

One Health and Emerging Infectious Diseases: Clinical Perspectives

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Abstract To date, there has been little articulation of specific One Health clinical activities for veterinary and human health care providers regarding emerging infectious diseases, yet they could play a critical role. Under current clinical paradigms, both human and animal health professionals routinely diagnose and treat zoonotic infectious diseases in their patients, but tend to work in parallel with little cross-professional communication or coordination of care. For this to evolve toward a One Health model, both types of clinicians need to see how individual cases can be “sentinel events” indicating environmental risk for disease emergence, and develop mechanisms of rapid communication about these risks. Human and animal clinicians also need to take a more proactive and preventive approach to zoonotic diseases that includes the occupational health of animal workers in farms, laboratories, veterinary clinics, and other settings, as well as the recognition of increased risk among immunocompromised individuals in contact with animals. This requires training in One Health clinical competencies including the ability to diagnose and treat zoonotic diseases, implement preventive care interventions for individual patients, provide occupational health services for animal workers, recognize sentinel cases, report cases to public health and clinical colleagues, and assess and help to intervene with environmental factors driving infectious disease risk in humans and animals. To provide an evidence base for such competency training, there is a need for development and testing of innovative protocols for One Health clinical collaborations.

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1 Overview: The Critical Role of Clinicians in One Health and Emerging Infectious Diseases

One Health is a concept that involves cooperation between professionals in human, animal, and environmental health. Such professionals may work in a number of sectors, including public health services, agriculture, environmental quality, and veterinary and human medicine. To date, much of the discussion and development of the One Health concept with respect to emerging infectious diseases has revolved around the role of public health and disease control agencies. Despite endorsements from professional societies, including the American Medical Association, the American Veterinary Medical Association, and the American Academy of Pediatrics, there has been far less articulation of the specific One Health clinical activities for veterinary and human health care providers. Current medical school curricula devote relatively little time to zoonotic diseases, and medical school courses in One Health are virtually nonexistent. In summary, One Health developments have proceeded without much involvement of the clinical professional community. In this chapter, we assert that human and animal health clinicians have a critical role to play in One Health efforts regarding emerging infectious diseases, and indeed unless clinicians begin to define a clear strategy for incorporating One Health principles into clinical practice, the development of One Health as a viable disease control paradigm will be severely hampered.

This chapter will illustrate how human and animal health clinicians currently providing services to individual humans and animals are already engaged with emerging zoonotic diseases. We point out how clinician training and development of enhanced clinical protocols could allow for the application of One Health principles to such care, and how this could result in improved disease control. We also describe the important role of clinicians in the preventive care of populations, including animal herds and animal workers, and how the provision of occupational health services for animal workers provides an ideal nexus for One Health collaboration between human and animal clinicians in order to prevent and detect zoonotic disease transmission at the human–animal interface. Finally, we review

the significant barriers to the creation of a cadre of One Health clinicians in both human medical and veterinary training centers, and outline strategies for overcoming such obstacles to achieve this vital goal.

1.1 Recognition and Treatment of Emerging Infectious Disease by Human and Animal Clinicians

1.1.1 Current Paradigms

In their daily clinical practices, human health clinicians may diagnose and treat patients with zoonotic infectious diseases. These diseases may appear as acute disease processes, such as salmonellosis in a child with reptile contact, or they could manifest in more chronic fashion, such as a brucellosis infection in a hunter. Sometimes zoonotic diseases spring from asymptomatic reservoirs, such as deer-mice (*Peromyscus spp*) that appear not to develop clinical illness from Hantavirus infection or the *Borrelia* spirochete that causes Lyme disease. Yet many zoonotic pathogens cause disease in both humans and animals, and veterinarians and physicians may find themselves treating similar disease complexes in their respective patients, even using similar antibiotic regimens.

Examples of this cross-species virulence include Rocky Mountain spotted fever, a severe and often fatal disease in both dogs and humans caused by tick-borne Rickettsia, and avian influenza, which has devastated poultry flocks in several continents as well as causing hundreds of human deaths.

Nevertheless, the current clinical paradigm is for human health clinicians to diagnose and treat the human patient infected with a zoonotic pathogen with little consideration for two critical aspects: first, whether there is a need for evaluation and treatment of the infected animal source, and second, whether the disease occurrence represents an emerging infectious disease event related to changes in environmental and ecosystem factors. As mentioned above, this approach of treating the human disease in isolation of animal and environmental health aspects may stem from a perception that animals harboring infectious pathogens are often asymptomatic and not in need of clinical care. Indeed, a common medical recommendation is to remove an animal from a household, as when an obstetrician inappropriately advises that a pregnant woman avoid all cat contact to prevent toxoplasmosis (Kravetz and Federman 2005).

For their part, veterinarians commonly encounter infectious diseases in their animal patients that may have zoonotic potential. Veterinary practices routinely identify hookworm (ancylostomiasis), roundworm (toxocariasis), and *Cryptosporidia* infestations, particularly in young companion animals (Hotez and Wilkins 2009). Kittens with flea infestations are epidemiologically linked with *Bartonella* infection in people (Klotz et al. 2011). Again, as with the human health clinicians, there is a tendency to treat the animal and not directly deal with issues of possible infection occurrence in nearby humans. However, veterinarians are trained to

counsel their clients about zoonotic risks, and may recommend that the client seek medical care if symptoms should develop. At the same time, it is rare for veterinarians to directly contact their medical colleagues in the community, even if they are treating members of the same household.

Veterinarians may also be likely to consider certain environmental factors predisposing to disease in the animal, such as overcrowding or contact with infected wildlife. In such a situation, the occurrence of disease in the animal could be a “sentinel case” providing warning of disease threat in the environment.

1.1.2 How Clinicians can Evolve

A key aspect of whether practitioners are taking a One Health clinical approach is the extent to which they are trained and capable of recognizing “sentinel” cases. Sentinels may indicate that preventive efforts have broken down and/or that there are emerging hazards in the environment. There have been well documented instances of animals serving as “sentinels” for human disease risk. The classic example is the “canary in the coal mine” where coal miners brought canaries into mine shafts because they had proved to be more susceptible than the miners to the effects of hypoxia and carbon monoxide exposure, and would literally fall off of their perch when sickened by the fumes, allowing the miners time to don protective equipment (Rabinowitz and Conti 2009).

An example of animals serving as sentinels of infectious disease risk is the tickborne rickettsial disease Rocky Mountain spotted fever (RMSF) which, as previously discussed, causes clinical disease in both humans and dogs. This is illustrated by a report of a fatal dog case providing warning of human disease risk and helping alert astute clinicians to human cases in the community (Paddock et al. 2002). By contrast, there are tragic cases where such animal disease events were either disregarded by human health authorities or information about them was not communicated between human and animal health clinicians, leading to delayed diagnosis and fatal human outcomes (CDC 2005).

Another well publicized example of animal sentinel disease events was the 1999 emergence of West Nile virus (WNV) in the United States. WNV caused an acute and fatal encephalitis in crows and other birds in Bronx NY at the same time that humans in the area were reporting an increase in encephalitis cases. The unusual pathology pattern in the affected birds was what alerted an astute veterinary clinician to the fact that this was a novel virus infection event. Eventually, the human cases were also found to be due to WNV (Kahn 2006). It would have been ideal, in these cases, for both human health and veterinary clinicians to have recognized the cross-species relevance of the cases and taken steps to notify both public health as well as each other directly. They also, ideally, would have used such case information to consider whether there were environmental changes driving the emergence of the cases and “shared risk” of infection across different species that warranted further investigation. In terms of RMSF, for example, the patterns of abundance of the tick vector are unevenly distributed across the landscape (CDC 2012a) and an increase in detected

cases and/or case severity could signify a change in the disease ecology (Adjemian et al. 2009). Using sentinel cases to focus investigations for environmental and ecological disruption and drivers of emergence is therefore a key aspect of One Health in clinical practice.

By the same token, there are a number of situations in which infectious disease events in humans may serve as sentinel events warning of infectious risks to animal health. An example would be a case of *Streptococcus suis* in an abattoir worker, who due to the fact that humans often receive greater diagnostic evaluation is diagnosed prior to the recognition of the organism in the swine herd. Such an instance represents a sentinel event with clinical importance both for the larger population of animal workers as well as the hogs to which the workers are exposed. Again in such cases, the veterinarian as well as the physician investigating the occurrence of *Streptococcus suis* in the herd and the animal workers must think about what changes in agricultural practices and environmental factors could have contributed to the emergence of the disease (Wertheim et al. 2009).

To detect animal-related infections, the physician must carry a high index of suspicion. One way is to ask questions about the patient's exposure to and health of animals as part of the medical history, especially for a patient with fever, respiratory, or diarrheal disease. Red flags in the history include the patients' exposure to "high risk animals", such as kittens, puppies, ducklings, chicks, reptiles, or other wild or exotic animals, immunocompromised animals, or animals with diarrhea or acute respiratory infection.

By the very nature of their work, veterinarians may be more attuned than their medical colleagues to the effects of the environment on human health. The veterinarian knows that inadequate housing, overcrowding, pathogen-contaminated pastures/kennels, or contact with infected wildlife can lead to infection and impaired immunity in animals under care. The veterinarian is also used to comparing health risks across multiple species, understanding the "shared risk" concept and the need to address the root causes of a zoonotic risk situation. One of the challenges for animal health professionals then, could be to educate their human health colleagues about this world view.

As One Health clinicians, both human and veterinary health professionals play a critical role on the "front lines" by reporting these sentinel surveillance cases to a public health authority where critical information about disease incidence can be shared and further acted upon.

1.2 Clinical Prevention of Disease: Herd Health, Occupational Medicine

1.2.1 Preventive Care of Individual Animals

The mainstay of veterinary practice is preventative medicine. "Herd health" is dependant upon appropriate nutrition, hygiene, vaccination, and strategic

deworming. In some cases, animal vaccinations reduce the risk of both the animal presenting with infection as well as zoonotic transmission to people. This is so, with rabies, leptospirosis, and brucellosis immunizations (Adams et al. 2011). The goal of strategic deworming is to eliminate individual parasite burdens as well as reduce the hazard of having hardy ova in the environment which can cause significant health problems in people. For example, ocular larval migrans from dog or cat roundworm infections are a preventable cause of childhood blindness. For this reason, puppies and kittens should be dewormed starting at 2 weeks of age, then every 2 weeks until they can receive an age-appropriate monthly intestinal deworming medication (Companion Animal Parasite Council 2012). Veterinarians can also guide appropriate pet selection to mitigate hazards to owners. Should an animal become infected with a zoonotic pathogen, timely diagnosis and treatment and proper husbandry will serve to reduce transmission to people. In these ways, veterinarians have a significant role in the public health controls of zoonoses.

1.2.2 Preventive Care of Individual Humans

On the human medical side, clinicians can provide counseling to their patients about animal contact-risk factors. Examples of preventive recommendations are as follows:

- People at increased risk of zoonotic infection include infants and small children younger than age 5, elderly, pregnant women, and immunocompromised persons.
- Zoonotic disease prevention includes routine veterinary care for all pets, hand-washing, proper hygiene in disposal of animal waste, appropriate diet for the pets, and timely treatment for diseased pets. Specific recommendations for all patients include hand-washing after handling pets and pet dishes, and avoiding contact with animal feces and vomitus through proper disposal. Pregnant women should avoid handling cat feces and litter, keep cats indoors, and not feed cats uncooked meat to reduce the risk of toxoplasmosis. Additionally, people at increased risk of zoonotic infection should not feed pets raw meat diets to prevent enteric pathogens.
- Keeping exotic pets carries increased risk of exotic pathogens, an example being an outbreak of monkeypox in the Midwest United States traced to imported African rodents (Reed et al. 2004). Wild animals kept as pets may pose a greater infection risk. Veterinarians can be referred to assist with appropriate pet selection.
- Pets that roam outdoors or that are fed outdoors may have greater contact with wildlife and the pathogens they carry.
- Particular habits of pet ownership may play a pivotal role governing transmission of pet pathogens. Sleeping with pets has been linked to cases of the plague, cat-scratch disease, and Chagas disease (Chomel and Sun 2012). Close animal contact, including biting, scratching, licking, and kissing, has resulted in transmission and infection from *Capnocytophaga canimorsus* (Valtonen et al. 1995), lymphocytic choriomeningitis, and *Pasteurella spp* (Kimura et al. 2004).

1.2.3 Occupational Health Services for Animal Workers

Millions of people worldwide engage in occupational activities involving animals, including farmworkers and food processing workers in animal meat and dairy production and processing, workers in fisheries, stables, kennels, pet trade and grooming facilities, zoos, wildlife facilities, animal clinics, and research laboratories. At present, many if not most of these individuals receive little to no preventive health services related to their work exposures including exposure to zoonotic pathogens. At the same time, zoonotic pathogens often first emerge at the animal-worker interface, and the occupational setting represents an ideal and underutilized setting for early detection and prevention of cross-species disease transmission. For example, the worldwide epidemic of severe acute respiratory syndrome (SARS) was first noted in a chef in Hong Kong who was preparing wild animal meat for consumption. Subsequent serological surveys of live animal market workers in China showed evidence of transmission between wild animals and these workers. The emergence of Nipah virus in Malaysia took place in the setting of large-scale swine production in the vicinity of rain forest that was home to the wildlife reservoir of the pathogen (flying foxes—*Pteropus sp.*) and the first human cases were swine workers exposed to diseased pigs (Chua 2010). One of the first recorded fatalities to highly pathogenic avian influenza was a veterinarian responding to the poultry outbreak of H7N7 avian influenza in the Netherlands, and highly pathogenic H5N1 avian influenza has caused numerous deaths in humans working with poultry in either the commercial or backyard setting (WHO 2012). While the exact circumstances of the reassortment event leading to the worldwide pandemic of 2009 H1N1 novel influenza A infection remain unknown, it is likely that the reassortment took place in swine and then crossed to human populations through a swine worker with close contact with infected animals. Since that original event, there have been documented cases of reverse zoonotic transmission of H1N1 from infected swine workers to pigs, and this may have contributed to the recent emergence of a recombinant H3N2 strain (CDCb). The growing industrialization of agricultural animal production demands a more organized approach to infectious disease risks in concentrated animal settings, and this must include both worker health and reduction of pathogen pollution from animal waste.

Occupational Health is a discipline that focuses on the recognition and prevention of hazardous exposures in the workplace setting. It applies a preventive medicine paradigm with a “hierarchy of controls” based on elimination of the hazard at the source and the use of engineering and other controls to reduce exposure in the environment. It also involves ongoing surveillance of workers to detect “sentinel cases” of occupational disease, in this case zoonotic disease transmission events between animals and animal workers, in settings ranging from bushmeat hunting to industrialized animal production. Occupational Health for animal workers therefore must involve human, animal, and environmental health in a One Health framework in order to prevent zoonotic disease transmission. It can build off proven models of risk reduction in health care workers for infectious hazards including tuberculosis and bloodborne pathogens.

Specific development of occupational health services along a One Health model could include expanded surveillance for animal workers to detect transmission events, assessment of infection risk in specific jobs and tasks, and reduction of such risk through animal disease control and interruption of transmission pathways by appropriate use of hygiene measures and personal protective equipment including gloves and respiratory protection. Input from animal health clinicians will be crucial in these efforts to ensure that steps are taken in such a way to maximize both human and animal health as well as agricultural viability and sustainability.

1.3 Role of the Human–Animal Bond

While consideration of the human–animal bond may seem peripheral to a discussion of emerging infectious diseases, it really is not. Our relationship with animals plays a key role in transmission pathways. This can both lead to increased contact between animals and humans (e.g., kissing dogs) but also to opportunities for enhanced levels of care and prevention (i.e., willingness to pursue diagnostic, therapeutic, and preventive strategies for beloved pets).

Majorities of surveyed households in the United States, Canada, Australia, and United Kingdom include at least one companion animal (Ipsos-Reid Corporation 2012; Australian Companion Animal Council 2010). In the US, more households have pets than children (United States Census 2010). Therefore, patients visiting their health care providers are more likely than not to share their living space with dogs, cats, birds, fish, reptiles, rodents, etc., noting that some of these animals may have been collected from the wild. A growing body of evidence supports the concept of the “human–animal bond phenomenon” (Friedmann and Son 2009). Companion animals are viewed as family members in many cultures and treated as child surrogates (Cohen 2002).

Physicians must consider that the psychosocial and physical benefits of Human Animal Interaction (HAI) in the context of owning pets, uses of animals for recreation (such as horseback riding), and in therapeutic settings. For people who like animals, these human–animal bond benefits are thought to outweigh the risks in most cases. Physicians and veterinarians can cooperate to maximize these benefits.

Several studies have shown pet owners in general to be healthier than their non-owning counterparts, controlling for confounding. This includes pet owners being more physically active, and having lower triglyceride and cholesterol levels, and decreased depression particularly among older adult pet owners and people with AIDS (Dembicki and Anderson 1996; Siegel et al. 1999). A corollary, however, is evidence of impoverished pet owners withholding their own nourishment in favor of their pet. Additionally, during impending hurricanes, some pet owners elected to stay in harm’s way rather than leave their pet, when no pet-friendly shelter options were available.

Animal assisted activity (AAA) occurs in a variety of settings in which people interact with (talk to, pet, groom) companion animals while the animal’s handler is

present. Even in these encounters, an intense attachment can rapidly develop between people and pets. Beneficial changes in cortisol, neurohormones, and blood pressure have been documented (Cole and Gawlinski 1995). Some nursing home residents were found to have lower cortisol levels with dog visits than with human visits. During and after animal visits, hospitalized patients used fewer analgesics, reporting less pain and lessened depression, and heart failure patients had decreased anxiety and epinephrine levels (Beck 2000; Gawlinski et al. 2007).

Animal assisted therapy (AAT) can be used as part of a patient's treatment plan for physical therapy, to decreased anxiety in psychiatric patients, and decreased agitation in older adults with dementia (Barker and Dawson 1998; Batson et al. 1997). Examples include increasing the number of brush strokes on a dog to exercise an impaired hand and eliciting a relaxation response using horseback riding AAT in children with spastic cerebral palsy (McGibbon et al. 1998). In therapy sessions involving a live dog, children with autism spectrum disorder were more likely to respond appropriately than with either a stuffed toy dog or a ball (Martin and Farnum 2002).

1.4 Challenges to Implementation of Clinical One Health Approaches

While many of the clinical One Health opportunities outlined above may seem self-evident and commonsense, there are a number of challenges and barriers to their implementation. These include the historical professional segregation between human and animal health professionals that continues into the present. Veterinarians and their human health care colleagues rarely encounter each other during medical education and training. Once in practice, there are no routine venues on either the local, national, or international level for inter-professional contact and information sharing.

On a daily practical level, it is challenging for a physician to directly contact a veterinarian about a patient, or a veterinarian to contact a physician regarding a client or animal. There are not established guidelines or protocols for such inter-professional communication and perceived barriers toward issues of information sharing and medical record documentation. While health departments can serve as conduits for sharing information that is relevant to both human health care providers and veterinarians, this is often restricted to reportable diseases or established epidemics, and may lose the richness of the data contained in the clinical encounters that can lead to the recognition of novel syndromes and disease emergence events.

In addition to the absence of protocols for cross referrals of patients and clients between human and animal health clinicians, there are issues of reimbursement. While an immunocompromised patient who has animal contact may benefit from a consultation with a veterinarian regarding reduction of zoonotic disease risk, there is no mechanism for the veterinarian's time and effort to be reimbursed by the patient's health insurance under current health care payment structures. This lack of reimbursement can be a major deterrent to such activities. In the occupational

health arena, cost is also a barrier for providing enhanced preventive services to animal workers, since this cost is assumed by the employer, and many farms, zoos, and animal clinics have narrow profit margins and are not accustomed to setting aside funding for worker occupational health services.

A related obstacle is the lack of time allotted for many clinical encounters that makes it more difficult for human health care providers to inquire about non-traditional issues such as animal contact during routine visits, or for veterinarians to step out of their usual practice patterns to initiate contact with a physician.

Since the One Health approach considers environmental health as central to addressing emerging infectious disease threats, a major obstacle to the incorporation of One Health principles is the lack of human and animal health clinicians' training or awareness regarding environmental health assessment and interventions. A basic understanding of patients' access to and quality of food, air, and water may provide clues to potential ongoing risks for infectious disease exposure. For example, having diagnosed a case of leptospirosis in a dog, there is often no further investigation to identify potential sources of contaminated water and communicate this information appropriately to prevent other animal or human infection. Similarly, private well water is often not tested for enteric bacteria beyond when the well was constructed, as many people are not aware of the need for ongoing testing. While it is currently unlikely that human and veterinary clinicians recommend well water testing and provide such information from the local health department, by doing so could prove the impetus to assess home water quality.

1.5 Overcoming Challenges to Clinical One Health

Overcoming the challenges to incorporating One Health principles into clinical practice will require a multi-level approach, including training on specific competencies, intervention effectiveness research, and policy change. These developments are interdependent and could best proceed in tandem.

A critical need is for training opportunities for "One Health Clinical Specialists" among the human health and animal health professional workforce. This training would stress a number of core competencies, including:

- Ability to diagnose and treat zoonotic diseases
- Ability to do preventive care interventions for individual patients
- Ability to provide occupational health services for animal workers
- Ability to recognize sentinel cases
- Ability to report cases to public health and clinical colleagues
- Ability to assess environmental factors driving infectious disease risk and work on environmental health interventions.

A goal of the training programs is to achieve competency in these areas, and certification in such competencies could lead to enhanced career opportunities for such clinicians.

In addition to training, there is a need to develop pilot protocols for cooperation and communication between animal and human health clinicians, and to research the clinical effectiveness of such protocols. Examples of such research could include early detection of emerging infections, reduction of opportunistic infections in immunocompromised individuals due to reduction of animal contact risks, and the use of a “One Health team” approach to reducing environmental health risks in communities where water contamination with pathogens from both human and animal sources is driving transmission of diarrheal diseases. If the One Health approach can be linked to improved disease outcomes in either or both humans and animals, such evidence can help to drive policy changes, including changes in reimbursement schemes.

A number of policy changes could lead to lasting improvements in clinicians’ ability to practice along a One Health model. These changes could involve reimbursement for preventive services by veterinarians to benefit human health, occupational health policies that encourage occupational health services for animal workers, and incentives for competency training in One Health.

Box

Practical Applications: Human and animal health professionals working on the front lines of clinical practice can play an important role recognizing, informing, and managing a wide range of health issues involving overlaps between human and animal health.

- Human health histories should include questions about patients’ interactions with animals given the pet ownership’s beneficial health impacts and possible health risks.
- Human and animal health clinicians can provide counseling to their patients about animal contact-risk factors.
 - This includes recognition of high risk scenarios (high risk pets and/or persons at increased infection risk).
 - Special precautions are required for significantly immunocompromised patients to minimize risk of infection.
 - Patients should be counseled about the risks of particular habits of pet ownership such as kissing or sleeping with pets.
- Human and animal health clinicians can share information about sentinel cases in order to detect environmental changes driving disease emergence.
- Veterinarians can assist with appropriate animal selection, health screening, and animal health maintenance.
- Human health clinicians and veterinarians can collaborate to prevent occupational transmission of zoonotic diseases between animals and animal workers.

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One Health: The Human-Animal-Environment Interfaces
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The Concept and Examples of a One Health Approach

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