excerpts from

Reducing Pandemic Risk, Promoting Global Health

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Rwanda has built a highly successful ecotourism industry that now represents one of the country's largest sources of foreign revenue. Ecotourism in Rwanda is largely centered on opportunities to view wild human-habituated mountain gorillas in Volcanoes National Park, which brings both local community members (park personnel) and international tourists into daily direct and indirect contact with mountain gorillas. Nyungwe National Park is an increasingly popular destination for tourists and is also home to human-habituated chimpanzees and 12 other primate species. Rwanda is also developing cave tourism, which brings tourists into close contact with roosting bats. Opportunities for wildlife contact in Rwanda are not restricted to national parks, however: in areas surrounding these national parks, as well as in urban, semi-urban, and rural communities, primates (e.g. vervet monkeys, blue monkeys, and olive baboons) range near and in people’s homes and crops, and contact with bats and rodents in and around homes is also common, especially in more rural locations.

Rwanda is continental Africa’s most densely populated country (World Bank 2014). Outside of urban centers, most Rwandans live in rural settings, in close contact with their domestic livestock. Use of land for subsistence crop and animal agriculture brings people into direct proximity to Rwanda’s only remaining natural habitats (national parks). People enter parks illegally to hunt or collect firewood, and wildlife exit parks to forage on crops.

Rwanda is considered a geographical hot spot for zoonotic diseases, and these aforementioned circumstances present unique opportunities for the emergence of pathogens from wildlife that could pose a threat to human health. Therefore, there was an urgent need in Rwanda to strengthen collaborations among government ministries, universities, and private partners, including commercial enterprises involved with tourism and conservation, and to better integrate
veterinary, agricultural, and public health services to enable disease surveillance at the interfaces among wildlife, domestic animals, and people. Through the PREDICT project, the US-based non-governmental organization Mountain Gorilla Veterinary Project (MGVP, Inc.) partnered with the University of California, Davis to survey wildlife for viral pathogens of zoonotic potential, build capacity through improvements in disease surveillance systems and diagnostic laboratory networks, operationalize One Health, and enhance zoonotic disease outbreak response preparedness. These efforts formed Rwanda’s first-ever zoonotic disease surveillance system targeting wildlife at high-risk human-animal interfaces in areas of Rwanda that are most vulnerable to zoonotic disease emergence.

The Government of Rwanda is at the forefront of applying a One Health approach to issues of human and animal health importance. It established a One Health Steering Committee that involves the Rwanda Biomedical Center (the implementation arm of the Ministry of Health), the Rwanda Development Board (the implementation arm of the Office of the President), the Rwanda Agriculture Board (the implementation arm of the Ministry of Agriculture), and University of Rwanda’s College of Veterinary Medicine and School of Public Health. Other relevant stakeholders, including the USAID Emerging Pandemic Threats PREDICT and RESPOND projects, USAID Mission Uganda, and the US Centers for Disease Control and Prevention (CDC), were also involved in the Steering Committee’s formulation of a One Health policy statement that will be adapted by the relevant government ministries for implementation purposes. This endeavor, amongst other initiatives, such as OHCEA (One Health for Central and East Africa), which twins schools of veterinary medicine and public health in East and Central Africa with counterpart universities in USA, and the Rwanda One Health student club, will be important platforms for promoting and operationalizing One Health strategies that are essential in mitigating emerging pandemic threats in the country.

PARTNERS
In conjunction with the Government of Rwanda, PREDICT-Rwanda was implemented by the non-profit Mountain Gorilla Veterinary Project (MGVP, Inc.), which in partnership with the University of California, Davis, runs the Gorilla Doctors program in Rwanda, Uganda, and the Democratic Republic of the Congo.

Key local partners included:

- Rwanda Development Board/Tourism and Conservation (RDB): RDB is the government agency with jurisdictional authority for implementing all tourism and conservation activities, including wildlife management and research in Rwanda; PREDICT’s chief point of contact was Dr. Antoine Mudakikwa, the veterinarian in charge of all wildlife health surveillance, research, and monitoring.

- Rwanda Agriculture Board (RAB): RAB is the government agency with jurisdictional authority for implementing all crop and animal agricultural, husbandry, and science
initiatives aimed at improving food security in Rwanda. PREDICT’s chief points of contact were Dr. Isidore Gafarasi, Head of RAB’s Veterinary Extension Services, and Dr. Christine Kanyandekwe, RAB’s Deputy Director General for Animal Resources.

- Rwanda Biomedical Center (RBC): RBC is the government agency with responsibilities for implementing all public health delivery and protection programs in Rwanda. Our chief point of contact was Dr. Thierry Nyatanyi, Head of the Epidemic and Infectious Diseases Unit.

Other partners included:

- USAID

- University of Rwanda’s School of Animal Science and Veterinary Medicine: the University is committed to One Health capacity-building through didactic and experiential learning opportunities.

- The One Health Steering Committee of the Government of Rwanda: this committee was established and is led by the Ministry of Health, the Ministry of Agriculture, and RDB/Tourism and Conservation Department.

### MAJOR ACHIEVEMENTS

- Systematically collected samples from 1,447 live free-ranging, captive, and confiscated wildlife (503 nonhuman primates, 402 rodents, 504 bats, and 38 other wildlife species) at high-risk disease transmission interfaces in areas where wildlife have high levels of interaction with humans and domestic animals; this work was accomplished in close partnership with the Rwanda Development Board.

- Participated in the establishment of the Government of Rwanda’s One Health Steering Committee to improve cross-sectoral systems and processes for human and animal disease outbreak response (see Success Stories for more information).

- Conducted extensive surveillance of potential zoonotic viruses in nonhuman primates in Rwanda (see Success Stories for more information).

- Served as a member of the Government of Rwanda’s Disease Outbreak Response Taskforce, helping inform the taskforce on the potential role of wildlife in the emergence and spread of zoonotic disease; PREDICT-Rwanda helped the taskforce consider potential wildlife contributions to a disease outbreak in cattle in Bugesera District, which later proved to be an outbreak of Rift Valley Fever.

- Established a large-capacity, secure biobank for long-term storage of wildlife samples.

- In partnership with the Rwanda Agriculture Board Animal Extension Services unit in Rubilizi, Kigali, PREDICT-Rwanda created...
Rwanda’s first BSL-2+ wildlife diagnostic laboratory. Laboratory personnel were trained on sample processing for application of molecular diagnostic techniques.

- Processed 632 nonhuman primate, bat, and rodent samples in the BSL-2 laboratory in Rwanda. PREDICT-Rwanda partnered with the Makerere University Walter Reed Project in Uganda to conduct broad-based testing of these samples for 18 viral families of pandemic potential, which led to the detection of both known and previously-unknown viral pathogens.

- Trained approximately 200 wildlife and government domestic animal veterinarians, veterinary and wildlife students, and other wildlife personnel in wildlife surveillance principles; biosafety; zoonoses; and primate, rodent, and bat sampling methods.

**SUCCESS STORIES**

**Enhancing Understanding of Spillover of Pathogens between Wildlife and People**

PREDICT-Rwanda conducted extensive surveillance for potential zoonotic pathogens in wildlife in Rwanda, particularly in primates; with primate viewing forming the backbone of Rwanda’s highly successful ecotourism industry, the information now in hand regarding what pathogens primates carry that may pose a threat to people, and *vice versa*, will help inform decision-making by wildlife and tourism authorities. The genetic relatedness of great apes and humans has led to concerns about bi-directional spillover of pathogens between people and gorillas. Investigation into a respiratory outbreak in mountain gorillas in 2009 by PREDICT researchers revealed human metapneumovirus lineage B2 in affected individuals (Palacios et al. 2011). The source of the virus is unknown; however, the strain was most recently described in South Africa and likely was transmitted to the gorillas by humans, highlighting the potential for bi-directional spillover of pathogens (Palacios et al. 2011). Although human viewing of mountain gorillas for ecotourism is necessary for their conservation, minimizing the risk of zoonotic pathogen transmission between people and gorillas is critical for their long-term survival and a healthy tourism revenue stream for Rwanda.

Gorillas are poached for the wildlife trade, and confiscated orphaned gorillas are placed into captivity where they are provided constant contact and care by staff. In Rwanda, an orphaned Grauer’s gorilla confiscated from poachers and held in captivity for more than two years developed oral lesions. Human herpes simplex virus Type 1 was detected in this gorilla (Gilardi et al. 2014). This study conducted by PREDICT and its partners was the first to document spillover of viruses from humans into Grauer’s gorillas and provides further evidence of the bi-directional spillover of pathogens between people and gorillas (Gilardi et al. 2014).

**Establishment of the Government of Rwanda’s One Health Steering Committee**

PREDICT-Rwanda participated in the establishment of the Government of Rwanda’s One Health Steering Committee to improve cross-sectoral systems and processes for human and animal disease outbreak response. PREDICT helped provide a broad understanding of the role of wildlife in zoonotic disease outbreaks and explained available techniques for conducting wildlife pathogen surveillance at high-risk human-wildlife interfaces. The One Health Committee is comprised of representatives of the Rwanda Biomedical Center (RBC),...
Rwanda Development Board (RDB), Rwanda Agriculture Board (RAB), EPT PREDICT and EPT RESPOND, University of Rwanda’s Veterinary Medicine College and Medical College, Centers for Disease Control and Prevention (CDC), USAID Mission Rwanda, FAO, and WHO. PREDICT was invited to participate in the establishment and formulation of the 5-year strategic plan and a cross-sectoral One Health policy statement to be adapted by the relevant ministries in the social cluster.

Rolex Recognizes PREDICT Field Veterinarian’s Vision for Wildlife Conservation

PREDICT Field Veterinarian Dr. Olivier Nsengimana received a 2014 Rolex Award for Enterprise in June 2014 in recognition of his achievement and future promise as a wildlife veterinarian in Rwanda. One of just five Young Laureates selected from among 1,800 nominees from around the world, Dr. Nsengimana will apply his award to a collaborative project with the Rwanda Development Board to repatriate illegally-kept Grey Crowned Cranes to rehabilitation centers and eventually back to the wild, where it is believed only 300-500 cranes remain. The knowledge and skills that Nsengimana gained in implementing PREDICT field surveillance activities, as well as the RDB’s capacity for, and commitment to, implementing wildlife conservation and One Health initiatives like PREDICT, position Nsengimana and his Rwanda colleagues for success on this important project.

CAPACITY BUILDING

Infrastructure Development

PREDICT-Rwanda established the first-ever wildlife virology laboratory at the Rwanda Agricultural Board in Kigali. The facility was equipped with BSL-2+ safety and diagnostic equipment for processing wildlife samples, including an isolation unit with a biosafety cabinet, equipment, and supplies for viral detection. Refurbishment of an existing generator and installation of an automatic generator switch ensured a steady power supply. This work was accomplished in close partnership with the Rwanda Agriculture Board Animal Extension Services unit in Rubilizi, Kigali. RNA extraction of more than 600 samples was conducted at the PREDICT-Rwanda lab and PCR was performed at the Makerere University Water Reed Project in Uganda through a newly established collaboration to improve capacity for a regional diagnostic laboratory network in East Africa.

Training

PREDICT-Rwanda conducted comprehensive training of wildlife and domestic animal veterinarians and veterinary and public health faculty and students on zoonotic disease outbreak investigation using PREDICT protocols and training modules covering personal safety during wildlife sampling, humane and effective capture and sampling of wildlife, and disease outbreak response and preparedness. As a result of this training, approximately 200 people gained the knowledge and skills to assist the Government of Rwanda with investigation of the role of wildlife in future human or animal disease outbreaks.
PREDICT conducted the first training for veterinarians in Rwanda on proper and safe sampling of wildlife, laboratory and biosafety protocols, and disease outbreak response. Participants included the Tourism and Conservation Department of the Rwanda Development Board, Rwanda Agriculture Board, University of Rwanda College of Veterinary Medicine, and Gorilla Doctors.

PREDICT-Rwanda also served as a regional training hub for nonhuman primate surveillance for the PREDICT project in east-central Africa, training the country coordinator and staff scientists from PREDICT-Tanzania on safe primate capture and sampling, thereby further strengthening regional and transboundary networks for disease surveillance.

**Operationalizing One Health**

PREDICT-Rwanda assisted with formation of the Government of Rwanda’s One Health Steering Committee, including development of a five year strategic plan and a cross-sectoral ministerial One Health policy statement. PREDICT’s active participation in this committee led to an improved understanding of the role of wildlife in zoonotic disease outbreaks and strategies for conducting surveillance targeted at high-risk human-wildlife disease transmission interfaces.

**SURVEILLANCE**

PREDICT systematically collected samples from 1,447 free-ranging, captive, and confiscated wildlife (504 bats, 402 rodents, 503 nonhuman primates, and 38 animals from other wildlife taxa) throughout Rwanda, targeting areas surrounding national parks, as well as urban centers and semi-urban communities (Figures 1 and 2). Surveillance was targeted at high-risk disease transmission interfaces, including ecotourism, agricultural settings, in and around human dwellings, sanctuaries, and hunted and consumed wildlife (Table 1).
Figure 1. Sites where PREDICT conducted virus surveillance in wildlife taxa at high-risk disease transmission interfaces between wildlife and humans.

Figure 2. Number of animals sampled by taxa.
Table 1. Number of animals sampled according to targeted transmission interfaces.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Nonhuman Primates</th>
<th>Rodents and Shrews</th>
<th>Bats</th>
<th>Other Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural settings</td>
<td>27</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Ecotourism and recreational activities</td>
<td>174</td>
<td>0</td>
<td>169</td>
<td>1</td>
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<tr>
<td>Extractive industries</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>In or near human dwellings</td>
<td>39</td>
<td>64</td>
<td>235</td>
<td>0</td>
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<tr>
<td>Hunted wildlife</td>
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<td>13</td>
<td>0</td>
<td>2</td>
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<td>Wildlife trade</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>Wildlife being studied</td>
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<td>Protected areas</td>
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<td>14</td>
<td>36</td>
<td>0</td>
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<td>Zoos and sanctuaries</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other high-risk interfaces</td>
<td>11</td>
<td>127</td>
<td>29</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>503</strong></td>
<td><strong>402</strong></td>
<td><strong>504</strong></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>

DISEASE OUTBREAK RESPONSE AND PREPAREDNESS

PREDICT-Rwanda served as a member of the Government of Rwanda’s Disease Outbreak Response Taskforce, helping guide the taskforce on the potential role of wildlife in the emergence and spread of zoonotic disease. For example, PREDICT helped the taskforce consider potential wildlife contributions to a disease outbreak in cattle in Bugesera District, which later proved to be an outbreak of Rift Valley fever.

REFERENCES
