excerpts from

Reducing Pandemic Risk, Promoting Global Health

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Cameroon has a wide range of landscapes and climates, from dry Sahel regions, grasslands, and highlands to dense rain forests. With its varied geography and diverse habitats, Cameroon has a remarkable diversity and abundance of wildlife (Republique du Cameroun 2014). Agriculture is the mainstay of the economy, employing a large percentage of its rural workforce. In addition, timber extraction is undertaken across much of the forested areas in Cameroon, and mining is of increasing importance with a number of sites currently undergoing assessment or development for extractive activities. Cameroon is also an important transportation hub for goods going to the Central African Republic, Equatorial Guinea, Gabon, and Chad. Increased investment in major infrastructure projects, including transportation, water supply, and power generation is underway in areas that were once largely inaccessible.

Economic progress has led to advancing education levels and improved health, yet poverty remains high at 40%, and life expectancy is lower relative to the regional averages (World Bank 2014). Hunting of wildlife is a major cultural and economic activity in Cameroon – important for rural food security and livelihoods. However, it has placed extreme pressure on some wildlife populations, as urban and rural demand for bushmeat increases. Hunting and eating wildlife carries a substantial risk for cross-species transmission of zoonotic pathogens of wildlife origin.

Wildlife pathogens, including new retroviruses, have been detected in people that hunt and butcher wild animals in Cameroon (Wolfe et al. 2004, 2005; Zheng et al. 2010). Importantly, this high-risk activity in Central Africa was the likely pathway by which HIV emerged in people. Preventing the emergence of new infectious diseases and pandemics requires an enhanced understanding of the diversity of pathogens in wildlife, especially in areas with recent
anthropogenic disturbance and high-risk human-wildlife contact, which increase the likelihood of emergence and spread of zoonotic pathogens.

In collaboration with the Government of Cameroon, PREDICT developed laboratory platforms and capacity to expand wildlife surveillance activities. The team conducted surveillance at high-risk human-wildlife interfaces in order to evaluate the diversity of known and novel viruses in wildlife that have the potential to spill over into people. In addition, project activities allowed for exploration of the implications of human and wildlife interactions on disease transmission and emergence. A focus on scientific collaboration and stakeholder and community engagement in Cameroon was key to our goals of increasing awareness of zoonotic disease risks, improving our understanding of disease emergence, and informing on potential mitigating measures to minimize the risk of cross-species transmission as well as rapid identification of viruses once they have crossed over into humans.

**PARTNERS**

PREDICT partners in Cameroon included:

- Ape Action Africa (AAA)
- Care and Health Program Cameroon (CHP)
- Centre Pasteur du Cameroun (CPC)
- Centre de Recherche de Sante des Armées/Army Health Research Centre (CRESAR)
- Global Viral Cameroon (GV-C)
- Limbe Wildlife Centre (LWC)
- Metabiota
- Ministère de la Defense/Ministry of Defence (MINDEF)
- Ministère de l’Environnement, de la Protection de la Nature et du Développement Durable/ Ministry of Environment, Protection of Nature and Sustainable Development (MINEPNDR)
- Ministère de l’Elevage, des Pêches et des Industries Animales/Ministry of Livestock, Fisheries and Animal Industries (MINEPIA)
- Ministère des Forêts et de la Faune/Ministry of Forestry and Wildlife (MINOF)
- Ministère de la Recherche Scientifique et de l’Innovation/Ministry of Scientific Research and Innovation (MINRESI)
- Ministère de la Santé Publique/Ministry of Public Health (MINSANTE)
- Projet Grands Singes (PGS)
- Université de Douala/University of Douala (UD)
- Université des Montagnes (UDM)
- Université de Maroua/University of Maroua (UM)
- USAID
MAJOR ACHIEVEMENTS

- Provided key support to the Government of Cameroon in its initiative to develop the first National Program for the Fight against Emerging and Re-emerging Zoonotic Diseases. Development of this program enabled the inclusion of many actors in multisectoral discussions on the use of a One Health approach to control zoonotic diseases (see Success Stories for more information).

- Worked closely with the Directorate of Disease, Pandemic and Epidemic Control (DLMEP) of the Ministry of Public Health (MoH) to develop training materials around Ebola surveillance and control for clinical and non-clinical public health staff. These trainings were deployed to all 10 regions of Cameroon in September 2014 and were coupled with the dissemination of a national strategy for the fight against Ebola and specific surveillance and hospital management directives from the MoH. Educational materials were produced and displayed in strategic public areas, such as airports and hospitals.

- Enhanced disease surveillance capacity through training provided to staff from collaborating ministries and NGOs. This capacity building permitted standardization of protocols, introduction of novel techniques, and piloting of new technology as part of PREDICT (see Success Stories for more information).

- Collaborated with local communities to incorporate local knowledge into the surveillance strategy in Cameroon. Regular health education sessions were provided to enhance understanding among people who hunt and butcher wild animals of the risks associated with these activities and to share ideas for risk reduction (see Success Stories for more information).

- Implemented wildlife surveillance at high-risk disease transmission interfaces through a network of existing and new PREDICT partners, collecting specimens from 11,394 animals. Close collaboration with wildlife sanctuaries in Cameroon allowed regular sample collection from nonhuman primates originating from the wild or wildlife trade during animal health checks as well as during treatment quarantine periods.

- Augmented laboratory diagnostic capacity through laboratory infrastructure improvements and development of consensus and degenerate PCR assays to rapidly detect 20 viral families. Working molecular biology expertise was put in place locally to provide training and oversee laboratory analyses.

- Detected and characterized known and novel viruses in high-risk wildlife taxa and improved our understanding of their animal reservoirs and their potential for spillover into people (see Microbe Discovery and Characterization below for more information).
SUCCESS STORIES

Development of the National Program for the Fight against Emerging and Re-Emerging Zoonotic Diseases

PREDICT provided key support to the Government of Cameroon in its initiative to develop the first national program for zoonotic disease control. The development of this program enabled multi-sectoral discussions on zoonotic diseases and the One Health approach. For some participants, this interaction was the first time that they had been exposed to the One Health concept.

A National One Health Policy and National Program for the Fight against Emerging and Re-emerging Zoonotic Diseases plan were drafted under the leadership of the Prime Minister’s Office and in collaboration with several ministerial departments and stakeholders, including hunting and conservation representatives. The plan was certified by four ministries, specifically the Ministry of Scientific Research and Innovation; the Ministry of Livestock, Fisheries and Animal Industries; the Ministry of Forestry and Wildlife; and the Ministry of Public Health. The ministries nominated points of contact for zoonotic diseases and One Health issues in order to develop a sustainable network of professionals for communication regarding One Health actions among ministries.

PREDICT staff provided guidance on field surveillance and laboratory diagnostics to ensure the program included innovations validated through PREDICT-Cameroon activities. The resulting program provided a sustainable framework that will guide and coordinate interventions among ministries and agencies with the goal of reducing zoonotic disease risks.

Building Capacity for a Sustainable Wildlife Surveillance Network

PREDICT’s implementation required a significant effort to collect wildlife samples for virus detection from key high-risk interfaces. This approach presented unique training opportunities for staff and officials from collaborating ministries and the national veterinary laboratory. Participants in the training sessions included senior, central-level ministerial officials responsible for management and policy development, regional ministerial staff responsible for day-to-day management of wildlife conservation and veterinary services, and national veterinary laboratory staff responsible for laboratory diagnostic analyses.

PREDICT facilitated a comprehensive cycle of training for all participants that included theoretical training sessions on One Health, practical demonstrations of sample collection in the field, and laboratory analyses. This approach had multiple benefits. It provided an understanding by ministerial management staff of what is involved in wildlife surveillance activities, including the strategies behind the risk-based approach. It also allowed both local and central ministerial staff to see elements of surveillance in action. Furthermore, because there was already an understanding of the approach to surveillance and laboratory analyses by ministerial staff at the results reporting stage, discussions with collaborating ministries were focused on implications of the results and potential interventions to decrease risk.
**Direct Community Engagement**

PREDICT Cameroon strived to ensure its work was applied and a direct benefit to the local population. We collaborated with communities to ensure that there was an understanding by the members regarding the justifications for and techniques used in the project and to benefit from local knowledge in developing strategies for surveillance and risk reduction. Using this participatory approach, health education sessions were conducted regularly in order to inform individuals who hunt and butcher wild animals of the risks associated with this activity and to share ideas among community members of strategies to minimize these risks. The sessions allowed individuals to make informed choices about their hunting and butchering activities and provided them with feasible approaches to decrease their risk of exposure.

From 2010 to 2014, a total of 390 education sessions were conducted in 82 villages in the southern forest areas of Cameroon. This collaboration enabled the collection of over 23,000 dry blood spot samples from wild animals. As laboratory results from these samples became available, PREDICT staff shared relevant information with the communities in order to enhance their understanding of the risks associated with exposure during hunting and butchering of wildlife.

**CAPACITY BUILDING**

**Capacity Building via PREDICT Staff**

Due to the specialized and original nature of PREDICT activities, training was necessary to develop the relevant capacity among project staff and collaborators. Training sessions on zoonotic diseases allowed PREDICT and collaborating staff from ministries and NGOs to understand zoonotic disease risks associated with wildlife contact and how to minimize those risks through PPE and biosecurity. Other training included safe wildlife capture and sampling with proper techniques for restraint, handling, and safe sampling of wild animals. Additional sessions included information on proper specimen selection and handling and maintenance of a cold chain for sample storage and transport. Practical training on these principles took place on the job during field activities.

Major infrastructure improvements were also made, including installation of new laboratory equipment needed for pathogen discovery. PREDICT developed techniques that allowed detection of both known and unknown pathogens in samples collected in Cameroon. These techniques, using both consensus and degenerate primers with conventional PCR were fully implemented for detection of 20 viral families/genera: astroviruses, alphaviruses, arenaviruses, coronaviruses, filoviruses, flaviviruses, paramyxoviruses, seadornaviruses, hantaviruses, enteroviruses, rhabdoviruses, henipaviruses, bunyaviruses, influenza viruses, herpesviruses, bocaviruses, poxviruses, adenoviruses, polyomaviruses, and retroviruses.
Laboratory training sessions were conducted in order to provide participants with the skills to maintain a safe and biosecure laboratory environment. Proper use of PPE was also included in this training. For this component, staff from ministries and other collaborating organizations received PPE training and specific fit testing, using internationally standardized procedures to ensure the appropriate PPE size and fit for each participant. Personnel were also trained on laboratory database management. Four full-time PREDICT laboratory technicians were comprehensively trained in all steps of sample processing and techniques for pathogen discovery. In addition, molecular biology expertise was established locally for the duration of the PREDICT project.

To augment disease response capacity in Cameroon, PREDICT staff received training on zoonotic disease outbreak response. Additional training sessions included GIS mapping and disease modeling and information technology emergency management through the World Food Program.

**Capacity Building for PREDICT Collaborators**

Training opportunities, including short internships, were also provided to students from higher education institutions in Cameroon in order to promote laboratory competencies in the next generation of laboratory diagnosticians. Eight master degree students from the Higher Institute of Medical Technology (ISTM) Yaoundé completed a one-month internship, and 19 fifth year veterinary students from the Université des Montagnes attended a three day workshop in the PREDICT Cameroon laboratory. Students received training on One Health, wildlife sampling, laboratory techniques and biosafety, and disease outbreak response. Two students from the University of Yaoundé completed internships at the PREDICT-Cameroon laboratory as part of the Field Epidemiology and Laboratory Management Masters training program supported by CDC. In the course of the internship, they conducted an evaluation of the waste management system in the laboratory.

In addition, collaborators from Limbe Wildlife Sanctuary and Ape Action Africa were also trained on animal capture and sampling, biosafety, specimen storage and shipping, laboratory safety, first aid, and fire safety. Two university employees were also trained in the field on wild animal capture and sampling, included the use of traps and mist-nets, animal identification, animal restraint, and sample collection and storage.

**Capacity Building for Cameroon Government Staff**

PREDICT facilitated comprehensive training for staff and officials from collaborating ministries and the national veterinary laboratory. Participants received training on One Health, field surveillance, and laboratory methodology. This training provided ministerial management staff with an understanding of PREDICT surveillance strategies and viral detection methods, which facilitated more in-depth discussions of
results. In total, 40 ministerial staff including 24 from the Ministry of Forestry and Wildlife; 15 from the Ministry of Livestock Fisheries and Animal Industries; and one from the Ministry of Environment, Protection of Nature, and Sustainable Development participated in PREDICT trainings.

Two PREDICT Cameroon staff members presented laboratory approaches for detection of known and novel viral pathogens at the FAO meeting for national veterinary laboratory directors and Chief Veterinary Officers supported by the Emerging Pandemic Threats (EPT) IDENTIFY project. Among the participants were FAO/Identify staff from Cameroon, Italy, Mali, Kenya, and Botswana, as well as Chief Veterinary Officers and national veterinary lab directors from Cameroon, Congo, Gabon, Central African Republic, Democratic Republic of Congo, South Sudan, Uganda, and Tanzania. PREDICT also assisted the Cameroon-IDENTIFY team (WHO) and Ministry of Health in training 11 laboratory technicians from public hospitals in four regions of Cameroon on sample collection, packing, and shipping to reference laboratories for disease surveillance and outbreak response.

**Regional Training Provided by PREDICT Cameroon**

The PREDICT Cameroon laboratory provided field and laboratory training support to other PREDICT country programs in central Africa (Democratic Republic of Congo (DRC), Republic of Congo (RoC), and Gabon). PREDICT Cameroon staff travelled to DRC to provide training on GAINS, animal sampling, animal and human safety, laboratory safety, personal protective equipment (PPE), sample shipment, and ethical treatment of animals during capture and sampling. To advance capacity for wildlife pathogen screening, PREDICT Cameroon laboratory personnel provided materials for and training on protocols and implemented the laboratory analyses with the proper controls. PREDICT-DRC, Gabon, and RoC laboratory technicians also visited the PREDICT Cameroon laboratory for training on sample collection, processing, and testing; laboratory management, workflow, and high throughput analysis; and laboratory results interpretation.

In collaboration with PREVENT, PREDICT-Cameroon mapped and collected data on roadside and market bushmeat vendors in the Woleu-Ntem Province in Gabon in order to determine the logistics and feasibility of conducting market ethnography in the region. Staff also travelled to La Lope Reserve in Gabon for a USAID training implemented by the EPT RESPOND project and African Union – Inter-African Bureau for Animal Resources (AU-IBAR) on the topic of One Health for middle and senior staff from the Ministries of Health, Livestock, and Environment. PREDICT provided expertise and training on wildlife capture and sampling techniques to this group. To assist with the H7N9 outbreak in China, PREDICT Cameroon staff also participated in a capacity building and technology transfer visit to the partner laboratory in Guangdong, China.
SURVEILLANCE
A broad surveillance program was established in Cameroon in order to encompass the great diversity of high-risk human-wildlife interfaces, species, and landscapes in the country (Figure 1). The field team implemented the program through coordination with a network of partners, including government agencies, NGOs, and communities. Surveillance activities targeted areas where there was high risk for human contact with wildlife, especially nonhuman primates, bats, and rodents (Figure 2 and Table 1).

Figure 1. Sites where PREDICT conducted virus surveillance in wildlife taxa at high-risk disease transmission interfaces between wildlife and humans.
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>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Ecotourism and recreational activities</td>
<td>0</td>
<td>35</td>
<td>136</td>
<td>11</td>
</tr>
<tr>
<td>In or near human dwellings</td>
<td>5</td>
<td>387</td>
<td>938</td>
<td>54</td>
</tr>
<tr>
<td>Hunted wildlife</td>
<td>1384</td>
<td>1770</td>
<td>596</td>
<td>4474</td>
</tr>
<tr>
<td>Wildlife being studied</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Farmed wildlife</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zoos and sanctuaries</td>
<td>1028</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Markets</td>
<td>25</td>
<td>62</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>Pristine habitat</td>
<td>141</td>
<td>54</td>
<td>113</td>
<td>67</td>
</tr>
<tr>
<td>Other high-risk interfaces</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>2584</td>
<td>2309</td>
<td>1812</td>
<td>4689</td>
</tr>
</tbody>
</table>

Surveillance sites were chosen based on their geographical distribution, the presence of high-risk wildlife taxa, and the risk of contact between people and the high-risk taxa. Sites with high-risk disease transmission interfaces were identified through expert technical advice and local community knowledge.

Three main types of sites were selected for surveillance activities:

- Sites in the southern forested area of the country where many people rely on forest resources for income generation and subsistence, including bushmeat hunting to supplement farming activities. PREDICT activities in these areas included educating hunters about reducing their risk of contracting zoonotic diseases and wildlife conservation.

- Sites in the Mount Cameroon area and savanna in northern Cameroon where there is a growing ecotourism industry and increased opportunities for contact between tourists and wildlife. These sites have diverse fauna that is distinct from the fauna in the southern forested areas. The landscape of these sites shares similarities with that of the area in Nigeria where the Lassa virus outbreak occurred.
Sites throughout Cameroon where peridomestic settings were targeted. Rodents and bats live in and around human dwellings and agricultural fields where they may come into direct or indirect contact with people.

A number of different collaborations facilitated surveillance activities. Wildlife samples were collected in partnership with people hunting and butchering wild animals at markets and in villages. While harvested wildlife provides an important source of protein in the daily diet of many villagers in Cameroon, the harvesting rate is not always sustainable. Therefore the field team, accompanied by Ministry of Wildlife officials, sought to reinforce community knowledge of protected species in an effort to reduce the harvesting of these species. In addition, collaborations with wildlife sanctuaries (Limbe Wildlife Sanctuary and Ape Action Africa) allowed regular sampling of nonhuman primates that originated from the wild or the wildlife trade. Furthermore, people holding nonhuman primates in private collections as pets provided samples.

DISEASE OUTBREAK RESPONSE AND PREPAREDNESS

Participation in the Ministry of Health Surveillance Meetings

PREDICT staff participated in weekly disease surveillance coordination meetings at the Department of Disease Control at the Ministry of Health. The purpose of these meetings was to follow-up on epidemics occurring at the national and international levels and to discuss control strategies. These meetings provided opportunities to build upon One Health networks and establish PREDICT surveillance strategies that are adaptive and integrated across the animal and human health sectors.

Deployable Disease Outbreak Response Team

To enhance preparedness for disease outbreak response, PREDICT Cameroon organized a deployable outbreak response team to assist with wildlife investigations during an outbreak. A series of response plans were developed, and capacity was established to screen for a range of pathogens in the field, including influenza A and B, Ebola virus, yellow fever, Lassa virus, dengue virus, and primate T lymphotrophic virus 3/4.

The team informed the Ministries of Health and Livestock on arenavirus animal surveillance activities undertaken by PREDICT during the outbreak of Lassa fever in Nigeria where 40 people died, and 400 people were diagnosed with the disease. The team’s activities were discussed with the Minister of Livestock and the Secretary of State for Pandemics and Epidemics at the Ministry of Public Health. At the suggestion of the Secretary of State, a request was submitted to the Ministry of Public Health to integrate the PREDICT Cameroon team into the epidemic response working group. A memo describing the outbreak response capacities of the PREDICT partner in Cameroon was submitted with this request.

DRC Outbreak Support

Two PREDICT Cameroon staff travelled to DRC in September 2012 to assist with the Ebola outbreak in Isiro (Haut Uele Province). PREDICT provided technical support for wildlife surveillance activities conducted by district personnel from the Ministry of Environment, Nature Conservation and Tourism and the Ministry of Agriculture and Livestock. A daily report was given to the International Committee on Scientific and Technical Coordination for Fighting
Three wildlife sampling strategies were implemented during the outbreak. Free-ranging wildlife in and around Isiro and surrounding villages were captured and sampled. In addition, pets and hunted wildlife in these areas were sampled. Samples were collected from 78 bats from 10 species, including two species known to be involved in the ecology of Zaire ebolavirus (Epomops franqueti and Hypsignatus monstrosus). Information gathered by PREDICT in Isiro during the visit indicated that hunting and consumption of bats, in particular Hypsignatus monstrosus and Epomops franquetii bats, occurs locally. In addition, the team travelled to the nearby towns of Nalamu and Xavierou to investigate reports of animal carcasses in the forest. They found cases of bushmeat for sale, despite current regulations against hunting in the area. Samples were collected from the hunted animals and transferred to the PREDICT / INRB laboratory in Kinshasa for testing.

**Monkeypox Outbreak in Chimpanzees**

PREDICT assisted the Ministry of Health, Ministry of Forestry and Wildlife, and Ministry of Livestock, Fisheries and Animal Production in responding to the first confirmed outbreak of Monkeypox in wildlife in Cameroon. In July 2014, the Ministry of Health was notified of chimpanzees with symptoms suggestive of a monkeypox outbreak in the Sanaga Yong Chimpanzee Rescue Centre. PREDICT assisted the government in the field investigation and confirmed the Monkeypox diagnosis in the PREDICT laboratory in collaboration with CDC. Following the notification of results to the sanctuary and the government, the Chief Veterinary Officer declared the outbreak via the OIE and undertook a follow-up site visit to ensure preventive measures recommended during the initial visit were in place and that the infections were not spreading.

**Ebola Outbreak Preparedness**

PREDICT-Cameroon worked closely with the Directorate of Disease, Pandemic and Epidemic Control (DLMEP) of the MoH to develop training materials for Ebola surveillance and control for clinical and non-clinical public health staff. Trainings were deployed to all 10 regions of Cameroon in September 2014 in conjunction with the dissemination of a national strategy for the fight against Ebola and specific surveillance and hospital management directives from the MoH. Educational materials were developed and displayed in targeted public places, including airports and hospitals. We also assisted the Ministry of Livestock in drafting an Ebola surveillance plan for wildlife in Cameroon and contributed to workshops to discuss priorities and the role of regional Ministry of Livestock staff.
MICROBE DISCOVERY, CHARACTERIZATION, AND CROSS-SPECIES TRANSMISSION

PREDICT built upon previous long-standing research collaborations with rural populations, wildlife sanctuaries, and government agencies in Cameroon to further investigate the potential for spillover of pathogens from nonhuman primates to people through a number of studies, including:

- **Evidence for Henipavirus Spillover into Human Populations in Africa.** Zoonotic transmission of lethal henipaviruses (HNVs) from their natural fruit bat reservoirs to humans has only been reported in Australia and South/Southeast Asia. However, one study discovered numerous HNV clades in African bat samples. To determine the potential for HNV spillover events among humans in Africa, PREDICT examined sets of bat and human serum samples from Cameroon for Nipah virus cross-neutralizing antibodies. We detected antibodies in 48% and 3-4% of the bat and human samples, respectively. Seropositive human samples were found almost exclusively in individuals who reported butchering bats for bushmeat. Butchering bat meat and living in areas undergoing deforestation were the most significant risk factors associated with seropositivity (Pernet et al. in press).

- **A Gorilla Reservoir for Human T-lymphotropic Virus Type 4 (HTLV-4).** This research identified gorillas as a nonhuman primate host for STLV-4 (LeBreton et al. 2014). These findings highlight the diversity of retroviruses being transmitted to people via the same pathway used by HIV in its emergence (LeBreton et al. 2014).

- **Widespread Infection with Homologues of Human Parvoviruses B19, PARV4, and Human Bocavirus of Chimpanzees and Gorillas in the Wild.** This research showed that the nonhuman primate homologues of the three human parvoviruses circulate extensively among wild ape populations with particular high rates of exposure in chimpanzees (Sharp et al. 2010). Further characterization of PARV4-like viruses in chimpanzees and colobus monkeys revealed that these viruses appear to be species-specific, despite vast opportunities for cross-species transmission, suggesting that the risk of spillover of PARV4-like viruses from nonhuman primates into humans is low (Adlhoch et al. 2012).

- **Species Association of Hepatitis B virus (HBV) in Nonhuman Apes – Evidence for Recombination between Gorilla and Chimpanzee Variants.** PREDICT investigated species-specificity of hepatitis B virus (HBV) among nonhuman primate species and between humans and nonhuman primates using complete genome sequencing and phylogenetic analysis (Lyons et al. 2012). Results of this study provide the first evidence for HBV circulation between chimpanzees and gorillas and among subspecies of chimpanzees, a conclusion that differs from the dogma of strict host specificity of HBV genotypes, suggesting that there is potential for spillover (and the emergence of new genotypes) of this virus into new species, including humans (Lyons et al. 2012).

- **High Seroprevalence of Enterovirus Infections in Apes and Old World Monkeys.** Enterovirus species A, B, and D were detected in wild chimpanzees. The potential for spillover and spread of enteroviruses from old world monkeys or apes to humans is unknown; however, evidence of enterovirus circulation among these nonhuman primates warrants assessment of potential sources for the periodic emergence of novel enteroviruses (Harvala et al. 2012).
• **Characterization of a New Simian Immunodeficiency Virus Strain in a Naturally Infected *Pan troglodytes* Chimpanzee with AIDS-related Symptoms.** PREDICT characterized a new simian immunodeficiency virus strain in a naturally infected *Pan troglodytes* chimpanzee with AIDS-related symptoms, the reservoir of the ancestors of HIV-1 in humans, (Etienne et al. 2011). This research revealed that SIV has an increasing viral diversity over time and provided further evidence that chimpanzees can have clinical progression to an AIDS-like disease (Etienne et al. 2011).

• **Failure to Detect Chronic Simian Immunodeficiency Virus in a Large Cameroonian Cohort with High Nonhuman Primate Exposure.** PREDICT assessed simian immunodeficiency virus (SIV) infection in individuals who hunt and butcher nonhuman primates in Cameroon, a population in which other nonhuman primate retroviruses were previously detected. Some individuals had evidence of previous exposure, but molecular sequences of SIV genes could not be detected, suggesting that SIV infection in humans could occur less frequently than infections with other retroviruses (Djoko et al. 2012).

• **African Origin of *Plasmodium vivax*.** PREDICT researchers also participated in a study investigating the origins of the malaria parasite, *Plasmodium vivax*. Results of this research indicate that *P. vivax* is of African and not Asian origin and that all extant human parasites evolved from a single ancestor that spread out of Africa. The high prevalence of *P. vivax* in wild-living apes has implications for malaria eradication efforts (Liu 2014).

**REFERENCES**


