USAID FROM THE AMERICAN PEOPLE

PREDICT
SIERRA LEONE

One Health in action (2016-2020)

Tracing the origins of Ebola

SIERRA LEONE
EBOLA HOST PROJECT

Nestled in the heart of coastal West Africa, Sierra Leone is a shining example of resilience and strength in the face of unprecedented health challenges. With nearly 5.7 million people living in a gradient of dense urban to very rural deep forest environments, Sierra Leone has long been recognized as a zoonotic virus emergence hot spot. During 2013-2016, what was initially thought to be a limited Ebola virus outbreak began along the Sierra Leone-Guinea-Liberia border. However, over the next three years the disease spread through nearly the entire three countries–leaving over 28,000 people infected and more than 11,000 dead.

This was the largest Ebola outbreak in history and further catalyzed efforts to identify the animal source, or reservoir, of Ebola to prevent future outbreaks. To meet this challenge, PREDICT designed and implemented the Ebola Host Project in Sierra Leone, along with neighboring Guinea and Liberia, to find the animal source of this and other devastating filoviruses, and to investigate human behaviors associated with virus spillover. A robust community engagement strategy was also undertaken, engaging over 400 stakeholders from the national, district, chiefdom, and local community levels. Additionally, our team worked closely with government officials in six districts to launch district-level One Health Platforms.

Through the University of Makeni and partners in the Ministries of Health and Sanitation and Agriculture and Forestry, PREDICT strengthened national capabilities for virus surveillance in wildlife, safely and humanely collecting samples from over 9,500 animals, (bats, rodents, livestock, dogs, cats, and non-human primates) across >50 independent locations.

In 2018, as proof of concept for PREDICT's approach, we detected an entirely new species of ebolavirus (*Bombali ebolavirus*) in insect-eating bats; the first time an ebolavirus was discovered before causing human or animal illness or death. A few months later, our team together with colleagues at the U.S. Centers for Disease Control and Prevention (CDC) and Njala University, detected a deadly known virus (Marburg virus) in fruit-eating bats, the first time this virus had been detected in West Africa.

PREDICT's full impact in Sierra Leone will take years to fully appreciate. Through analysis of project data and findings, PREDICT was able to identify risks and educate communities and health professionals on behavior change and intervention strategies designed to protect people and wildlife from disease threats. Our staff continue to promote One Health as a key approach to obtaining health security through their roles as leaders in health, agriculture, and the environment.

LOCAL PARTNERS

- University of Makeni
- Ministry of Health and Sanitation
- Minsitry of Agriculture and Forestry

250

DEVELOPED the One Health Workforce by training 250 people in Sierra Leone.

>9.5K

OPERATIONALIZED One Health surveillance and sampled over 9.5K animals and people, to identify ways to help minimize the spillover of zoonotic disease threats from animals into human populations.

LABORATORY STRENGTHENING

· University of Makeni
· UC Davis One Health Institute

29,160
TESTS

3 PREDICT **5** KNOWN
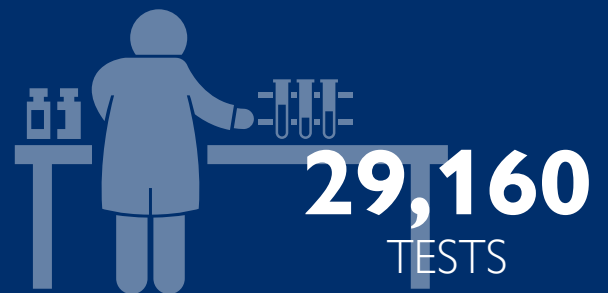
DETECTED 8 unique viruses in bats.

Global Health Security Agenda

MOHAMED TURAY

Field Ecologist
University of Makeni

"It has been a pleasure working with PREDICT. I have learned a lot. I am not actually a scientist – I am an IT person, but I have build my system to love the science. I love my work that I am doing, it is nice and I am learning a lot. It gives me what it takes to reach to communities, offer what I have to offer. I love what I am doing."

FATMATA BAIROH

Field Ecologist
University of Makeni

"I have had an amazing work experience with PREDICT. The project was not all about us collecting animal samples but PREDICT gave back to me by building my capacity in lab and biosafety training. I can now identify the different species of bats through their external feature and their inhabitants. Ultimately with PREDICT, I became a better person when it came to team work."

ACHIEVEMENTS

- Discovered an entirely new species of ebolavirus (*Bombali ebolavirus*) in bats before any known human or animal illnesses or deaths (Goldstein et al., Nature Microbiology October 2018)

- Discovered a known and deadly human pathogen (Marburg virus) in bats for the first time in West Africa, more than 2,400km from any known endemic area (Amman et al., Nature Communications January 2020)

- Supported outbreak response efforts for a pig die-off and coordinated efforts between the Government of Sierra Leone's Central Veterinary Laboratory, USAID, and US Department of Agriculture to facilitate diagnostic testing for samples collected from dead animals. These efforts and confirmatory USDA testing led to the diagnosis of African Swine Fever, the first occurrence of this disease in Sierra Leone, which was swiftly reported to OIE in February 2020.

- Trained >160 district-level government officials in One Health skills and supported the development of six district-level One Health Platforms, a collaboration between Ministry of Health and Sanitation, Ministry of Agriculture and Forestry, and the Environmental Protection Agency to sustain multi-sectoral coordination and bolster national health security

- Catalyzed efforts within the Ministry of Health and Sanitation's Health Education Division leading to the development of formalized risk messaging and communication campaigns for living safely with animals and preventing zoonotic disease transmission

- Served as a functional platform and role model of technical assistance that led to the the establishment of an emerging Zoonotic Disease Surveillance Task Force within the Ministry of Health and Sanitation's Emergency Operations Center, a monumental step towards proactive solutions to emerging pathogens at the national level.

ONE HEALTH SURVEILLANCE

FINDING THE ELUSIVE WILDLIFE HOSTS OF EBOLAVIRUSES AND OTHER VIRAL THREATS

In collaboration with in-country partners, an extensive surveillance program was implemented in Sierra Leone to successfully identify the animal source and reservoir of Ebola virus and other closely related filoviruses (ebolaviruses and marburgviruses). Across >50 locations in six districts, biological specimens were safely and humanely collected from >9,500 animals (bats, rodents, nonhuman primates, livestock, and domesticated animals such as dogs, cats, goats and sheep) before being released.

VIRUS TABLE

VIRAL FAMILY	VIRUS	SPECIES	SAMPLING LOCATION	# OF POSITIVE INDIVIDUALS TOTAL	WET SEASON	DRY SEASON
Filovirus	Bombali virus (BOMV)	Angolan Free-Tailed Bat, Little Free-Tailed Bat	Gbindi, Kamabai, Robuya, Rosanda, Yelisanda	6	5	1
	Marburg virus (MARV)	Egyptian Fruit Bat	Kakoya, Koema, Peidu	5	2	3
Coronavirus	Bat coronavirus HKU9	Egyptian Fruit Bat	Kakoya, Peidu	5	5	0
	Coronavirus 229E (Bat strain)	Noack's Roundleaf Bat	Koema	1	1	0
Paramyxovirus	PREDICT_PMV-180	Angolan Fruit Bat	Koema	1	1	0
	PREDICT_PMV-183	Jones's Roundleaf Bat	Koema	1	1	0
Arenavirus	Lassa mammarenavirus	Natal Multimammate Mouse	Blama Puila, Kamaseh	5	4	1
Total				**24**	**19**	**5**

VIRUS DETECTION

Our team discovered an entirely new species of ebolavirus in Angolan Free-tailed Bats and Little Free-tailed Bats (*Mops condylurus,* n=1; *Chaerephon pumilus*, n=5), insect-eating bats in the Bombali district that were sampled in and around people's homes and the broader community. This discovery in 2018 marked the first time ever that an ebolavirus was found before causing any reported human or animal illnesses or deaths.

This new virus (*Bombali ebolavirus*) is now recognized as the sixth species of ebolavirus. Further characterization of the virus is ongoing to understand the zoonotic potential . Despite this finding and more than 40 years of research, data on the true reservoir host for the virus that caused the West African 2013-2016 outbreak (*Zaire ebolavirus*) remains elusive, though our team did detect *Zaire ebolavirus* in bats sampled in Liberia. The discovery of Bombali virus and detection of *Zaire ebolavirus* contributes to the growing body of evidence that bats are the likely hosts of this deadly group of viruses.

A few months after this discovery, PREDICT and partners with Njala University and the US Centers for Disease Control and Prevention (US CDC) detected the known and highly-lethal Marburg virus in five Egyptian fruit bats (*Rousettus aegyptiacus*) sampled at roosting sites in the Koinadugu, Kono, and Moyamba districts. This finding was significant, as the closest known endemic area for Marburg virus was more than 2,400km east in Gabon. Following the discovery, PREDICT, CDC, and Njala worked closely with the Government of Sierra Leone to risk communication and messaging strategies for the public health sector (laboratories, hospitals, and emergency response teams) and the general population to raise awareness of this new health threat.

Samples from over 300 domestic animals (cats and dogs) were tested using consensus PCR (cPCR) to screen for filoviruses, no viruses were detected.Samples collected from wildlife were also tested using cPCR to screen for filoviruses, with a subset of samples screened for arenaviruses, coronaviruses, and paramyxoviruses. Virus findings were confirmed through genome sequencing and interpreted to better understand the relationship of the detected sequence to those from known animal and human pathogens. A total of seven viruses, 4 historically known and 3 PREDICT -discovered viruses, were detected in 24 animals.

FINDINGS IN BATS

The bat coronavirus HKU9 was found in five Egyptian Fruit Bats (*Rousettus aegyptiacus*). There is to date, also no evidence to suggest that this virus poses a threat to human health.

This virus is not related to the novel coronavirus strain (HCoV-19SARS-CoV2) causing Coronavirus Disease (COVID-19) and leading to thea public health emergency of international concern. Additionally, coronavirus 229E, known to cause respiratory illness in people, was found in one Noack's Roundleaf Bat (*Hipposideros ruber*). This particular strain virus infects bats but does not cause respiratory illness in people and is not considered a public health threat.

Additionally, two new unique paramyxoviruses were detected, one in a Jones's Roundleaf Bat (*Hipposideros jonesi*) and one in an Angolan Fruit Bat (*Lissonycteris angolensis*). There is no evidence that PREDICT_PMV-183 poses a threat to human health. Genetically, PREDICT_PMV-180 is related to henipaviruses, several of which are known to cause disease in animals and people (e.g., Nipah virus, Hendra virus) and genome sequencing is ongoing to further characterize this virus and the zoonotic risks it may pose, if any.

FINDINGS IN RODENTS

Lassa mammarenavirus was found in five Natal Multimammate Mice (*Mastomys natalensis*). This strain is known to cause Lassa hemorrhagic fever in humans. Testing for this virus was performed as part of the separately funded PREEMPT project, which is strengthening capacity for surveillance and detection of Lassa virus in Sierra Leone and working with an international team to develop Lassa virus risk models, prevention strategies and potential countermeasures to combat this public health threat.

IDENTIFYING BEHAVIORAL RISKS FOR VIRUS SPILLOVER & SPREAD

HUMAN-ANIMAL CONTACT QUESTIONNAIRE

Our team conducted interviews to learn more about human behaviors that may be associated with zoonotic disease transmission or virus spillover. A standardized questionnaire was used in interviews with 588 individuals (304 females and 284 males) at 20 sites (19 rural and one urban) across five districts, sites that our team also targeted for animal surveillance activities. A total of 82% of respondents in these communities reported raising animals with 77% reporting sharing water sources with animals for washing. The majority (64%) reported observing animal feces in or near food supplies, and 69% reported eating food after it was touched or damaged by animals. Twenty six percent (26%) reported being scratched or bitten by an animal in the past year and 23% reported trapping or hunting animals. These findings are particularly concerning as several of these communities are in areas known as hotspots for zoonotic diseases such as Lassa fever, a deadly virus transmitted to people by mice rodents in and around people's homes and food supplies, and where concentrated efforts have been focused for years on awareness, risk eduction, and behavior change.

> Sometimes we find their droppings in our water, we throw the water away and other times we use the water to bathe, etc.

> They do fry them and sell them, sometimes they can cook them in the form of a soup, while sometimes it's being prepared as the way they prepare chicken and put it in the tray for sale. But what I normally see is the fried bats being sold.

IN-DEPTH BEHAVIORAL RISK INTERVIEWS

Additionally, our team conducted six focus group discussions and 94 in-depth ethnographic interviews in four communities within the districts of Bombali, Koinadugu, and the Western Area to explore risky human behaviors and people's interactions with wildlife. This formative ethnographic research led our team to identify communities at high-risk for contact with bats in the Bombali district, where we then focused investigations on two sites. In Bombali we conducted focus group discussions and in-depth interviews with 28 individuals with direct or indirect contact with bats, including bat hunters. It was clear that the interviewees were not aware of the potential health risks posed from human-bat contact. Interviewees shared that insectivorous bats were seen as pests, were commonly found roosting in roofs of homes, and their excreta (urine and feces) were contaminating food and water supplies.

Through interviews with the fruit bat hunters, we learned of more high-risk exposure to bats. While individuals were aware that bats were implicated in the Ebola epidemic, they did not have an adequate understanding of how zoonotic diseases are transmitted or of the health risks that bats pose. Members of both communities heard public health messages concerning bats and wildlife during the Ebola epidemic, but they seemed unsure of the messages' veracity or relevance. The infrequency of zoonotic spillover events presents a particular challenge for health communication around Ebola and wildlife. Furthermore, the knowledge-focused health interventions implemented during the Ebola outbreak seem to have fallen short of motivating long-term behavior change, as virtually all of the hunters had resumed bat hunting by the resolution of the outbreak.

COMMUNITY OUTREACH RISK COMMUNICATION

Following the discovery of the Bombali virus in bats, PREDICT worked closely with USAID, the Ministry of Health and Sanitation, and Ministry of Agriculture and Forestry to swiftly develop a communications plan and a behavior change intervention resource to help raise awareness among community members about ways to reduce disease risks associated with human-to-bat contact. To identify the most culturally appropriate, feasible, and effective intervention resource format, our team developed a framework for assessing potential materials, channels of communications, respective audiences, and core messaging. A moderated picture book format, delivered by a trusted community leader, was selected as the best tool to put into the hands of our local team and in-country stakeholders. A communications plan was developed with ministry partners to ensure a well-coordinated effort and timely discussions with community stakeholders, following the release of the new ebolavirus finding.

This new resource, Living Safely with Bats, leveraged the subject matter expertise of PREDICT's interdisciplinary One Health team who contributed technical content. All illustrations were developed by a team member trained in animal biology and

Living Safely with Bats

visual arts to ensure accurate, consistent, and compelling visual representations throughout the book. Our Sierra Leone team took this resource into communities where the viruses were detected and met directly with each community and their respective district level government and chiefdom officials. This behavioral risk

communication campaign utilizing Living Safely with Bats reached an estimated 1,000 individuals in 90% of communities engaged during the project. During the campaign, our team emphasized that while bats may harbor potentially infectious pathogens, they also play a very important role in the ecosystem by pollinating crops and reducing insects that can spread other diseases, such as mosquitoes. To reduce the risk of human exposure to potential pathogens, it was stressed that people should avoid direct contact with bats, their droppings or fluids, and food materials that have been fed upon by bats and other wildlife. In addition, our team shared messages for reducing risks of contact between bats and domestic animals and livestock, especially through indirect contact with bat excreta in animal feed, animal pens, and under orchards where animals graze and forage.

STRENGTHENING CAPACITY

PREDICT worked diligently to increase capacity for surveillance in animals and to strengthen testing capacity for filovirus detection in the country. Moreover, PREDICT recognized the importance of broader regional capacity with other nearby West Africa countries. In October 2017, PREDICT hosted a 10-day multi-national continuing education training, reaching more than 20 multi-disciplinary PREDICT staff from Senegal and Guinea at the University of Makeni. Participants were trained on safe and humane animal capture techniques, biological specimen collection and sampling, and safe transport of biological specimens from remote locations to virus detection laboratories with appropriate cold-chain.

PREDICT also provided comprehensive training for district-level wildlife, medical, and government officers on community engagement, risk communication, and wildlife and livestock sampling across all 16 districts in Sierra Leone.

The training of One Health individuals that began with PREDICT has directly befitted the government and citizens of Sierra Leone in combating SARS-CoV-2, the virus causing the COVID-19 pandemic. Currently, PREDICT-trained officers are working within four districts to support the tracking of COVID-19 cases in-country. These individuals have been instrumental in providing technical support to the WHO-Sierra Leone Surveillance Pillars at both the national and district levels, and in contact tracing and case investigation of COVID-19 positive individuals to mitigate viral spread.

PRACTICAL IMPLICATIONS

Further testing of newly discovered filoviruses, like Bombali virus, will greatly enhance our collective understanding of 'pre-emergent' viral diversity and the associated risks to human health. There remains much to understand about the specific factors leading to spill-over of these types of viruses and the threat they may pose if people become infected. Working with partner institutions in the US government and other universities, PREDICT is working to determine the potential mechanisms used by Bombali virus could use to avoid immune responses leading to spread and possibly disease in bats and people. Understanding these "pathways of pathogenesis" are critical to develop effective countermeasures like vaccines or anti-viral drugs to augment our preparedness in the face of potential future outbreaks. PREDICT proved that by putting extensive cross-sectoral and transdisciplinary One Health collaboration into practice at national, district, and community levels, Sierra Leone is now better positioned to improve national and global health security through zoonotic viral surveillance.

Communication about risks was an essential component of PREDICT´s approach to zoonotic disease surveillance, and it is encouraged that these efforts remain a central element for future vigilance efforts in Sierra Leone.

The *Living Safely with Bats* risk messaging book was highly valuable for community interventions to reduce and prevent exposures to potential pandemic viruses. Moreover, USAID's Breakthrough Action project and the Sierra Leone Ministry of Health and Sanitation Health Education Division collaborated to adapt and broaden the message of the bat book by developing a *Living Safely with Animals*, risk messaging book. Similarly, the Ministry of Health and Sanitation developed and refined a communication campaign related to animal bites and living safely with animals. Initiatives focused on risk messaging will continue to strengthen prevention and preparedness for zoonotic diseases throughout the country.

The power of the PREDICT approach to disease surveillance and preparedness was recognized by the government of Sierra Leone and stimulated tThe creation of a Zoonotic Disease Surveillance Task Force within the Ministry of Health and Sanitation's Emergency Operations Center. This was a monumental step towards proactive solutions to emerging pathogens in the country. With more attention, resources, and effort placed into One Health surveillance, the country and by extension the West Africa region will be further ahead of any potential zoonotic disease outbreaks.

REFERENCES

• Goldstein, T., Anthony, S. J., Gbakima, A., et al. (2018). The discovery of Bombali virus adds further support for bats as hosts of ebolaviruses. Nature Microbiology, 3(10), 1084-1089. https://doi.org/10.1038/s41564-018-0227-2

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For more information
view the interactive report at
p2.predict.global

FILOVIRUS SURVEILLANCE IN SIERRA LEONE

Following the epidemic, PREDICT launched the Ebola Host Project (EHP) to conduct Ebola virus surveillance in livestock and wildlife in the three West African countries most affected by the outbreak. In 2018, EHP found a novel species of ebolavirus (*Bombali ebolavirus*) in Bombali, Sierra Leone in two species of insect-eating bats that were roosting in people's homes.

Learn more at **https://bit.ly/2SURLaC**

INSIGHTS ON THE GEOGRAPHIC DISTRIBUTION OF MOLOSSID BATS IN WEST AFRICA

In direct response to the detection of Bombali virus in Molossid bats and in recognition of the limited data available regarding bat distribution in the region, the Government of Guinea requested assistance identifying areas in the country and greater West Africa region at highest risk for virus spillover from bats.

Learn more at **https://bit.ly/3fH56Nw**

VIRUS X HUNTERS: OPERATIONALIZING ONE HEALTH IN EMERGENCY RESPONSE & SURVEILLANCE

In Sierra Leone, the Ebola Host Project (EHP), which is part of the larger PREDICT project, was implemented to identify the animals that may act as reservoirs or transmission hosts for Ebola and other filoviruses, to further understand the spread of the virus and recommend prevention measures as well as strengthen in-country capacity to prevent, detect and respond to emerging threats.

Learn more at **https://bit.ly/3bpb0zw**

SPECIAL FEATURES