GLOBAL LIVESTOCK CRSP

New Medicine for Emerging Zoonoses: Reducing Disease Risk at Human-Animal-Environment Interfaces in Tanzania Using a One-Health Approach

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When livestock and wildlife are in close proximity, diseases can have severe impacts on livelihoods, biodiversity, and even human health. Using a transdisciplinary ecosystem approach rooted in the "One Health" paradigm, an increasingly important prism through which governments, non-governmental organizations, and practitioners view human health, we are addressing disease transmission and its impacts on livelihoods in water-limited, rural Tanzania. Critical information gaps targeted for data collection included disease testing in animals and water, human health and socioeconomic surveys, and evaluation of wildlife and livestock demography and land usage. The resulting data were used to assess risk of transmission of the bovine tuberculosis, brucellosis, and waterborne pathogens identified in the area and to identify science-based interventions likely to be implementable in the current economic and cultural contexts. The HALI platform has reinforced the importance of the One Health concept and provided lessons for the development of a new approach to global health. Effective surveillance, assessments, and interventions are only possible by crossing the organizational gaps between local citizens and institutions studying and managing wildlife, livestock, water, and public health. Collecting detailed data regarding land use and agricultural practices, food consumption, and water use habits, illness in animals and people, and access to healthcare will help appropriately tailor education efforts for priority diseases and pandemic prevention. Though strong science is an excellent foundation on which to base recommendations, interventions can succeed only if stakeholders are involved in the characterization of the problem and are willing to make the tradeoffs necessary to balance their short-term economic needs with those of the long-term health of the ecosystem. Finally, the donor community should be encouraged to transcend disciplinary conventions and invest in holistic health projects that have the best chance of affecting change.

Background

Every day thousands of children and adults die from under-diagnosed diseases that have arisen at the human-animal-environment interface, especially diarrheal and respiratory diseases in developing countries. Explosive human population growth and environmental changes have resulted in increased numbers of people living in close contact with wild and domestic animals. Unfortunately, this increased contact together with changes in land use, including livestock grazing and crop production, have altered the inherent ecological balance between pathogens and their human and animal hosts. In fact, zoonotic pathogens account for the majority of emerging infectious diseases in people. Nowhere in the world are these health impacts more important than in developing countries, where daily workloads are highly dependent on the availability of natural resources. Water resources are perhaps most crucial, as humans and animals depend on safe water for health and survival, and sources of clean water are dwindling due to demands from agriculture and global climate change. As water becomes more scarce, animals and people are squeezed into smaller workable areas, increasing contact among infected animals and people, and facilitating disease transmission (Clifford et al., 2008).

These conditions are particularly prevalent in rural Africa and near remaining wildlands. Rapid population growth and consequent demands for natural resources are making African wildlands increasingly vulnerable to conversion to other land-uses, such as logging, agriculture, and pastureland. A recent analysis by Wittemyer et al. (2008) found that average annual population growth rates were higher in buffers to protected areas than in rural areas in Africa and Latin America. Protected areas provide some of the last supplies of ecosystem goods and services for expanding human populations, yet their porous edges provide refuge for the vectors of zoonotic disease transmission.

The interconnectedness of human, animal, and environmental health is at the heart of 'One Health,' an increasingly important prism through which governments, non-governmental organizations, and practitioners view human health. An important implication of the One Health approach is that integrated policy interventions which simultaneously and holistically address multiple and interacting causes of poor human health – unsafe and scarce water, lack of sanitation, food insecurity, and close proximity between

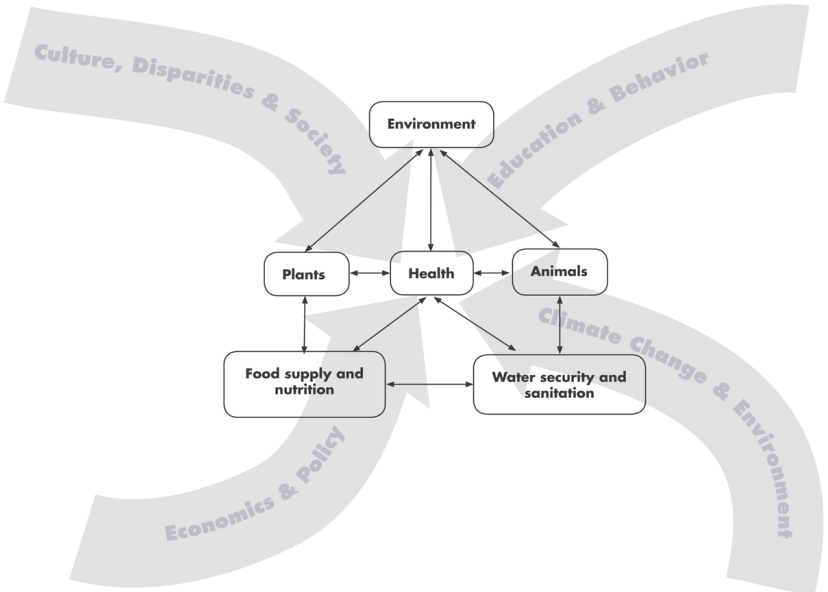

Figure 1. Local and global influences impacting human health, including the interdependence of people, animals, plants, and the environment, and associated food and water availability, safety, and security.

animals and humans – will yield significantly larger health benefits than policies that target each of these factors individually and in isolation. By its very nature, the One Health approach is trans-disciplinary, since it is predicated on working collaboratively to improve and promote both human and animal health. Figure 1 depicts the interdependent relationships and influences that interact to affect human health. This complexity necessitates professionals from multiple disciplines to collaborate on the design of effective interventions.

In 2006, the Health for Animals and Livelihood Improvement (HALI) project was initiated to test the feasibility of the One Health approach in rural Tanzania and to find creative solutions to these problems. HALI is investigating the impact of zoonotic disease on the health and livelihoods of rural Tanzanians living in the water-limited Ruaha ecosystem, one of Tanzania's largest wild areas, where virtually all communities depend entirely on the natural resource base and where livestock are central to traditional natural resource management. The HALI approach recognizes that the health of domestic animals, wildlife, and people are inextricably linked to the ecosystem on which all depend (Clifford et al., 2008).

Zoonotic diseases known to be of public health importance, like rabies and Rift Valley Fever, are present in wildlife, domestic animals, and people in Tanzania; however, the role of under-diagnosed disease, like bovine tuberculosis (BTB), has only just begun to be characterized. Nearly 40,000 new cases of tuberculosis (human, bovine, or atypical strain) are diagnosed per year in Tanzania, with anywhere from 21-77% of Tanzanian tuberculosis patients also infected with HIV. The extra-pulmonary form of tuberculosis (EPTB) in people, often associated with BTB infection from animals, accounts for 20% of the reported cases in Tanzania. Therefore, bovine tuberculosis became a focal disease for the HALI project due to its high livestock prevalence, wildlife data paucity, and the large, susceptible HIV/AIDS-infected human population living in close association with livestock and wildlife. Additional priorities for HALI were determined through gender-balanced interviews with affected communities. Through these interviews and stakeholder meetings, an overwhelming consensus emerged:

A significant proportion of the rural population in the Ruaha Landscape is affected by diseases impacted by water supply, and these diseases are affecting health, agricultural productivity, food security, and biodiversity in the region.

Accordingly, HALI is assessing the impact of the interactions between water and disease in Ruaha by simultaneously investigating the medical, ecological, socioeconomic, and policy issues driving the system.

Achievements

The map in Figure 2 illustrates our multi-level approach which includes: testing of wildlife (n=70), livestock (n=1350 in 102 households), and their water sources (10 sources sampled monthly for two years) for zoonotic pathogens and disease; environmental monitoring of water quality, availability, and use (with above); assessing wildlife population health and demography (surveys in association with Wildlife Conservation Society, Tanzania National Parks, and the local community managing wildlife); evaluating livestock and human disease impacts on livelihoods of pastoralist households (n=159 household surveys examining economic and disease transmission risk factors, including gender differences, subset resampled seasonally); examining land and water use impacts on daily workloads and village economies (n=18 detailed diaries); introducing new diagnostic techniques for disease detection (technology transfer between University of California, Davis and Sokoine University of Agriculture); training Tanzanians of all education levels about zoonotic disease (over 950 local people by outreach programs, 24 game scouts and technicians, four Honors Bachelor and Extern Projects, two Masters theses, one Rwandan PhD); and developing new health and environmental policy interventions to mitigate the impacts of zoonotic diseases (currently underway). Perhaps most importantly, HALI is

examining these issues in a common framework with specific emphasis on the interactions between them, instead of attempting to isolate a single issue.

The HALI project has identified bovine tuberculosis and brucellosis in livestock and wildlife in the Ruaha ecosystem and is using this information to identify geographic areas with varying water availability where risk of transmission between wildlife, livestock, and people may be high. In addition, *Salmonella, Escherichia coli, Cryptosporidium,* and *Giardia spp.* that can cause disease in humans and animals have been isolated from multiple water sources used by people and frequented by livestock and wildlife. These data are now being used to examine spatial and temporal associations between landscape factors and disease and to identify risk factors and health impacts that may be mitigated through policy changes and outreach. Preliminary findings also indicate that more than two-thirds of participating pastoral households do not believe that illness in their families can be contracted from livestock, and nearly half believe the same of wildlife. Furthermore, when HALI began working in this region, 75% of households did not consider sharing water sources with livestock or wildlife a health risk, illustrating the need for effective community education.

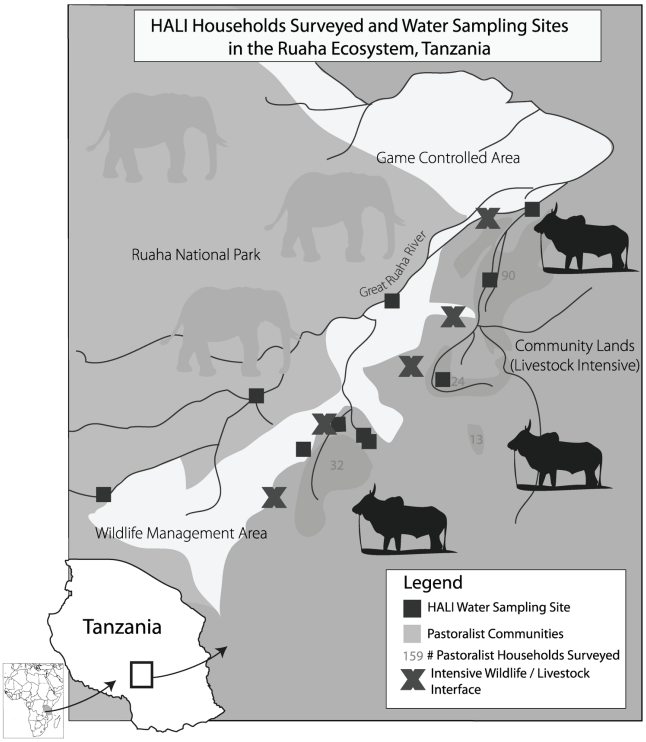

Figure 2. Map of the HALI project study area in the Ruaha Ecosystem, Tanzania.

The HALI project is currently focusing efforts on continued disease surveillance, health education and outreach, and collaboration with the Tanzanian medical community to better integrate animal and human health in rural areas of Ruaha. In 2009, HALI research in Ruaha formed a key component in obtaining a competitive research award of up to $75 million over five years to host a new USAID Emerging Pandemic Threats program entitled *PREDICT: Building a global early warning system for emerging diseases that move between wildlife and people.* PREDICT, now underway, is a research and capacity strengthening program working to improve disease surveillance and detect new and emerging diseases in wildlife that threaten humans in infectious disease hotspots around the world, like Ruaha. The PREDICT consortium is led by HALI Lead PI Dr. Jonna Mazet, and hosted within the UC Davis School of Veterinary Medicine's new One Health Institute.

Lessons Learned

The HALI platform has reinforced the importance of the One Health concept and provided lessons for the development of a new approach to global health. First, it is crucial to recognize that zoonotic pathogens are present and emerging in rural communities and that their emergence is spatially and temporally variable within these communities. Most people living in high risk areas are not aware of the danger or what can be done to reduce it. In addition, transmission can be exacerbated by common animal husbandry and food and water handling practices. Therefore, data collection strategies should include the evaluation of spatial, temporal, and demographic patterns of pathogen prevalence and disease in human, domestic animal, and wildlife populations in likely hotspots for disease emergence. The underlying water and land-use determinants of disease and the social, economic, and cultural barriers to control and prevention must be explored. While local stakeholders and international institutions actively involved in animal health, conservation, and livelihood assessment and improvement were quick to engage in HALI, physicians and public health experts (local and international) have been slower, likely due to competing demands on time and resources already dedicated to addressing malaria and tuberculosis of human origin. Concerns over the financial escalation of projects directly measuring pathogens in human subjects was also an obstacle to engaging medical professionals for these neglected diseases.

Second, the role of water in disease transmission and zoonosis emergence should be further explored. Water scarcity increases work stress, especially in women and children, and brings animals and people together more frequently, increasing the likelihood of water contamination and transmission of infectious diseases. Likewise, the manner in which water is used for agricultural and animal production affects worker health, food safety, and the health of those who drink and bathe in it. Improving water safety

and security, including sanitation, in ecologically appropriate ways that reduce disease risk will require a transdisciplinary approach in which economists, ecologists, epidemiologists, and engineers play important roles with public and animal health practitioners.

Finally, the determinants and consequences of zoonotic diseases, as well as the interventions to mitigate their deleterious effects, are all cross-sectoral. Effective surveillance, assessments, and interventions are only possible by crossing the organizational gaps among institutions studying and managing wildlife, livestock, water, and public health. It is clear that education in global health, especially emerging zoonotic diseases, is urgently needed at all levels from research institutions to pastoralist communities. Collecting detailed data regarding land use and agricultural practices, food consumption, and water use habits, illness in animals and people, and access to healthcare will help appropriately tailor education efforts for priority diseases and pandemic prevention. While strong science is an excellent foundation on which to base recommendations, interventions can succeed only if stakeholders are involved in the characterization of the problem and are willing to make the tradeoffs necessary to balance their short-term economic needs with those of the long-term health of the ecosystem. The donor community should be encouraged to transcend disciplinary conventions and invest in holistic health projects that have the best chance of affecting change.

Further Reading

The content presented here is reprinted from: Mazet, J., D. Clifford, P. Coppolillo, A. Deolalikar, J. Erickson, and R. Kazwala 2009. "A 'One Health' approach to address emerging zoonoses: The HALI project in Tanzania." *PLoS Medicine* 6: e1000190.

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The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet. She can be contacted via post at Wildlife Health Center, One Shields Ave., School of Veterinary Medicine, University of California, Davis, CA 95616, USA, or via email: jkmazet@ucdavis.edu.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East and West Africa, and Central Asia.

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