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# One Health proof of concept: Bringing a transdisciplinary approach to surveillance for zoonotic viruses at the human-wild animal interface

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ABSTRACT

As the world continues to react and respond inefficiently to emerging infectious diseases, such as Middle Eastern Respiratory Syndrome and the Ebola and Zika viruses, a growing transdisciplinary community has called for a more proactive and holistic approach to prevention and preparedness – One Health. Such an approach presents important opportunities to reduce the impact of disease emergence events and also to mitigate future emergence through improved cross-sectoral coordination. In an attempt to provide proof of concept of the utility of the One Health approach, the US Agency for International Development's PREDICT project consortium designed and implemented a targeted, risk-based surveillance strategy based not on humans as sentinels of disease but on detecting viruses early, at their source, where intervention strategies can be implemented before there is opportunity for spillover and spread in people or food animals. Here, we share One Health approaches used by consortium members to illustrate the potential for successful One Health outcomes that can be achieved through collaborative, transdisciplinary partnerships. PREDICT's collaboration with partners around the world on strengthening local capacity to detect hundreds of viruses in wild animals, coupled with a series of cutting-edge virological and analytical activities, have significantly improved our baseline knowledge on the zoonotic pool of viruses and the risk of exposure to people. Further testament to the success of the project's One Health approach and the work of its team of dedicated One Health professionals are the resulting 90 peer-reviewed, scientific publications in under 5 years that improve our understanding of zoonoses and the factors influencing their emergence. The findings are assisting in global health improvements, including surveillance science, diagnostic technologies, understanding of viral evolution, and ecological driver identification. Through its One Health leadership and multi-disciplinary partnerships, PREDICT has forged new networks of professionals from the human, animal, and environmental health sectors to promote global health, improving our understanding of viral disease spillover from wildlife and implementing strategies for preventing and controlling emerging disease threats.



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[1] http://www.vetmed.ucdavis.edu/ohi/predict/publications/Authorship.cfm

[2] Much of this review is based on material covered more thoroughly in *USAID PREDICT: Reducing Pandemic Risk, Promoting Global Health*, PREDICT Consortium, One Health Institute, University of California, Davis, December 2014 (www.report.predict.global).

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## 1. Introduction[2]

Throughout history, societies have been plagued by emerging diseases and their rapid or insidious spread. Recent generations have borne the costs of HIV/AIDS, Severe Acute Respiratory Syndrome (SARS), and Middle Eastern Respiratory Syndrome (MERS), tallied in lives and livelihoods lost and profound impacts on broader-scale economies. The most recent emergence and spread of the Zika virus and Ebola virus disease (EVD) in West Africa demonstrate how ill prepared the world remains to respond to and control rapidly changing disease dynamics. The global panic resulting in significant financial and social consequences also illustrates the disappearing boundaries between the countries and continents working to protect their citizens. The majority of emerging infectious diseases (EIDs) are zoonotic, or those diseases caused by pathogens that are shared between people and animals (Jones et al., 2008). These diseases result in tens of thousands of deaths annually, and the economic losses from a single outbreak can amount to tens of billions of dollars (World Bank, 2012). While prevention and early control of outbreaks could be the key to reducing the impact of epidemics and potential pandemics, especially in less developed countries as demonstrated by the recent EVD epidemic in West Africa, the world still remains positioned only to respond, not to prevent.

Despite greater recognition of the importance of zoonotic diseases, little attention has been given to advancing the understanding of the underlying causes for emergence and drivers of spread (Murray and Daszak, 2013). A growing transdisciplinary community, often led by veterinarians and epidemiologists, has responded to this knowledge gap on disease dynamics by advocating for a more holistic or One Health approach that recognizes the need to expand disciplinary expertise in public health. From the beginning of the One Health movement, veterinarians have strongly advocated for an approach that considers all public, animal, and environmental aspects of health as a problem-solving paradigm (Cook et al., 2004). Notwithstanding the philosophical acceptance of the need for such an approach, the animal and environmental foundations of this three-legged stool often receive only cursory attention when major health problems are addressed in policy and practice.

Recent examples of emerging and re-emerging diseases, such as H1N1 pandemic influenza, H5N1 and H7N9 avian influenza, EVD, and Zika virus, serve as a reminder that the health of humans, animals, and ecosystems are interconnected and that early detection and response to emerging pathogens requires a coordinated, interdisciplinary, collaborative, cross-sectoral approach at local, regional, and global levels (Heymann and Dixon, 2013; Karesh et al., 2012; Morse et al., 2012). In addition to the burden on human and animal health, the economic impacts associated with emerging and pandemic pathogens can be catastrophic, including costs associated with decreased commerce, travel, and tourism, as well as those incurred from treatment and control efforts (Karesh et al., 2012; World Bank, 2012). As our world becomes increasingly connected through trade and travel, emerging infectious diseases pose a greater threat to the global community, requiring collaboration between ministries of health and institutions involved in health, trade, agriculture, and the environment (Mazet et al., 2014). The One Health approach presents important opportunities to reduce the impact of emergence events and also to prevent future emergence through improved knowledge and coordination. In this article, we share One Health approaches applied by the US Agency for International Development's PREDICT project consortium to highlight the potential for successful One Health outcomes that can be achieved through developing cross-sectoral networks and establishing strong collaborative, transdisciplinary partnerships.

## 2. Observation of need at the human-wildlife interface

Arguably, veterinarians and veterinary epidemiologists have been among the most vocal advocates for the One Health approach. Pioneers of the One Health concept understood the value of comparative medicine and recognized the critical role that environmental factors play in the health of people and animals. Over the past decade, this concept was expanded to be much more inclusive of ecosystem health (Cook et al., 2004), due in part to the contributions of veterinarians witnessing firsthand the intimate connection among animal, human, and environmental health (Gibbs and Gibbs, 2013). For example, although veterinarians working in global health recognize the role that wildlife trade and consumption play in human nutrition and livelihoods in many countries around the world, they have expressed concern about the risks these practices pose with regard to spillover of zoonotic pathogens, as well as to conservation (Ahuka-Mundeke et al., 2011; Karesh et al., 2005; Karesh and Noble, 2009; Peeters et al., 2002; Smith et al., 2012; Wolfe et al., 2005). Human immunodeficiency viruses (HIV) types 1 and 2 are examples of pandemic infections resulting from cross-species transmission of simian immunodeficiency virus (SIV) from infected nonhuman primates to humans (Sharp et al., 2010). The documented spillover and pandemic potential of simian retroviruses illustrate the public health threat associated with close and frequent contact with wild animals, as occurs with wildlife trade and consumption (Switzer et al., 2012).

However, it should not be ignored that pathogens spill over in both directions, also threatening the health of wild animals. Tuberculosis in nonhuman primates and Asian elephants has long been associated with contact with infected humans (Mikota and Maslow, 2011; Montali et al., 2001). Investigation into a respiratory outbreak in mountain gorillas in Rwanda by PREDICT veterinarians revealed human metapneumovirus infection in affected individuals (Palacios et al., 2011). The source of the virus remains unknown; however, the strain was most recently described in human patients in South Africa and likely was transmitted to the gorillas by humans, illustrating the potential for bi-directional spillover of pathogens (Palacios et al., 2011). The parks where mountain gorillas reside are surrounded by very dense human populations, and research and ecotourism bring thousands of people into direct and indirect contact with the gorillas annually. Veterinarians documented 18 outbreaks of respiratory disease among these gorillas between 1990 and 2010 (Spelman et al., 2013). It is unclear if the increasing frequency and severity of respiratory disease outbreaks among mountain gorillas in the Virunga Massif (Spelman et al., 2013) are related to the growing human population surrounding the parks. Nevertheless, these findings provided further rationale for implementation of stricter visitation rules in some parts of the mountain gorillas' range in order to minimize the risk of disease transmission between visitors and wild human-habituated gorillas.

In Rwanda, an orphaned Grauer's gorilla confiscated from poachers and held in captivity for more than two years developed oral lesions. The consortium detected human herpes simplex virus Type 1 (HSV-1) in this individual (Gilardi et al., 2014), documenting spillover of another virus from humans into gorillas and further illustrating the need for targeted disease surveillance at the human-wildlife interface (Gilardi et al., 2014).

## 3. One health on a regional scale: the PREDICT project

The US Agency for International Development (USAID) initiated the Emerging Pandemic Threats (EPT) program in 2009 with the goal of strengthening capacities in developing countries to prevent, detect, and control infectious diseases. In part because of their One Health leadership and research focused at the

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