ONE HEALTH

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ABSTRACT

One Health is defined as an approach of integrating animal, human, and environmental health to mitigate diseases. One Health promotes public health by studying all factors, such as agriculture, food, and water security, mechanisms of toxicity and pathogenesis of acute and chronic diseases, sociology, economics, and ecosystem health (to name a few). Such an approach is essential because human, animal, and ecosystem health are inextricably linked; therefore, with this One Health approach, we are called to work together to promote, improve, and defend the health and well-being of all by enhancing cooperation and collaboration between physicians, veterinarians social scientists, economists, psychologists, legal professionals, philosophers, and other scientific health and environmental professionals. As such, the One Health movement and approach is a growing vision in global health and is gaining increasing recognition by national and international institutions, organizations, stakeholders, NGOs, and health policymakers. Likewise, the role of world-class universities is pivotal in discovering One Health scientific knowledge and translating them to policy and evidence-based practices. Universities have responsibilities to train future professionals capable of solving global health issues through interdisciplinary scientific knowledge, integrative approaches to teaching, research collaboration,

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community linkages, and leadership. This chapter discusses the importance of One Health and the role of higher education institutions' One Health partnerships to improve global health.

Keywords: Animal; human; environmental health; partnerships; international; One Health

INTRODUCTION

In October 2014 American healthcare workers contracted Ebola and spread fear across the nation. As soon as national panic arose, the disease was soon contained in the United States because, unlike most developing countries, the United States has the means to contain such a disease. However, as of November 2015, Ebola has claimed more than 11,000 lives around the world (WHO, 2015a).

Ebola was first detected in 1976 in Sudan and Zaire with unknown origins. Later, in 1994, a female ethologist found an Ebola strain in a dead chimpanzee in Cote d'Ivoire, Africa (Pigott et al., 2014). Many attribute the outbreak in December 2013 to a little boy's contact with wild animals, such as bats, but nothing definitive was proven. However, deforestation from mining and timber harvesting seem to be blamed for the origin of the disease from a little known section of the world called Meliandou, Guinea (WHO, 2015b).

While Ebola seems to be a mysterious disease with a difficult lineage, the pattern of emerging infectious diseases seems the same. As humankind continues to dominate the ecosystems and destroy forests for harvesting of goods (and thus change the ecology of the host, the pathogen, or a mixture of both), wild animals emerge out of their dwellings and infest humans and their habitat with bacterial or viral infections. Global travel and commerce exchange, including the translocation of animals to new regions of the world, spread animal-borne diseases across nations and continents (Bashford, 2006; Rupprecht, Smith, Fekadu, & Childs, 1995). Diseases caused by such merging of environments, animals, and human activity seem to be growing and old diseases seem to reemerge. Up to 75% of emerging infectious diseases among humans have zoonotic origins – which are diseases transmitted from animals to humans. Just a short list of such diseases include the Hendra and Nipah viruses, the Ross River virus disease, rinderpest in Africa, severe acute respiratory syndrome (SARS) coronavirus, bovine spongiform encephalopathy (BSE), avian and swine influenza,

dengue fever, West Nile virus, and the more well-known diseases such as HIV/AIDS (Cutler, Fook, & van der Poel, 2010). Influenza A viruses are becoming more virulent and prevalent than in the past, bypassing pigs and infecting humans (Koçer, Jones, & Webster, 2013). Trypanosomiasis is another zoonotic disease that has recently plagued Uganda.

The uneasy integration of the three elements – people, animals, and the environment – show imbalances that cannot keep up with the demanding changes of human population growth and their expansive culture. Even when animals without pathogens are introduced into a new environment, the potential for disease can emerge (Oldroyd, 1999). Global health has become a "wicked problem" (Rittel & Webber, 1973) because there are innumerable causes, has no unitary answer, and is difficult to resolve. According to the Centers for Disease Control and Prevention (the CDC) the One Health (OH) concept recognizes this interconnectedness of human health to animal and environmental health. The CDC works with physicians, ecologists, and veterinarians to monitor health threats and learn from each other about spreadable diseases (Rupprecht et al., 1995). Since scientists and researchers at universities are pivotal in joining forces with other professionals to solve problems, the CDC, the WHO, and One Health leaders have called for universities to help educate the masses and to create research teams (Gibbs, 2014). This coming together of professionals has come to define One Heath as stated by the One Health Commission: "One Health is the collaborative effort of multiple health science professions, together with their related disciplines and institutions – working locally, nationally, and globally – to attain optimal health for people, domestic animals, wildlife, plants, and our environment"(Gibbs, 2014).

In this chapter, we explore the various philosophical underpinnings behind OH, explain the historical developments behind the OH movement, and then focus on the adoption of OH in several universities. In so doing, we define OH, explain the progress that has been made in the OH movement, and then focus on university partnerships.

THE PHILOSOPHICAL DEFINITIONS OF ONE HEALTH

Since One Health has to do with the approach of scientific discovery, we presume a naturalistic evolutionary epistemology, barring other approaches

such as creationism. Within evolutionary epistemology, or the biological basis for evolution based on cognitive behavior (or activity) of all organisms (Popper, 1972), there is an inherent assumption that science itself evolves according to selection. From Popper's work, scientific theories arise not from empirical testing but rather from social and pragmatic methods that closely fit the given problem. Each problem therefore is unique to its environment, and all theories can be made false, but not necessarily true. To explain the evolutionary biological basis behind One Health, we state metaphors from biology that exemplify the underlying philosophy of the One Health approach.

Even the smallest unit of our body, the cell, demonstrates the interweaving of ecological ties between its neighbors. When cells encounter viruses, for example, they send signals to other cells and study the virus until they can come to conclusions. Specific cells have a way of adapting to the virus's characteristics so that it remembers the virus and when it is encountered again, it knows how to defend the body against that virus. However, when too many viruses contact the cells, and there happens to be no memory of how to encounter the virus, the cells are in trouble and start to die off, causing the disease to run rampant in the rest of the body. This process is complex and adaptive and thus scientists refer to complex adaptive systems to describe many such ecosystems. In university settings, the call is for researchers and educators to together promote this systems-based, complex adaptive approach to work across transdisciplinary lines. However, by the very fact that all these disparate groups are called to function together, several difficulties may have to be overcome. These hindrances involve the boundaries of the definition of One Health itself (Gibbs, 2014), the complex nature of systems thinking, the difficulties working across transdisciplinary teams, and the traditional structure of universities.

Our Health Is Socially Constructed

Likewise, humans interact with the environmental elements and biologically adapt. For example, during the migration of early humans out of Africa, those that survived in the different areas they settled throughout Europe and the rest of the world acquired genes that could cope with the different forms of foods found in those areas. In fact, the microbiomes of each of these geographical survivors established themselves in the context of those unique foods and diets (Trosko, 2014). Environmental changes

affect cultural and behavioral changes (Urry, 2003, 2005) but in turn our cultural behavior affect the environment in this "anthropocene" era that we live in. Thus, the ongoing flow of events is a mix of physical and social relations that interacts with the environment. A mix of science, technology, economics, politics, and nature (or the environment) creates a culture that defines our state of being (Latour, 1993). One Health is aligned with these ideas (Trosko, 2015).

For example, in our current modern age, the biggest cause of pressure on the health of all living organisms is the modernization and the resultant culture, particularly with modern methods of food, tools, and land acquisition. Our ability to think, use tools, create new ideas and technologies, and to make value choices using language has created this culture (Trosko, 2003; Vygotsky, 1978) and the world in which we now live. Currently, there are more than 7 billion people on earth. In less than a century, that number will increase to 10 billion. The increasing dynamic and extremely complex interactions of human cultural activities on the genes (mutations) and their expression (epigenetics) is the basis of the collision of our slow biological evolution and our rapid and quixotic cultural evolution that is affecting the human disease patterns we are witnessing today – as well as the overall ecosystem alteration. One Health is concerned with food security and safety, antibiotic resistance, climate change, and environmental degradation, aside from possible pandemics (Gibbs, 2014).

As health outcomes are socially constructed, so are its solutions. As stated at the end of the Manhattan Principles (2004), "It is clear that no one discipline or sector of society has enough knowledge and resources to prevent the emergence or resurgence of diseases in today's globalized world." Linking these OH problems of the changing ecological, animal, and human health are not only the scientific understanding of the health of each of these interacting organism systems, but also of the other disciplines generated when modernization dictated the way we sustain our health. The institutions of social structures of communities, of law, of economics, of politics, and religions had to be created to ensure the production and now "processing" of foods. These all contribute and are interlinked to the OH concept. Just as the cells in our body self-organize and learn, so do teams of OH people under a growing movement to improve the health of all. They engage in complex adaptive systems behavior as many people of variegated disciplines come together, share ideas, learn from one another, and honor the best solution to the given health problem.

No One Approach Sustains One Health

In addition, implicit in some philosophical definitions of One Health is the need for "sustainability." However, the challenge to the current elaborations of this concept of One Health is the absence of the fact that there is an inevitable and ongoing change in the physical, chemical, and biological make up of all living creatures. In other words, the concept of physical and biological evolution and cultural evolution needs to be integrated into the definition of "One Health." Over-arching all of this is the fact that all living organisms have DNA (genes) that provided each individual within each species the means to survive these dynamic, broad "environmental" interacting factors (such as temperature; time of eating; unique foods and processing of foods; seasonal availability of foods, to name a few examples). That DNA is under constant potential of change from association and interaction with the environment. In addition, even more easily, the expression of specific genes can be modulated at inappropriate times during development resulting in epigenetic toxicity. Thus, the problem with "One Health" is that it is very broad and encompasses so many differing fields. There is no microbial "One Health" process because our biological change processes lack homogeneity and unidirectional paths. Both virus-driven and host-driven forces for influenza A virus, for example, are subject to constant change because of the nature of viral genes that develop resistance to antiviral drugs or because of the error-prone nature of viral replication (Kocer et al., 2013).

For example, when one looks at a specific case of the last few generations of Japanese women, one sees that they have contributed to the longest median life spans on earth and according to nutritionists, having the classic Japanese diet seems to be one of the best (Armstrong & Doll, 1975; Chanlett-Avery & Nelson, 2014; Hirayama, 1978). However, because of the Western influences on that traditional Japanese diet, the next generation of Japanese women will not contribute to the longest median life span diet, while being important in life span, is not the only factor that is also changing. Patterns of disease occurrences all over the earth are changing because food production, food distribution, economics, and technologies are changing. This causes the delicate inter-dependence of "One Health" for all individuals within all species within all the three domains of life – (animal, human, and environment). Therefore, the old concept of "One Health" has no hope of finding some universal set of scientific principles to maintain all existing life forms in an inevitable dynamically changing world. Indeed, although some microbial scientists define One Health in

these terms, finding a universal set of scientific principles is not the goal of the One Health movement. One Health recognizes the tensions in cultural homogenization, that one model will not fit all models, and that, even in doing good, the politically powerless can become even more hegemonized and a complete understanding of world's problems is impossible (Baudrillard, 1995). Yet, because infectious diseases make us all co-dependent, One Health unites diversity into one common goal. Likewise, Bashford (2006), a noted health historian, states that a scholarship of global health still needs a biopolitical governance system, one that asks, "What about the possibility and imperative of health as it was figured internationally, transnationally and even globally over the 20th century?"

Not Survival of the Fittest, But Survival of Co-Dependence

On the contrary, One Health is or has become a process or a framework rather than a science. One Health frames climate change, for example, and its dynamic effects on pathogen lifecycles, diseases of domestic and wild animals, effects on fauna and ecosystems, and the destruction of habitat for both humans and animals (Patz & Hahn, 2013). For example, frequent rains and rising temperatures are said to be responsible for the increasing numbers of malaria cases in India and Africa (WHO, n.d.). Similar to how Ebola spread to other continents of the world from Africa, global tourism and business travel, as well as trade of animal goods, food, and other goods can readily transport diseases.

Humans, unlike other animal species, can adapt to change more rapidly by studying and researching for better survival techniques (Catton & Dunlap, 1978). This shifts the favor in the direction of humans within the balance of human–animal and environment adaption. And yet, the repercussions of our actions are unknown and we are still part of the same ecosystem and its laws. For example, by genetically modifying the mosquito, we can alter its ability to carry the Zika virus, but we do not know what repercussions that creates.

In summary, the dynamics of economics, health, education, and commerce is shifting, thus calling for a need for a new paradigm shift to manage the planet. Food production and agricultural methods have changed, deforestation and consumption of natural goods affect the health of animals, humans and the environment, global transportation systems and worldwide trade of goods transfer diseases more readily than ever before, and climate change affects fauna and animal habitats, increasing the

chances for diseases. Such a paradigm shift involves the complex adaptive systems around us such as the interaction of the animals, humans, and the environment. These shifts in the economic and natural environment require all members of the planet to come together to study and improve the planet. These factors all demonstrate that complex adaptive behavior is needed and point to the need for a One Health approach. In this section we described the philosophical underpinnings which led to the definition of One Health as a movement and an approach. In the next section, we will describe how this approach came to be and what the One Health movement intends for collaboration with higher education.

HISTORICAL BACKGROUND OF THE ONE HEALTH MOVEMENT

One Health is a relatively new movement which started almost three decades ago; however, the concept was first described in the mid-1800s by a German pathologist, Rudolf Virchow. He stated "*between animal and human medicine there is no dividing line, nor should there be*." The common "loose" interpretation of "One Health" is the interconnectedness of all life forms, namely, how the ecology (air, soil, water, plants, and microbes), animals, and human health are inexorably linked to each other.

One Health is an initiative to integrate environmental, ecological, and social scientists with health and medical professionals to collaborate and communicate across disciplines. The aim is to improve the lives of people globally by fighting zoonotic infections, balancing ecological, environmental, and economic systems, and to guard public health. More than 800 leaders worldwide have endorsed this movement.

In the 1980s, epidemiologist Calvin Schwabe called for a unified approach to prevent zoonotic diseases, providing the modern foundation for OH. In 2004 The Manhattan Principles arose out of a symposium about OH (see Table 1). In support of OH movement, in 2008, the American Veterinary Medical Association and the American Medical Association adopted a vision supporting the concept of OH and formed a task force on OH initiative. In addition, international organizations such as Food and Agriculture Organization (FAO), the World Organization for Animal Health (OIE), the World Health Organization (WHO), have all endorsed the concept of OH.

Examples of collaboration are growing. The 2006 outbreak of avian flu (H5N1), which is a pathogenic microorganism, led to collaboration of

Table 1. The Manhattan Principles.

We urge the world's leaders, civil society, the global health community, and institutions of science to:

1. Recognize the essential link between human, domestic animal and wildlife health and the threat disease poses to people, their food supplies and economies, and the biodiversity essential to maintaining the healthy environments and functioning ecosystems we all require.

2. Recognize that decisions regarding land and water use have real implications for health. Alterations in the resilience of ecosystems and shifts in patterns of disease emergence and spread manifest themselves when we fail to recognize this relationship.

3. Include wildlife health science as an essential component of global disease prevention, surveillance, monitoring, control, and mitigation.

4. Recognize that human health programs can greatly contribute to conservation efforts.

5. Devise adaptive, holistic, and forward-looking approaches to the prevention, surveillance, monitoring, control, and mitigation of emerging and resurging diseases that take the complex interconnections among species into full account.

6. Seek opportunities to fully integrate biodiversity conservation perspectives and human needs (including those related to domestic animal health) when developing solutions to infectious disease threats.

7. Reduce the demand for and better regulate the international live wildlife and bushmeat trade not only to protect wildlife populations but to lessen the risks of disease movement, cross-species transmission, and the development of novel pathogen-host relationships. The costs of this worldwide trade in terms of impacts on public health, agriculture, and conservation are enormous, and the global community must address this trade as the real threat it is to global socioeconomic security.

8. Restrict the mass culling of free-ranging wildlife species for disease control to situations where there is a multidisciplinary, international scientific consensus that a wildlife population poses an urgent, significant threat to human health, food security, or wildlife health more broadly.

9. Increase investment in the global human and animal health infrastructure commensurate with the serious nature of emerging and resurging disease threats to people, domestic animals, and wildlife. Enhanced capacity for global human and animal health surveillance and for clear, timely information-sharing (that takes language barriers into account) can only help improve coordination of responses among governmental and nongovernmental agencies, public and animal health institutions, vaccine/pharmaceutical manufacturers, and other stakeholders.

10. Form collaborative relationships among governments, local people, and the private and public (i.e., nonprofit) sectors to meet the challenges of global health and biodiversity conservation.

11. Provide adequate resources and support for global wildlife health surveillance networks that exchange disease information with the public health and agricultural animal health communities as part of early warning systems for the emergence and resurgence of disease threats.

12. Invest in educating and raising awareness among the world's people and in influencing the policy process to increase recognition that we must better understand the relationships between health and ecosystem integrity to succeed in improving prospects for a healthier planet.

Source: Manhatan Principles – from http://www.oneworldonehealth.org/sept2004/owoh_sept04.html

federal agencies and global coordination for prevention and response readiness activities. The most recent example of disease outbreak, which resulted in coordination and communication of several national and international inter-agencies, includes Ebola. The Center for Disease Control and Prevention (CDC) along with the World Health Organization (WHO) and several other local and global stakeholders worked in an interdisciplinary and collaborative manner to identify the source of outbreaks and to take necessary epidemiologic, preventive, educational, communicative, public health and clinical measures to contain the Ebola virus in West Africa – thus, preventing the virus from global spread. Today the One Health initiative and implementation has a historical opportunity to extend its interdisciplinary scope by including fields such as environmental and biomedical engineering, agriculture, food and water security, and social and behavioral sciences.

May 2010 was a historical turning point for the OH movement. A collaborative meeting of CDC, OIE, FAO, and WHO convened in Stone Mountain, Georgia, entitled *Operationalizing "One Health": A Policy Perspective – Taking Stock and Shaping and Implementing Roadmap*. The Stone Mountain meeting provided a forum for national and international stakeholders to discuss policy measures as well as the implementation of OH approaches. They addressed the interface of human and animal health with the specific goal of identifying robust actions to move the concept of OH from vision to implementation. A series of workshops were organized to address the policy and implementation such as teaching, OH global networking, information clearing house, needs assessment, capacity building, proof of concept, and business planning.

A series of meetings ensued. One Health, One Planet and One Future: Risks & Opportunities was the theme GRF-Davos One Health Summit of 2013, which was held in Davos, Switzerland. In this conference implementation policy of OH and global opportunities for an OH roadmap was addressed. Reza Nassiri, the Director of the Institute of International Health at Michigan State University, in his plenary address, discussed the strategic priorities of OH roadmap focusing on immediate priorities such as leadership, expertise, stakeholders, funding resources, international collaborative research, and development of a white paper. In addition, Prof. Nassiri shared with conference attendees the benchmarks of OH quality and standards of excellence including the safety and regulatory issues, and application of evidence-based and science-based metrics to measure OH quality outcomes. In his way forward address, Prof. Nassiri cultivated a vision for OH integration and collaboration by introducing the following three important concepts – innovation, implementation, and impact.

Since then, policymakers have realized that context is very important. Social scientists, anthropologists, and educators are called to team up with health workers and scientists to successfully approach infectious diseases in all countries, especially in resource deprived areas of developing countries (Smith, Taylor, & Kingsley, 2015). While Western nations emphasize One Health, in a less developed country, less money and attention is paid to the One Health concept, although such an approach is vital (WHO, 2016). In developing countries, many health workers receive poor training in patient care and equipment operations (Peabody, Taguiwalo, Robalino, & Frenk, 2006). Moreover, studies suggest that health improvements dramatically contribute to a rise in per capita GNP of a developing nation. A careful study of the state health system in such a country is necessary to properly engage with stakeholders and leaders. Many studies in the 1990s to the present have shown how careful diffusion of inexpensive interventions and knowledge can dramatically improve health and save thousands of lives despite the low level of a country's income (Peabody et al., 2006).

One Health, however, is not about creating a formula that explains or controls all diseases. The whole point of One Health is that infectious diseases cannot be studied in isolation of the socioeconomic, zoonotic, cultural, political, ontological, or epistemic beliefs from which the germination of the disease emanates and that all contexts differ. For example, the H1N1 virus, which derived its virulence from avinonic origins, must involve the study of chicken farms, the nature of processing, of growing the chickens, and the social life of chickens. The nature of chicken farming differs from pig farms, although the latter also serve as incubators of diseases (Hinchliffe, 2015). Culture, social mores, political systems, and microbial social worlds all interact producing infectious disease that cross-breed across biological and social relationships. Therefore, anthropologists teaming with sociologists might help to solve some of the OH puzzle as well.

In summary, the importance of the OH concept has gained increasing momentum in the past decade. Although the definition of OH is currently debatable among the global health and scientific community, there is consensus that novel integrated and interdisciplinary approaches are essential to solve global health issues and challenges relating to human, animal, and ecosystems. The approach and the movement to unite disciplines to solve these health issues has become the key definition of OH. The practice of OH, which acknowledges the system integration of human health, animal health, and environmental health, has been acknowledged by numerous national and international institutions as the most cohesive and outcome-producing approach for preventing and controlling diseases at the interface

of human, animal, and ecosystems. The expansion of human and animal populations, ecological changes, in particular climate change and global warming, as well as technological advancements, global movement of goods, humans, and animals, have all resulted in an increased risk of emerging and reemerging disease transmission between animals and humans. The approach to OH emphasizes solving such triple threats by improving communications, cooperation, and collaboration among stakeholders and across disciplines, organizations, and institutions.

The key idea is that One Health is not based on a unifying conceptual approach to health, but rather a process of examining global health issues based on team science and complex adaptive behaviors. As such, it requires economists, anthropologists, social scientists as well as healthcare workers in order to understand and deliver an integrated One Health plan to all parts of the world, especially in developing countries where most infectious diseases originate.

THE ROLE OF WORLD-CLASS UNIVERSITIES IMPLEMENTATION OH APPROACH AND ROADMAP

As a corollary to the recent emergence of diseases, the One Health paradigm promotes environmental surveillance, prediction, and prevention. Yet, in the majority of conversations, education and approach is not one of proactively confronting the underlying causes of these diseases but reacting to the proliferation and spread of the disease itself (Atlas & Maloy, 2014). Once the disease is contained, we seem to continue our study of the disease, not the inherent problems that spread the disease itself.

To achieve optimal One Health standards, the contributing role of universities is pivotal in One Health knowledge, research, economy, policy, and governance. Large, world-class universities house multiple disciplines which can come together to study and solve problems. In addition, engagement of multiple stakeholders at the local, regional, national, and international levels is essential to leverage One Health action. World-class universities can provide such a forum for all academics, physicians, veterinarians, agriculturalists, environmental health scientists, public health scientists, and officers, and students along with national and international health agencies, NGOs, and government agencies. For example, one immediate need is for academics to find ways to detect new or resurging zoonotic diseases and monitor sources of antibiotic resistance. These

collaborations can follow a process of research, validation, policy development, practice development, and scale-up for better impact. Fig. 1 summarizes the elements of impact.

In summary, differing dimensions of One Health confuses the already difficult way of engaging in systems thinking, which is what One Health is all about. "The beauty of One Health is its complexity and its interactions," said Mike Chaddock, Associate Dean of the College of Veterinary Medicine at Michigan State University. Therefore, even at the university level, such complexity makes OH work difficult. First, recent sociological literature points out that complex adaptive systems (such as One Health) require complex adaptive behavior. Adaptive work is suitable for occasions in which no one person has all the answers and only by collaborating together and sharing solutions can they adapt to the situation well enough to solve problems. Working in transdisciplinary teams requires such behavior. There is no one leader, but everyone takes a leadership role as they self-organize around a common problem. They share data from their area of expertise, explain occurrences around their local area, and in doing so, the team comes up with an integrated solution. Contrary to such behavior, traditional universities have a hierarchical structure system based on tenure and publications.

The second difficulty is the teamwork concept required in OH work. Researchers should strive to form teams that are greater than the sum of their parts to learn from one another and develop solutions that transcend each discipline. Because OH is a complex and evolving topic, with virulent diseases that are often intractable, complex adaptive leadership may also need to become a part of the curricula. Just as cells (in our body as explained earlier) self-organize and learn, students may need to be taught how to work across collaborative teams, self-organizing around knowledge, and become interdependent, but independent agents. As students learn that

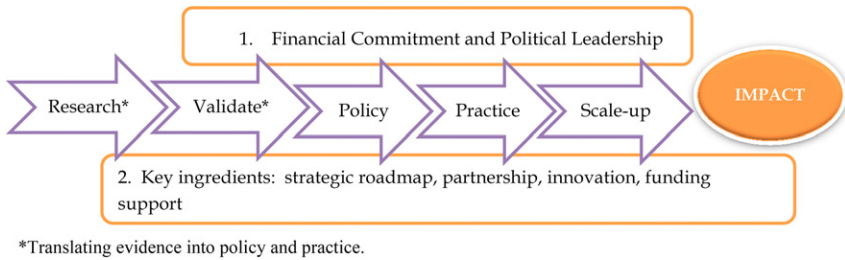

Fig. 1. Taking One Health Approach to Impact.

a small part of the system can affect behavior of the whole system, they will learn to focus on the interdependencies of systems in both processes as well as in science. We conclude then that One Health curricula include the "science of team science" (Stokols, Taylor, Hall, & Moser, 2006) and systems thinking methods around complex adaptive behavior.

The third difficulty is that for adaptive learning and team behavior to occur at universities, structural changes may have to occur. The main problem in universities is that departments work in their own silos and are acculturated for individual rather than integrative work with other departments. Each department's funding structure and accountability structure are all not very conducive for collaborative, transdisciplinary work. Even things like parking structure or lack thereof can hinder collaboration because each discipline is housed in separate buildings. For example, at Michigan State University, many individual scholars are engaged in One Health research with one other person from another department, but for true interdisciplinary and transdisciplinary work to occur, there may need to be at least 4–5 disciplines coming together. Mike Chaddock explains this problem well after having worked on the One Health Initiative at Texas A & M University and now at Michigan State University. At both universities he sees the same problem of independent departments whose financial and working structures may need to be reorganized for collaborative approaches.

MODELS OF ONE HEALTH EDUCATION

Like all new ideas, One Health movement's diffusion into universities requires incremental steps to adoption. Higher education institutions progress through certain stages or models of adoption when a new concept or discipline is introduced into universities. Clark (1968) published four models of institutionalization as follows: organic growth model; differentiation model; diffusion model; and the combined process model. Examples of One Health infusion show a combination of these models. However, for One Health, as with most new innovations, the models translate into stages of adoption. The following three stages of innovation diffusion provide a lens for us:

Stage one: This stage is a combination model of an organic growth model and the beginnings of a diffusion model. In the combined process model, the institution looks outside and inside the university and develops

programs simultaneously in both camps. This phase is also exemplified in early stage of the diffusion model of adoption where information gathering and dissemination is prominent. Those outside the university are invited to professional meetings such as conferences which serve as a vehicle of information exchange and new information creation. A conversation begins on campus and more conferences and linkages are established.

To this end, the CDC together with other NGOs, have been gathering at various universities to educate students and faculty about One Health. Included in the dialogue is the importance of integrating wildlife health science when talking about human and domestic animal health (see item #3 of the Manhattan Principles, Table 1). Partnerships form to eventually grow into a stronger presence on various campuses, with the presumption of creating a new discipline for student learning. Educating future generations about the One Health approach is one of the priorities of the leaders involved in One Health (Gibbs, 2014).

An example of this stage is exemplified at Michigan State University (MSU). The International Institute of Health (IIH) at MSU held a series of workshops with the CDC and Canadian One Health representative to begin the conversation. The U.S. Center for Disease Control and Canadian Public Health Association modeled cross-disciplinary teaming by holding seminars about One Health at MSU in 2014. Then networking with Japan, Turkey, Korea, and Brazil the IIH began a series of conferences to spread the exchange of information.

An innovation is more likely to be adopted institutionally "the closer an innovation is to the central values of a social system … and the more intellectually sophisticated the conceptual schemes of an innovation" (Hamilton, 1995, pp. 241−242). Along these lines, because Michigan State University is a world class land grant institution with one of the oldest agricultural programs and four schools of medicine (College of Veterinary Medicine, College of Human Medicine, College of Osteopathic Medicine and College of Nursing), One Health is more likely be institutionalized.

Stage two: Stage two of One Health adoption seems to be composed of a combination model which has elements of both internal and external organic growth. However, the internal growth supersedes external involvement. In this stage, there are adequate mechanisms in the university for a discipline to form. These mechanisms include funding (usually from a combination of external and internal resources), structural changes, value climate (or culture) conducive to accepting the innovative new discipline. This stage also is a combination of the diffusion model with the differentiation model.

The information has been shared, evaluated, adopted, funded and the institution has differentiated the innovation within their existing structure to be a unique discipline. Funding tends to attract faculty from various disciplines to come together. Such an example of One Health adoption is at the University of Florida, Gainesville.

At University of Florida, the One Health Center is differentiated under their Emerging Pathogens Institute which includes more than 150 faculty from various disciplines such as Environmental and Global Health, Food Systems, Geography, Plant Pathology, Medicine, Agricultural Communication, Molecular Genetics and Microbiology, and the list continues. The Emerging Pathogen's Institute and the One Health Center formed as a result of massive donations and grants from external sources such as the United States Agency for International Development. The Center's goal is to bring together these various people from various disciplines for research and to share resources while working in more than 50 countries across the world. The One Health Center offers both a PhD and a Master of Health Sciences in One Health, with emphasis on infectious diseases. Both programs emphasize the integration of public health, environmental health, and veterinary health while patching together faculty from the Emerging Pathogens Institute, the Aquatic Pathobiology Laboratory, College of Medicine and the College of Veterinary Medicine or the Center for Environmental and Human Toxicology.

Stage three: In the final stage of adoption, an idea infiltrates the university to the full extent that it can infuse the concepts into all colleges and into as much curricula across campus as logically reasonable. One Health lends itself to a behavior-based curricula as well as knowledge-based curricula since it addresses "wicked" problems which require planetary changes. The next step at a university setting like the one at University of Florida, Gainesville, is to inculcate the One Health concept through all colleges and thereby infuse the concept into all curriculum. For this to happen, the faculty may need to work across disciplines to research and to teach. The curriculum may include the science of teamwork, the critical thinking practices required for complex adaptive systems, and the creative thinking methods. These are all elements of adaptive systems thinking (Casti, 1979; Dodder & Dare, 2000). The curriculum may also need to be reflective of the practice in that the faculty themselves work in teams and engage in complex adaptive systems thinking.

The idea is that One Health concepts may eventually permeate all of society. For example, one cannot deny that ethics is a philosophical

discipline. However, ethics is also a discipline that may need to permeate all other disciplines, to the extent logically possible. Environmental science began to institutionalize in the 1980s and now is infused into most university curriculum across the country. Similarly, One Health requires such an infusion because of its multifacetedness and because global health affects the health of all humans on the planet. This third stage of adoption occurs when enough people in the public learn about One Health so that the teaching of the young does not merely occur at the university level but at all levels, from grade school on up, and the vocabulary and the philosophy behind One Health becomes common knowledge. There has yet to be a model of an institutionalization at this third stage, since most people do not yet know what the One Health movement espouses. Both the One Health Commission and the One Health Initiative are calling for a united effort to educate the masses, from K-12 to professional education (Lueddeke, 2016).

In looking for such a model, perhaps in Southeast Asia (which is a region known for scarcity of resources and greater vulnerability to vector-borne diseases such as malaria), such permutation is occurring.

There, a wider reach into NGOs and professionals across the region shows promise of faster inculcation of the One Health movement. A broad education strategy in South Asia involves a two-pronged approach (Vink, McKenzie, Cogger, Muellner, & Boreman, 2013). The first step is to provide Masters degree programs in epidemiology, public health, and biosecurity with One Health emphasis. Already, Massey University created two online masters in epidemiology and biosecurity (Masters in Public Health & Master of Veterinary Medicine) which attracted a cohort of 70 students from various south Asian countries composed of veterinary and medical professionals. The second step involves educating existing professionals who work in health institutions. There are workshops to create transdisciplinary teams who will train others and disseminate educational materials. Experts also gather to assist and train newly interested teams and inculcate the value and application of the "One Health" approach at the national and regional levels.

SUMMARY

While our planet is suffering from systems-based environmental challenges that affect human and animal health such as climate change, we lack a systems-based solution to meet these challenges. The answer lies in

collaborating across divisions of veterinary medicine, human medicine, food security systems, and disciplines that study the disruption of environmental ecosystems. Using knowledge-based advocacy to seek optimal health for all living humans and animals on earth, the One Health concept guard against environmental degradation.

Universities have academic and educational responsibilities to train future professionals capable of solving global health issues through interdisciplinary scientific knowledge, integrative approach, collaboration, communication, and leadership. Human health, animal health, and ecosystem health are inextricably linked and with this One Health approach, we must work together to promote, improve, and defend the health and well-being of all by enhancing cooperation and collaboration between physicians, veterinarians, and other scientific health and environmental professionals. The goal of OH is to integrate efforts in human & animal health, public health, agriculture, food and water security, and ecosystem health. The One Health movement and approach is a growing vision in global Health, which is gaining increasing momentum and recognition by national and international institutions, organizations, stakeholders, NGOs, and health policymakers. The role of world-class universities is pivotal in discovering One Health scientific knowledge and translating them to policy and evidence-based practice. However, while many promote interdisciplinary learning, suggesting ways to make interdisciplinary team science to facilitate positive teamwork outcomes interdisciplinary teamwork is difficult by its very nature (Stokols et al., 2006). Of course, opposing forces such as those who want to promote department silos voice their outcry at the interdisciplinary movement (Jacobs, 2013) and say that interdisciplinary approaches diminish faculty power and confuse the financial structures of the university. In the end, what Jacobs says "Interdisciplinarity depends on strong disciplines," might be exactly right. In the end, there will probably not be a reorganizing of the university, but new institutes of interdisciplinary studies, such as the one at University of Florida. Such institutes will spring up to herd faculty from various disciplines to come together for special projects and research, all the while maintaining their status quo in their own departments. Therefore, One Health leaders, such as the One Health Commission, need to articulate and strategize better around focused goals (Gibbs, 2014) at universities. Using strategic planning outcomes measures seem to be a better accountability system for global health issues (Fox, 2014).

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