Chapter 12
One Health Successes and Challenges

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Abstract The concept of One Health encompasses a wide range of issues and is subject to a variety of interpretations as a term. Central to the concept, however, is the interconnectedness of human, animal, and environmental health. This chapter reviews the experience of a number of disease detection and control efforts that have relevance to the One Health concept. These examples include rabies control, lead poisoning surveillance, animals as sentinels of environmental health hazards, parasitic disease control, and comparative clinical medicine research. The successes and shortcomings of these efforts illustrate both the potential of the One Health concept as well as the inherent challenges in its implementation. The chapter describes how integrated risk assessment and integrated disease control and prevention strategies involving human, animal, and environmental health components are central to the success of the One Health approach. It also outlines ways to overcome existing barriers to implementing such integrated strategies.

Keywords Animal sentinel • Comparative clinical medicine • Environmental intervention • Integrated assessment

As the different chapters in this book illustrate, the concept of One Health encompasses a wide range of issues and is subject to a variety of interpretations as a term. Central to the concept, however, is the interconnectedness of human, animal, and environmental health. This chapter reviews the experience of a number of projects, including rabies control, lead poisoning surveillance, parasitic disease control, and comparative medicine research, illustrating both the potential of the One Health concept as well as the inherent challenges in its implementation.

In judging the success or failure of "One Health" efforts, it is useful to have a working definition of what constitutes a successful One Health approach to a particular problem. For the purposes of this discussion, we have focused on particular disease prediction or control efforts that simultaneously considered the

A working definition of One Health: a transdisciplinary approach involving human, animal, and environmental health aspects.

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A. Yamada et al. (eds.), *Confronting Emerging Zoonoses*,
DOI 10.1007/978-4-431-55120-1_12

spheres of human, animal, and environmental health. In particular, we propose that One Health involves *integrated assessment* of human, animal, and environmental health aspects of a disease problem, as well as *integrated interventions* across these spheres to prevent or manage such diseases.

12.1 Rabies Prediction and Control: A One Health Success and Challenge

Rabies is a classic zoonosis transmitted by the bites of domestic and wild animals and remains almost uniformly fatal to humans. While the disease has been a focus of veterinary and human public health efforts for centuries, it continues to cause thousands of human deaths yearly, mostly in developing countries, is resurgent in a number of regions, and would therefore seem to be a prime candidate for the attention of a One Health approach. Modern management techniques include effective vaccines for humans and animals, and in many countries there is ongoing and effective communication between animal health and human health professionals regarding rabies detection and prevention. Yet attempts to control the spread of rabies epizootics in wildlife by incorporating an environmental or ecosystem aspect such as ecological manipulation have largely been unsuccessful. Rabies control therefore illustrates some of the challenges to implementing One Health concepts.

The bullet-shaped, single stranded RNA rabies virus is spread typically via the bite of an infected animal to its next host. Non-bite transmission mechanisms such as inhalation of aerosols or organ and corneal transplantation are rarely reported (Constantine 1962; Winkler et al. 1973; Wohlsein et al. 2011). The neurotropic virus replicates in its new host at the entry point and quickly works centripetally through the nervous system. Once established in the central nervous system (CNS), the resulting encephalitis is responsible for the characteristic furor and rage seen among “mad” animals. This occurs concomitantly with further replication and viral shedding in the host’s saliva, thus promoting viral transmission into subsequent hosts. However, the virus itself is fragile and short-lived outside a host. Indeed, washing a bite wound thoroughly to flush out the virus may aid in preventing infection.

The incubation period from infection to clinical signs varies, depending on how close the site of infection is to the CNS. From days to months following infection, the resulting disease is progressive from malaise, fever, headache, agitation, paralysis, and finally coma and death. People rarely survive rabies once they exhibit clinical signs; there are rare documented/reported exceptions including an unvaccinated Wisconsin girl who underwent extreme medical measures to survive (Porras et al. 1976; Willoughby et al. 2005; Health News 2011).

Rabies virus is found on all continents with the exception of Antarctica. While the virus can infect all mammals, different strains have been identified by monoclonal antibody analysis among certain (typically mesocarnivore and bat) species with "spillover" occurring when these reservoir hosts infect other mammals, including humans. Principal reservoir hosts vary worldwide from dogs in Latin America, Africa and Asia to wild mesocarnivores (especially raccoons, foxes, coyotes and skunks) and bats in the Americas and Europe (insectivorous species in North America and Europe and hematophagous species in South America). The Brazilian marmoset is the sole primate identified with a unique viral variant associated with human rabies cases (Favoretto et al. 2013).

12.1.1 History of Rabies Control

Louis Pasteur began the field of immunology by working on two zoonotic diseases: fowl cholera and bovine anthrax. In 1885, he developed the first vaccine against rabies, basing his work on that of Dr. Pierre-Victor Galtier, a veterinarian and professor at the Veterinary School of Lyon, France (Jackson 2013). Two years later, he established the interdisciplinary Pasteur Institute for the purpose of furthering translational research. Today, prophylactic vaccination among high-risk individuals, including animals, provides protection. In addition, post exposure prophylaxis (PEP), involving vaccine and rabies immune globulin (RIG) are critical to preventing rabies (http://www.cdc.gov/rabies/resources/acip_recommendations.html. Accessed July 2013; http://www.who.int/rabies/human/postexp/en/. Accessed July 2013). In the United States, public health veterinarians frequently provide consultation to human health clinicians regarding rabies management.

In North America and Europe, the public health approach to controlling rabies includes vaccinating dogs and controlling strays. The resulting reduction of the dog strain of rabies combined with PEP has led to human rabies becoming relatively rare in developed countries. In the USA, dog strains of rabies have been declared eradicated (Velasco-Villa et al. 2008).

Distributed into the environment, oral rabies vaccine (ORV) in baits targeted toward foxes, coyotes and raccoons has been a rabies control strategy used with some success in Europe, Texas and eastern North America, respectively (http://www.aphis.usda.gov/wildlife_damage/oral_rabies/. Accessed July 2013). Indeed, ORV development and distribution has been a fruitful partnership between wildlife biologists and public health professionals. ORV has also been used as a strategy to immunize dogs in developing countries.

NOTE: As another example of interdisciplinary cooperation between human, animal, and environmental health professionals, state wildlife health officials in Kentucky were recently facing budget limitations in their effort to track and control white nose syndrome, an emerging fungal disease of bats. Surveillance for white nose syndrome is labor intensive and expensive. The

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National Park Service proposed a plan to make use of ongoing surveillance for rabies in bats to test the animals simultaneously for white nose syndrome. This successful pooling of resources provided cost-effective benefits for human and domestic animal health as well as wildlife disease control (Griggs et al. 2012).

12.1.2 One Health Challenges for Rabies Control

Over 50,000 human deaths, particularly in children bitten by rabid dogs, are estimated to occur in Asia and Africa, each year, demonstrating that, global rabies prevention and control remains an urgent challenge (http://www.who.int/mediacentre/factsheets/fs099/en/index.html. Accessed July 2013). Further, rabies spillover from domestic dogs to wildlife populations results in additional stresses to threatened and endangered species such as the Ethiopian wolf and the African wild dog (Randall et al. 2004). In some developing countries, dog control efforts are often underfunded or met with resistance (http://www.who.int/vaccine_research/diseases/zoonotic/en/index4.html. Accessed July 2013).

In North America and Europe, the shift from rabies in domestic to wild animals presents new challenges for disease control. Recent human cases in the United States are attributed most frequently to bat strain rabies with occult exposure (http://www.cdc.gov/rabies/bats/education/. Accessed March 2014). There are currently no oral rabies vaccines available for bats, and as with other reservoir species, widespread depopulation of bats is impractical, unethical and contraindicated ecologically due to their dual role in reducing noxious insect populations and pollinating fruit trees (Rupprecht et al. 1995). Rabies ecology is also influenced by human development encroaching into wildlife habitat or creation of "wildlife islands" which can concentrate susceptible animals.

12.1.3 Going Forward

International efforts to improve rabies control in developing countries have advocated for a One Health approach involving multiple sectors. Presently, these efforts are focusing on the domestic dog reservoir because that is the most direct threat to human health, and current canine vaccination levels are low in many countries (Lembo and Partners for Rabies Prevention 2012). While disease modeling suggests that focusing on domestic dogs could be effective for control at country level, even in countries where wildlife canines are abundant, there is the possibility that wildlife rabies reservoirs will become more important as the domestic dog reservoir is controlled, as has happened in developed countries (Fitzpatrick et al. 2012). Because rabies virus persists in diverse ecologic communities, the One Health approach must be enhanced in the future to pursue further understanding of enzootic maintenance mechanisms, in essence incorporating more consideration of environmental health and ecological systems into an integrated One Health assessment framework. This necessitates the partnership of multiple disciplines including wildlife biologists to provide rabies control programs that are efficacious, cost effective, publicly supported, and have negligible negative impacts on humans, animals, and the environment.

12.2 Animal Sentinels for Lead and Other Hazards

A promising application of One Health principles is the prediction of infectious and non-infectious disease events and risk in the environment. These prediction efforts are based on the concept that one species may serve as a "sentinel" for another species, just as the "canary in the coal mine" was used to warn miners of the presence of dangerous gases (Rabinowitz 2009). While non-human animals can serve as "sentinels" for human health threats in the environment, in some circumstances humans themselves may be the sentinels for such shared environmental health risks.

The usefulness of the sentinel concept is exemplified by case reports of dogs found to have lead toxicity, leading to the discovery that children sharing the same household were found to have lead poisoning as well (Dowsett and Shannon 1994). Similarly, cats and even cows have also been found to serve as sentinels for environmental lead poisoning risk in humans (Bischoff et al. 2010).

Sentinel disease events can be incorporated into formal prediction systems in order to provide more effective early warning. A study in California found that the most effective combination of warning signals for West Nile virus infection risk to humans involved environmental (climate) data as well as data on mosquitoes and animal cases of disease (Kwan et al. 2012). Other examples of sentinel events for human disease include:

- abundant wild piñon nut years in the Four Corners region of the USA predicting deermice population explosions associated with hantavirus outbreaks in humans (Mills et al. 1999),
- increased rainfall in East Africa predicting Rift Valley fever epizootics in livestock and epidemics in humans (Linthicum et al. 1999),
- Monkey deaths in India predicting Kyasanur Forest disease (Pattnaik 2006), and
- Rat deaths (rat-fall) in India predicting plague (Dennis and Staples 2009).

12.3 Schistosomiasis Prevention: Integrating human, animal and environmental health

To date, a limited number of disease intervention and control efforts simultaneously incorporated and documented the human, animal, and environmental health aspects of the intervention. One project in China that took such approach was an effort to prevent new cases of *Schistosoma japonicum*, a zoonotic form of Schistosomiasis with a bovine reservoir. The traditional approach to controlling the disease in humans was to treat human cases with anti-parasitic medication. Investigators found, in a controlled intervention study, that when they simultaneously treated humans and bovines (an animal reservoir for the disease), infection rates in both humans and the environment (the rate of infection in freshwater snails) was much lower than when only humans were treated (Gray et al. 2009). In a separate study, they found even better results when they carried out environmental sanitation measures including restricting cows from access to water bodies and installing latrines on boats to prevent human fecal contamination of the same bodies of water (Wang et al. 2009). While the authors of the study did not specifically label their approach as "One Health", it met the criteria described above for an integrated One Health intervention.

One Health approaches in agriculture have also shown promise. One study found that when humans and horses developed respiratory conditions related to the presence of high levels of organic dusts in a barn, better ventilation of the barns improved the air quality as well as the health of both species (Wålinder et al. 2011).

12.4 Challenges to Implementing One Health

There are a number of reasons why One Health successes have been relatively uncommon. These include professional segregation, difficulty engaging the human health sector, separation of regulatory functions, reliance on traditional animal disease models, funding priorities, and difficulty of incorporating environmental health aspects of an assessment or intervention.

Professional segregation is the phenomenon of human, animal, and environmental health professionals receiving training in separate institutions, with often little or no opportunity to interact with each other. Subsequently, in their professional lives, these individuals find no routine way to communicate or collaborate. The recent interest in One Health approaches may be breaking down such segregation among the upcoming generation of professionals.

Another challenge for One Health has been its differential visibility in veterinary medicine as compared to human medicine or environmental science. For example, the Journal of the American Veterinary Medical Association regularly features One Health, yet no medical or environmental health journals currently have an equivalent forum for One Health topics (https://www.avma.org/KB/Resources/

Reference/Pages/One-Health.aspx. Accessed 20 March 2014). Similarly, many veterinary medical schools have One Health courses or programs, but such curricula are currently absent from most medical schools and public health schools. Possible reasons for the difficulty in engaging human health in the One Health concept include lower levels of awareness and knowledge about zoonotic diseases among human health care providers and the historical professional segregation described above.

On the governmental level, there has been an historical separation of the agencies responsible for human, animal, and environmental health. Departments or ministries of agriculture traditionally deal with animal health and disease issues, while departments or ministries of public health oversee human health, while usually another separate department may handle environmental issues. In the US, there have been up until recently few examples of different agencies working together in a One Health model, although internationally, such models are being explored (Kenya One Health national Plan 2013). Again, with the growing discussion of One Health approaches at the international and national level, these traditional barriers between governmental agencies may be changing in the years to come.

12.5 Comparative Clinical Medicine and One Health

An important component of One Health is its comparative medicine approach to cross-species health and disease, noting the similarities and differences. Of course, human medicine has long relied on animal models of disease. However, most current comparative medicine research efforts involve laboratory animal models, and there has been little exploration of comparative clinical and observational approaches that could bring together human and animal health clinicians and epidemiologists. One example would be exploring the different expression of cancers in dog breeds to shed light on risk factors, both innate and environmental, for cancers in humans. Another example would be asthma in cats, a disease condition that closely resembles human asthma and could serve as a model for how the lung responds to the environment. The One Health related "Zoobiquity" initiative is an educational effort to bring human and animal clinicians together to identify clinical overlaps between human and animal medicine which remain largely unexplored but appear to hold great promise for providing new insights into disease treatment and prevention across species (Natterson-Horowitz and Bowers 2012). These efforts to move comparative medicine outside of the laboratory to consider naturally occurring diseases in multiple species could be termed "Comparative Clinical Medicine".

The lack of readily available funding or a dedicated funding agency for One Health projects is another serious barrier to implementation. The National Institutes of Health by law must prioritize human health above animal and environmental health, and has not established funding mechanisms encouraging the type of interdisciplinary approach provided by One Health. On the clinical level, medical insurance does not reimburse preventive visits to a veterinarian, even though such visits may help prevent zoonotic disease transmission from a pet to an owner.

Human and animal medicine share many of the same pharmaceutical types of interventions. One success has been the development of ivermectin, an antiparasitic agent used widely in veterinary medicine, and more recently the same medicine has been used in human medicine against lymphatic filariasis (Campbell 2012). Intervening on the environmental level requires a different set of skills and perspectives. For example, while both human and animal health professionals, including public health professionals, learn in their training how to apply the tools of disease epidemiology, they do not receive training in disease ecology and ecological principles. It has been proposed that to effectively work at the human-animal-ecosystem interface, there needs to be an appreciation of ecological concepts such as population dynamics, community structure, and ecosystem aspects including complexity, resilience, and geochemistry (Preston et al. 2013). Developing practical, evidence-based applications of such environmental and ecological principles will be a major challenge. Even when specific environmental interventions can be proposed, they can be costly in the short run. For example, a published analysis of a project controlling Tungiasis, a parasitic disease, acknowledged that better environmental control of water runoff could produce the greatest benefit on disease risk, but according to the authors would have the greatest short term costs compared to the medical expense of treating symptomatic patients (Pilger et al. 2008).

12.6 Future Needs

Despite the barriers listed above, there is a critical need for One Health approaches to a number of pressing problems. To develop such approaches, interdisciplinary cooperation along the lines described above will be essential.

As the world's human population increases, there has been a parallel rapid growth in the global population of food animals. There is also a trend toward intensification of animal production, with greater number of animals housed in production facilities. The intensification and crowding of food animals creates potential for amplification of disease outbreaks, evolution and emergence of zoonotic pathogens, occupational risks to workers, and risks for environmental contamination by animal waste and other facility emissions. There is a need to develop One Health models for food animal production that simultaneously maximizes the health of the involved humans (workers and consumers of food), the animals, and the local environment and minimizes the risks (Sarkar et al. 2012). Such models need to be applied both in small scale farming, where biosecurity is low, as well as large scale intensive animal agriculture, where biosecurity may be higher, but the scale of production amplifies some of the disease and environmental risks, as well as issues of animal welfare.

Another challenge is to define a One Health approach to the keeping of companion animals. There is growing evidence of the importance and possible health benefits of the human animal bond. In general, the positive aspects of pet ownership are believed to outweigh the risks of zoonotic diseases or other animal-associated health issues, even for immunocompromised individuals. However, increasingly urbanized lifestyles and the frequent presence in a home of an immunocompromised individual pose special challenges for pet ownership, as does the widespread ownership of exotic and wild pets. Keeping parks and beaches free of fecal contamination is an important environmental responsibility of pet ownership. Veterinarians and human health care providers, as well as environmental health specialists, need to collaborate to help define healthy models of living with companion animals.

Clinicians have an important role to play in One Health efforts. Sentinel cases of disease in humans or animals can indicate a risk in the environment that is shared and relevant for both humans and animals in the household. An example is when the diagnosis of a dog with the rickettsial disease Rocky Mountain spotted fever provides evidence of the presence of infected ticks in the environment and potential risk to humans. Clinical communication between veterinarians and human health care providers can also help with the early detection and prevention of zoonotic disease transmission. Lessons learned from diagnosing and treating one species, including the recognition of particular susceptibilities to environmental stressors, can be used to improve the health care of other species. Challenges to such communication include the professional segregation and financial obstacles mentioned above. There is therefore a need to define pathways and procedures for routine clinical collaboration between human health care providers and veterinarians.

There have been relatively few published examples of disease prevention and control interventions that effectively integrate human, animal, and environmental health. The examples cited in this chapter should serve as a basis for larger controlled interventions for a number of diseases shared between animals and humans. While One Health is a promising model, there is a need to develop the evidence base to support its integrated approach to disease prevention and control.

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