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PREDICT KENYA

One Health in action (2014-2020)



Understanding how diseases are transmitted from animals to humans, sharing information between health professionals, strengthening capacity for rapid detection and response to viral pathogens, and identifying zoonotic diseases before they become pandemic threats.

KENYA



Increasing human, livestock, and wildlife populations, expanding agricultural commercialization and animal production value chains places Kenya at significant risk for viral spillover. In addition to these drivers of infectious disease emergence, the occurrence of hemorrhagic viral outbreaks in Kenya's neighboring countries of Uganda and South Sudan have warranted concern for the risk of epidemics within Kenya due to increased cross-border trade.

Faced with these challenges, Kenya has become a leader in establishing One Health priorities and encouraging multi-sectoral coordination to address both known and emerging zoonotic disease threats. The PREDICT team worked closely with key government/ministry, university and research partners to strengthen mechanisms to detect and respond to zoonotic disease threats and build capacity in both the laboratory and field for the next generation of Kenya's One Health workforce. In addition,

the team engaged interdisciplinary partners to facilitate dialogue and share One Health information across animal and public health sectors.

To strengthen capabilities for national health security, the PREDICT project in Kenya conducted One Health surveillance at high-risk, human-animal interfaces. At the same time, interviews with local community members were conducted to better understand the social and behavioral factors associated with zoonotic disease transmission.

Finally, the team strived to achieve sustainable, lasting health impacts through training, education, outreach and capacity strengthening with in-country partner institutions. The team trained 400 individuals in One Health field and laboratory skills, provided professional development for 118 students, and educated and empowered local communities to make informed decisions that benefit community health.

The project actively participated in the development of Kenya's One Health National Strategic Plan (2017-2022), effectively bridging the gap between advocacy and action related to wildlife and environmental health. Collectively, PREDICT/Kenya's efforts have helped build a framework that can be used to develop effective intervention, disease prevention and control strategies at local, regional, and national scales in Kenya.

LOCAL PARTNERS

- Central Veterinary Investigatory Laboratory, Directorate of Veterinary Services-Ministry of Agriculture-Livestock
- Directorate of Veterinary Services-Ministry of Agriculture-Livestock
- Food and Agricultural Organization-Kenya
- Institute of Primate Research
- International Livestock Research Institute
- Kenya Agricultural Livestock Research Organization
- Kenya Medical Research Institute-Ministry of Health
- Kenya Wildlife Service-Ministry of Environmental Conservation
- Mpala Research Center, Laikipia County
- One Health Central East Africa
- University of Nairobi (schools of public health and veterinary medicine)
- Zoonotic Disease Unit



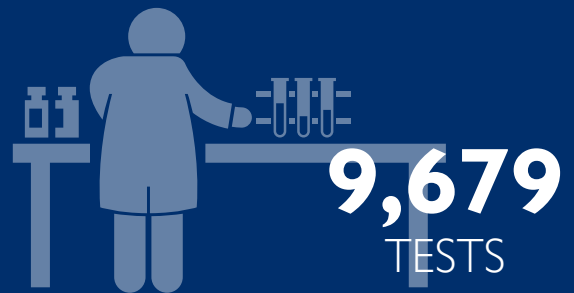
DEVELOPED the One Health Workforce by training more than 400 people in Kenya.



OPERATIONALIZED One Health surveillance and sampled over 1.8K animals and people, to identify ways to help minimize the spillover of zoonotic disease threats from animals into human populations.

LABORATORY STRENGTHENING

- Kenya Medical Research Institute
- Institute of Primate Research



DETECTED 2 unique viruses in animal populations.



JOSEPH
KAMAU

Country Coordinator
Institute of Primate Research

“As a veterinarian, molecular biologist of infectious diseases and a zoonoses WHO-certified expert, I assumed that I had all that it takes to handle any pandemic, but my professional experience is only one side of the coin in handling an outbreak. PREDICT-2 provided the other side—the role that communities play. I’ve learned a lot from my interactions, including the knowledge that communities have in solving disease emergence or spread when well trained and guided, and what biosafety and biosecurity education can do to preventing disease outbreaks. I hope to use the lessons learned in many areas of my work and share them widely.”



FATIMA
HASSAN
HUSSEIN

Research Scientist
Institute of Primate Research

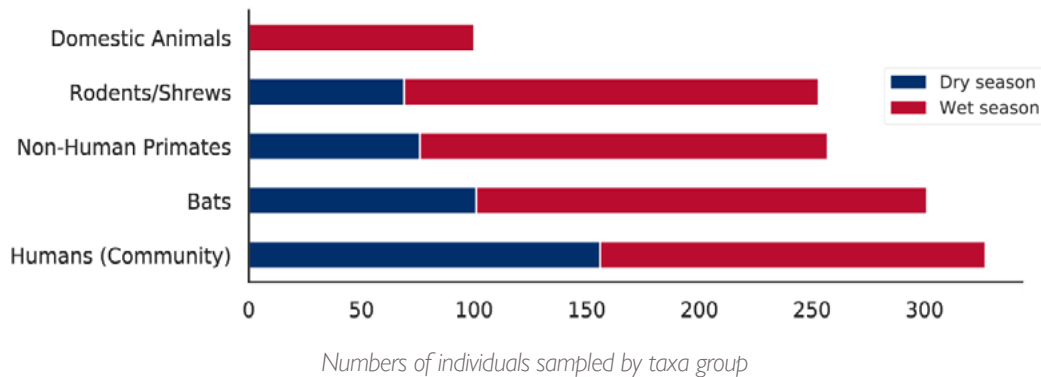
“The PREDICT Project has opened my eyes from a narrow clinical diagnosis framework to a more global One Health approach by targeting emerging zoonotic viruses posing a threat not only to Kenya, but to the world.”

ACHIEVEMENTS

- Trained >400 people, including the next generation of multidisciplinary One Health professionals, by developing two courses for Master’s degree students in infectious disease and global health from experiences gained during project implementation.
- Safely sampled > 1,800 individuals (1,534 animals and 327 people) in at-risk areas for zoonotic virus spillover and spread.
- Interviewed > 300 people to better understand the social and behavioral factors associated with zoonotic disease transmission risk.
- Detected two viruses (one known and one new) in Angolan free-tailed bats.
- Contributed in drafting the One Health National Strategic Plan (2017-2022) under the stewardship of the Zoonotic Disease Unit.
- Adapted the Smithsonian’s National Museum of Natural History’s mobile “Outbreak!” DIY exhibition materials to engage the local community, while providing context during dissemination of project results and intervention strategies.
- The community health workers, nurses, and clinical officers used the PREDICT project training protocols on surveillance as part of their continued professional development - knowledge that can be used by the health workers for future surveillance and disease outbreak response.
- Through partnerships with One Health Central and East Africa (OHCEA) and the University of Nairobi, strengthened disease detection, surveillance, and response capabilities of the future One Health workforce through student trainings in hands-on field and laboratory skills.
- As the first zoonotic disease surveillance project in Kenya to heavily focus on wildlife viral surveillance, PREDICT/Kenya highlighted gaps in communication and information-sharing between human, domestic animal, and wildlife health sectors and helped identify gaps in multi-sectoral communication and made recommendations for improved zoonotic disease prevention, detection, and response.

ONE HEALTH SURVEILLANCE

In Kenya, the project's One Health surveillance was designed to train, equip, and enable the workforce to collect data and build the evidence base to understand how diseases are transmitted from animals to humans. The PREDICT team worked closely with key government/ ministry, university and research partners to strengthen mechanisms to detect and respond to zoonotic disease threats and build capacity in both the field and laboratory for the next generation of Kenya's One Health workforce.



ONE HEALTH SURVEILLANCE STRATEGY FOR NATIONALLY RECOGNIZED PRIORITY ZOOONOTIC DISEASES

The PREDICT project conducted One Health surveillance to detect priority viruses and emerging diseases in animals and people at high-risk, human-animal interfaces. The team conducted interviews with local community members to better understand the social and behavioral factors associated with zoonotic disease transmission. By facilitating dialogue and sharing information between interdisciplinary partners, the project strengthened One Health platforms and knowledge exchange between animal and public health sectors.

To enable assessment of potential trends in virus spillover and spread across space, time and season, the PREDICT team conducted surveillance activities at key sites in Laikipia and Turkana Counties in Rift Valley Province over a five-year period. These sites were identified by stakeholders as locations of national importance due

to their dynamic human-wildlife-livestock interfaces and presence of the dromedary camel animal value chain in the region. Three land use strategies are implemented in this region: pastoralism, commercial ranching, and wildlife conservancies. These land use systems are not mutually exclusive. For example, Laikipia County has experienced significant increases in domestic animal and wildlife populations over recent decades due to expansion of animal production industries and wildlife conservancy areas, creating conflict and competition for limited water and grazing resources especially during drought.

During three seasonal surveillance trips in Laikipia and one in Turkana, the PREDICT team collected over 9,130 specimens from non-human primates (NHP), bats, rodents, and camels at sites where there was a high level of interaction between humans and animals. Camel samples were

collected at ranches in Laikipia, and from pastoralist herds in Turkana. Concurrent bat, rodent, and NHP samples were collected from animals in adjacent dwellings, cropland, and natural areas within close proximity to public spaces.

The team also performed human behavioral risk assessments of Laikipia residents, many of whom have direct contact with camels or wildlife and may be at risk for zoonotic disease exposure. Residents enrolled in the study also provided specimens for viral testing.

Animal samples were tested at the Institute of Primate Research (IPR) and human samples were tested at IPR as well as the Kenya Medical Research Institute. Both laboratories used PREDICT protocols to screen for known zoonotic viruses of national public health concern, like Ebola Virus, as well as for new and emerging viral threats.

HUMAN SURVEILLANCE

Through the PREDICT project's multidisciplinary One Health surveillance approach, our teams worked with local communities to learn about and better understand social and behavioral factors associated with risks of zoonotic disease transmission, focusing on the “how” and “why” of risk. Using data-driven methods, our team also worked to identify potential policies and intervention strategies that might be effective in preventing or mitigating zoonotic viral spillover and spread. Insights into behavior helps direct efforts to raise public awareness of personal and occupational zoonotic disease risks.

In Kenya, 327 people completed questionnaires on their behavior and livelihoods at high risk animal-human interfaces and provided samples for zoonotic virus testing. Participants were community members from within four Laikipia County townships.

	Clinic-based surveillance	Community-based surveillance		
Sites/ Land Use	Commercial Ranching (n=56)	Pastoralist 1 (n=102)	Pastoralist 2 (n=100)	Commercial Ranching/ Wildlife Conservancy (n=69)
Gender				
Female	21 (37.5%)	61 (59.8%)	72 (72.0%)	40 (58.0%)
Male	35 (62.5%)	40 (39.2%)	28 (28.0%)	29 (42.0%)
Other	0 (0.0%)	1 (1.0%)	0 (0.0%)	0 (0.0%)
Age				
<18	7 (12.5%)	6 (5.9%)	28 (28%)	2 (2.9%)
18-49	43 (76.8%)	71 (69.6%)	58 (58%)	63 (91.3%)
50+	6 (10.7%)	25 (24.5%)	14 (14%)	4 (5.8%)

TABLE: Participant characteristics across all surveillance sites in Laikipia County

SANITATION IN THE COMMUNITY

The type and frequency of high-risk behaviors related to food and water consumption and animal interaction practices varied by land use. However, high-risk activities were identified in all communities. Over 90% of people surveyed have high levels of contact with animals through pet ownership, handling and raising livestock, or sharing food/water sources with animals. The majority use an uncovered water source such as a well, pond or river and 66% do not treat their drinking water prior to consumption. These kind of intimate and frequent interactions with animals and their waste products increases the likelihood and opportunity for disease transmission from animals to humans.

Sanitation concerns were particularly observed in the pastoralist communities. Exposure to animal feces was facilitated by keeping livestock in household complexes and sharing water sources with both livestock and wildlife. Other sanitation issues included a lack of human waste

locations in one pastoralist community (Pastoralist 1). Analysis revealed that having a designated location for human waste was associated with lower likelihood of illness reports among participants.

ACCESS TO HEALTH CARE

Health care access is a significant driver of disease vulnerability. Access is highly variable among communities, and is determined by distance from the community, availability of timely transportation, and cost. The pastoralist communities at greatest risk of behavioral exposure also have the least access to health services due to distance (up to 7km to the nearest facility) and cost.

PERCEPTION OF DISEASE RISKS FROM ANIMALS

Consuming raw meat, milk, or blood from livestock are common practices in many Kenyan communities. Most people interviewed (93%) had eaten raw meat or a sick animal in the last year. These

practices have been linked to outbreaks of Rift Valley Fever (RVF) and brucellosis in rural Kenya. Both diseases have devastated livestock productivity and caused human morbidity and mortalities.

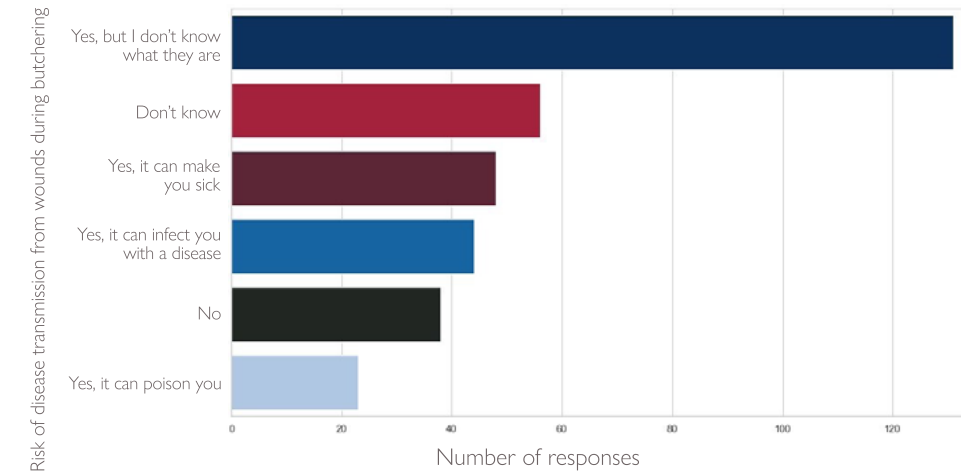
Hunting was rarely reported across all communities, but data for this behavior is unlikely to be accurate since hunting wildlife is illegal in the region. Bushmeat availability was highly reported in pastoral communities, with 76/112 people reporting that it is available to eat at or near their workplace, suggesting hunting is a common practice.

A high proportion of interviewees had been scratched or bitten by an animal within the previous year but over half of the community participants (67%) either did not know or did not think there is a risk of getting diseases from open wounds when butchering animals (Fig. 1). This explains why very few people (12%) take preventative measures (e.g. disinfecting lacerations) or seek medical treatment when injured while butchering dead animals.

OCCUPATIONAL DISEASE RISKS

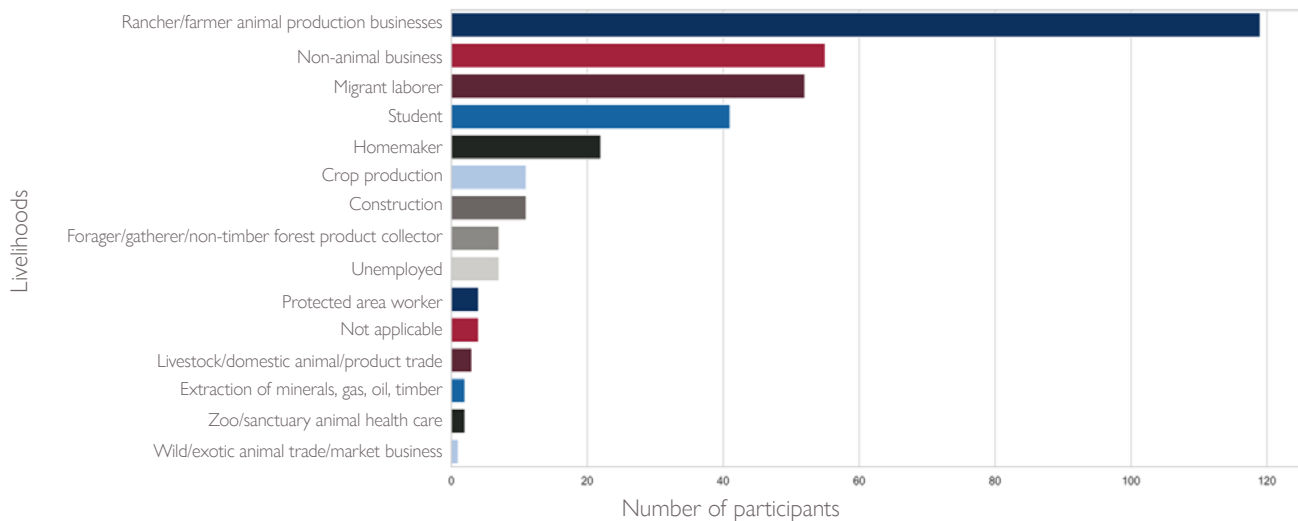
Most people interviewed worked in the animal production business (Fig. 2). Contact with infected bodily fluids or consumption of products from ill animals have previously facilitated outbreaks of Rift Valley Fever in Kenya. Fifteen percent of pastoralists in Pastoralist 1 township reported an outbreak of diseases in animals during the previous year, yet only 5% said animals were quarantined or destroyed. Combined with the common practice of consuming farmed meat onsite (107/112), there is a significant risk of disease transmission from the consumption of sick animals.

Interventions emphasizing practical behaviors in industries with frequent and intimate interactions such as



animal production should be explored. Community education on safe animal husbandry practices and how to identify and manage sick animals could have far reaching effects on reducing incidence of human illness. Provision and use of protective gear or clothing (e.g. gloves,

face masks) to prevent wounds and contact with infected animal fluids would reduce occupational exposure, given 82% of workers in this industry are not using any personal protective equipment (PPE).



VIRUS FINDINGS IN HUMANS

The PREDICT partner laboratory, Kenya Medical Research Institute (KEMRI), safely tested oral and/or fecal samples from all 327 community participants. A total of 1,845 individual tests were conducted, and all were negative for priority viral families (Coronaviridae, Filoviridae, Orthomyxoviridae, and Paramyxoviridae) using consensus PCR, a broadly-reactive molecular methodology that is capable of detecting both known and unknown viruses within samples. This finding suggests that at the time of sampling, no one had an active infection, but the protocol does not assess previous exposure to viruses.

To address this issue, the team collected serum samples from 100 participants at two townships (Pastoralist 1 and Commerical Ranching/Wildlife Conservancy). Serum contains antibodies that are produced by the immune system when a person is exposed to virus in response to a previous infection. By looking for the presence of antibodies, serological methods provide an indication of past exposure to viruses. The PREDICT team used a new technology to test samples for eight viruses of concern. Among the 100 participants, people were reactive to Crimean-Congo Hemorrhagic Fever Virus, Rift Valley Fever Virus, Alphaviruses, and Flaviviruses. These serology results are considered preliminary and samples will need further

confirmation. However, these results are consistent with other studies that found high seroprevalence of flaviviruses among certain Kenyan communities. The following factors may help explain these results: the Commercial Ranching/Wildlife Conservancy community is close to rivers and a dam, providing favorable breeding habitat for mosquitoes that harbor the vector-borne viruses; wildlife have been suggested as hosts of flaviviruses, such as Yellow Fever and Dengue viruses, and previous studies have shown that conservancy areas in Laikipia have significantly higher population densities of wildlife when compared to pastoralist areas, thus facilitating close contact and a potential transmission interface.



WILDLIFE SURVEILLANCE

Between July 2016 and May 2018, the PREDICT team safely and humanely collected samples from 911 individual animals at high-risk interfaces in Laikipia and Turkana Counties (Table 2); 257 non-human primates, 252 rodents, 302 bats and 100 camels. The PREDICT laboratory at the Institute of Primate Research tested 1,651 fecal and oral swabs for priority viral families (Coronaviridae, Filoviridae, Orthomyxoviridae, and Paramyxoviridae) using consensus PCR, which tests for active virus infection at the time of capture and sampling.

VIRUS FINDINGS IN WILDLIFE

Two viruses were found in eight Angolan free-tailed bats (*Mops condylurus*) in Naibor. The known virus Chaerephon bat alphacoronavirus/Kenya/KY22/2006 (Genbank Accession no. HQ728486) was detected in the oral swabs from three female bats. A novel alphacoronavirus named PREDICT_CoV-90 was detected in the oral swabs from three female bats and in fecal swabs from two male bats. There is no evidence at this time to suggest either virus poses a

threat to human health. All other samples from bats, rodents, shrews, non-human primates and camels were negative for priority viral families (Coronaviridae, Filoviridae, Orthomyxoviridae, and Paramyxoviridae).

VIRUS TABLE

VIRAL FAMILY	VIRUS	SPECIES	SAMPLING LOCATION	TOTAL POSITIVE INDIVIDUALS
Coronavirus	PREDICT_CoV-90	Angolan Free-Tailed Bat	Naibor	5
	Chaerephon bat coronavirus/ Kenya/KY22/2006	Angolan Free-Tailed Bat	Naibor	3
Total				8

EPIDEMIOLOGICAL & BEHAVIORAL RISK

COMMUNITY ENGAGEMENT & RISK COMMUNICATION

The PREDICT project has been committed to community engagement - working with local villages and partners to raise awareness of zoonotic disease threats and strengthening capacity for prevention, surveillance, and detection. Sensitization meetings were held at all project sites over the life of the project. At these meetings, our team worked with local communities to create a dialogue and build trust for implementation of surveillance activities and a platform to communicate One Health approaches.

Implementation of outreach and engagement activities provided a forum in Kenya to empower community members to make the most informed decisions regarding their own health security on an individual level and from a community perspective. Participants included County veterinary and public health officials, One Health Workforce students, community leaders and community health and animal health workers. The PREDICT team conducted workshops to introduce the One Health approach and discuss potential sources

of zoonotic diseases, behavioral risk factors, and the strategies for disease prevention, detection, and response. In addition, our team employed a variety of visual education tools to invite discussion on specific recommended mitigation strategies, while being mindful of potential conflicts between cultural or customary traditions and health safety. Further topics focused on clinical signs that should be monitored by health clinics and encouraged rapid reporting to local health officials.

Through behavioral risk characterization, we were able to identify risk factors and target zoonotic disease risk mitigation at the local community scale. In community meetings, the PREDICT team provided summaries of project findings and shared resources to raise awareness of disease prevention. Our teams communicated the importance of reducing contact with animals and their parts/products through practicing good hygiene, as well as using barrier protection against wildlife in households. Key visual education tools were shared to support specific public health recommendations, including a mobile Outbreak DIY panel exhibition developed in conjunction with Smithsonian's National Museum of Natural History, a documentary film featuring core PREDICT staff, and the

behavior change picture book *Living Safely with Bats* that is designed to minimize risks of infection to bat-borne viruses such as Ebola, Marburg, and MERS Coronavirus. These resources were also used to teach primary school students best hygiene practices and encourage positive and safe associations with nature and wildlife. Targeted early education of children provides a lifelong lesson with positive, cumulative effects on disease prevention for future generations.

OUTBREAK RESPONSE & PREPAREDNESS

During the avian influenza outbreak in neighboring Uganda and the Marburg alert in northwestern Kenya, the PREDICT team participated in preparedness and response discussions in partnership with the Directorate of Veterinary Services and the national Zoonotic Disease Unit (ZDU) / One Health Technical Working Group. By sharing protocols for disease surveillance, detection and response, our team provided support and expertise to help prepare for and prevent these diseases from spreading into/across the country.



ONE HEALTH WORKFORCE CAPACITY STRENGTHENING

In Kenya we strived for sustainable, lasting health impacts through training, education, outreach and capacity-strengthening with in-country partner institutions. The team trained 382 individuals in One Health field and laboratory skills, provided professional development for 165 students, and educated and empowered local communities to make informed decisions that benefit community health. The PREDICT team actively participated in the development of Kenya's One Health National Strategic Plan (2017-2022), in close collaboration with government and academic partners. This activity effectively bridges the gap between advocacy and action related to wildlife and environmental health policy. Table-top simulations were conducted with the Zoonotic Disease Unit, in partnership with FAO and other EPT-2 partners. Participants were trained in transmission dynamics, experienced how to identify potential disease sources, and learned how to collaborate with relevant government authorities in disease response.

In collaboration with key partners,

the Kenya team provided field training for zoonotic disease surveillance and public health education for community health and animal health workers. These workers are subsequently better equipped to identify and address potential sources of zoonotic disease exposure and behavioral risk factors in the community as a result of human-animal contact. Their newfound knowledge will be disseminated amongst the community members and will help identify targets for intervention and risk mitigation.

Overall, our efforts helped build a framework that can be used to develop effective intervention, disease prevention and control strategies at local, regional, and national scales in Kenya. Additionally, we increased Kenya's national laboratory capability to perform viral disease detection by partnering with and training the Institute of Primate Research (IPR) and Kenya Medical Research Institute (KEMRI). In-country expansion and self-sustainability of the workforce was achieved through cross-training when IPR hosted Central Veterinary Lab (CVL) staff for a two-week in-service training using PREDICT testing protocols to detect zoonotic diseases.



PRACTICAL IMPLICATIONS

In Kenya, the PREDICT team developed sustainable and lasting health impacts through One Health training in field and laboratory skills, capacity-strengthening in-country partner institutions, professional development of students, and education and empowerment of local communities in making informed decisions. These activities have benefited national and community health surveillance, preparedness, and response. Our activities bridged the gaps between advocacy and action and connected human, animal, and environmental health sectors. Our work can be applied towards identifying targets for intervention and developing effective disease prevention and control strategies at local, regional, and national scales.

Our key findings included a low level of awareness across at-risk communities that contact with animals can cause disease in people, and that risk mitigation strategies need to be tailored to specific sites for appropriate social and cultural fit. Targeted training of community-identified / community-based health workers provide one of the best opportunities for disseminating public health initiatives to vulnerable people living at high-risk human-animal interfaces.

RECOMMENDATIONS

Rural communities at high risk sites throughout Kenya should be engaged in conversations that reveal underlying beliefs and behaviors influencing disease dynamics. Subsequently, public health interventions should be tailored to address the most prevalent high-risk behaviors. Educational outreach programs in one of the Kenya PREDICT sites, for example, should target food safety and human-animal interactions specifically on the **risks of eating raw meat and sick animals**.

Effective community intervention should also emphasize **training for local health workers**, who were liaisons between the PREDICT project and at-risk communities, and who can increase agency awareness by presenting information in a relevant and culturally sensitive way. Further, **implementing health safety education programs** in primary schools (the predominant level of education at one site) and at free health clinics can also be strategically targeted to reach as many residents as possible.

While high risk behaviors depended on site / land use, all communities would benefit from **enhanced water safety and waste management**. Working with communities to develop realistic and scalable solutions to improve sanitation practices would be a reasonable first step in promoting safe practices.

These outreach strategies can strengthen local response capacities and mitigate high-risk behaviors while being rooted in a One Health approach.

PUBLICATIONS & PRESENTATIONS

- Kamau, J., Ashby, E., Shields, L.M., Ambala, P., Kwallah, A., Vodzak, M., Murray, S., Zimmerman, D. 2020. The intersection of land use and human behavior as factors influencing zoonotic disease risk in Laikipia County, Kenya. Submitted to PLOS NTD. Poster presented at 2019 Annual Meeting of the American Society of Tropical Medicine & Hygiene, 23 November 2019, Fort Washington, MD.
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EcoHealth Alliance



METABIOTA™



Smithsonian Institution