Perspective: **One Health: A Compelling Convergence**

T. Samuel Shomaker, MD, JD, Eleanor M. Green, DVM, and Suzanne M. Yandow, MD

### 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, plants, and our environment.” The broadly based One Health movement includes domains as diverse as agricultural and animal science, environmental science, climatology, veterinary medicine, human medicine, and public health. One Health, previously espoused by Virchow, Osler, and other pioneers in medical education, is not a new idea, but, as an approach for dealing with the many global health problems in an increasingly interconnected world, it has become more important than ever. The 1999 North American West Nile virus epidemic illustrates that pathogens can, and frequently do, have major effects on animal and human populations simultaneously and that the interface between humans and animals is frequently the source of new or resurgent diseases. Further, climate change will result in widespread alterations to environmental conditions worldwide. How humanity addresses the resulting challenges to human and animal health as well as to the world’s water and food supplies will have a major impact on how, or even if, the global community survives.

One Health touches on all the missions of academic health centers: population or public 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 among the scientific disciplines now encompassed under the One Health banner to create a whole greater than the sum of its component parts.

---

**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. In late August, an unusual cluster of eight cases of meningoencephalitis associated with severe muscle weakness was reported to the New York City Department of Health. 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 eight patients had spent time doing yard work outside their homes. Public health officials suspected that 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 single-stranded RNA viruses known as flaviviruses.

West Nile virus was first reported in the West Nile district of Uganda in 1937 and was known in Africa, the Middle East, South Asia, Europe, and Australia. Until 1999, no cases had been reported in the Western Hemisphere. Shortly after the cases were reported in New York, scientists isolated West Nile virus from tissue specimens taken from a dead Chilean flamingo who had lived at the Bronx Zoo, and the strain most closely resembled that recovered from a dead goose in Israel in 1998.

The West Nile virus is transmitted through mosquito vectors which bite and infect birds. The virus multiplies rapidly in birds, and then mosquitoes that have bitten infected birds transmit the virus to humans when they (the mosquitoes) go on to bite humans. Humans are not the only accidental hosts. Shortly after the first human cases from the United States were reported, veterinarians diagnosed an epidemic of the virus in horses—40% of the infected animals died of the strain. Upon investigation, scientists discovered that a new strain of the virus had emerged in 2002 and then rapidly spread across most of the United States, Canada, and Mexico, infecting both human and equine populations.

The authors of this 2008 study concluded that higher environmental temperatures helped the virus spread rapidly, and they warned that global warming could sharply accelerate the spread of West Nile into cooler regions of the globe. Since 1999, the Centers for Disease Control and Prevention (CDC) in the United States has reported nearly 30,000 cases and over 1,000 deaths (including, in 2010 alone, 1,021 cases and 57 deaths). Researchers developed a widely used equine vaccine against West Nile in 2001, but to this point in time no clinically approved human vaccine is available.

### The Definition of One Health

The story of West Nile’s transmission to and establishment in the United States demonstrates how closely interconnected human, animal, and environmental health have become in the 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, plants, and our environment.” The One Health movement is broadly based, including domains as diverse as agricultural and animal science, environmental science, climatology, veterinary medicine, human medicine, and public health. As the global economy becomes more and more interconnected, 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 focuses on 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 interdependent is not new. During the Medieval and Renaissance eras, physicians who ministered to humans learned much of the anatomy and physiology they knew from studies on animals because dissection of human bodies was often discouraged or prohibited. In 1713, Pope Clement sent the Italian physician Giovanni Lancisi to investigate an epidemic decimating cattle populations in Rome; Lancisi suspected that the disease spread among cattle through contact, and he recommended isolation of infected animals, thus helping to retard its spread. In 1796, Edward Jenner used a live strain of the cowpox virus from bovines to develop the first smallpox vaccine for humans, and in the 19th century a great generation of “doctors of universal medicine”—including Nobel Prize winners Robert Koch, a microbiologist who articulated the principles of disease causation known as Koch’s postulates, and Paul Erlich, an immunologist who made seminal discoveries in hematology and chemotherapy—made contributions to both veterinary and human medicine. In the mid-1880s, 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 is no dividing line—nor should there be. The object is different, but the experience obtained constitutes the basis of all medicine.” 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.

The history of One Health in the 20th century dates to 1958 when Joseph Klauder published “Interrelations of human and veterinary medicine; Discussion of some aspects of comparative dermatology” in the New England Journal of Medicine. In the article, he 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, which advanced the view that animal illnesses have much to teach physicians 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. A number of U.S. and international organizations have since further developed Schwabe’s work, now more commonly termed “One Health.” For example, the CDC 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. One Health is also the central theme of the One Health Initiative. This initiative focuses on “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 worldwide; and seeks to promote activities such as joint professional education, the sharing of clinical information, joint disease surveillance, comparative medicine studies, environmental research, and the education of policy makers. Further, the One Health Commission is a partnership of organizations including, 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. The large number and variety of organizations involved in One Health show that as an approach to health problems, the concept is gaining currency nationally and internationally.

The Imperative for One Health

In the past decade, 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 among veterinary medicine, human medicine, public health, and environmental and agricultural sciences (see One Health Successes, below). The global human population, now over seven billion, places unprecedented pressure on the planet. Evidence of the stress facing the natural and manmade systems on which both human and nonhuman animals 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 humanity face to face with new public health challenges that a One Health approach can help solve.

For example, in the past 25 years, 38 new pathogens have emerged, 75% of which originated as animal diseases. During that same time frame, physicians and public health officials have battled entirely new zoonotic diseases, such as HIV/AIDS (originating from West African monkeys and chimpanzees) and SARS (originating from Chinese bats and palm civets). Further, new variants of known species—jumping diseases have caused worry and panic, as in the near
One Health and the Environment

The environment profoundly influences both human and animal health, especially through effects on the water and food supply and through global climate and air quality.

The World Health Organization estimates that waterborne illnesses kill 2.5 million people across the globe annually, most of them children.\(^{22}\) 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 to humans and animals through the food supply is very common given the growth of industrial farming and the worldwide distribution of foodstuffs. In 2011 alone, listeria-contaminated cantaloupes claimed 30 lives in the United States,\(^ {24}\) and 50 people who consumed bean sprouts contaminated by *Escherichia coli* O104:H4 died in Europe.\(^ {25}\) The CDC estimates that each year, one of every six Americans—that is, over 50 million people—has an episode of foodborne 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 United States, has not declined in the last 15 years despite efforts to educate the population about ways to prevent the transmission of this pathogen.\(^ {27}\)

Environmental influences on the food supply can also affect the animals that humans eat. Mad cow disease, or bovine spongiform encephalopathy (BSE), is a fatal degenerative neurological disease of cattle caused by infectious proteins called prions.\(^ {28}\) BSE, which is transmitted by giving BSE-prion-contaminated feeds to cattle, nearly destroyed the cattle industry in Great Britain in the late 1980s.\(^ {29}\) In 1996, a human variant of Creutzfeld–Jacob disease was reported and linked to the consumption of BSE-infected beef.\(^ {30}\)

Research also clearly shows that the foods making up our diet, produced in agricultural regions across the world, play an important role in a range of chronic diseases from diabetes and cancer to heart disease.\(^ {31}\)

Global warming poses perhaps the greatest threat to the survival of humans.\(^ {32}\) Carbon dioxide (CO\(_2\)) has increased from 315 parts per million by volume (ppmv) in 1958 to nearly 390 ppmv today,\(^ {33}\) coincident with a nearly 0.6 °C increase in global average surface temperature.\(^ {34}\) 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° to 6° C by 2100.\(^ {35}\)

Projected changes in global climate will also have profound impacts on animals and plants, both domestic and wild. A recent study predicted that 1 in 10 species of animals and plants inhabiting the earth will face extinction by the year 2100 if current climate trends continue.\(^ {36}\)

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 responses. Finally, scientists are concerned about the psychological impacts of these stressors on individual human beings and on animals.\(^ {37}\)

Clearly, the environment will increasingly influence human and animal health in the future.\(^ {38}\) A One Health approach can help to mitigate the damaging influences and find and increase healthful influences.
The Implications of One Health for Academic Health Centers

One Health is important to academic health centers (AHCs) because it has implications for population health and epidemiology or public health, the care of individual patients, biomedical research, and health professions education.

Schools of public health in the United States 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 antimicrobials, 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. Schools of public health are 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 frequently where new disease threats emerge, and understanding this two-way transmission potential involves knowledge of not just veterinary medicine, human medicine, and public health but also of wildlife and ecosystem biology.

One Health is relevant to frontline clinicians caring for individual patients in hospitals and clinics because the early detection of communicable diseases frequently requires a high index of suspicion. As safety net providers in many communities across the United States, AHCs frequently serve as places for the care of large immigrant populations, and, as such, they 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 originally misdiagnosed with influenza, which delayed their appropriate treatment and contributed to their deaths. Many of the same considerations hold true in the veterinary profession: As frontline veterinary clinicians care for animal patients in veterinary hospitals and on farms, they frequently serve as the first to recognize disease clusters. Disease surveillance programs are critical in detecting patterns of disease in animals. Although clinical vigilance has always been important in human medicine (as well as veterinary medicine), today AHCs are leading the way in developing detection tools based on the clustering of cases mined from electronic health records.

One Health is also relevant to the biomedical research under way in AHCs. Humans share 98% of the same genes with chimpanzees and even 75% with a species as different as the mouse, making animal models of human diseases critical in biomedical research. Why is it that chimpanzees are immune to AIDS and 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 and AIDS? Why is it that veterinary medicine has been able to develop a vaccine against West Nile virus for horses while human medicine has failed to do so for people? These and a myriad of other questions form the substrate of transspecies collaborative research. Researchers are using animal models to study human diseases in new ways. Because scientists now realize that rodents are not ideal research models for many human diseases and that human clinical trials are expensive and complex, scientists are studying diseases that spontaneously occur in animals and applying what they learn to humans.

Infectious disease is not the only area in which human and veterinary medicine can complement and supplement 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. Because osteosarcoma is strikingly similar in presentation, biology, treatment, and complications in humans and dogs, dogs serve as an excellent model system for the study of this cancer. Using the model of osteosarcoma in dogs, 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. For example, since scientists have learned that certain membrane cytoskeleton proteins promote tumor growth in osteosarcoma in both humans and dogs, investigators are conducting several clinical trials in dogs with osteosarcoma to examine the feasibility of blocking these proteins. Both the Children’s Oncology Group and the National Cancer Institute’s Comparative Oncology Trials Consortium have endorsed these trials.

Work going on in the Texas A&M University System further exemplifies the power of collaborative research, such as that undertaken in a One Health approach. Investigators working at the Texas Institute of Preclinical Studies, which is collocated within the Texas A&M College of Veterinary Medicine and Biomedical Sciences and the Texas A&M Health Science Center College of Medicine, are collaborating on a project using positron emission tomography to facilitate improved imaging for early diagnosis of osteosarcoma. Additionally, researchers at the College of Veterinary Medicine and Biomedical Sciences are collaborating with researchers at the University of Texas MD Anderson Children’s Cancer Hospital to develop new immune therapies for advanced stage non-Hodgkin lymphoma. In another collaboration with the University of California, San Francisco, scientists at the Texas A&M Health College of Veterinary Medicine and Biomedical Sciences are studying noninvasive 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 that scientists at Texas A&M are currently studying.

One Health also has important implications for health education. Curricula and programs in both graduate and undergraduate medical education must prepare graduates to play appropriate roles in the detection, treatment, and reporting of potentially
transmissible infectious diseases. Curricula and programs should also include information on epidemic and mass casualty management. Furthermore, educational leaders and curriculum/program designers should develop interdisciplinary educational activities involving veterinary medicine, human medicine, public health, and environmental/biomedical students that not only illustrate the importance of population health in both humans and animals but also effectively demonstrate the critical importance of the human–animal interface in the context of emerging zoonotic diseases. Finally, educators must make veterinary, medical, and public health trainees aware of the changes in disease incidence that are being driven by global warming, climate change, and other changes in ecosystems. Although unusual in the United States, infectious diseases, especially those resulting from poor sanitation and contaminated water, remain major problems in much of the developing world. Some universities and medical schools are exploring aspects of One Health in their global health programs. Nearly 40% of U.S. and Canadian medical schools now include global health topics in their mandatory and elective curricula to help to educate the current generation of trainees about the scope and real-world impact of such problems worldwide. For example, driven by broad student interest, Weill Cornell Medical College developed an extensive, four-year elective global health curriculum consisting of over 100 hours of training.

**Recommendations for AHCs**

1. Create centers of excellence in One Health that bring together multidisciplinary teams of experts who can begin to address the multitude of emerging and established health problems driven by changes in global and regional ecosystems. Creating such a center might be easier at universities that have both a college of human medicine and one of veterinary medicine, but faculty in colleges of medicine, in schools of public health, in departments of wildlife and environmental biology, and in departments of agricultural sciences—as well as faculty from 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 facilitate interdisciplinary research within and among departments, schools, colleges, and institutions.
4. Develop educational programs that address the major emerging public health problems facing planet Earth and ensure that trainees are prepared to play a role in dealing with these issues in their day-to-day practices as well as in public health emergencies.
5. Develop outreach programs, such as the One Health Challenge, that engage communities in the One Health concept. (The One Health Challenge is a national initiative of the Student American Veterinary Medical Association which seeks, via partnerships with other health professions students, to raise public awareness of a major One Health Topic. For example, the 2009 theme was obesity, and students organized fitness events for both humans and dogs.)

**One Health Successes**

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 1980s. The effects of CFCs on the ozone layer will peak in the year 2020 with an effective increase in ultraviolet radiation exposure of 10% relative to levels in the 1980s. Researchers predict a 10% increase in skin cancer incidence in both humans and animals in the United States by the year 2050. 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 midcentury. The Montreal Protocol is an example of scientists from different disciplines coming together to improve the health of individuals, populations, animals, and the environment.

The lack of access to a source of pure drinking water is a major determinant of human and animal health and, thus, an important topic in One 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 a nonprofit group called Potters for Peace. Using a design developed by the Potters, the team developed a water filter, made from clay and sawdust and containing colloidal silver, that is capable of removing 99% of disease-causing bacteria from water. The team deployed the filters in the Colonias region of South Texas, which is home to about 2,000 communities spread across a 1,500-mile stretch of the U.S.-Mexican border. 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 waterborne disease that efforts are now under way to spread this simple and inexpensive technology to international sites where people suffer from lack of clean water.

**In Sum**

Given the many and increasingly significant effects of the interdependence of human, animal, and environmental health and the truly monumental challenges facing our planet, now is the time for veterinarians, physicians, public health officials, scientists, and academics to break down the traditional silos that have impeded collaboration across their disciplines. It is incumbent on them to learn from one another and to imbue in their students—the next generation of health care providers and scientists who will be called on 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.

Funding/Support: None.

Other disclosures: None.

Ethical approval: Not applicable.

References


