necessitate the understanding of emerging diseases with special reference to their region. These meetings should also involve stake holders and policy makers (Leonardi *et al*., 2006; Madigan and Dacre, 2009; Dhama *et al*., 2012a). This cooperative approach on health will facilitate easy control and prevention of emerging zoonotic diseases. This approach needs an efficient national surveillance and monitoring system capable of rapidly detecting emerging zoonoses, generating reliable information on the disease situation, and notifying them to all

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the collaborating countries. This should also suggest the disease management measures by collaborating with international organizations like World Organization for Animal Health, (WOAH), Food and Agricultural Organization (FAO) and World Health Organization (WHO). All the international organizations should have the regional referral diagnostic laboratories, local emergency plans, priorities and autonomy from the political bias (United Nations, 2008). These networks should make use of the highly sensitive and specific methods like molecular based as well as serological methods in diagnosing pathogens at the earliest. They should develop the cost effective and pen-side diagnostic methods (Coughlin *et al*., 2006; John *et al*., 2008; Dehove, 2010; FAO-OIE-WHO 2010b).

PREVENTION AND CONTROL OF ZOONOSES – PART OF DISASTER MANAGEMENT

With respect to preventive and control measures for emerging diseases like the viral diseases of animals, no real alternative exists since there are no antiviral drugs suitable for widespread application in the field conditions (Jebara, 2004). Furthermore, with the increasing problem of antimicrobial resistance among zoonotic bacteria, use of antibiotics in the treatments in animals has been put under scanner. Also, the inadequate compensation provided by the government during adoption of stamping out policies to control epidemics has a clear negative social effect on the livelihood of smallholder, particularly with respect to the poultry industry (Grunkemeyer, 2011; Dhama *et al*., 2012a,c). All these suggest the possible way to control zoonotic disease in animals would be through the use of vaccines. With the recent molecular developments in vaccinology like recombinant subunit, di-deoxy nucleic acid (DNA) and non-pathogenic virus vectored vaccines including the reverse vaccinological approaches using expression library are to be explored fully so as to achieve most cost-effective methods of producing antigens that are free from the exogenous materials as associated with conventional vaccines (Gamble and Zarlenga, 1986; Casais *et al*., 2001; Fingerut *et al*., 2003; Dhama *et al*., 2008b; Weiner, 2008). The delivery systems like nanoparticle, liposome, viral vector and cell based vaccination procedures too need to be explored and applied to achieve effective and protective immune responses (Babiuk *et al*., 2003; Emerich and Thanos, 2003; Suri *et al*., 2007). Many pathogens causing infectious diseases gain entry through the mucosal sites (immune response being the first line of defence) and establish initial infection in these sites. Mucosal vaccines can offer lower costs, better accessibility, needle and medical waste-free delivery, and higher capacity of mass immunizations during pandemics (Dhama *et al*., 2013c). Such vaccination provides protective immunity against pathogenic entities both locally and systemically. However, majority of the licensed vaccines are administered parenterally, with the exception of poultry vaccines. Therefore, more efforts are required to design and develop effective and potent mucosal vaccines, mucosal adjuvants and their delivery systems for human, livestock, poultry, wild and aquatic animals (Chadwick *et al*., 2010, Fujkuyama *et al*., 2012, Pavot *et al*., 2012, Rhee *et al*., 2012, Woodrow *et al*., 2012; Dhama *et al*., 2013c) Furthermore, regulations governing registration and marketing of vaccines for livestock or wildlife should become more flexible, so that these vaccines can meet the epidemiological requirements of field. However, animal disease control recommendations should take into account scientific and technological progress as well as the new vaccines available (Moran *et al*., 2009; WHO, 2006; Gargano *et al*., 2013).

Vaccination is without a doubt the best means of prevention, wherever possible. But good management practice and biosecurity can, however, never be replaced by vaccination as most emerging diseases pose the obstacles like residual virulence, variability in the strains, extensive safety precautions regarding personal and environmental contamination, difficulty in production, sometimes requirement of specific growth conditions, cost constraints or prohibitively expensiveness. In addition, there are fundamental biological differences that will influence vaccination protocols, between various species and even within each species particularly when there are numerous strains developed artificially like in poultry (Paul-Pierre *et al*., 2009; Dhama *et al*., 2012a). There is increase trend of controlling major poultry diseases through vaccination along with other measures. Attention should also be given to heighten biosecurity measures, disease surveillance and monitoring activities (Hafez, 2005). The new trends in veterinary vaccinology should not only focus the causative agent but also the host (Movahedi and Hampson, 2008). Research on selective breeding of animals resistant to certain diseases should also be given emphasis as it is being used in Marek's disease in poultry (Jacqueline *et al*., 1997; Linda, 1998; Dhama *et al*., 2007; Singh *et al*., 2012). It is also necessary that veterinary services consider animal welfare as large-scale emergencies and disasters affect both human and animals and most of the disease outbreaks either have animal origin or are associated with such conditions (Leonardi *et al*., 2006). Veterinary institutions must develop their training and curricula to allow veterinarians to effectively engage in missions envisaged by the OIE for participating in global animal welfare programmes. Provision for veterinary care of injured or sick animals along with plans to vacate animals and their shelters should reflect the normal standard care to animals in the society and thus is a result of regional socio-economic realities and geographic factors (Madigan and Dacre, 2009; OIE, 2010)

WILDLIFE AND EMERGING/REEMERGING ZOONOTIC DISEASES

Interaction of human with wildlife gives rise to various re-emerging global zoonotic pandemics viz., SARS corona virus as well as H5N1 and H1N1 influenza viruses; Nipah and Hendra viruses; human immunodeficiency virus (HIV) (Day *et al*., 2011). Some of the holistic approach need to be adapted to prevent epidemic/epizootic diseases and to conserve integrity of ecosystem as is given below:

- Relationship between man and animals including wildlife needs to be understood.
- Judicious use of land and water.
- Wildlife health science is crucial for global disease management and requires attention.
- Generating approaches towards the management of emerging and re-emerging diseases accounting for the complex interconnections among species.
- Biodiversity conservation perspectives; human and domestic animals needs must be fully integrated when developing solutions to infectious disease threats.
- Wildlife population impose an important and urgent threat to humans and at the same time to food security for which multidisciplinary efforts and scientific concerns to restrict culling of wild species are required.
- Increased investment in the global human and animal health infrastructure.
- Collaborative efforts by both public and private sectors are needed to ensure conservation of global health and biodiversity.
- Common people need to be made aware and educated regarding the problems.

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NUTRITION AND IMMUNITY

The innate and acquired immunity in humans and animals is significantly influenced and modulated by the nutrition and nutritional status. The knowledge and understanding of the molecular and cellular immunological mechanisms involved in nutrient-immune interactions will help in the discovery of new dietary factors, which may be included in the diet to augment immune defenses and increase the pathogen/disease resistance of the host (Harbige, 1996, Chandra, 1997, Cunningham-Rundles *et al*., 2005; Mahima *et al*., 2013).

In fact, malnutrition is the most common cause of immunodeficiency in the world, leading to inadequate intake of energy and macronutrients as well as selected micronutrient deficiencies. Unfortunately, immunosuppression and dys regulation of immune responses are the grave consequences. Protein-energy malnutrition can cause significant impairment of cell-mediated immunity mediated by phagocytes, complements and cytokines and secretary immunoglobulin A (IgA) concentrations. Impairment of these responses can compromise the integrated immunity and increases one's susceptibility to infection (Harbige, 1996, Cunningham-Rundles *et al*., 2005). Many developing countries are putting in policies for addressing the problem of malnutrition, which can have a direct and indirect influence on the health. India for example is working on the Food Security Bill.

ISSUES IN THE IMPLEMENTATION OF ONE HEALTH

Research and education in this relatively new field of science is very important for the successful implementation of One Health approaches. Recently, a conference was organized to address the One Health issues, priorities, research, and education at the Southeastern Regional Center of Excellence for Emerging Infections and Biodefense. The group focused on research aspects of One Health and identified two broad issues (Gargano *et al*., 2013): 1) the need to develop and evaluate interventions with the potential to provide economic benefits to human or animal health to demonstrate a return on investment and 2) the need to engage behavioral science researchers and social marketers in conducting research to better understand consumer perspectives on One Health issues. The another group in the conference emphasized on inclusion of One Health concept in courses of science classes in schools, colleges, and universities; involvement of professional societies; embedding training opportunities within industry; and using social media and networking tools. University of Florida and University of North Carolina have already started the educational programs in One Health (Gargano *et al*., 2013). One Health Central and East Africa (OHCEA) was established for connecting public health and veterinary medicine schools in Africa that ensured spontaneous improvement of health and well-being of human, animals and ecosystems through multi-dimensional research, training and community service. The One Health Alliance of South Asia (OHASA) was established to predict and prevent emerging infectious diseases on the Indian subcontinent. However, the One Health concept has not reached to all the people involved in the fields related to animal, human and public health, particularly in the developing countries and there should be more emphasis on this in the future.

CONCLUSION AND FUTURE PERSPECTIVES

It can be summarized that scientific and policy-focused presentations from leaders, public health and scientific communities covering topics on current global activities focusing on surveillance for emerging infectious diseases in the ecosystem are important. Moreover, round table discussions to effectively generate multi-sectorial, trans-boundary surveillance initiatives need to be regularly organized, bringing together participants from diverse scientific backgrounds. This will provide an environment for the free exchange of ideas among experts from various fields and between scientists and policymakers, at global, regional and National level. An overall emphasis should be on epidemiology, surveillance and networking, prevention and control policies of zoonoses focusing the current and future perspectives. Equitable coordination between the public and private sectors is advisable and needs of the hour, in order to make available high-quality, safe, effective and affordable diagnostic and prophylactic products. For this purpose, collaborative / coordinating mechanisms, and inter-departmental / multi-disciplinary activities and strategic priorities are required with effective preparedness and response to diseases emerging on the human-animal interface for benefit of individual country / region in particular and global health community in general. The One Health concept should not only be viewed as a new field of public health, but it should also be well integrated with the basic science research areas of human and animal health. Lessons learnt from the pathogen- animal host interaction should be applied to understand the pathogen-human interaction. While applying this, we also need to be cautious about the influence of environmental interaction. The concept of One Health is still in its infancy though it has been emphasized by several professional organizations and their members, still it has not reached the students, healthcare professionals in the field of human, animal and public health specialists and policy makers. A major emphasis needs to be given in the education and research of the One Health concept of 'One World, One Medicine, and One health' and its message should reach everyone.

REFERENCES

Ahmed SS, Ersbøll AK, Biswas PK, Christensen JP, Hannan AS and Toft N (2012). Ecological determinants of highly pathogenic avian influenza (H5N1) outbreaks in Bangladesh. PLoS One. 7(3): e33938.

Ahmed JS, Sparagano O and Seitzer U (2010). One Health, One Medicine: Tackling the Challenge of Emerging Diseases. Transbound. Emerg. Dis. 57: 1-2.

Ali A, Khatri M, Wang L, Saif YM and Lee CW (2012). Identification of swine H1N2/ pandemic H1N1 reassortant influenza virus in pigs, United States. Vet. Microbiol. 158(1-2): 60-68.

Amonsin A, Choatrakol C, Lapkuntod J, Tantilertcharoen R, Thanawongnuwech R, Suradhat S, Suwannakarn K, Theamboonlers A and Poovorawan Y (2008). Influenza virus (H5N1) in live bird markets and food markets, Thailand. Emerg. Infect. Dis. 14: 1739-1742.

Babiuk LA, Gomis S and Hecker R (2003). Molecular approaches to disease control. Poult. Sci. 82(6): 870-875.

Battisti D and Naylor RL (2009). Historical warnings of future food insecurity with unprecedented seasonal heat. Sci. 323 (5911): 240-244.

Belák S (2007). Molecular diagnosis of viral diseases, present trends and future aspects. A view from the OIE collaborating centre for the application of polymerase chain reaction methods for diagnosis of viral diseases in veterinary medicine. Vaccine, 25(30): 5444-5452.

Bender JB and Shulman SA (2004). Reports of zoonotic disease outbreaks associated with animal exhibits and availability of recommendations for preventing zoonotic disease transmission from animals to people in such settings. J. Am. Vet. Med. Assoc. 224: 1105–1109.

Bengis RG, Leighton FA, Fischer JR, Artois M, Mörner T and Tate CM (2004). The role of wildlife in emerging and re-emerging zoonoses. Rev. Sci. Tech. Off. Int. Epiz. 23(2): 497-511.

Bergquist R (2011). New tools for epidemiology: a space odyssey. Mem. Inst. Oswaldo Cruz. 106(7): 892-900.

Block SM. (2001). "The growing threat of biological weapons. Am. Scientist, 89(1): 28-37.

Bloom DE (2011). 7 Billion and Counting. Sci. 333(6042): 562-569.

Bollo E (2007). Nanotechnologies applied to veterinary diagnostics. Vet. Res. Commun. 1: 145-147

Casais R, Thiel V, Siddell SG, Cavanagh D and Britton P (2001). Reverse genetics system for the avian coronavirus infectious bronchitis virus. J. Virol. 75(24): 12359-12369.

ISSN: 2307-8316 (Online)

Cascio A, Bosilkovski M, Rodriguez-Morales AJ and Pappas G (2011). The socio-ecology of zoonotic infections. Clin. Microbiol. Infect. 17: 336–342.
Centers for Disease Control and Prevention (2003). Multistate outbreak of monkeypox-Illinois, Indiana, Kansas, Missouri, Ohio, and Wisconsin. Morb. Mortal. Wkly. Rep. 52: 642-646.
Chadwick S, Kriegel C and Amiji M (2010). Nanotechnology solutions for mucosal immunization. Adv. Drug. Deliv. Rev. 62: 394–407.
Chakraborty S (2012). Prevalence of Nipah viral infection in Asiatic region - An overview. Int. J. Trop. Med. Pub. Health. 1(1): 6-10.
Chandra RK (1997). Nutrition and the immune system: an introduction. Am. J. Clin. Nutr. 66: 460S-463S.
Cosivi O, Grange JM, Daborn CJ, Raviglione MC, Fujikura T, Cousins D, Robinson RA, Huchzermeyer HF, De Kantor I and Meslin FX (1998) Zoonotic tuberculosis due to *Mycobacterium bovis* in developing countries. Emerg. Inf. Dis. 4: 59-70.
Coughlin JF, Pope J and Leedle BR (2006). Old age, new technology, and future innovations in disease management and home health care. Home Hlth. Care Manag. Pract. 18(3): 196-207.
Cunningham-Rundles S, McNeeley DF and Moon A (2005). Mechanisms of nutrient modulation of the immune response. J. Allergy Clin. Immunol. 115: 119–1128.
Daszak P, Cunningham AA and Hyatt AD (2001). Anthropogenic environmental change and the emergence of infectious diseases in wildlife. Acta Trop. 78: 103–116.
Daszak P, Tabor GM, Kilpatrick AM, Epstein J and Plowright R (2004). Conservation medicine and a new agenda for emerging diseases. Ann. N Y. Acad. Sci. 1026:.1–11.
Day MJ (2011). One health: the importance of companion animal vector-borne diseases. Parasit. Vectors, 4: 49.
Dazak P, Cunningham AA and Hyatt AD (2000). Emerging infectious diseases of wildlife: threats to biodiversity and human health. Sci. 297: 443-449.
Deb R and Chakraborty S (2012). Trends in veterinary diagnostics. J. Vet. Sci. Tech. 3: e103. doi: 10.4172/2157-7579.1000e103.
Dehove A (2010). One World, One Health. Transbound. Emerg. Dis. 57(1): 3-6.
Dhama K, Chauhan RS, Kataria JM, Mahendran M and Tomar S (2005). Avian influenza: the current perspectives. J. Immunol. Immunopathol. 7(2): 1-33.
Dhama K, Mehrotra S, Mahendran M and Tomar S (2007). Current strategies for enhancing immunity against diseases in poultry: an overview. Poult. Punch, 23(12): 32-53.
Dhama K., Mahendran M and Tomar S (2008a). Pathogens transmitted by migratory birds: Threat perceptions to poultry health and production. Int. J. Poult. Sci. 7(6): 516-525.
Dhama K, Mahendran M, Gupta PK and Rai A (2008b). DNA Vaccines and their applications in veterinary practice: current Perspectives. Vet. Res. Commun. 32(5): 341-56.
Dhama K, Pawaiya RVS and Kapoor S (2010). Hendra virus infection in horses. In: Advances in Medical and Veterinary Virology, Immunology, and Epidemiology - Vol. 7 : Tropical Viral Diseases of Large Domestic Animals- Part 1, Editor : Thankam Mathew, Thajema Publishers, 31 Glenview Dr., West Orange NJ 07052-1010, USA / Xlibris Corporation, United Kingdom, ISBN 978-1-4415-8160-0, Section A, Chapter 15, pp: 292-308.
Dhama K, Mahendran M, Tiwari R, Singh SD, Kumar D, Singh SV and Sawant PM (2011). Tuberculosis in birds: Insights into the *Mycobacterium avium* infections. Vet. Med. Int. Vol. 2011, Article ID 712369, 14 pages, doi:10.4061/2011/712369.
Dhama K, Wani MY and Tiwari R (2012a). Surveillance/networking, prevention and control strategies for zoonotic avian pathogens in context to one health concept with particular reference to south-asia. Lead Paper Presented in International Symposium on One Health : Way Forward to Challenges in Food Safety and Zoonoses in 21st Century and XIth Annual Conference of Indian Association of Veterinary Public Health Specialists (IAVPHS), Dec. 13-14, 2012 at School of Public Health and Zoonoses, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India.
Dhama K, Verma AK, Rajagunalan S, Deb R, Karthik K, Kapoor S, Mahima, Tiwari R, Panwar PK and Chakraborty S (2012b). Swine flu is back again: A review. Pak. J. Biol. Sci. 15(21): 1001-1009.
Dhama K, Tiwari R and Singh SD (2012c). Biosecurity measures at poultry farms and thumb rules to avoid developing a serious zoonotic illness from birds. Poult. Punch, 28(3): 30, 35-36, 38, 51.
Dhama K, Wani MY, Tiwari R and Kumar D (2012d). Molecular diagnosis of animal diseases: the current trends and perspectives. Livestock Sphere, May issue, pp: 6-10.
Dhama K, Verma AK, Tiwari R, Chakraborty S, Vora K, Kapoor S, Deb R, Karthik K, Singh R, Munir M and Natesan S (2013a). A perspective on applications of geographical information system (GIS); an advanced tracking tool for disease surveillance and monitoring in veterinary epidemiology. Adv. Anim. Vet. Sci. 1(1): 14-24.
Dhama K, Chakraborty S, Mahima, Wani MY, Verma AK, Deb R, Tiwari R and Kapoor S (2013b). Novel and emerging therapies safeguarding health of humans and their companion animals: A review. Pak. J. Biol. Sci. 16(3): 101-111.
Dhama K, Wani MY, Deb R, Karthik K, Tiwari R, Barathidasan R, Kumar A, Mahima, Verma AK and Singh SD (2013c). Plant based oral vaccines for human and animal pathogens – a new era of prophylaxis: current and future prospective. J. Exp. Biol. Agri. Sci. 1(1): 1-12.
Eberhart-Phillips J (2000). Diseases delivered in human cargo. *In*: Outbreak Alert. New Harbinger Publications, Oakland CA, USA. 62-64.
Emerich D and Thanos C (2003). Nanotechnology and medicine. Expert. Opin. Biol. Ther. 3: 655-663.
FAO Media Centre (2010). Improved disease prevention in animal health could save billions of dollars; One Health approach to more efficiently combat new pathogens is gaining strength. http://www.fao.org/news/story/en/item/44327/icode/›, last accessed 23 December 2010.
FAO-OIE-WHO (2010a). A Tripartite Concept Note - Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interfaces - The FAO-OIE-WHO Collaboration.
FAO-OIE-WHO Collaboration (2010b). http://www.oie.int/downld/FINAL_CONCEPT_NOTE_Hanoi.pdf.
Fenner F, Henderson DA, Arita L, Jezek Z and Ladnyi ID (1988). Smallpox and its Eradication. Geneva: World Health Organization; 1988.
Fingerut E, Gutter B, Gallili G, Michael A and Pitcovski J (2003). A subunit vaccine against the adenovirus - EDS using part of its fiber protein. Vaccine, 21(21-22): 2761-2766.
Foreign Agriculture Service (2003). -*Trade Data*. U.S. Department of Agriculture.
Fujkuyama Y, Tokuhara D, Kataoka K, Gilbert RS, McGhee JR, Yuki Y, Kiyono H and Fujihashi K (2012). Novel vaccine development strategies for inducing mucosal immunity. Expert Rev. Vaccines. 11: 367-79.
Gamble HR and Zarlenga DS (1986). Biotechnology in the development of vaccines for animal parasites. Vet. Parasitol. 20: 237-250.
Gargano LM, Gallagher PF, Barrett M, Howell K, Wolfe C, Woods C and Hughes JM (2013). Issues in the Development of a Research and Education Framework for One Health. Emerg. Infect. Dis. J. 19(3) DOI: 10.3201/eid1903.121103
Garrett L (1994). Searching for solutions. *In:* The Coming Plague. Penguin Books, New York, NY. 618- 619.
Glouberman S and Millar J (2003). Evolution of the determinants of health, health policy, and health information systems in Canada. Am. J. Pub. Health, 93(3): 388-392.
Godfroid J, Cloeckaert A, Liautard JP, Kohler S, Fretin D, Walravens K (2005). From the discovery of the Malta fever's agent to the discovery of a marine mammal reservoir, brucellosis has continuously been a re-emerging zoonosis. Vet. Res. 36: 313–326.
Grunkemeyer VL (2011). Zoonoses, public health, and the backyard poultry flock. Vet. Clin. North Am. Exot. Anim. Pract. 14(3): 477-490.
Gupta A (2001). Cows, bugs and drugs: an investigation of sporadic illness due to multidrug-resistant Salmonella Newport. NARMS Presentations. Centers for Disease Control and Prevention, Atlanta GA, USA.
Hafez HM (2005). Governmental regulations and concept behind eradication and control of some important poultry diseases. World Poult. Sci. J. 61: 569-581.
Hamburg MA and Lederberg J (2003). Microbial threats to health. Institute of Medicine of the National Academies. National Academy Press, Washington DC, USA. 53-55.
Harbige LS (1996). Nutrition and immunity with emphasis on infection and autoimmune disease. Nutr. Health. 10: 285-312.
Howe R and Christopher S (2004). Population health management: Healthways' PopWorks. HCT Project 2004-07-17, 2(5): 291-297.
Huff JL and Barry PA (2003). B-virus (Cercopithecine herpesvirus 1) infection in humans and macaques: potential for zoonotic disease. Emerg. Infect. Dis. 9: 246–250.
Jacqueline PJ, Jack MG, Henry RW and Ben FM (1997). Avian diseases transmissible to humans. Fact Sheet. University of Florida.CES, Institute of Food and Agricultural Sciences.
Jebara KB (2004). Surveillance, detection and response: managing emerging diseases at national and international levels. Rev. Sci. Tech. Off. Int. Epiz. 23 (2): 709-715.
Jensenius M, Fournier PE and Raoult D (2004). Rickettsioses and the international traveler. Clin. Infect. Dis. 39: 1493-1499.

ISSN: 2307-8316 (Online)

John K, Kazwala RR and Mfinanga GS (2008). Knowledge of causes, clinical features and diagnosis of common zoonoses among medical practitioners in Tanzania. BMC Infect. Dis. 8: 162.
Jones KE, Patel NG, Levy MA, Storeygard A and Balk D (2008). Global trends in emerging infectious diseases. Nature, 451: 990–-93.
Kahn LH, Kaplan B and Steele JH (2007). Confronting zoonoses through closer collaboration between medicine and veterinary medicine (as 'one medicine'). Veterinaria Italiana. 43(1): 5-19.
Karesh WB, Cook RA and Bennett EL (2005). Wildlife trade and global disease emergence. Emerg. Infect. Dis. 11(7): 1000-1002.
Kindig D and Stoddart G (2003). What is population health? Am. J. Pub. Health, 93(3): 380-383.
King LJ (2004). Emerging and re-emerging zoonotic diseases: challenges and opportunities. 72nd General Session, World organization for animal health, Office des International Epizootics, Paris. pp. 1-9.
Knight J, Kenney JJ, Folland C, Harris G, Jones GS, Palmer M, Parker D and Scaife A (2009). Do global temperature trends over the last decade falsify climate predictions? Bull. Amer. Meteor. Soc. 90 (8): S75–S79.
Kumar N, Pal BC, Yadav SK, Verma AK, Jain U and Yadav G (2009). Prevalence of Bovine Brucellosis in Uttar Pradesh, India. J. Vet. Public Health, 7(2): 129-131.
Kumar R, Verma AK, Kumar A, Srivastava M and Lal HP (2012). Prevalence and antibiogram of campylobacter infections in dogs of Mathura, India. Asian J. Anim. Vet. Adv. 7(5): 734-740.
Leonardi M, Borroni R and di Gennaro M (2006). Veterinary medicine in disasters. Ann. Ist. Sup. Sanitá. 42(4): 417-421.
Leslie J (2000). Newcastle disease: outbreak, losses and control policy costs. Vet. Rec. 146: 603-606.
Linda P (1998). Zoonotic diseases: Birds to human transmission. Winged Wisdom. Pet bird Ezine.
Madigan J and Dacre I (2009). Preparing for veterinary emergencies: disaster management and the Incident Command System. Rev. Sci. Tech. Off. Int. Epiz. 28 (2): 627-633.
Mahima, Verma AK, Kumar A, Rahal A and Kumar V (2012). Veterinarian for sustainable development of humanity. Asian J. Anim. Vet. Adv. 7(5): 752-753.
Mahima, Ingle AM, Verma AK, Tiwari R, Karthik K, Chakraborty S, Deb R, Rajagunalan S, Rathore R and Dhama K (2013). Immunomodulators in day to day life: a review. Pak. J. Biol. Sci. (In Press).
Manual of Diagnostic Tests and Vaccines for Terrestrial Animals (2010).www.oie.int
McKeown T (1972). An interpretation of the modern rise in population in Europe. Popul. Stud. 26: 345–382.
Moran M, Guzman J, Ropars A-L, McDonald A and Jameson N (2009) Neglected disease research and development: How much are we really spending? PLoS Med. 6: e1000030.
Morse SS (1995). Factors in the emergence of infectious diseases. Emerg. Infect. Dis. 1(1): 7.
Movahedi A and Hampson DJ (2008). New ways to identify novel bacterial antigens for vaccine development. Vet. Microbiol. 131: 1-13.
Myers SS and Patz JA (2009). Emerging threats to human health from global environmental change. Annual Rev. Env. Resources, 34: 223-252.
National Research Council (2005). Animal Health at the Crossroads — Preventing, Detecting, and Diagnosing Animal Diseases. *National Academies Press*. http://www.nap.edu.
Nolen RS and Kahler SC (2007). Veterinarian, physician collaboration focus of AVMA convention. JAVMA News. September 1.
OIE (2004). Chapter 1.1.1. General definitions. *In:* Terrestrial Animal Health Code, 13th Ed. OIE, Paris, 3-11.
Osburn B, Scott C and Gibbs P (2009). One World – One Medicine – One Health: emerging veterinary challenges and opportunities. Rev. Sci. Tech. Off. Int. Epiz. 28(2): 481-486
Patz JAD, Holloway C-LT and Foley JA (2005). Impact of regional climate change on human health. Nature. 438(7066): 310-317.
Paul-Pierre P (2009). Emerging diseases, zoonoses and vaccines to control them. Vaccine, 27: 6435–6438.
Pavot V, Rochereau N, Genin C, Verrier B and Paul S (2012). New insights in mucosal vaccine development. Vaccine, 30:142-54.
Pawaiya RVS, Dhama K, Mahendran M and Tripathi BN (2009). Swine flu and the current influenza A (H1N1) pandemic in humans: A review. Indian J. Vet. Pathol. 33(1): 1-17.
Ratcliff RM, Chang G, Kok T and Sloots TP (2007) Molecular diagnosis of medical viruses. Curr. Issues Mol. Biol. 9(2):87-102.
Rhee JH, Lee SE and Kim SY (2012). Mucosal vaccine adjuvants update. Clin. Exp. Vaccine Res. 1: 50-63.
Rogers DJ and Randolph SE (2006). Climate change and vector-borne diseases. Adv. Parasitol. 62: 345-381.
Rweyemamu MM and Cheneau Y (1995). Strategy for the global rinderpest eradication programme. Vet Microbiol. 44: 369-376.
Saif YM, Barnes HJ, Glisson JR, Fadly AM, McDougald LR and Swayne DE (2003). Diseases of poultry. 11th edn. Ames, Iowa State Press, USA.
Sakoda Y, Ito H and Uchida Y (2012). Reintroduction of H5N1 highly pathogenic avian influenza virus by migratory water birds, causing poultry outbreaks in the 2010–2011 winter seasons in Japan. J. Gen. Virol. 93(Pt 3): 541-550.
Schmitt B and Henderson L (2005). Diagnostic tools for animal diseases. Rev. Sci. Tech. Off. Int. Epiz. 24(1): 243-250.
Schneider MC, Belotto A, Ade MP, Leanes LF, Correa E and Tamayo H (2005). Epidemiologic situation of human rabies in Latin America in 2004. Epidemiol. Bull. 26: 2–4.
Sengupta R, Rosenshein L, Gilbert M and Weiller C (2007). Eco-regional dominance in spatial distribution of avian influenza (H5N1) outbreaks. Emerg. Infect. Dis. 13(8): 1269-1270.
Singh SD, Barathidasan R, Kumar A, Deb R, Verma AK and Dhama K (2012). Recent trends in diagnosis and control of Marek's Disease in poultry. Pak. J. Biol. Sci. 15(20): 964-970.
Slingenbergh J, Gilbert M, de Balog K and Wint W (2004). Ecological sources of zoonotic diseases. Rev. Sci. Tech. Off. Int. Epiz. 23(2): 467-484.
Statistics Division, United Nations (2003). Online Statistical Database.
Suri SS, Fenniri H and Singh B (2007). Nanotechnology-based drug delivery systems. J. Occupational Med. Toxicol. 2: 16.
Taylor LH, Latham SM and Woolhouse ME (2001). Risk factors for human disease emergence. Philos Trans. R. Soc. Lond. B. Biol. Sci. 356: 983–989.
Taylor LH, Latham SM and Woolhouse MEJ (2001). Risk factors for human disease emergence. Phil. Trans. Royal Soc. B. 356: 983-989.
Taylor WP, Bhat PN and Nanda YP (1995). The principles and practice of rinderpest eradication. Vet. Microbiol. 44: 369-376.
Taylor LH, Latham SM and Woolhouse ME (2001). Risk factors for human disease emergence. Philos. Trans. R. Soc. Lond. B. Biol. Sci. 356: 983-989.
The Maclean's Health Reports (1999). Toronto, Ontario, Canada: Maclean Hunter Publishing Ltd.
The World Bank (Agriculture and Rural Development. Health, Nutrition and Population) (2010). People, Pathogens and Our Planet. Volume I: Towards a One Health Approach for Controlling Zoonotic Diseases, 50833-GLB.
Tiwari R and Dhama K (2012). Avian / Bird flu: an update. Poult. Fortune, 14(1): 36-42.
Tsui AO, McDonald-Mosley R and Burke AE (2010). Family planning and the burden of unintended pregnancies. Epidemiol. Rev. 32 (1): 152-174.
U.S. General Accounting Office (GAO) (2000). West Nile Virus Outbreak — Lessons for Public Health Preparedness. GAO/HEHS-00-180. http://www.gao.gov.
United Nations (2008). Contributing to one world, one health: strategic framework for reducing risk of infectious diseases at the animal-human-ecosystem interface. FAO/OIE/WHO/UNICEF/UNSIC/World Bank. Available at: http://un-influenza.org/files/OWOH_14Oct08.pdf.
United Nations Framework Convention on Climate Change (UNFCCC) (2011). Status of Ratification of the Convention, UNFCCC Secretariat: Bonn, Germany: UNFCCC.
Van Borm S, Thomas I, Hanquet G, Lambrecht B, Boschmans M and Dupont G (2005). Highly pathogenic H5N1 influenza virus in smuggled Thai eagles. Belgium Emerg. Infect. Dis. 11: 702–705.
Varma MGR (2001). Kyasanur Forest disease. In: Service MW, editor. The encyclopedia of arthropod-transmitted infections. New York: CABI Publishing; p. 254–60.
Verma AK, Sinha DK and Singh BR (2007). Salmonella in apparently healthy dogs. J. Vet. Public Health. 5(1): 37-39.
Wagner M, Moore A and Aryel R (2006). Handbook of Bio-surveillance, San Diego, California, United States: Academic Press.
Webster RG, Bean WJ, Gorman OT, Chambers TM and Kawaoka Y (1992). Evolution and ecology of influenza A viruses. Microbiol. Rev. 56: 152-179.
Weiner DB (2008). DNA vaccines: crossing a line in the sand. Vaccine, 26: 5073-5074.
Wilson PR (2002). Advances in health and welfare of farmed deer in New Zealand. N. Z. Vet. J. 50(Suppl): 105–109.
Wittemyer G, Elsen P, Bean WT, Coleman A and Burton O (2008). Accelerated human population growth at protected areas edges. Sci. 321: 123-126.
Wolfe N, Daszak P, Kilpatrick AM and Burke DS (2005). Bush meat hunting: Deforestation, and prediction of zoonotic disease emergence. Emerg. Inf. Dis. 11: 1822-1827.
Wolfe ND, Dunavan CP and Diamond J (2007). Origins of major human infectious diseases. Nature, 447: 279-283.
Woodford MH and Rossiter PB (1993 Disease risks associated with wildlife translocation projects. Rev. Sci. Tech. 12: 115–135.

ISSN: 2307-8316 (Online)

Woodrow KA, Kaila M, Bennett KM and Lo DD (2012). Mucosal vaccine design and delivery. Annu. Rev. Biomed. Eng. 14: 17-46.

World Health Organization (2006). The control of neglected zoonotic diseases: A route to poverty alleviation. Report of a joint WHO/DFID-AHP meeting, 20 and 21 September 2005, WHO Headquarters, Geneva, with the participation of FAO and OIE.

World Health Organization (2009). Data and statistics: Causes of death. Geneva: World Health Organization. Available: http://www.who.int/research/en/.

Zinsstag J and Tanner M (2008). One health: the potential of closer cooperation between human and animal health in Africa. Ethiopian J. Develop. 22: 1-4.

Zinsstag J, Schelling E, Roth F, Bonfoh B, De Savigny D and Tanner M (2007). Human benefits of animal interventions for zoonosis control. Emerg. Infect. Dis. 13: 527-531.

ISSN: 2307-8316 (Online)