

Introduction: One Health Perspective

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The One Health concept is a worldwide strategy—a paradigm shift—for expanding interdisciplinary collaborations and communications in all aspects of health care for humans and animals. The synergism achieved will advance health care for the 21st century and beyond by accelerating biomedical research discoveries, enhancing public health efficacy, expeditiously expanding the scientific knowledge base, and improving medical education and clinical care. When properly implemented, it will help protect and save untold millions of lives in present and future generations.¹

“One Health” promotes the integration of human, animal, and environmental health through communication and collaboration among physicians, osteopaths, veterinarians, wildlife professionals, environmental and public health experts, dentists, nurses, biomedical engineers, physicists, biochemists, plant pathologists, and others.

Important US agencies are already exploring implementation of the One Health Initiative. At a meeting in November 2009 of the newly formed One Health Commission (www.onehealthcommission.org)—a national nonprofit organization that includes the National Institutes of Health (NIH), Centers for Disease Control and Prevention (CDC), Food and Drug Administration (FDA), Department of Agriculture (USDA), and others—the Institute of Medicine announced a proposed joint study with the Institute for Laboratory Animal Research to examine the interdependencies of human, animal, and ecosystem health and assess the potential value of a One Health approach both nationally and internationally. The study will also evaluate (1) the possible integration of training and research across the human, animal, and environmental health sciences and (2) the potential for enhancing public health,

scientific innovation, professional and public education, the biomedical and pharmaceutical industries, and national security. The results of the study will be used to develop a strategic roadmap for public and private policies and measures to support the implementation of One Health.

Under One Health principles, elimination of artificial barriers such as perennial “turfs” or domains will result in greater and more expeditious advances while at the same time preserving domain individuality. Each domain will be a significant part of the whole, strengthening its integrity and impact through linkage with other coequal participants in a united and more intellectually active powerbase (in military terms, this approach would be called a “force multiplier”).

Application of the One Health philosophy has been limited thus far, but its use has invariably resulted in beneficial synergies by, for example, facilitating better understanding of disease processes through a comparative medicine approach, involving public health, environmental health, biomedical research (including laboratory animal science), and clinical medicine and surgery.

Through the One Health approach, scientists and health professionals of the 21st century have the opportunity to reshape and advance the future of health care for humans and animals worldwide.

Critical Contributions from the 19th Century to the Present

There are prominent examples of One Health proponents in the 19th, 20th, and early 21st centuries (Kahn et al. 2007a).

Early Pioneers

Rudolf Virchow (1821–1902) is considered the father of comparative medicine, cellular biology, and veterinary pathology. Through his contributions to medicine and his lifelong support for incorporating veterinary medicine in human health care, he effectively launched the One Health concept in the 19th century. His assertion that “between animal and human medicine there are no dividing lines—nor should there be” holds true to this day (Kahn et al. 2007b). He also coined the term “zoonosis” for a disease transmissible from animals to humans.

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¹Kaplan and Echols 2009a,b; www.onehealthinitiative.com.

Sir William Osler (1849–1919), called the “Father of Modern Medicine,” was greatly influenced by Virchow when he studied under him in Berlin. Virchow conveyed to Osler the importance of including veterinary medicine in efforts to address human health care concerns. Osler subsequently returned to Canada, where he taught parasitology and physiology at the Montreal Veterinary School in addition to his duties at the McGill University medical school. He also conducted research on several animal diseases (e.g., hog cholera, verminous bronchitis in dogs) in collaboration with his most prominent veterinary medical student, Albert Clement (a future American Veterinary Medical Association president), with whom he later published case reports.

The organism causing various forms of Salmonellosis, including foodborne illnesses, was named after veterinarian Daniel E. Salmon (1850–1914), who hired physicians to work for him at the early USDA Bureau of Animal Industry (now called the Animal and Plant Health Inspection Service; APHIS). Salmon’s physician researchers made important discoveries working together with veterinarians; for example, Salmon and physician Theobald Smith (1859–1934) jointly discovered that heat-destroyed pathogens could immunize animals (and humans) against live pathogens. This monumental discovery was the foundation for development of the vaccine against typhus and for physician Jonas Salk’s production of the polio vaccine. Smith and veterinarian Frederick L. Kilborne (1858–1936), another Salmon employee, discovered that ticks cause the transmission of Babesiosis in cattle. Their seminal work has been credited as helping to set the stage for physician Walter Reed’s discovery of yellow fever’s transmission via mosquitoes.

John McFadyean (1853–1941) received his veterinary medical diploma from Edinburgh veterinary school in 1876, graduated from medical school in 1882, and earned his science degree in 1883. He wanted degrees in medicine and science to prepare himself for an academic career in pathology and microbiology, based on the work of Robert Koch and Louis Pasteur. Although enthralled with Koch’s many accomplishments (e.g., the famous Koch’s postulates), McFadyean challenged Koch’s erroneous assertion that bovine tuberculosis was of little, if any, concern in its transmission to humans via milk and milk products. Within 10 years, he proved that bovine tuberculosis impacted human health, and in 1905 was knighted for his service to veterinary science and agriculture as well as his work on the Royal Commission on Tuberculosis. He devoted his life to teaching pathology and anatomy, developing the field of veterinary research, and administering the London veterinary school. To this day, confirmation of a laboratory diagnosis of anthrax relies on demonstration of the organism in blood, lesions, or discharges using McFadyean’s methylene blue stain for the bacillus capsule.

20th Century Leaders

Karl F. Meyer, born in Switzerland (1884–1974), studied medicine at the University of Munich but subsequently became a

veterinarian. In 1910 he joined the faculty of the University of Pennsylvania School of Veterinary Medicine, and in 1915 moved to the University of California, Berkeley, where he founded what is now the School of Public Health. Over a span of more than 60 years, he made enormous contributions to the field of infectious diseases and epidemiology, working on human and animal diseases, including typhoid fever, malaria, influenza, brucellosis, anthrax, and plague. He discovered the etiologic agent of equine encephalomyelitis in the western United States, showed that coccidioidomycosis was an infectious disease, and unraveled the enzootic cycle of *Yersinia pestis*. He was awarded the Lasker prize in 1951 and was the winner in 1961 of the Animal Care Panel’s Griffin Award. Meyer made an indelible impact on public health and zoonotic diseases by integrating the fields of human and veterinary medicine.

Veterinarian Calvin W. Schwabe (1927–2006) was a noted epidemiologist and parasitologist who pioneered the use of human disease-tracking techniques in the study of animal illnesses. A global authority on zoonoses, he was an early visionary in a field that today is marked by the emergence of pathogens such as avian influenza, bovine spongiform encephalopathy, and severe acute respiratory syndrome (SARS). Schwabe proposed a unified human and veterinary approach to zoonotic diseases in his seminal textbook *Veterinary Medicine and Human Health* (1984). Known as the “founder of veterinary epidemiology,” he coined the term “One Medicine,” now commonly called “One Health.”

James H. Steele (b. 1913), a veterinarian and renowned public health authority, is known as the international doyen of veterinary public health. He was the founder of the CDC’s veterinary public health division and has actively promoted the One Health concept (frequently referring to it as “One World, One Medicine, One Health”) throughout the nearly 7 decades of his career.

Recognition of the merits of collaboration between human and veterinary medicine was evident in the awarding of the 1996 Nobel Prize to physician Rolf M. Zinkernagel (b. 1944) from Switzerland and veterinarian Peter C. Doherty (b. 1940) from Queensland, Australia (now Chair of the Department of Immunology at St. Jude’s Children’s Hospital in Memphis, Tennessee). Zinkernagel and Doherty discovered how the body’s immune system distinguishes normal cells from virus-infected cells, a monumental discovery in basic science that continues to inform medical intervention against pathogenic virus infections in humans and animals.

Most recently, eminent virologists Frederick A. Murphy, a veterinarian, and Karl M. Johnson, a physician, worked closely together (along with others) to help unravel the mystery surrounding the initial outbreak of Ebola hemorrhagic fever (Kahn et al. 2009).

Recent One Health Publications

Scientific contributions by 53 prominent physicians, veterinarians, and health scientists from 12 countries present a powerful case for One Health in a recent monograph (Kaplan et al. 2009),

about which Russell Currier, formerly of the American College of Veterinary Preventive Medicine, wrote: “This issue of *Veterinaria Italiana*...promises to be a useful reference for advancing this concept” (ACVPM 2009).

In December 2009, a unique One Health book was published entitled *Human-Animal Medicine: Clinical Approaches to Zoonoses, Toxicants, and Other Shared Health Risks*, by physician Peter M. Rabinowitz (a contributor to this issue) and veterinarian Lisa Conti, who describe collaborative clinical approaches to current and emerging zoonotic disease.

Various Applications of One Health Principles

Zoonotic Agents

A number of zoonotic agents require a One Health approach for their effective surveillance, detection, and treatment. Hantaviruses and arenaviruses, for example, exist in various rodent reservoirs, persistently infecting the hosts, which show no disease symptoms. Specific hantaviruses and arenaviruses transmitted from the contaminated urine and feces of infected rodents cause important human diseases, including hemorrhagic fever with renal syndrome, hantavirus pulmonary syndrome (CDC 2010), Argentine hemorrhagic fever, and Lassa fever. Influenza viruses have been isolated from a variety of animals in addition to humans—pigs, horses, wild and domestic birds, and sea mammals (Kruse et al. 2004; Reed et al. 2003). Nipah virus is a newly discovered virus of fruit bats responsible for encephalitis outbreaks in Southeast Asia (WHO 2009), and West Nile, a virus of birds, invaded the United States in 1999 and is now endemic (CDC 2009).

The list of emerging bacterial disease agents transmitted by food animals is long and continues to expand (Hansen et al. 2001). It includes *Escherichia coli* O157:H7, various *Salmonella* species, *Campylobacter* species, and *Streptococcus iniae* (from farmed fish).²

Zoonotic diseases from companion (pet) animals are of low incidence in humans but can cause serious health problems (Table 1 shows notable examples).

Veterinary Medical Practice

A number of practicing veterinarians educate pet owners about the risks of acquiring zoonotic diseases. They also reduce transmission risks by vaccinating pets against zoonotic diseases and by reducing pets’ burden of parasites that may infest the animals’ owners.

While most people suppose that private practice veterinarians focus solely on pets and farm animals, the true dimensions and contributions of veterinary medicine are much broader and reflect expanding societal needs. Veterinary medicine has responsibilities in individual human health, public

health, and research. The profession is responsible for the care of companion animals, food-producing domestic animals, and exotic and wildlife animals as well as making significant contributions to biomedical research, ecosystem management, public health, food and agricultural systems safety, and biosecurity (Phillips et al. 2009).

Laboratory Animal Research

The American College of Laboratory Animal Medicine (ACLAM) was recognized by the American Veterinary Medical Association in 1957. ACLAM certification is a means to “(1) Encourage education, training and research in laboratory animal medicine. (2) Establish standards of training and experience for qualification of specialists in the field.... (3) Recognize qualified specialists by certification” (AVMA 2008–2009).

Similar descriptions are applicable for other interdisciplinary collaborations among veterinarians, physicians and health science researchers. Examples of areas of common interest in which veterinarians and physicians have collaborated include cancer (CDC 2010; Thamm and Dow 2009), obesity, diabetes, cardiovascular diseases, biomechanical devices such as orthopedic joint replacements (Bian et al. 2008), flexible coil balloon expandable intracoronary stent development, heart valve advances, and vaccine development.

In This Issue

The variety of types and applications of One Health collaborations and principles are evident in the following articles.

Mainstreaming Animal-Assisted Therapy

Palley, O’Rourke, and Niemi (2010)—two veterinarians and a physician—discuss animal-assisted therapy (AAT) as a treatment modality for advancing human emotional and possibly physical well-being. The authors contend that the literature on the subject, while often positive, requires more substantial scientific validation via better-designed studies with consistent epidemiological methodology. The collaboration of interdisciplinary investigators in such studies could help confirm (or dispel) long-held views about the clinical merits of AAT and enhance understanding of the underlying mechanism(s) of the human response to companion animal exposure. As the authors observe, “Establishing standards for AAT interventions would not only facilitate the execution and reproducibility of clinical studies but also enable interpretation of results across studies and the eventual integration of AAT into medical practice.”

Cross Talk from Pets to People: Translational Osteosarcoma Treatments

Withrow and Wilkins (2010), a veterinarian and physician, respectively, illustrate One Health by demonstrating how synergistic efforts of human and veterinary medicine can elucidate the basic biology and treatment modalities for cancer.

²Among infections carried by nonfood animals, leptospirosis is the most common rat-transmitted disease in the United States.

Table 1 Notable potential zoonoses from household pets

Zoonosis	Species reservoir	Agent
<i>Brucella canis</i> infection (brucellosis)	Dogs (rarely)	Bacterium
<i>Campylobacter</i> infection (campylobacteriosis)	Dogs, cats, farm animals	Bacterium
Cat scratch disease (<i>Bartonella henselae</i>)	Primarily kittens, also adult cats	Bacterium
<i>Cryptosporidium</i> infection (cryptosporidiosis)	Dogs (especially puppies), cats, farm animals	Parasite
<i>Dipylidium</i> Infection (tapeworm)	Dogs, cats via fleas	Parasite
Dirofilariasis (rare) (<i>Dirofilaria immitis</i>)	Dogs via mosquitoes	Parasite
<i>Giardia</i> infection (giardiasis)	Dogs (as well as other domestic and wild animals), their environment/water	Parasite
Hookworm infection (<i>Ancylostoma</i> spp., <i>Uncinaria</i> sp.)	Dogs, cats, their environment	Parasite
<i>Leishmania</i> Infection (leishmaniasis)	Dogs and sandflies outside the United States (predominantly in tropical and subtropical countries)	Parasite
<i>Leptospira</i> infection (leptospirosis)	Dogs and other domestic and wild animals	Bacterium
Lyme disease (<i>Borellia burgdorferi</i>)	Dogs via ticks	Bacterium
Lymphocytic choriomeningitis	Pet hamsters; rodents	Virus
Monkeypox (rare)	Pet rodents	Virus
Plague (rare) <i>Yersinia pestis</i>	Cats primarily, dogs	Bacterium
Psittacosis (<i>Chlamydia psittaci</i>)	Parakeets, parrots, lovebirds; poultry; pigeons, canaries, seabirds, and others	Bacterium
Q fever (<i>Coxiella burnetii</i>)	Occasionally dogs	Bacterium
Rabies	Various animals including dogs, cats	Virus
Rat bite fever (rare) (<i>Spirillum</i> sp.; <i>Streptobacillus</i> sp.)	Pet rodents or laboratory rats	Bacterium
Ringworm (<i>Microsporum</i> spp.; <i>Trichophyton</i> sp.)	Dogs, cats (especially puppies, kittens), others	Fungus
Rocky Mountain spotted fever (<i>Rickettsia rickettsii</i>)	Dogs via ticks	Bacterium
<i>Salmonella</i> Infection (salmonellosis)	Various (e.g., dogs, reptiles, farm animals)	Bacterium
Toxocara infection (toxocariasis, roundworm)	Dogs, cats, and their environment	Bacterium
Toxoplasmosis (<i>Toxoplasma gondii</i>)	Cats and other felines	Parasite
Tularemia (rare) (<i>Francisella tularensis</i>)	Pet rodents, rabbits, hares; livestock	Bacterium

They explain the relevance of dog models for studying and translating approaches to a difficult bone cancer, osteosarcoma, that occurs in both humans and dogs and seriously challenges physician and veterinarian oncologists.

Modeling Opportunities in Comparative Oncology for Drug Development

Research veterinarians Gordon and Khanna (2010) note that “Conventional drug development pathways are relatively

unidirectional—agents are first considered in preclinical (in vitro and in vivo) models and then move sequentially through human clinical trials.” They explore the strengths and shortcomings of current preclinical and clinical cancer drug evaluation methods and conclude that “translational studies in pet dogs...may provide an opportunity to answer...questions in a more appropriate and predictive model system.” In other words, the application of One Health principles may change the status quo of conventional drug development and speed efficacy rates for cancer therapies.

Zoonotic Enterohemorrhagic *Escherichia coli*: A One Health Perspective

García, Fox, and Besser (2010) discuss the threats of zoonotic enterohemorrhagic *Escherichia coli* (EHEC) from a One Health perspective. Research scientist García developed an experimental rabbit model to elucidate the pathophysiology of hemolytic uremic syndrome (HUS), a leading cause of acute renal failure in children; Fox (scientific editor of this issue) represents the American Association of Veterinary Medical Colleges on the US One Health Commission, is Director of the Division of Comparative Medicine and a professor in the Division of Biological Engineering at the Massachusetts Institute of Technology, and has been studying gastrointestinal disease for over 30 years; and Besser has had many interdisciplinary research collaborations and publications related to human and animal studies of *E. coli* O157:H7 and its ecology and epidemiology (the essence of One Health). These distinguished authors observe that “Like other zoonotic infections, EHEC are illustrative of the One Health concept as they embody the complex ecology of agricultural animals, wildlife, and the environment in zoonotic transmission of EHEC O157.” They further present a strong case that EHEC O157:H7 “zoonotic disease is not associated with simple transmission from a reservoir host, but instead is involved with a complex environmental-host ecology that directly affects the likelihood of EHEC O157 zoonotic transmission” and note that “Significant aspects of the microbiology, epidemiology, and host-pathogen interactions of EHEC in animals remain undefined.” Further research is needed.

Methicillin-Resistant *Staphylococcus aureus* in Animals

Weese (2010) is a public health and zoonotic disease microbiologist in the Department of Pathobiology at the University of Guelph (Canada), where his research program has focused on infectious diseases, in particular those of zoonotic importance. In his article on methicillin-resistant *Staphylococcus aureus* (MRSA) he notes that it “is an excellent example of the ‘One Health’ concept as it can reciprocally affect human and animal populations.” He also points out that much remains unknown about the implications of the epidemiology and significance of the organism’s interactions between humans and animals.

Microbe Hunting in Laboratory Animal Research

Palacios, Briese, and Lipkin (2010) focus on the development of new tools to diagnose zoonotic viral agents and detect novel agents (pathogen discovery). The authors—two prominent researchers and a noted physician—express concern about the limited availability of these technologies in the developing nations where the risks and burdens of hemorrhagic fevers are most prominent. However, they “are

encouraged that academicians, public health practitioners, and corporate partners are beginning to focus on smaller footprint solution phase and microarray platforms that promise to perform in resource-poor environments.”

Understanding Risk Perceptions to Enhance Communication about Human-Wildlife Interactions and the Impacts of Zoonotic Disease

Decker and colleagues (2010) “[explore] how treatment of the topic of zoonoses in One Health may affect public acceptance of wildlife and support for wildlife conservation.” Public perceptions play a critical role in the continued support of wildlife conservation as a component of the global ecosystem, and so effective communication of zoonotic disease risks requires intelligent integration of One Health principles. It is essential to work with mass media and communications experts to incorporate the articulation of wildlife health and management as a core goal of the One Health approach.

Animals as Sentinels: Using Comparative Medicine to Move Beyond the Laboratory

Rabinowitz and colleagues (2010) compellingly argue for the use of One Health principles in scientific efforts to identify and prevent health risks common to humans and animals. Failure to recognize the advantages of closer inter-professional communication and collaboration has impeded the accumulation of knowledge, and the long-standing segregation of human and veterinary medicine has prevented timely recognition, interpretation, and action based on important sentinel surveillance data.

Lessons from Pandemic H1N1 2009 to Improve Prevention, Detection, and Response to Influenza Pandemics from a One Health Perspective

Pappaioanou and Gramer (2010) discuss lessons to be learned from pandemic H1N1 2009 from a One Health perspective. They assert that stronger collaboration among human, animal, and environmental health sectors is crucial to more effectively prevent, detect, and respond to influenza pandemics (and presumably other zoonotic infectious diseases) in order to improve human, animal, and environmental health. The continual global circulation of human, swine, and avian influenza viruses via interspecies transmission calls for better transdisciplinary influenza surveillance in pigs, birds, and other animals to aid in monitoring and assessing the mounting risk of future pandemic viruses. Early detection and more rapid response to emerging pathogenic pandemics are key to reducing potentially devastating consequences.

A Global Veterinary Medical Perspective on the Concept of One Health: Focus on Livestock

As a state agricultural veterinarian and noted author with international experience, Sherman (2010) documents the case for a multidisciplinary approach from an agricultural viewpoint. He argues that “Veterinarians, by virtue of their formal training in comparative medicine and population medicine, are well positioned to embrace the concept of One Health and take a leadership role in moving it forward as a rational approach to addressing issues of health and disease in today’s complex, global society.” We second this point—and hope that steps forward are made sooner rather than later.

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