# One Health: A Compelling Convergence

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## Abstract

One Health has been defined as "the collaborative effort of multiple disciplines-working locally, nationally, and globally-to attain optimal health for people, animals and our environment." The One Health movement is broadly based, including domains as diverse as veterinary medicine, agricultural and animal science, wildlife biology, environmental science, global trade and commerce, climatology, human medicine and public health. One Health is not a new idea, having previously been espoused by Virchow, Osler and other pioneers in medical education, but it is more important than ever as an approach to dealing with the many global health problems in our ever more interconnected world. The 1999 North American West Nile virus epidemic illustrates that pathogens can, and frequently do, have major impacts on animal and human populations simultaneously and the interface between humans and animals is frequently the source of new or resurgent diseases. Climate change will result in widespread alteration in environmental conditions worldwide. How we are able to address the resulting challenges to human and animal health as well as the world's water and food supplies will have a major impact on how, or even if, we survive as a global community. In academic health centers One Health has implications for population health, the care of individual patients, biomedical research and health education. Texas A&M University is working to break down the barriers that have impeded collaboration between the scientific disciplines now encompassed under the One Health banner to create a whole greater than the sum of its component parts.

## Key Words

Medical education; veterinary medicine; inter-professional education; public health; environmental medicine

# Introduction

In August, 1999 residents of New York City observed an unusually large number of dead crows, particularly in the borough of Queens. Around the same time a number of exotic birds, including flamingos and pheasants, died at the Bronx Zoo.[1] In late August an unusual cluster of 8 cases of meningoencephalitis associated with severe muscle weakness was reported to the New York City Department of Health. [2] All of these patients, ranging from 58 to 87 years of age, had been healthy previously and lived within a 16 square mile area in northern Queens. Although they had no obvious common exposure, all had spent time doing yard work outside their homes. Public health officials suspected an arthropod borne virus was the etiologic agent. Eventually, 51 additional cases were reported and although most patients recovered from their illness, 7 died and 10 developed paralysis. Spinal fluid, serum, and tissue samples from these patients were tested and the causative agent was identified as West Nile virus, a member of the Japanese encephalitis group of flaviviruses. West Nile virus was first reported in the West Nile district of Uganda in 1937[3] and was known in Africa, the Middle East, South Asia, Europe and Australia but had not been reported previously in the Western Hemisphere. Shortly thereafter, scientists isolated West Nile virus from tissue specimens taken from a dead Chilean flamingo and the strain most closely resembled that recovered from a dead goose in Israel in 1998.[4]

The West Nile virus is transmitted through mosquito vectors which bite and infect birds. The virus multiplies rapidly in birds and mosquitos that have bitten infected birds transmit the virus to humans when they go on to bite humans.[5] Humans are not the only accidental hosts. Shortly after the first human cases were reported from the US veterinarians diagnosed an epidemic of the virus in horses, which killed 40% of the infected animals.[6] In 2002 a new strain of the virus emerged and rapidly spread the disease across most of the US, Canada and Mexico, infecting both human and equine populations. A 2008 study concluded that higher environmental temperatures helped the virus spread rapidly and warned that global warming could sharply accelerate the spread of West Nile into cooler regions of the globe.[7] Since 1999 nearly 30,000 cases and over 1,000 deaths have been reported by the Centers for Disease Control and Prevention in the US, including 1,021 cases and 57 deaths in 2010..[8] Researchers developed a widely used equine vaccine against West Nile in 2001[9] but to this point in time no clinically approved human vaccine is available.

## One Health Defined

The story of West Nile's transmission to and establishment in the US demonstrates how closely interconnected human, animal and environmental health have become in our ever shrinking global community. The convergence of these domains has been termed "One Health." A 2008 task force report from the American Veterinary Medical Association defined One Health as,"the collaborative effort of multiple disciplines-working locally, nationally, and globally-to attain optimal health for

people, animals and our environment."[10]The One Health movement is broadly based, including domains as diverse as veterinary medicine, agricultural and animal science, wildlife biology, environmental science, global trade and commerce, climatology, human medicine and public health. In our interconnected global economy environmental influences, including human-animal interactions, occurring locally, regionally or internationally can affect the health of individuals and populations anywhere else on earth. Given this reality, One Health applies an interdisciplinary approach to the study of the health challenges faced by the human and animal species that share planet earth. In addition, One Health is concerned with fundamental issues affecting the environment, such as global climate change, the loss of biodiversity and the adequacy of the world's supply of food and clean water.

## The History of One Health

The notion that human and animal health are highly inter-dependent is not new. From early times physicians who ministered to humans learned much of the anatomy and physiology they knew from studies on animals, as dissection of human bodies was forbidden by law and religious conviction. In 1713, Pope Clement sent Italian physician, Giovanni Lancisi, to investigate an epidemic decimating cattle populations in Rome.[11] He suspected the disease was passed between cattle by contact and recommended isolation of infected animals, thus helping to retard its spread. In 1796, Edward Jenner used a live strain of the cowpox virus to develop the first smallpox vaccine. In the nineteenth century a great generation of "doctors of

universal medicine,"[12] including Robert Koch and Paul Erlich, made contributions to both veterinary and human medicine. Rudolf Virchow, the father of cell biology and the first scientist to describe a zoonotic disease, recognized the relationship between human and animal health stating, "Between animal and human medicine there are no dividing lines—nor should there be. The object is different, but the experience obtained constitutes the basis of all medicine."[12] One of Virchow's pupils, Sir William Osler, brought the "'one health" perspective to North America. While serving as a faculty member at the Montreal Veterinary College, he undertook a study of the parasites in the city's pork supply.[13]

The more modern history of One Health dates to 1958 when Joseph Klauder, MD published "Interrrelations of human and veterinary medicine-discussion of some aspects of comparative dermatology"[12] in the New England Journal of Medicine. The article pointed out the many common clinical problems, the reciprocal influences on research and the similarities in training shared by physicians and veterinarians. In 1964 veterinary epidemiologist Calvin Schwabe published *Veterinary Medicine and Human Health* [14]which advanced the view that animal illnesses have much to teach us about human health. Schwabe is given credit for coining the term, "One Medicine,'' to describe the importance of the interface between human and animal health.[15] The theme of Schwabe's work, now more commonly termed One Health, has been further developed by a number of national and international organizations. The Centers for Disease Control and Prevention has created a "One Health Office" that sponsors scientific meetings and provides a forum to foster collaboration

among interested organizations, such as the World Health Organization, the World Organization for Animal Health and the United Nations Food and Agriculture Organization.[16] The One Health Initiative, which "is dedicated to improving the lives of all species-human and animal-through the integration of human medicine, veterinary medicine and environmental science ," lists a large group of sponsoring organizations world-wide and seeks to promote activities such as joint professional education, the sharing of clinical information, joint disease surveillance, comparative medicine and environmental research and the education of policy makers.[17] The One Health Commission is a partnership between, among others, the American Medical Association, the Association of American Medical Colleges, the Association of Academic Health Centers, the American Veterinary Medical Association, the Association of American Veterinary Medical Colleges, and the American Public Health Association.[18] Thus, the notion of One Health as an approach to health problems is gaining currency nationally and internationally.

## Why One Health

In recent times the concept of One Health has expanded beyond an examination of the human-animal health interface to encompass the health and sustainability of the world's ecosystems. One Health catalyzes solutions to some of the most pressing challenges facing the world today by breaking down the barriers that have historically existed between human medicine, veterinary medicine, public health and environmental and agricultural sciences. The global human population, now over 7 billion, places unprecedented pressure on our planet. Evidence for the stress

facing the natural and man-made systems upon which we depend to survive is everywhere. Rapid urbanization, economic disparities, shortages of food, water and natural resources, wild habitat destruction, global warming, severe natural disasters, international conflict and terrorism, political revolutions and population migrations are just a few signs of this stress. These problems have brought us face to face with new public health challenges. For example, in the past 25 years, 38 new pathogens have emerged, 75% of which originated as animal diseases.[19] During that time we have experienced entirely new zoonotic diseases, like HIV/AIDS (West African monkeys and chimpanzees) and SARS (Chinese bats and palm civets) and new variants of old species jumping diseases, like the near miss of a global H1N1 influenza pandemic (swine).[5] Today, given the ease of intercontinental travel, disease transmission can outpace our ability to detect it, placing almost the entire globe one flight away from vulnerability to new pandemic threats.

Antibiotic microbial resistance, another threat facing both human and animal populations, is increasing due to inappropriate use of antibiotics in human populations and commercial animal husbandry.[20] Scientists have recently learned that humans can transmit methacillin resistant Staphylococcus aureus (MRSA) to household pets[21] and a new strain of MRSA infecting milk cattle in Britain has been implicated in several human cases of infection.[22]

## One Health and the Environment

Our environment profoundly influences both human and animal health. The World Health Organization estimates that water borne illnesses kill 2.5 million people across the globe annually, most of them children.[23] Nearly 10% of the global disease burden results from poor sanitation and the lack of a safe drinking water supply.[23] Transmission of infectious agents through our food supply is very common given the growth of industrial farming and the world-wide distribution of foodstuffs. In 2011 alone, listeria-contaminated cantaloupes claimed 30 lives in the US[24] and 50 people who consumed bean sprouts contaminated by E Coli O104:H4 died in Europe.[25] The Centers for Disease Control and Prevention estimates that each year one of every six Americans, over 50 million people, has an episode of food borne illness, resulting in over 128,000 hospitalizations and 3,000 deaths.[26] The incidence of Salmonella, the most common cause of food borne illness in the US, has not declined in the last 15 years despite efforts to educate the population about ways to prevent the transmission of this pathogen.[27] Air pollution has been linked to the increased incidence of asthma and cardiovascular disease in humans[28,29] and air quality has been linked with pulmonary health in equine athletes. It is also clear that our diet plays an important role in a range of chronic diseases from diabetes and cancer to heart disease.[30]

However, the most significant impacts of the environment on human, animal and planetary health lie in the future. The world's human population is altering our global ecosystem through mechanisms like climate change, biodiversity loss, land

degradation and deforestation, and marine pollution. The human race is changing the earth's environment, creating living conditions that our species has never before seen.

Global warming poses perhaps the greatest threat to our survival.[31] $CO_2$ has increased from 315 parts per million by volume in 1958 to nearly 390 ppmv today,[32] coincident with a nearly 0.6 degree C increase in global average surface temperature.[33] At the current rate of greenhouse gas accumulation $CO_2$ levels are likely to exceed 500 ppmv, driving global temperatures to increase by an additional 2-6 degrees C by 2100.[34] Projecting the impacts of climate change on human health is complex. Humans are resilient and capable of adapting to a range of environmental challenges. However, major impacts on human and animal health will result from these changes in global climatic conditions. Some health impacts from climate change are already appearing, such as the rising direct death toll from more frequent extreme weather events and the public health challenges posed by displaced populations resulting from these events.[35,36]

In the future more significant impacts on health resulting from global warming are likely, but harder to quantify. Based on computer modeling, scientists project that surface and ocean temperatures will increase making many regions drier and that rising sea levels caused by polar ice melts, will result in large scale population displacement, threats to fresh water supplies, and decreased agricultural production. We also expect that famine and political unrest driven by inadequate

supplies of food and water are likely to occur with growing frequency. More frequent heat waves and droughts, increased air pollution, and the expansion of the range of vector borne infectious agents, like malaria and Lyme disease are also predicted[35,36] Finally, scientists are concerned about the psychological impacts of these stressors on individual human beings and animals.[37] Many of the most severe effects of climate change will occur in the developing areas of Africa, Asia, and Latin America, exactly those regions of the world least able to mount effective adaptive responses. Thus, it is clear our environment will increasingly influence human and animal health in the future.[35-37]

## The Implications of One Health for Academic Health Centers

One Health is important to academic health centers because it has implications for population health and epidemiology, the care of individual patients, biomedical research and health professions education. Our schools of public health are involved in assessing the infectious disease threats facing populations across the nation and around the world. These threats highlight the importance of a strong public health infrastructure. Public health authorities across the world will have to collaborate with one another to detect and contain new epidemics in their early stages, to educate providers about the appropriate use of anti-microbials and to collect data on emerging trends in disease incidence. The World Health Organization has developed the Global Outbreak Alert and Response Network to help public health authorities in individual nations prepare plans for detecting, reporting and

responding to potential pandemics.[38] Schools of public health are often key actors in developing and implementing these plans, often working in conjunction with public health authorities. Scientists now understand that the human-animal interface is often where new disease threats emerge and understanding this two-way transmission potential involves not just human and veterinary medicine and public health but also wildlife and ecosystem biology.

Front line clinicians caring for individual patients in our hospitals and clinics are relevant to One Health, because the early detection of communicable diseases frequently requires a high index of suspicion. As safety net providers in many communities across the US, academic health centers frequently care for large immigrant populations and may be the first line of defense against the spread of rare diseases from abroad. The anthrax bioterrorism attacks of 2001 that claimed the lives of 5 of the 11 patients infected provide an example of the importance of clinical suspicion. A number of these patients were mis-diagnosed as having influenza delaying appropriate treatment and contributing to their deaths.[39] Many of the same considerations hold true in the veterinary profession, as front-line veterinary clinicians care for animal patients in veterinary hospitals and on farms and are frequently the first to recognize disease clusters. Disease surveillance programs are critical in detecting patterns of disease in animals. Although clinical vigilance will always be important, today academic health centers are leading the way in developing detection tools based on the clustering of cases mined from electronic health records.[40]

One Health is also relevant to the biomedical research underway in academic health centers. We share 98% of the same genes with chimpanzees[41a]nd even 75% with a species as different from our own as the mouse,[42] making animal models of human diseases critical in biomedical research. Why is it that chimpanzees don't get AIDS or malaria? What can we learn from studying the chimpanzee genome that might provide clues as to how to treat or prevent human cases of malaria or AIDS? Why is it that veterinary medicine has been able to develop a vaccine for West Nile virus where human medicine has failed? These and a myriad of other questions form the substrate of trans-species collaborative research. Researchers are using animal models to study human diseases in new ways . Because we now realize that rodents are not ideal research models for many human diseases and that human clinical trials are expensive and complex, scientists are turning to spontaneously occurring animal disease models.

Infectious disease is not the only area where human and veterinary medicine can learn from one another. Osteosarcoma is the most common primary bone cancer in both humans and dogs. Despite recent advances in treatment, it remains a significant source of human morbidity and mortality, especially in adolescents. Osteosarcoma is strikingly similar in presentation, biology, treatment and complications in humans and dogs.[43] Dogs serve as an excellent model system for the study of this cancer. Using this model, cancer biologists can study pathogenesis and molecular biology, oncologists can evaluate new biomarkers or therapeutic

agents, bioengineers can study enhanced imaging techniques or develop new prosthetic devices, and surgeons can develop new techniques to preserve limb functionality, all of which may have direct application in the diagnosis and treatment of human osteosarcoma. Scientists have learned that certain membrane cytoskeleton proteins promote tumor growth in osteosarcoma in both humans and dogs.[44,45] Several clinical trials in dogs with osteosarcoma are studying the feasibility of blocking these proteins. These trials were endorsed both by the Children's Oncology Group and by the National Cancer Institute's Comparative Oncology Trials Consortium.[46]

The power of collaborative research ventures is exemplified by work going on in the Texas A&M University System. The Texas Institute of Preclinical Studies (TIPS) at the Texas A&M College of Veterinary Medicine & Biomedical Sciences and the Texas A&M Health Science Center College of Medicine are collaborating in a project using Positron Emission Tomography to facilitate improved imaging for early diagnosis of osteosarcoma. Additionally, researchers at the College of Veterinary Medicine & Biomedical Sciences are collaborating with researchers at the University of Texas MD Anderson Children's Cancer Hospital to develop new immunotherapies for advanced stage non-Hodgkin lymphoma. In another collaboration with the University of California San Francisco, scientists are studying non-invasive treatments of naturally occurring spinal cord injuries in dogs that have the potential to translate to humans with spinal cord injuries. Multiple sclerosis and muscular dystrophy are two more examples of spontaneously occurring animal diseases with

the potential for translation to human medicine currently being studied at Texas A&M.

One Health has important implications for health education. Our programs in graduate and undergraduate medical education must prepare graduates to play appropriate roles in detection, treatment and reporting of potentially transmissible infectious diseases, including epidemic and mass casualty management. Furthermore, we could develop interdisciplinary educational activities involving medical, veterinary and public health students that illustrate the importance of population health in both humans and animals and demonstrate that the human-animal interface is critical in the context of emerging zoonotic diseases. Finally, it will become more important we must make our trainees aware of the changes in disease incidence being driven by global warming, climate change and other changes in ecosystems. Although unusual in this country, infectious diseases, especially those resulting from poor sanitation and contaminated water, remain major problems in much of the developing world. Many medical schools have recently included topics and elective experiences in global health in their curricula to help to educate the current generation of trainees about the scope and real-world impact of these problems worldwide.

## Recommendations for Academic Health Centers

1. Create centers of excellence in One Health bringing together multi-disciplinary teams to confront the multitude of new and old health problems

driven by changes in global and regional ecosystems. This might be easiest at universities that have both colleges of medicine and veterinary medicine, but faculty in colleges of medicine, schools of public health, wildlife and environmental biology and agricultural sciences at other universities could also collaborate on important problems.

2. Create and practice epidemic preparedness plans. Collaborate with local and regional public health authorities to contribute expertise and personnel to the development of their response plans.
3. Establish a culture of One Health by encouraging individual investigators to imagine how their work might be applicable to One Health and to seek out new collaborators to partner on specific projects and facilitating interdisciplinary research within and between colleges and institutions
4. Develop educational programs dealing with the major emerging public health problems facing our planet and make sure our trainees are prepared to play a role in addressing these issues in their day-to-day practice as well as in public health emergencies.
5. Develop outreach programs that engage communities in the One Health concept.

## Conclusion

Two final case studies prove that collective and collaborative global action can overcome human-created threats to health. The depletion of the earth's

stratospheric ozone layer via the release of industrial chemicals, such as chlorofluorocarbons (CFCs) used in refrigeration and spray can propellants, became a recognized public health concern in the 1980's. The effects of CFCs on the ozone will peak in the year 2020 with an effective increase in ultraviolet radiation exposure of 10% relative to levels in the 1980's. Researchers predict a 10% increase in skin cancer incidence in both humans and animals in the US by the year 2050.[36] Despite the unalterable future adverse effects on human health, most of the countries in the world collectively adopted the Montreal Protocol in 1987, rolling back the emission of ozone destroying CFCs, and climate scientists now believe that a near complete recovery of the ozone layer will occur by mid century.[47]

The lack of access to a source of pure drinking water is a major determinant of human and animal health. The Texas A&M University Water Project combines the expertise of a multidisciplinary team of artists, engineers, housing staff and health care providers from Texas A&M University, the Texas A&M Health Science Center and Potters for Peace, a non-profit group. Using a design developed by the potters the group developed a water filter made from clay and sawdust, containing colloidal silver and capable of removing 99% of disease causing bacteria from water. The filters were deployed in the Colonias region of South Texas, a group of 2000 communities spread across a 1,500 mile stretch of the border with Mexico. More than 500,000 people in the Colonias have no running water or sewage systems in their homes. This project has shown such promise in reducing water borne disease

that efforts are now underway to spread this simple and inexpensive technology to international sites which suffer from lack of clean water.[48,49]

Given the many and increasingly significant effects of the interdependence of human, animal and environmental health and the truly monumental challenges facing our planet, it is time for us to break down the traditional silos that have impeded collaboration across our disciplines. It is incumbent on us to learn from each other and to imbue in our students, the next generation of health care providers and scientists who will be called upon to solve these pressing problems, an openness to ideas generated across species lines. Given our ever shrinking and flattening globe, we truly have entered the era of One Health.

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