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# PREDICT
# DEMOCRATIC REPUBLIC
## of the CONGO

One Health in action (2009-2020)

*Improving One Health surveillance capabilities to detect (re)emerging disease threats in the heart of the Congo Basin*

# DEMOCRATIC REPUBLIC of the CONGO

Goma ★
★ Kinshasa

## WESTERN DR CONGO:

Throughout the central African region, demand for wild animal meat (also known as 'bushmeat') is constant, with as much as one million metric tons of bushmeat eaten each year in the Congo Basin. The Democratic Republic of the Congo (DRC) is home to endangered wildlife, including forest elephants, chimpanzees, bonobos, and lowland and mountain gorillas who inhabit the lush forests. Unfortunately, the biggest threat and leading cause of wildlife loss in the Congo Basin is the commercial bushmeat trade, driven by an ever-increasing market. As was heard during interviews with vendors by PREDICT project staff, many wealthy city dwellers indicate a preference for wild meat and will pay a premium for it, even when their protein requirement can be met with cheaper sources (Foerster et al., 2012; Schenck et al., 2006). Serving bushmeat from protected species is a status symbol in urban populations and harkens back to the nostalgia of hunting traditions in the village. Vigorous trading of wild meat to satisfy urban demand is widespread in all major Central African cities (Hennessey & Rogers, 2008; Mbete 2011), including in the great metropolis of Kinshasa, DRC's capital city of nearly 12 million people.

For these reasons, our team adopted a specific focus on the bushmeat trade and movement of wild animal meat along the animal value chain from nearby hunting and trapping communities in Kongo Centrale, which serves as a source of wild animal meat feeding into the bushmeat markets in Kinshasa. In addition to targeting markets in the capital city, we conducted syndromic disease surveillance in two large hospitals in Kinshasa, which are proximate to key bushmeat markets, and where market workers go for affordable medical care when they are ill.

We initiated enhanced, coordinated surveillance capacity between members of the Ministry of Health, the Ministry of Fisheries and Livestock, and the Ministry of Environment to explore the high-risk disease transmission interfaces. Since 2009, the PREDICT project in Western DRC was implemented by the Institut National Recherche Biomédicale (INRB), DRC's premier reference lab, in close partnership with the Kinshasa School of Public Health, private partners, public hospitals, and local communities.

## EASTERN DR CONGO:

From 2014-2019, the PREDICT project has focused zoonotic virus surveillance in wildlife and people in the North and South Kivu Provinces because the region presents complex challenges at the human-wildlife interface. Virunga National Park (PNVi) in North Kivu is a large and highly biodiverse protected area with abundant wildlife resources, but is a place where militia and rebel groups routinely set up camps inside the park, hunters and harvesters illegally enter the park to set snares and make charcoal, and community members utilize bat roosting caves inside and adjacent to the park as water sources. PNVi is also visited by international tourists who come to trek human-habituated mountain gorillas. Generally speaking, the area sees a tremendous flux of people crossing DRC's borders with Uganda and Rwanda. PREDICT worked inside the Mikeno sector of PNVi and in the adjacent communities, capturing and sampling primates and bats. As well, PREDICT enrolled consenting febrile patients (including park workers) presenting to health clinics in surveillance activities, collecting biological samples and administering questionnaires to better understand the extent to which patients were in contact with wildlife. PREDICT also worked in and around Kahuzi-Biega National Park in South Kivu Province, where militia and rebel groups are engaged in illegal activities inside the park (such as mining and bushmeat hunting), where subsistence agriculture occupies the corridor between the park's highlands and lowlands, and where a national road transecting the park brings heavy traffic of people and livestock into the park in vehicles and by foot from Tanzania, Uganda, Burundi and Rwanda. Adjacent to PNKB is the Centre por Primate Rehabilitation de Lwiro, which receives and cares for confiscated and rescued wildlife, mainly great apes and other primates.

In North and South Kivu, the PREDICT team collected samples from 141 non-human primates, 289 bats, 12 rodents and 416 febrile human patients. Molecular methods (PCR) were used at the Institut National de Recherche Biomédicale (INRB) in Kinshasa and at the University of California Davis One Health Laboratory to screen samples for evidence of infection with or exposure to potentially zoonotic pathogens of pandemic potential.

# DEMOCRATIC REPUBLIC of the CONGO

## LABORATORY STRENGTHENING

· Institut National de Recherche Biomédicale

**52,958**
TESTS

**22** PREDICT   **29** KNOWN
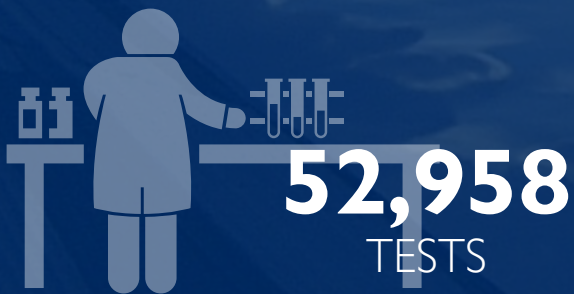
**DETECTED** 51 unique viruses in both animal and human populations.

Global Health Security Agenda

**>100**

**DEVELOPED** the One Health Workforce by training more than 100 people in DR Congo.

**>5.8K**

**OPERATIONALIZED** One Health surveillance and sampled over 5.8K animals and people, helping minimize the spillover of zoonotic disease threats from animals into human populations.

## LOCAL PARTNERS

- Centers for Disease Control
- Central Veterinary Laboratory of Kinshasa
- Food and Agriculture Organization
- Institut Congolais pour la Conservation de la Nature (ICCN)
- Institut National de Recherche Biomédicale (INRB)
- Kinshasa School of Public Health (KSPH)
- Lola Ya Bonobo Sanctuary, Kinshasa
- Metabiota, Inc.
- Ministry of Environment
- Ministry of Fisheries and Livestock, Direction de la Production et Santé Animale (DPSA)
- Ministry of Health
- Mountain Gorilla Veterinary Project (MGVP)
- WHO DRC Disease Surveillance team
- World Organisation for Animal Health, DRC

## CHARLES KUMAKAMBA

Country Coordinator
*Metabiota*

*"The PREDICT Project has enabled young scientists like myself to improve our knowledge of microbiology and sample collection through its protocols. With PREDICT, I gained much experience and grew scientifically."*



## MARIA MAKUWA

Laboratory Advisor &
Administrative Coordinator
*Metabiota*

*"I have benefited from learning new methods of detection and characterization of viral pathogens as part of the PREDICT Project. My training as a researcher in the laboratory has been enriched by field work and exchanges with the local populations—activities hitherto unknown to me. This program also allowed me to share my knowledge with my young colleagues and learn from their experience."*

# ACHIEVEMENTS

- Detected bocavirus DNA resembling human bocaviruses in 6 wild non-human primates, which indicates viral sharing; uncovered evidence of more than a dozen different bat coronaviruses, which are of high interest in light of past outbreaks of SARS and MERS; amplified 20 different herpes viruses from over 100 primates and rodents, shedding more light onto the diversity of this viral family; and identified 3 novel species of rodent adenovirus DNA, highlighting how little we know about the hosts of this virus family.

- Confirmed the presence of *Zaire ebolavirus* RNA from a human, as part of an outbreak response where the PREDICT team assisted the government of DRC in identifying the causative agent of an unknown hemorrhagic fever and yielding the first sequence of this outbreak's strain, contributing to the rapid containment of the epidemic.

- Organized an International One Health Day zoonotic disease awareness campaign at the La Liberté and Ndolo markets where bushmeat is sold, and held discussions with market vendors, managers, and patrons about the possibility of disease transfer between wild animals and humans while distributing information on how to keep safe from infection.

- Helped establish functional communications and collaboration between animal and human health organizations enabling ministries to better communicate research findings, organization goals, and challenges, thus demonstrating how the One Health framework can provide value to national health security.

- Conducted 179 semi-structured qualitative interviews and 12 focus groups with vendors, butchers, and other actors in the animal value chain and identified risky behaviors, interfaces, and key areas to inform continued and targeted surveillance, as well as risk reduction recommendations for improved health security.

# ONE HEALTH SURVEILLANCE



The PREDICT project's One Health surveillance approach was designed to strengthen capacity for detection of emerging viral threats and to improve our understanding of risk of zoonotic diseases in communities with close and frequent animal contact. Our team sampled wildlife, including both live animals and dead animals being sold for food (also known as "bushmeat"), and people concurrently, targeting high-risk populations for virus spillover, amplification, and spread in rural and highly urbanized settings in DRC. We also conducted syndromic surveillance of patients presenting to local hospitals serving the communities. Data collection and sampling was performed longitudinally over a three-year period during both the rainy and dry seasons, and identification of bat and rodent species was confirmed using DNA barcoding, a molecular-based laboratory assay.

The PREDICT team collected animal samples from nine bushmeat markets around Kinshasa. Through hospital based syndromic surveillance, the PREDICT/Western DRC team enrolled 418 sick individuals at St. Joseph and Kingasani hospitals in Kinshasa targeting individuals with acute febrile illness with the intention of detecting zoonotic viruses among occupationally exposed humans. The team further explored the high-risk human-animal interface of bushmeat markets by conducting qualitative research with bushmeat vendors, butchers, transporters, and middlemen, to explore practices and behaviors with the potential to facilitate spillover and spread of zoonotic viruses.

## SURVEILLANCE SITES

### KINSHASA

bats; humans; non-human primates; rodents/shrews

### BUTA

bats; non-human primates; rodents/shrews

*The PREDICT team also worked with local communities to increase awareness on One Health and the benefits of the approach for living healthier lives. For example, in November 2018 the team organized an International One Health Day awareness campaign at the La Liberté and Ndolo markets in Kinshasa, where bushmeat is sold. The team had discussions with market vendors, managers, and patrons about the possibility of pathogen transmission between wild animals and humans and handed out outreach materials with suggestions on how to keep themselves safe around live animals and bushmeat.*

*Through coordinated animal and human surveillance, the PREDICT/ Western DRC team succeeded in improving coordination between animal and human health government sectors, national NGOs, and international organizations through regular consultation and data sharing, thus allowing for early awareness of public health alerts and animal die-offs. By bringing members of the Ministry of Health, the Ministry of Fisheries and Livestock, and the Ministry of Environment together to reach a common goal, the PREDICT project has demonstrated how the One Health framework can provide valuable benefits to all partners.*

## KINSHASA

Numbers of individuals sampled by taxa
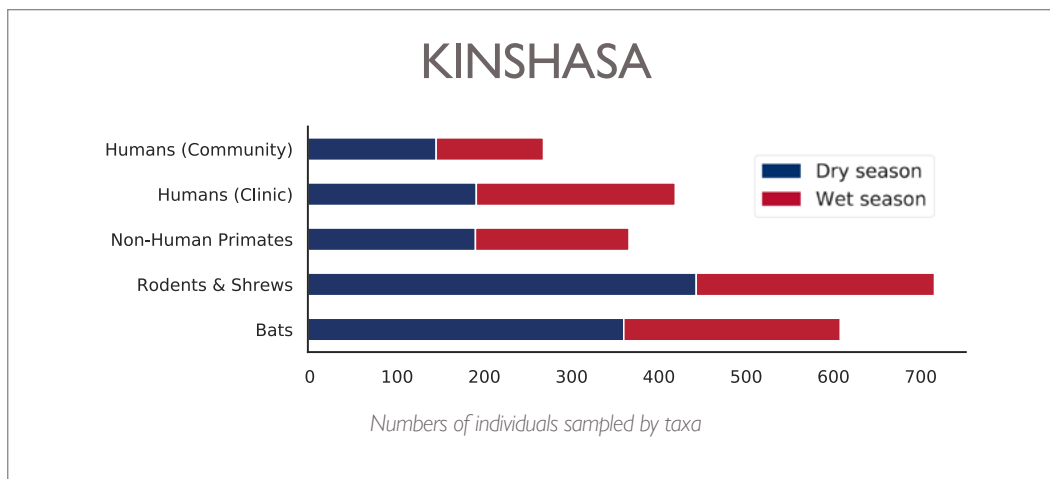
# VIRUS DETECTION

The PREDICT program was designed to not only detect those viruses which are known to cause human disease, but also unknown viruses. This was done through the use of consensus PCR, a technique that uses specially-designed, broadly-reactive primers capable of amplifying genetic material of both known and novel viruses. During the first phase of the PREDICT project (PREDICT-1; 2009-2014), 25 different assays capable of detecting a diverse array of viral families were included in surveillance activities. In PREDICT-2 (2015-2020), however, the number of viral families investigated was reduced, in order to significantly increase the focus on those which are known to harbour the most dangerous human pathogens with pandemic potential, namely: coronaviruses, filoviruses, paramyxoviruses, flaviviruses, and influenza viruses.

Throughout the 10 years of PREDICT project work in DRC, several viruses were detected. Some of the highlights include the detection of bocavirus DNA resembling human bocaviruses in several wild non-human primates, suggesting cross-species transmission (Kumakamba et al. 2018); uncovering several different bat coronaviruses, which are of high interest in light of past outbreaks of SARS, MERS, and the novel 2019 coronavirus, SARS-CoV-2, originating from Wuhan, China; and the detection of many herpesviruses from over 100 primates and rodents, which is shedding more

light onto the diversity of this viral family. PREDICT project testing also confirmed the presence of *Zaire ebolavirus* RNA from a human, which was part of an outbreak investigation in which the PREDICT project assisted the government of DRC in identifying the causative agent of an unknown hemorrhagic fever. This work yielded the first sequence of this outbreak's strain and helped contribute to the rapid containment of the epidemic. Importantly, it was also the first instance of a domestically confirmed case of Ebola Virus Disease in DRC.

In PREDICT-2, the DRC team identified four unique coronaviruses in 21 individual bats belonging to both fruit-eating and insect-eating bat families. These coronaviruses are known viruses and are not believed to pose a threat to human health. We also detected one novel paramyxovirus, PREDICT_PMV-15, in three individual free-tailed bats (*Mops condylurus*) from Kinsasha. In addition to wildlife virus findings, we also detected Influenza B in a 4 year old child who presented to the hospital in Kinsasha with acute febrile illness.

# VIRUS TABLE

| VIRAL FAMILY | VIRUS | SPECIES | SAMPLING LOCATION | # OF POSITIVE INDIVIDUALS |
|---|---|---|---|---|
| Filovirus | Ebola Virus (EBOV) | Human | Bikoro | 1 |
| Coronavirus | Bat coronavirus Hipposideros | Noack's Roundleaf Bat | Buta | 1 |
| | Chaerephon bat coronavirus/Kenya/KY22/2006 | Angolan Free-Tailed Bat, Unidentified Chaerephon Bat | Kinshasa | 9 |
| | Eidolon bat coronavirus | Straw-Coloured Fruit Bat | Kinshasa | 8 |
| | Kenya bat coronavirus/BtKY56/BtKY55 | Peter's Dwarf Epauletted Fruit Bat, Unidentified Myonycteris Fruit Bat | Kinshasa | 3 |
| Paramyxovirus | PREDICT_PMV-15 | Angolan Free-Tailed Bat | Kinshasa | 3 |
| Influenza virus | Influenza B | Human | Kingasani Hospital (Kinshasa) | 1 |
| **Total** | | | | **26** |

# EPIDEMIOLOGIC & BEHAVIORAL RISK

## HOSPITAL-BASED SURVEILLANCE & COMMUNITY WORK

Based on the questionnaires administered to hospital patients and individuals involved in the animal value chain, 52% of respondents reported consuming raw or undercooked meat, and 26% reported having slaughtered an animal in the past year. Nearly 75% of participants said they are worried about diseases in live animals in their local markets. However, participants showed a lack of understanding about the risks associated with slaughtering or butchering animals when they have an open wound, with over half responding "I don't know" when asked if there is any risk involved. The majority of individuals reported attending a hospital or clinic when ill, while 7% reported visiting a traditional healer.

Of the people enrolled from both hospital and community settings, 39% had reported a fever within the last year, and 22% reported a fever which was also associated with headache and weakness. Fever accompanied by acute diarrhea was reported by 9% of participants, while 1% of people were admitted to hospital due to unexplained bleeding.

In DRC, biological samples and questionnaires were requested from eligible febrile patients in St. Joseph and Kingasani hospitals, but biological samples were not taken from community members in bushmeat markets and community settings.

PARTICIPANT CHARACTERISTICS ACROSS HOSPITAL & SURVEILLANCE SITES

| | COMMUNITY-BASED SURVEILLANCE | CLINIC-BASED SURVEILLANCE | |
|---|---|---|---|
| SITES | KINSHASA MARKETS, BUTA, & OTHER INDEPENDENT SITES (n = 27) | ST. JOSEPH (n = 207)[#] | KINGASANI (n = 212) |
| GENDER | | | |
| FEMALE | 7 (26%) | 114 (55%) | 66 (31%) |
| MALE | 20 (74%) | 93 (45%) | 146 (69%) |
| AGE (YEARS)* | | | |
| <18 | - (-) | 47 (2 - 17) | 58 (2-16) |
| >18 | 27 (24 - 68) | 159 (18 - 86) | 154 (18 -85) |

*Mean (range)
#No age data for one participant

## IN-DEPTH ETHNOGRAPHIC INTERVIEWS & FOCUS GROUPS

A major focus of PREDICT's behavioral surveillance in DRC was exploring the animal-human interface in the bushmeat markets in Kinshasa, elucidating important behavioral risk and zoonotic disease exposure dynamics. Throughout PREDICT-2, the DRC team conducted 179 semi-structured qualitative interviews and 12 focus groups with vendors, butchers, and other actors in the animal value chain. Interviews took place in Kinshasa bushmeat markets, in nearby hunting villages in Kongo-Central, in Mbandaka where much of the hunted non-human primates are sourced that feed into the Kinshasa markets, and in Buta, Bas-Uele province in northern DRC.

Vendors and others who work in the bushmeat trade were interviewed about behavioral risk, wild animal contact, and disease exposure. Most participants expressed a general lack of knowledge of disease transmission, particularly about the role of animals in the transmission of illness. Most vendors reported that wild animals cannot carry disease and therefore could not transmit diseases to humans. Bushmeat is perceived to be "natural" since it is not raised by humans. Some said they had heard Ebola was spread by animals but others attribute Ebola to witchcraft. Multiple bushmeat vendors stated, "This story of Ebola is false. There was a trapper whose animal was stolen and people ate it, and to get revenge he made a fetish and he killed all those who had eaten his meat....[clients] continued to eat bushmeat because they knew that it wasn't Ebola but rather a history of bushmeat and witchcraft."

## KEY INSIGHTS

From our behavioral research, the following risk characterization insights were gleaned regarding bushmeat practices:

- Nearly all bushmeat butchers avoid cleaning their cutting/butchering utensils or the work surfaces with soap. Almost unanimously, they said that rinsing with water is sufficient, and a significant number said they do not rinse tools at all, since the taste of the bushmeat might be affected by the soap and water.

- Participants do believe cleaning the market work area is important, but practices vary widely. Market cleaning and rubbish disposal seem generally well-organized. Better access to soap and clean water, combined with educational messages, could have positive uptake.

- Many butchers and bushmeat vendors wear clothes for market work that are kept separate from home clothes. This use of dedicated clothing could be reinforced as a self-protective measure and serve as a means to discuss other PPE use. PPE such as gloves, masks, or proper footwear, were rarely used by bushmeat vendors or butchers.

- Few participants were aware of disease risks from slaughtering/butchering with an open wound, and most market workers simply rinse wounds with water and continue working. Education around this exposure risk is warranted. Proper wound care and treatment components should be taught to reduce exposure risk during butchering.

- Bushmeat is usually frozen overnight, but then left out to thaw in the daytime. With inconsistent and unreliable electricity in the market, and the fact that bushmeat often takes several days to sell, there is a public health risk related to the inadequate preservation of meat.



## OUTREACH & RISK COMMUNICATION

Given the zoonotic disease risk associated with bat contact that was identified through the PREDICT project's global surveillance activities, we conducted community outreach campaigns in Kongo Centrale, focusing on villages where bats are a regular food staple and meat source, serving both as sustenance and income generation. The purpose of the visit to communities was to increase awareness and promote risk reduction strategies. Our team held a risk reduction campaign using materials developed by the PREDICT project, including PREDICT's behavior change communication and risk reduction resource *Living Safely with Bats.* Community members, both adults and children, participated in this event to learn about bats, their important contributions to ecosystem services, and strategies for reducing risk of exposure to bat-borne zoonoses, while ensuring conservation of the bats. The outreach focused most intensively on considerations for alternative protein and income sources, as people are very reliant on bats in these communities.

# CAPACITY STRENGTHENING

For DRC nationals, one of the highlights of the PREDICT program was the laboratory trainings provided to broad groups of trainees including government staff, medical and veterinary students, and other health specialists, which significantly increased their lab skills. Not only did dozens of people learn the steps involved in preparing samples for testing, performing the testing, and interpreting results, they also learned about the proper management of a highly functional laboratory, which includes keeping inventory, sample workflow to avoid contamination, and preparing for maintaining sample integrity in the event of power outages. The guidance and mentorship provided by the PREDICT project in DRC has expanded the molecular diagnostic platform at the Institut National Recherche Biomédicale (INRB) to include screening for important known and new viral zoonoses enabled the expansion of available services and has provided the capability to allow for the identification Ebola virus by amplifying viral RNA, as was done at INRB in partnership with PREDICT, in both 2014 and 2017.

# OUTBREAK RESPONSE & PREPAREDNESS

In the 10 years that the PREDICT project has been operating in DRC, there have been many opportunities for the team to assist with and contribute to outbreak investigation and response. During this time, the team assisted the DRC government with investigations of suspected zoonotic disease cases and outbreaks, including Ebola virus, Yellow Fever, an unknown viral hemorrhagic fever which was caused by the newly identified Bas Congo virus, and unknown bonobo illnesses. The PREDICT project has been able to aid in the response to outbreaks by providing diagnostic testing, technical capacity, and field equipment. For example, the PREDICT project supplied PPE, PCR equipment, and laboratory supplies for Ebola outbreaks and procured a mobile laboratory for the surveillance of Yellow Fever as the result of a large outbreak. That mobile laboratory has since been repurposed for use during Ebola outbreak response. More broadly, the PREDICT team has been actively training government, animal, and human health staff to identify, manage, and to control outbreaks, leaving the country more prepared than ever to respond to emerging disease threats.

# LOCAL PARTNERS

- Central Veterinary Laboratory, Kinshasa
- Centre de Rehabilitation des Primates de Lwiro, South Kivu Province
- Gorilla Rehabilitation and Conservation Education Center, North Kivu Province
- Institut Congolais pour la Conservation de la Nature (ICCN)
- Institut National de Recherche Biomédicale (INRB), Kinshasa
- Mountain Gorilla Veterinary Project, Inc.
- National Veterinary Laboratory, Goma
- Provincial Agriculture Departments (IPAPEL) of North and South Kivu, Goma and Bukavu
- Provincial Health Departments (IPS) of North and South Kivu, Goma and Bukavu
- Provincial Ministry of Environmental Conservation and Tourism, North Kivu Province
- School of Veterinary Medicine, University of Butembo
- School of Veterinary Medicine, University of Lubumbashi
- Union of Conservation for Gorilla Conservation and Community Development (UGADEC)

## EDDY
### KAMBALE SYALUHA
Country Coordinator
*Gorilla Doctors*

*"In the course of implementing PREDICT in North and South Kivu, we were very often asked by park personnel, health clinic workers, and members of the community what was the purpose of our sampling efforts, as they had never seen anybody doing anything like it. It was heartening to see how people received PREDICT messages about the One Health approach to human health protection. Awareness is now so high that human health clinic staff now alert PREDICT about patients who had been bitten by wild animals."*

## JEAN PAUL
### LUKUSA KABEMBA
Human Surveillance
Coordinator
*Gorilla Doctors*

*"As a medical technologist who has spent many years working with Gorilla Doctors to manage our Employee Health Program, I was extremely happy to help implement the PREDICT project in eastern DR Congo. It helped me better appreciate how closely people come into contact with wildlife in their daily lives, and I am happy to have helped people understand how they can protect themselves from zoonotic disease while also appreciating how important wildlife are in our world."*

# ACHIEVEMENTS

The world's second largest Ebola virus outbreak in history was declared in North Kivu Province in August 2018. The PREDICT project has played an important role in outbreak response and preparedness and has:

• Stockpiled outbreak investigation kits that are ready for deployment, should an outbreak spread to areas in and around Virunga National Park (PNVi).

• Led a workshop for 60 governmental laboratory technicians, district veterinarians, and public health workers on the importance of One Health approaches to disease outbreaks like Ebola virus, and conducted multiple awareness-raising meetings in and around PNVi to inform park personnel and their families about Ebola virus, the outbreak, and how to protect themselves from infection.

• Worked closely with partners to advise Virunga National Park on how best to protect park workers and mountain gorillas from Ebola virus infection, and on best practices should there be a positive Ebola virus case in a person or gorilla.

• Participated in a training session along with government personnel (Ministry of Agriculture Animal Health Laboratory in Goma) and the Central Veterinary Laboratory of Kinshasa in collaboration with Université Pédagogique Nationale (UPN) on JICA protocols on Quick Ebola Virus Disease test.

• Worked with outbreak affected communities to raise awareness of zoonotic disease threats and strategies for risk reduction using the PREDICT project-developed resource *Living Safely with Bats* as an entry point for sharing health education and conservation messages.

# ONE HEALTH SURVEILLANCE

*From 2014-2019, the PREDICT project focused One Health surveillance at the human-wildlife interface in North and South Kivu Provinces. Our teams worked inside the Mikeno sector of Virunga National Park (PNVi) and in the adjacent communities, capturing and sampling primates and bats. In addition, our team enrolled consenting febrile patients (including park workers) presenting to local health clinics in our surveillance effort, collecting biological samples and administering questionnaires to better understand the social and behavioral risks for animal contact and zoonotic disease transmission. We also focused surveillance in and around Kahuzi-Biega National Park in South Kivu Province, home to the Centre por Primate Rehabilitation de Lwiro, which receives and cares for confiscated and rescued wildlife, mainly great apes and other primates. In total, our team safely and humanely collected samples from 154 non-human primates, 288 bats, and 12 rodents, and together with local health centers, we enrolled and collected samples from 416 febrile human patients.*

## VIRUS DETECTION

Samples from wildlife and humans were safely tested using consensus PCR (cPCR) to screen for priority zoonotic viral diseases and emerging threats such as filoviruses (e.g. Ebola and Marburg), influenzas, coronaviruses (e.g. SARS and MERS), paramyxoviruses, and flaviviruses. 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. Virus testing of both animal and human samples was performed at the Institut National de Recherche Biomédicale (INRB) in Kinshasa and at the University of California, Davis One Health Institute (OHI) laboratory.

Two known viruses that cause respiratory illnesses were detected in seven people from North Kivu at the clinic serving the Virunga National park area: Influenza A virus (n = 2) and Betacoronavirus 1 (OC43) (n = 5). Three of the seven positive individuals were children under the age of eight; the other four positive individuals were adults between the ages of 19 and 34.

Betacoronavirus 1 (OC43), or Human Coronavirus OC43 (HCoV OC43), was detected in oral swab samples from two children and three adults, in both males and females from the two age groups. HCoV OC43 is one of the known viruses that causes the common cold, as well as severe lower respiratory tract infections, and can cause pneumonia in infants, the elderly, and immunocompromised individuals such as those with HIV/AIDS.

Influenza A was detected in one female child and one adult male. Both of the positive detections came from oral swab samples.

There were no virus findings from any of the tested wildlife samples.

## SURVEILLANCE SITES

### NORTH & SOUTH KIVU PROVINCES

bats; humans; non-human primates; rodents/shrews

N & S KIVU PROVINCES

# VIRUS TABLE

| VIRAL FAMILY | VIRUS | SPECIES | SAMPLING LOCATION | # OF POSITIVE INDIVIDUALS |
|---|---|---|---|---|
| Coronavirus | Betacoronavirus 1 (OC43) | Human | Clinic (Virunga National Park) | 5 |
| Influenza virus | Influenza A | Human | Clinic (Virunga National Park) | 2 |
| **Total** | | | | **7** |

# OUTREACH & RISK COMMUNICATION

## COMMUNITY OUTREACH

Through One Health surveillance, the PREDICT team in North and South Kivu engaged local communities and experienced a very positive attitude and acceptance among community members and park employees. Community members stated that it was very important to know about potential risks for contracting diseases from wildlife given their high level of contact – whether from utilizing shared water sources in bat caves or wetlands frequented by forest buffaloes, fending off baboons, chimpanzees, and gorillas feeding on their crops, or sharing their own dwellings with bats.

Our team was active during the Ebola virus outbreak in North Kivu and Ituri Provinces, and in general we found that people realized wildlife pose a potential health threat, and that there are actions they can take to protect themselves. By engaging at-risk communities, the PREDICT team shared the risk reduction and behavior change communication resource, *Living Safely With Bats*, and used the resource an entry point for explaining to people that they can take steps to avoid contact with bats, such as avoiding hunting, bushmeat trading, and wildlife trafficking, while also allowing bats to continue to play their vital roles in our ecosystem as pollinators and seed dispersers, and in controlling insect populations.



Living Safely with Bats



Kuishi salama na popo

# DEMOCRATIC REPUBLIC OF THE CONGO
## PRACTICAL IMPLICATIONS

The PREDICT project's work in DRC has been pivotal in establishing the premise of a One Health platform in-country. While some of the world's foremost experts on Ebola response are based in DRC, the PREDICT project's family-level assays brought important PCR diagnostic confirmation at a crucial time, helping to quickly provide real-time solutions in the face of an Ebola outbreak. The PREDICT project has brought into focus the importance of zoonotic disease spillover in the Congo Basin, one of the hotspots of infectious disease emergence. With its emphasis on capacity expansion, the PREDICT team has reinforced human and animal health preparedness and response capabilities in the country and increased awareness among communities of the potential for spillover of wildlife viruses. Because of close collaborative ties across the PREDICT consortium, Congolese health experts now have regional colleagues that they reach out to for consultation and collaborative reinforcement. This rich multidisciplinary, transborder partnership established by the PREDICT project will persist, we hope, in sustaining the vigilant surveillance of zoonotic disease risk in DRC and throughout the region.

The PREDICT project has provided technical trainings for dozens of government workers, health and medical staff, veterinary and wildlife workers, and for students who will become the next leaders in global health. For nearly a decade, the DRC team has also performed vital services such as assisting with disease outbreak investigations, conducting studies assessing risk associated with bat guano farming and tourist interactions with bats, performing follow-up studies of Ebola virus exposure in outbreak zones, creating opportunities for enhancing awareness about zoonoses in bushmeat markets and with wildlife hunters, and spreading the knowledge gained by this program across the world through both peer reviewed publications and presentations at international conferences. The seeds have been planted and the DRC efforts will continue to grow from the strong roots that USAID has helped nurture through the PREDICT project.

As we say in French, Lingala, and Kiswahili:

*L'equipe restera forte!*

*Toko koba makasi!*

*Timu itabaki kuwa imara!*

*The team will stay strong!*

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For more information
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# EBOLA OUTBREAK IN MBANDAKA

In May of 2018, the DRC province of Equateur experienced an outbreak of Ebola virus – it's second outbreak following the one in 2014. It isn't known where the virus originated but is was suspected that bushmeat may be to blame. To learn more about this outbreak and how people could possibly have become infected, PREDICT/DRC dispatched a team to the capital city of Equateur, Mbandaka, to dig deeper into the mystery.

To learn more about this study: bit.ly/39NMsRJ



# ONE HEALTH PREPAREDNESS FOR EBOLA VIRUS DISEASE OUTBREAKS

Given the potential for Ebola virus to infect habituated mountain gorillas and cause devastating losses of this endangered species, the PREDICT eastern DRC team took action to build greater awareness of Ebola virus as a One Health pathogen among health professionals and in communities, using these outreach efforts to educate people on the virus and how to minimize risk for infection. The PREDICT team convened an all-day workshop involving veterinarians, public health workers, and laboratory technicians, educating attendees about animals as sources of human disease and the role of veterinarians in helping protect human health. They used the Ebola outbreak as impetus for reviewing hygiene practices that help minimize infectious disease transmission. A similar training was held for people working in national parks and forest reserves adjacent or near to the EVD outbreak zone.

To learn more about this study: bit.ly/39Oql8s

# EVIDENCE FOR EXPOSURE TO EBOLAVIRUSES PRIOR TO THE 2018 OUTBREAK

The second largest Ebola virus disease (EVD) outbreak began in North Kivu Province in eastern DRC in July 2018 and soon spread to neighboring Ituri Province. Concurrently, another outbreak affected Equateur Province in western DRC. Data suggest that these outbreaks were not epidemiologically linked, and that independent introduction of Ebola virus (EBOV) into humans had occurred in both areas. Therefore, we conducted serologic testing for exposure to ebolaviruses in febrile patients seeking care in North Kivu Province prior to the EVD outbreak. Serum samples from 272 indivduals (152 adults and 120 children, of which 164 were female and 108 were male) that presented with fever to the Rubare Health Center (in the Rutshuru Health Zone) before the start of the EVD outbreak were analyzed at the OHI lab. Of the samples analyzed, 30 were reactive on initial screening against Ebola virus, and of those, 29 were determined to be positive for antibodies to Ebolavirus Zaire and one for antibodies to the newly detected *Bombali ebolavirus* (BOMV; Goldstein et al., 2018). Positives were equally distributed among adults (11%, 16/152) and children (12%, 14/120); more females were positive (14%, 23/164) than males (6%, 7/108). Most illuminating, seropositive people were detected even in the months prior to the current 2018 North Kivu/Ituri Ebola virus outbreak. This is also the first documented evidence of exposure to ebolaviruses in people in eastern DRC and the first known detection of antibodies to BOMV, previously detected in bats in West and East Africa, which shows that human exposure to BOMV has occurred. Our data suggest human exposure to ebolaviruses may be more frequent and geographically widespread than previously thought.

Adapted from Goldstein et al. 2020. Spillover of ebolaviruses into people in Eastern Democratic Republic of Congo prior to the 2018 Ebola Virus Disease Outbreak. In review.

**SPECIAL FEATURES**