One Health scientists are changing the way we fight infectious disease, and projects in many countries are focusing on determining where emerging diseases come from and what can be done to stop them. In other words, we are working with a more intense regional focus in many areas, to combat global problems. In veterinary medical education, many of us are trying to determine what the specific educational outcomes associated with One Health are, and how best to deliver these meaningfully within the curriculum. Regional variations due to the environment and animal management practices will result in differing priorities when it comes to a One Health Educational Curriculum but the general principles will remain the same (e.g. principles of zoonosis are the same no matter where you are, but the risk factors and the pattern of the disease will vary by location). In addition, it has been stated that veterinary education in One Health should comprise more than efforts related to current veterinary students. Many have identified an urgent need for continuing education for already practicing veterinary practitioners, many of whom have had minimal, if any, training in veterinary public health. Indeed, van Knapen (2000) pointed out that veterinary medicine is the only discipline that can advise over: environmental pollution/protection, surface water/swimming water quality, stray animals, pet policies in cities, allergies, zoonosis control, food hygiene, and the social aspects of having companion or sport animals, among other things.

The PREDICT project is an example of a project that has created local training workshops for veterinarians and graduate students related to vector capturing, biosafety, biosecurity, and sampling. Future work will also focus on developing materials that will engage and educate veterinary students about possible pandemic threats and the role they may play in fighting them. For further information on this interesting initiative….

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PREDICTing the Next Pandemic: How One Health Scientists Are Changing the Way We Fight Infectious Diseases

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Ebola, Zika, SARS, and MERS - these diseases have caused great concern in recent years, ravaging communities, spreading across continents, and disrupting economies. Each of these viral diseases is responsible for a considerable number of human infections, deaths, and millions to billions of US dollars in lost GDP. Such infections, referred to as emerging infectious diseases in the public health community, may have the potential to rapidly spread from person to person in communities, hospitals, and around the world once they have entered a population. But where do these emerging diseases come from, and what is being done to stop them?

These questions are being addressed right now in Jordan and 29 other countries through an innovative viral disease surveillance project funded by USAID, the United States Agency for International Development.

The PREDICT project, part of USAID's Emerging Pandemic Threats (EPT) program, started in 2009 in response to the emergence of HIV, SARS, avian influenza, and numerous other infections. Implemented in 20 countries across South America, Africa, and Asia, the first phase of the project, PREDICT-1, sought to understand viral diversity in wildlife, and to use that

information to better understand which animals harbor viruses typically associated with severe human illness.

Emerging Diseases from the Animal World

Why target animals? Analyses by Taylor et al. (2001) and Jones et al. (2008) estimate somewhere between 60% to 75% of all emerging infectious diseases among humans originate in animal hosts. This includes pandemic influenza viruses which are native to avian species; HIV which is believed to have originated in non-human primates; and Ebola which is believed to have originated in bats.

But why do viruses spill over from animals into humans in the first place? Part of this question can be answered through adoption of the One Health approach, in which the interconnectedness of human, animal, and environmental health is acknowledged and studied. As it turns out, One Health researchers believe there are multiple factors that may increase the likelihood of a pathogen jumping from an animal into a human. Intensification of animal livestock production, deforestation, rapid land-use change, climate change, and hunting and poaching behaviors all contribute to the changing landscapes of animal-human interfaces and to the shifting boundaries of human interactions with wildlife. These practices can open pathways between a person and an animal, where individual may be exposed to an animal's respiratory droplets, feces, blood, etc., one or more of which may contain viruses. Once direct or indirect contact is made with these biohazards, it is possible for pathogen exchanges to occur, orchestrating the movement of an animal pathogen into a human body.

Of course, the pathogen must be capable of adapting to the conditions of the human body and infecting human cells in order to cause an infection. But once this is achieved for the first time, a new disease has emerged. Many of these events, typically called spillover events, do not progress past a singular human infection. However, under the right conditions and circumstances, a spillover event may lead to person to person transmission.

Recent literature suggests this phenomenon is occurring with increasing frequency. A study by Smith et al. (2014) found that outbreaks of zoonotic infections are occurring more frequently than just 10 years ago, and far more frequently than in the 1980s. Globalization, climate change, and industrialization are frequently cited by researchers as driving forces behind this trend. Increasing numbers of spillover events inevitably raise the possibility of an epidemic or even a pandemic, an outbreak of disease stretching across countries and sometimes across continents.

Understanding Zoonoses

The findings of PREDICT-1 helped narrow the focus of USAID's goal to prevent pandemics. The project determined bats, rodents, and non-human primates as the most significant reservoirs of viral families that pose threats to humans like Orthomyxoviridae (e.g., influenza), Filoviridae (e.g., Ebola), Coronaviridae (e.g., SARS and MERS), Paramyxoviridae (e.g., Nipah), and Flaviviridae (e.g., Zika). It further provided evidence of disease emergence "hot spots," locations where viral spillover from animals to humans is most likely to occur based on sociodemographic, environmental, and ecological factors. PREDICT-1 answered which animals

are most likely to spawn a human pandemic, which viral families among animals are most likely to cause a human pandemic, and where the origins of a possible pandemic may be located.

Stopping Spillover

PREDICT-2, the second and current phase of this project, seeks to answer the next set of questioning: is spillover occurring where we think it is, what viruses are circulating that are of the greatest concern, and what can be done to interrupt the spillover process?

These questions are being addressed by scientists around the world, thanks to USAID and the governments of each country in PREDICT-2. In countries participating in PREDICT-2, a team of experts from the host country coordinate triangulated surveillance among humans, wildlife, and domestic animals for the key viral families identified in PREDICT-1. At various human-animal interfaces, wildlife and domestic animals are tested for these viral families around the same time as when humans are tested. Participating individuals are also asked to complete an interview so epidemiologists can identify behavioral practices associated with viral spillover.

If there is evidence of viral spillover at a particular location, and it is associated with specific occupational exposures or behavioral practices, PREDICT-2 generates knowledge about spillover pathways that may be interrupted with specific public health interventions. This knowledge can then be shared with the affected community and the country's ministries of health, agriculture, and environment, in order to protect the local community and the greater population from viral spillover, which may have led to a pandemic if left unaddressed.

PREDICT-2 also identifies known and novel viruses from the investigated viral families, knowledge which is made publicly available following approval from the host government. These data, once released, are accessible to anyone in the world, and can be used by scientists to understand global viral diversity and viral circulation, as well as to potentially develop therapies and vaccines should the virus spread.

PREDICT-2 was launched in Jordan in late 2016, and already the collaboration has surveyed hundreds of camels, bats, and humans for the key viral families, and particularly for MERS Coronavirus, a specific concern in the region. PREDICT-2 Jordan is being implemented by a team at the Jordan University of Science and Technology (JUST), which focuses on surveillance of wildlife and humans. The Food and Agriculture Organization of the United Nations (FAO) focuses on surveillance of domestic livestock. Given the focus on MERS in Jordan, wildlife surveillance focuses on bats and domestic livestock surveillance focuses on camels, two animal taxa that are the primary suspects in the evolution (bats) and transmission (camels) of MERS.

The PREDICT-2 Jordan Country Coordinator, Dr. Ehab Abu-Basha, works closely with the Jordanian Ministries of Health, Agriculture, and Environment, USAID/Jordan, and other key governmental and non-governmental partners to successfully execute the project. Dr. Abu-Basha believes "the coordination with Jordanian ministries is critical to the success of this project. Each partner plays an equal role in the efforts to understand disease emergence dynamics among wildlife, livestock, and humans by engaging in a meaningful implementation of the One Health approach."

Virus Hunting in Jordan

A number of times throughout the year, the team at JUST spends the entire evening outside bat caves, hoping these nocturnal mammals will fly into their near-invisible nets stretching meters into the sky. For the bats they catch, the team carefully untangles them from the net, takes precise morphometric measurements for species identification, collects oral, urogenital, and fecal swabs, and takes a tiny amount of blood. After the sampling is completed, the bats are diligently cared for until they are able to fly away safely on their own.

The collected samples will undergo viral family testing at the laboratories of the Faculty of Veterinary Medicine at JUST. If a specimen tests positive for one of the viral families, the product's genome will be sequenced at JUST's Princess Haya Biotechnology Center housed at King Abdullah University Hospital, so it can later be classified as a known or novel virus and characterized by the PREDICT-2 Global Laboratory Team. PREDICT-2 Jordan Laboratory Co-Lead Dr. Mustafa Ababneh says "discovering whether a detected virus has the potential to infect humans and to cause illness is a central part of the project. We may find a multitude of viral RNA in our samples, so prioritizing which findings are of greater importance helps us sort through the data."

On other days, the team will head to nearby human-animal interfaces like camel farms and slaughterhouses to ask individuals in the area for their participation in the project. If they agree, the team will collect nasal and oral swabs and blood for viral testing, and serum for detection of MERS antibodies. Following this, they are asked to complete an interview about their behavioral and occupational practices at the site, as well as their beliefs about animal diseases and reports about recent illnesses.

One member of the community surveillance team, JUST graduate student Ola Ababneh, recounts the challenges and opportunities posed by the administration of the questionnaire. "It is difficult to enroll community members when there is a widespread belief that animals do not spread disease to people. However, I hope the work of PREDICT-2 will show that viruses are spilling over and convince individuals in high-risk interfaces to consider preventative measures."

The information garnered through the interview is crucial to understanding and identifying possible public health interventions, because it will allow for comparisons between those who have been infected with specific viruses and those who have not. This comparison may highlight certain practices that are associated with infection. "Behavioral risk characterization for animal-exposed communities in Jordan will allow us to develop and implement appropriate and targeted infection control measures, which may reduce the occurrence of spillover events," says PREDICT-2 Jordan Community Surveillance Coordinator, Dr. Basil Amarneh.

All of these data are later linked with the camel surveillance data generated by FAO, to provide a comprehensive picture of the triangulated surveillance. Dr. Zaidoun Hijazeen, EPT-2 Liaison at FAO Jordan, says "concurrent viral surveillance among livestock, wildlife, and humans may tell us which viruses are circulating at these interfaces, and may even help us find evidence that MERS is actively spilling over from camels into humans."

Prediction for Prevention

With 2 years remaining in the second phase of PREDICT, the Jordan team, along with the other 29 country teams, hope to contribute significant knowledge toward viral spillover processes and human spillover risks that can be used to stop a pandemic before it happens. Emerging infections are increasing globally, and it will require a collaborative effort of multidisciplinary scientists, policy makers, and the public to prevent disease spillover and large-scale outbreaks. Crucial to all this will be communication and education. Scientific knowledge by itself cannot solve the problems of the world. It is a start, but it is leadership and changed human behaviors that will ultimately safeguard vulnerable communities and minimize the risks of spillover and propagation. One Health projects like PREDICT are leading the charge to prevent pandemics and changing the way the public health community fights infectious diseases, by moving the battle to the frontlines of viral emergence among humans – animal hosts – and providing the vital evidence to educate communities at this edge of links between wildlife, domestic species and themselves when it comes to their health and that of their families.

Photo

Photo from Field trip to camel Farms and Bats caves by PREDICT-2 Jordan