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PREDICT MALAYSIA

One Health in action (2009-2020)



The PREDICT project in Malaysia is an exemplary One Health success between EcoHealth Alliance and the Malaysian Government (human, wildlife and veterinary authorities) working together to find new viruses and strengthen human and laboratory capacity, an important step towards sustainable disease surveillance.

MALAYSIA



The PREDICT project, as part of USAID's Emerging Pandemic Threats program, seeks to discover zoonotic viruses in wildlife before they become human epidemics, and identify the factors that drive their emergence, amplification, and spread in populations. EcoHealth Alliance (EHA) and Conservation Medicine, the Ministry of Health, Department of Wildlife and National Parks Peninsular Malaysia, and the Department of Veterinary Services have been working together on zoonotic disease surveillance in Malaysia since 2005. Expanding to Sabah in 2012, EHA, Sabah Wildlife Department, and Sabah State Health Department began a

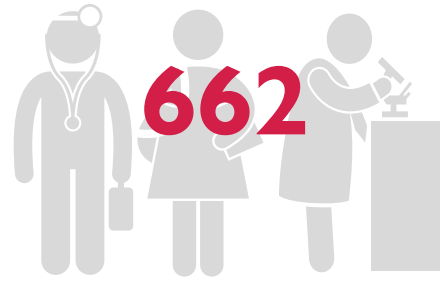
collaboration on zoonotic disease surveillance. This close working and committed group of individuals and institutions have made significant advances in Malaysian research and surveillance infrastructure and have strengthened technical capacity in that time, including the creation of two internationally certified labs dedicated to wildlife disease screening. In Malaysia, the project to date has identified 76 novel viruses and 29 known viruses, providing the Malaysian government with actionable data to inform risk mitigation policies at the national and state level.

LOCAL PARTNERS

BCI	Bio Community Initiative	MZL, NWFL	Molecular Zoonosis Laboratory, National Wildlife Forensic Laboratory
BMHRC, UMS	Borneo Medical and Health Research Centre, Universiti Malaysia Sabah	NPHL	National Public Health Laboratory
BSBCC	Bornean Sun Bear Conservation Centre	NWFL	National Wildlife Forensic Laboratory
DGFC	Danau Girang Field Centre	SORC	Sepilok Orangutan Rehabilitation Centre
DHRU, UMS	Development and Health Research Unit, BMHRC, Universiti Malaysia Sabah	SSHD	Sabah State Health Department
DVS	Department of Veterinary Services	SWD	Sabah Wildlife Department
DWNP	Department of Wildlife and National Parks Peninsular Malaysia	CTED, FM, UNIMAS	Universiti Malaysia Sarawak
FVM, UPM	Virology Laboratory, Faculty of Veterinary Medicine, Universiti Putra Malaysia	VRI	Veterinary Research Institute
KKPHL	Kota Kinabalu Public Health Laboratory	WHGFL	Wildlife Health, Genetic and Forensic Laboratory
MoH	Ministry of Health	WHU	Sabah Wildlife Health Unit
		WRU	Sabah Wildlife Rescue Unit

(Cover and opposite page)

PHOTO: TOM HUGHES, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE



662

DEVELOPED the One Health Workforce by training 662 people in Malaysia.

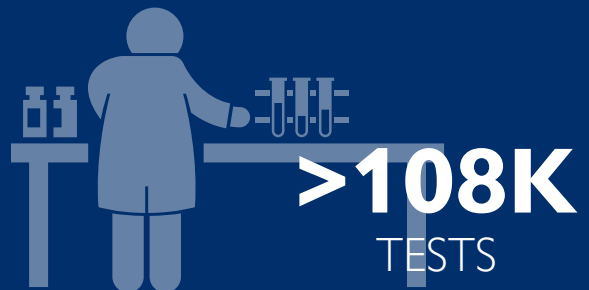


>7.3K

OPERATIONALIZED One Health surveillance and sampled over 7.3K animals and people, helping minimize the spillover of zoonotic disease threats from animals into human populations.

LABORATORY STRENGTHENING

- Wildlife Health, Genetic & Forensic Laboratory, Sabah Wildlife Department
- Virology Lab, Faculty of Veterinary Medicine, Universiti Putra Malaysia
- DWNP Molecular Zoonosis Laboratory at the National Wildlife Forensic Laboratory
 - National Public Health Laboratory
 - Kota Kinabalu Public Health



>108K
TESTS



76
PREDICT



29
KNOWN

DETECTED 105 unique viruses in both animal and human populations.



NUR AMIRAH MD SUNGIF

Laboratory Technician, *EcoHealth Alliance*

“The experiences that I gained while working on the PREDICT project enabled me to enhance my laboratory and field techniques. Good teamwork is actually the key to how we managed to complete this project successfully and I am happy I am part of this team.”



ANDREW GINSOS

Team Leader, *Wildlife Health Unit/Sabah Wildlife Department*

“It was great to work with PREDICT, I really enjoyed the challenging work and learnt a lot through the project. I am amazed at how much work was done by the team to enhance biosafety and develop a surveillance network in Malaysia.”

ACHIEVEMENTS

- The PREDICT project in Malaysia has trained 662 people in the last 10 years. Throughout the second phase of the PREDICT project (PREDICT-2; 2014-2019), a total of 532 people have been trained - 224 people in Peninsular, 212 people in Sabah, and 49 people in Sarawak (47 individuals from Peninsular and Sabah were only partially trained, as they did not complete training or failed the quizzes). Most received multiple trainings over the 10 years with 478 from PREDICT-2 being trained in two or more PREDICT project modules. These trainings helped build capacity and ensure the competency and safety of lab and field teams during project surveillance and beyond.
- To improve our understanding of pathogen circulation and exposure risks, the PREDICT Malaysia team conducted concurrent animal-human sampling in 9 Orang Asli villages. Behavioral surveys were conducted to identify perceptions and practices around wildlife, domestic animals, hunting, and livelihood. Working with our partners from the Ministry of Health (MoH) District Health Teams, the Department of Wildlife and National Parks (DWNP), and the Department of Veterinary Services (DVS), we sampled 1,390 people, 736 wild animals and 696 domestic animals and pets – a huge sampling effort that helped strengthen the One Health partnership between MoH, DWNP, and DVS.
- To date, this work with the Orang Asli has found 2 novel coronaviruses in 3 bats, 4 known coronaviruses in 15 people, 1 known influenza in 1 person, 1 known coronavirus in 2 chickens, and 1 known coronavirus in a rat. Serological screening of people and wildlife in Orang Asli communities is being conducted. Initial results suggest that there has been exposure to Nipah-related & Ebola-related viruses in bats, non-human primates (NHP), and indigenous communities. This ongoing work will build from PREDICT and continue to improve our understanding of zoonotic virus spillover risk in communities living in close association with wildlife.
- The PREDICT Malaysia team conducted trainings within 4 communities in Sabah and 9 in Peninsular Malaysia on how to live safely with bats, using the PREDICT project developed resource *Living Safely with Bats*. 829 people attended these community meetings, 95 bat books were provided in Malay, and 10 were provided in the Dusun language to community leaders and the local schools as leave behind material that can continue to be shared with the communities. The PREDICT Malaysia team continues to receive requests and find uses for the developed material, and is preparing *Living Safely with Bats* in the Murut language as an aid for local meetings with communities that rely on subsistence hunting in southern Sabah near the border with Kalimantan.

(Opposite)

PHOTO: JIMMY LEE, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE

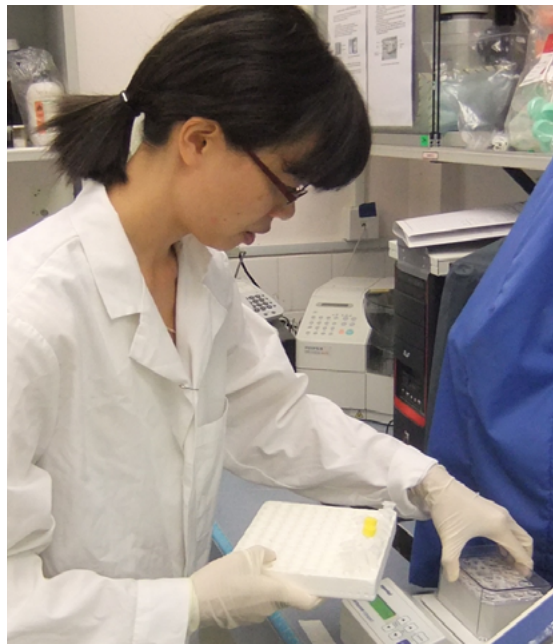
ONE HEALTH SURVEILLANCE

Throughout PREDICT-2 (2014 – 2019), the project focused on zoonotic disease surveillance at high-risk interfaces such as Peninsular Malaysia's Orang Asli communities (many of which practice subsistence hunting of wild animals) and those living or working in areas with lots of wildlife contact and conflict in Sabah Malaysia. PREDICT-2 performed concurrent human, wildlife, and domestic animal/livestock surveillance and identified human behaviors contributing to transmission risk. In addition to this targeted surveillance at high-risk interfaces, hospital-based surveillance was also conducted. In the state of Sabah, some of the indigenous groups still practice traditional, and in many cases subsistence hunting of wild animals, while land use change results in increasing contact and conflict between humans and wildlife. Every year across Sabah patients die in clinics and hospitals across the state from diseases of unknown origin. Of the 76 novel viruses discovered through the PREDICT project to date in

Malaysia, 65 were found in Sabah. The use of hospital-based syndromic surveillance could begin to identify the cause of some of these undiagnosed deaths and potentially improve healthcare and outcomes for patients in the future. This effort will continue post PREDICT.

In 2016, the PREDICT Malaysia team began zoonotic disease surveillance of the Orang Asli indigenous communities in Peninsular Malaysia. These communities employ traditional methods of subsistence hunting of wild animals including bats, rodents, non-human primates, and other mammals, and raise domestic animals such as chickens and hunting dogs around their homes. These communities are often in heavily forested remote areas with limited access to medical and health services. As a result of the high degree of contact with wild and domestic animals through hunting and rearing practices, they are vulnerable to infection with zoonotic pathogens. The remote locations of these Orang Asli communities prevent or lengthen the duration for the identification and treatment of these pathogens.

In June 2018, concurrent sampling at Orang Asli villages across Peninsular Malaysia kicked back into full swing. The PREDICT Malaysia team, working side by side with our partners from the District Health Teams of Gua Musang, Kuala Lipis, Kuala Kangsar, and DWNP, battled raging rivers, deep mud, collapsed bridges, and sickness to enroll, administer the questionnaire, and sample 1,013 people, 381 wildlife, and 383 domestic animals in just 5 months! In just two dry seasons we sampled a total of 1,390 people, 736 wild animals, and 696 domestic animals and pets. This huge sampling effort helped strengthen the One Health Partnership between MoH, DWNP, and DVS, and provided an opportunity to talk to over 2,000 Orang Asli villagers at community meetings about zoonoses, the One Health concept, and the risks posed by contact with wildlife and how to minimize these risks, such as not touching dead wildlife. The PREDICT project also provided a meal to over 1,200 Orang Asli villagers (many who are under nourished) who attended community meetings or were enrolled in the study.



EcoHealth Alliance Malaysia laboratory coordinator Mei-Ho Lee processing samples at Diagnostic Laboratory of the Department of Wildlife and National Parks.

PHOTO: TOM HUGHES, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE

VIRUS TABLE: PREDICT-2

VIRAL FAMILY	VIRUS	SPECIES	SAMPLING LOCATION	# OF POSITIVE INDIVIDUALS			
				TOTAL	WET SEASON	DRY SEASON	
Coronavirus	Alphacoronavirus NL63	Human	Kuala Kangsar	2	2	0	
	Betacoronavirus 1 (OC43)	Human	Kuala Kangsar	4	4	0	
	Coronavirus 229E (Human strain)	Human	Kuala Lipis	1	1	0	
	Human coronavirus HKU1	Human	Kuala Kangsar, Gua Musang, Kuala Lipis	8	8	0	
	PREDICT_CoV-52	Diadem Roundleaf Bat, Fawn-Coloured Roundleaf Bat, Horsfield's Myotis	Pristine 3, Semi-Disturbed 1, Semi-Disturbed 2	5	5	0	
	PREDICT_CoV-76	Fawn-Coloured Roundleaf Bat, Dark-Tailed Tree Rat	Batu Supu, Semi-Disturbed 1, Semi-Disturbed 3	5	5	0	
	PREDICT_CoV-78	Accuminate Horseshoe Bat, Arcuate Horseshoe Bat, Clear-Winged Woolly Bat, Creagh's Horseshoe Bat, Fawn-Coloured Roundleaf Bat, Lesser Short-Nosed Fruit Bat, Trefoil Horseshoe Bat, Unidentified Rhinolophus Bat, Black Rat, Horse-Tailed Squirrel, Long-Tailed Giant Rat, Müller's Giant Sunda Rat, Red Spiny Rat, Whitehead's Spiny Rat	Telupid Pristine 2, Telupid Pristine 3, Telupid Semi-Disturbed 1, Telupid Semi-Disturbed 2, Telupid Disturbed 1, Telupid Disturbed 2, Pristine 1, Pristine 2, Semi-Disturbed 1, Semi-Disturbed 3, Disturbed 1, Disturbed 2, Gua Madai	24	16	8	
	PREDICT_CoV-84	Creagh's Horseshoe Bat	Pristine 3, Semi-Disturbed 1, Semi-Disturbed 2	3	3	0	
	PREDICT_CoV-87	Dawn Bat, Indian Pipistrelle, Malayan Slit-Faced Bat	Kuala Kangsar, Putrajaya	4	4	0	
	PREDICT_CoV-101	Hardwicke's Woolly Bat	Telupid Disturbed 3	1	0	1	
	PREDICT_CoV-104	Lesser Bamboo Bat	Kuala Kangsar	1	1	0	
	PREDICT_CoV-105	Creagh's Horseshoe Bat	Gua Madai	1	1	0	
	PREDICT_CoV-110	Arcuate Horseshoe Bat, Creagh's Horseshoe Bat	Gua Madai, Pristine 1	4	2	2	
	Philippines/Diliman1525G2/2008	Horsfield's Fruit Bat, Temminck's Tailless Fruit Bat	Telupid Semi-Disturbed 2, Telupid Semi-Disturbed 3	2	1	1	
	Murine coronavirus	Dark-Tailed Tree Rat, Müller's Giant Sunda Rat, Unidentified Niviventer Rat, Whitehead's Spiny Rat	Telupid Semi-Disturbed 1, Telupid Semi-Disturbed 3, Telupid Disturbed 3, Disturbed 1, Kuala Lipis	6	4	2	
	Paramyxovirus	Infectious bronchitis virus (IBV)	Domestic Chicken	Gua Musang, Kuala Kangsar	2	2	0
		Human parainfluenzavirus 2	Human	Hospital Queen Elizabeth	1	0	1
		PREDICT_PMV-72	Creagh's Horseshoe Bat, Fawn-Coloured Roundleaf Bat	Semi-Disturbed 1	2	2	0
		PREDICT_PMV-74	Fawn-Coloured Roundleaf Bat	Pristine 2, Pristine 3	2	1	1
		PREDICT_PMV-81	Fawn-Coloured Roundleaf Bat	Semi-Disturbed 1	5	5	0
		PREDICT_PMV-98	Fawn-Coloured Roundleaf Bat	Pristine 3	1	1	0
		PREDICT_PMV-99	Fawn-Coloured Roundleaf Bat	Pristine 3	1	1	0
		PREDICT_PMV-105	Creagh's Horseshoe Bat	Semi-Disturbed 1	1	1	0
		PREDICT_PMV-106	Creagh's Horseshoe Bat	Pristine 1, Semi-Disturbed 2	2	2	0
		PREDICT_PMV-107	Arcuate Horseshoe Bat, Creagh's Horseshoe Bat	Pristine 3	2	2	0
		PREDICT_PMV-108	Diadem Roundleaf Bat	Pristine 3	1	1	0
		PREDICT_PMV-110	Fawn-Coloured Roundleaf Bat	Semi-Disturbed 2	1	1	0
PREDICT_PMV-137		Trefoil Horseshoe Bat	Telupid Disturbed 2	1	0	1	
PREDICT_PMV-120		Moonrat	Pristine 2	1	0	1	
Influenza virus		Influenza A	Human	Kuala Lipis	1	0	1
Flavivirus	PREDICT_Flavi-6	Diadem Roundleaf Bat	Pristine 3	1	1	0	
Total				96	77	19	



VIRUS FINDINGS IN PEOPLE

Pathogen surveillance has historically been lacking in indigenous communities, and there is a poor understanding of infection rates of known disease, let alone novel zoonotic viruses. Although novel viruses were not detected in people at any of the Orang Asli study sites, the PREDICT Malaysia team identified 15 cases of 4 unique, previously known human coronaviruses (NL63, OC43, 229E, and HKU1) and 1 case of Influenza A. One known paramyxovirus, Human parainfluenza virus 2, from a patient in the hospital-based syndromic surveillance

study in Sabah was detected. Despite serological evidence from another ongoing study suggesting suggesting possible exposure to one or more henipaviruses and filoviruses in bats and people at the Orang Asli study sites, no henipavirus or filovirus nucleic acid was detected in any human or animal sampled. The presence of antibodies suggests that spillover may have occurred, and may occur in the future, providing valuable information to help government partners develop targeted surveillance and intervention strategies.

VIRUS FINDINGS IN ANIMALS

Throughout the second phase of the PREDICT project (2014 – 2019), we detected 3 known viruses and 22 novel viruses in wildlife and domestic animals using the PREDICT testing strategy of consensus PCR assays that detect a broad range of viruses, known and novel, from priority virus families: coronaviruses, paramyxoviruses, filoviruses, influenza viruses, and flaviviruses.

The three known viruses detected were all coronaviruses: Infectious bronchitis virus was found in domestic chickens, Murine coronavirus was

found in several rodent species, and Philippines/Diliman1525G2/2008 coronavirus was found in two bat species.

The 22 novel viruses detected were predominately paramyxoviruses (n = 12) and coronaviruses (n = 9), with one belonging to the flavivirus family. These viruses were found in a diverse array of bat genera, representing at least 14 unique species, as well as within 7 unique rodent species, and one moonrat, which despite its name, is a carnivorous mammal not closely related to rodents (Figure 1).

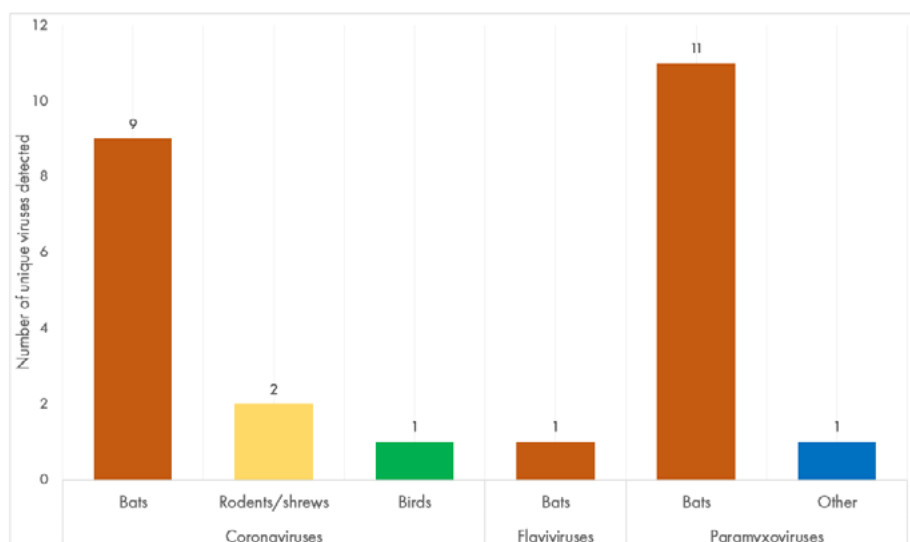


FIGURE 1. Summary of known and novel virus detections across major host taxonomic groups

Mohd Izman Mokhtar
Kuala Kangsar Medical
Assistant drawing blood
from a participant

PHOTO: TOM HUGHES, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE

EPIDEMIOLOGICAL & BEHAVIORAL RISK

EXPOSURE RISKS IN THE INDIGENOUS POPULATION OF PENINSULAR MALAYSIA, THE ORANG ASLI

To gain a more complete understanding of viral spillover risk, the second phase of the PREDICT project expanded the scope to include human data collection concurrently with wildlife and domestic animal sampling. To improve understanding of pathogen circulation and exposure risks, the PREDICT team conducted concurrent animal-human sampling in 9 Orang Asli communities. Behavioral surveys were conducted to identify perceptions and practices around wildlife, domestic animals, hunting, and livelihoods. Working with our partners from the Ministry of Health (MoH) District Health Teams (from Gua Musang, Kuala Lipis, and Kuala Kangsar), the Department of Wildlife and National Parks (DWNP) and the Department of Veterinary Services (DVS), we sampled 1,390 people, 736 wild animals (bats and rodents) and 696 domestic animals and pets, including dogs, chickens, goats, wild boars, monkeys and a masked palm civet.

The Orang Asli practice traditional and in many cases subsistence hunting of wild animals and raise domestic animals such as chickens and hunting dogs around their villages. Their health and nutritional status tends to be far worse than the rest of the Malaysian population. Many of these communities have limited

access to medical services which means disease spillover events could be going unrecorded. Because of the high degree of contact with wild and domestic animals through hunting and rearing practices the Orang Asli are vulnerable to infection with zoonotic pathogens. Encroachment on their ancestral lands for agriculture expansion and mining leads to increased contact and conflict with wildlife, contamination of their water supplies, and disrupts their traditional way of life, thus increasing their vulnerability. Despite the potential risks for zoonotic pathogen transmission, there are few studies from these communities characterizing behaviors related to animal contact that could influence risk of viral spillover.

The PREDICT team and partners sampled and administered questionnaires to 1,390 Orang Asli individuals, 820 (59%) of which were female and 570 (41%) were male. In total, 119 (8.6%) Orang Asli participants were aged 18-20 years old, 482 (34.7%) were aged 21-30 years old, 346 (24.9%) were aged 31-40 years old, 239 (17.2%) were aged 41-50 years old, 137 (9.9%) were aged 51-60 years old, 46 (3.3%) were aged 61-70 years old, 18 (1.3%) were aged 71-80 years old, and 3 (0.1%) were aged 81-90 years old. Participants were from 9 communities representing 3 districts in Peninsular Malaysia (Gua Musang, Kuala Kangsar, and Kuala Lipis) to investigate the risk of zoonotic diseases based on multiple factors such as livelihood, travel, work, and types of contact with wildlife.

Districts Orang Asli Participants Sampled

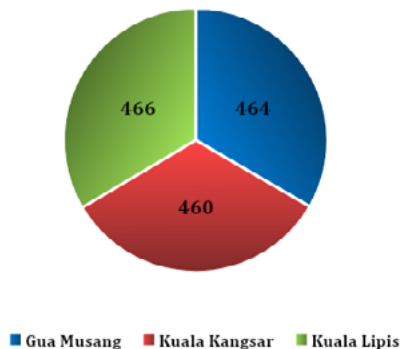


FIGURE 2. Number of Orang Asli individuals sampled in each district

Top three daily activities reported by participants

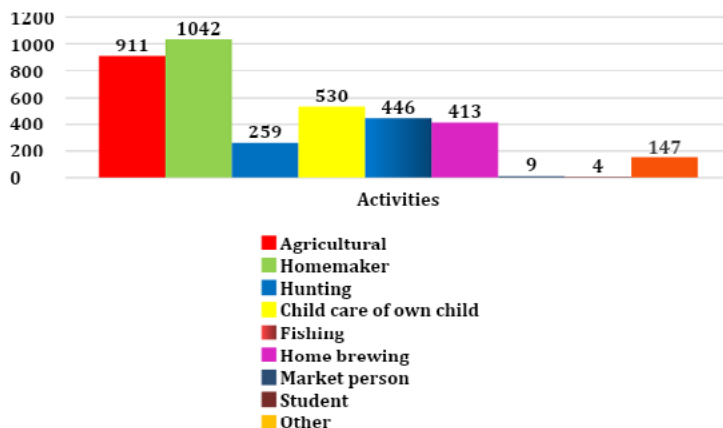


FIGURE 3. Distribution of Orang Asli participants' top three daily activities



EcoHealth Alliance Field Veterinarian Dr. Zahidah Zeid collecting samples from a wild boar piglet being kept as a pet in an indigenous village

PHOTO: JIMMY LEE, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE

The PREDICT project provided an opportunity, through its commitment to community outreach in Malaysia, to talk to over 2,000 Orang Asli villagers. They are not entirely isolated from the rest of Malaysia, traveling to more populous and sometimes urban areas for education, work, health care, or to visit other communities. As these communities become increasingly connected through agricultural expansion, urban spread, and an improved road network, they become increasingly important as a sentinel population. Through trust built between PREDICT and the communities, virus surveillance was coupled with education and outreach about

the risks associated with wildlife contact. At all community meetings and sampling events the PREDICT team talked to community leaders and members about zoonoses, the One Health concept, and the risks posed by contact with wildlife and how to minimize these risks, such as not touching dead wildlife. Surveillance of Orang Asli communities represents a critically important opportunity to detect spillover of zoonotic viruses. The book *Living Safely with Bats* was used as an education and risk communication tool in some of the indigenous communities who participated in PREDICT project surveillance.

COMMUNITY ENGAGEMENT & RISK COMMUNICATION

Gaining the trust of the Orang Asli communities generated an entry point for continued engagement. Despite the remoteness of many of the sites, the logistical challenges they posed, and the need for multiple visits to each village to meet community leaders to explain the study and how it would benefit their communities, the team managed in just three dry seasons to do what many thought was not possible. Each sampling trip started with a community meeting and meal to share information about zoonoses and also provided a chance for these communities to get to know the team. Participants were given a health assessment and provided with treatment by the District Health Teams, providing a pathway for improved access to health care. Returning to each community to share results with participants and a summary of project findings strengthened this relationship and provided another opportunity to share health information such as the

PREDICT project-developed guide *Living Safely with Bats*. This work demonstrates how One Health novel pathogen surveillance and outreach can be combined with wider public health service delivery for known disease threats to tackle overall health needs.



CAPACITY STRENGTHENING & MALAYSIA ONE HEALTH PARTNERSHIPS

Since 2010, the PREDICT Malaysia team has trained a total of 662 participants (130 in PREDICT-1 and 532 PREDICT-2), increasing the One Health capacity in Malaysia. Training programs provided by the PREDICT project covered both field and lab activities in order to build capacity across the human, wildlife, and livestock sectors for disease surveillance, and to minimize the risks faced by the One Health workforce and students who will join the One Health workforce when carrying out disease surveillance whether in the lab or field. Participants from different backgrounds including senior government staff, scientists, researchers, wildlife conservationists, lecturers, students, rangers, veterinarians, hospital staff, and District Medical teams have received PREDICT project training in surveillance and diagnostics, including the sharing of standard operating procedures (SOPs) and protocols. Many training sessions have been run with participants from different government departments helping to build working relationships and strengthen

communication across the human, wildlife, and livestock sectors and between government and academia. Many participants have been involved in multiple ongoing trainings since 2010.

Participants from governmental and non-governmental agencies including MoH, SWD, WRU, WHU, DWNP, DVS, VRI, NPHL, KKPHL, NWFL, BSBCC, DGFC, Lok Kawi Wildlife Park, WWF, KL Bird Park, Kyoto University, Orangutan Appeal UK, Oregon Zoo, Sunway Lost World of Tambun, Myne Resort, Sedafiat Sdn Bhd, Texas Technology University, Selangor Turf Club, UNIMAS, UMS, UPM, Management and Science University, University Tunku Abdul Rahman, University of Queensland Australia, University California- Davis, British Columbia Institute of Technology, Burnaby BC, Iowa State University, Zoo Negara, and Taiping Zoo have joined in the PREDICT project capacity building trainings and utilize the information and skills learned in their daily activities.



Dr. Zahidah Zeid and Ranger Adilah Aziz conducting health check on a Bornean sun bear at Bornean Sun Bear Rehabilitation Centre.

PHOTO: Yuery Wazlan, EcoHealth Alliance/Conservation Medicine

STRENGTHENING THE MALAYSIA ONE HEALTH WORKFORCE: WILDLIFE DEPARTMENTS ENGAGING IN DISEASE SURVEILLANCE AND PANDEMIC PREPAREDNESS

An excellent example that highlights the Government of Malaysia's commitment to One Health and the sustainable capacity developed by the PREDICT project is the establishment and sustained commitment to the Molecular Zoonosis Laboratory at the National Wildlife Forensic Laboratory based at DWNP headquarters in Kuala Lumpur. The BSL 2 certified laboratory, developed in partnership with PREDICT Malaysia conducts all of the wildlife testing for the PREDICT project in Peninsular Malaysia and has expanded to include serology with support from the Defense Threat Reduction Agency's Cooperative Biological Threat Reduction Program. As a sign of the Government of Malaysia's commitment to wildlife surveillance, the Ministry of Natural Resources and Environment has provided operational funding to maintain the lab's infrastructure. In addition, the Wildlife Disease Surveillance Program established by DWNP, which includes the 46 officers from DWNP trained by the PREDICT project, conducts regular wildlife surveillance for the PREDICT project and other disease surveillance projects and outbreak response related to wildlife viruses.

In Sabah, PREDICT Malaysia established the Wildlife Health, Genetic and Forensic Laboratory (a BSL 2 certified laboratory) and the Wildlife Health Unit (WHU) with SWD and DGFC in 2012. The WHU is responsible for leading the physical and diagnostic evaluation of rescued and relocated wildlife across Sabah, as well as conducting sampling trips to trap and sample free-ranging wildlife for the PREDICT project and Deep Forest Project. In 2018-2019, the WHU shone when team leader Andrew Ginsos from SWD WRU helped to organize and run field trips when the PREDICT Malaysia team was deep in the jungle on Peninsular Malaysia and unavailable. Andrew lead the WHU team in Sabah allowing the team to complete the Deep Forest Project as planned. To date EHA has trained 13 WRU staff who have worked as part of the WHU since 2012. Staff who have spent time in the WHU are now seen as a huge asset to SWD and the WRU by helping to train their colleagues and conduct risk assessments for their various activities not directly related to the PREDICT project, thus ensuring the safety of their colleagues and the wildlife they work with.

The inclusion of wildlife departments in national zoonotic disease surveillance strategies is central to the One Health framework and fundamentally important for cohesion among sectors monitoring zoonotic pathogens in wildlife, livestock, and people. Historically, wildlife departments have rarely been part of public health infrastructure, however, Malaysia has led the way over the last decade in response to the recognition of the importance of wildlife as reservoirs for zoonotic pathogens and the gaps that exist in surveillance systems. Malaysia has been a leader in coordinated government response to zoonotic disease largely as a result of its history with Nipah virus, which emerged in humans from bats via pigs in 1998. Through its partnership with the Government of Malaysia and Sabah State government agencies, the PREDICT project has sustainably strengthened existing surveillance and response systems and paved the way for continued leadership in pandemic preparedness and response.

Disease outbreak response and preparedness capacity was strengthened to support the public health capabilities in Malaysia. Outbreak response training was provided to 25 people in Peninsular and 42 people in Sabah. This training provided an introduction to the theory and skills needed to safely collect samples and work during an outbreak. It included lectures on: Zoonotic diseases of rodents, primates, and bats; Biosafety and PPE; Human safety; Lab safety; Safe animal capture and sampling; Implementing a cold chain for safe sample transport; Packing and shipping biological samples; Trizol training; Risk assessment training; Wet labs on PPE and mask fit test; and a table top exercise preparing front line medical staff on how to deal with an unknown infectious disease outbreak. Additionally, these trainings were bolstered as an additional 53 people in Peninsular and 52 people in Sabah were trained on the PREDICT Emergency Preparedness Module (Figure 5).

Gender

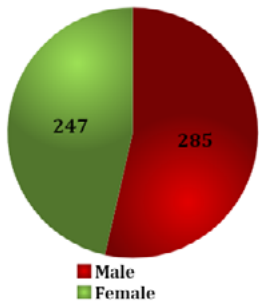


FIGURE 4. Number of people trained in One Health throughout the PREDICT project (2014 - 2019) based on gender.

People trained in Outbreak Response and Emergency Preparedness Module

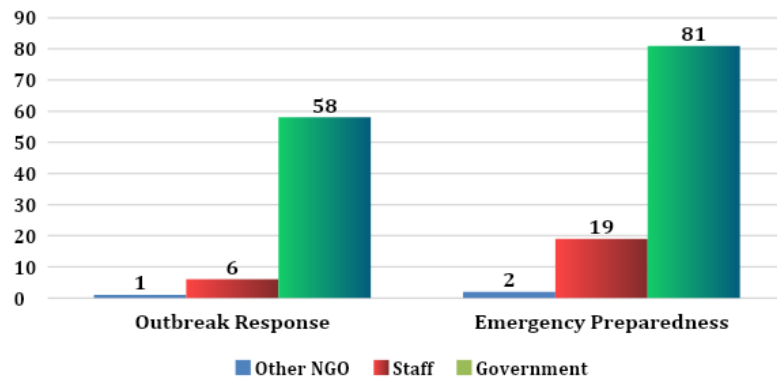
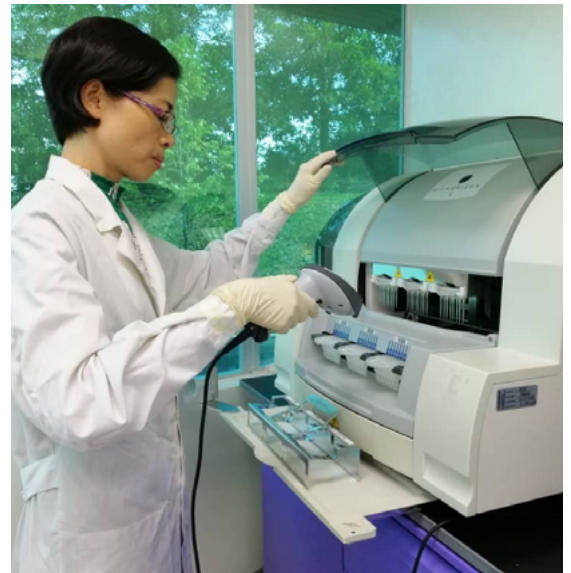


FIGURE 5. Number of people trained in Outbreak Response and Emergency Preparedness Module under the PREDICT project from 2014 – 2019.

PROMOTING CONSERVATION & STRENGTHENING LAB CAPACITY

Sabah is home to various endangered wildlife species, thus the PREDICT project is working closely with Sabah Wildlife Department and local non-governmental organizations to promote conservation and enhance the lab capacity for disease testing. In order to better understand the health of key wildlife species and the threats faced by zoonosis and anthroponosis, health checks and disease screenings have been carried out by the PREDICT team in collaboration with Sabah Wildlife Department, Sepilok Orangutan Rehabilitation Centre (SORC), Bornean Sun Bear Conservation Centre (BSBCC), and the Wildlife Rescue Unit for the endangered orangutans, sun bears, and Bornean elephants held in captivity as well as from the wild. The PREDICT team sampled 74 orangutans, 64 sun bears, and 13 elephants in Sabah and samples were tested at the WHGFL. This state-of-the-art facility enables wildlife health monitoring, population/conservation genetics research, and wildlife forensic work. It was the first certified BSL 2 level facility in the region dedicated to wildlife work and allows the Sabah Wildlife Department to rapidly assess wildlife health prior to relocation, to engage in comprehensive disease screening efforts, and support research projects. Through PREDICT lab testing, we have found a total of 6 novel and 6 known viruses from these three iconic species. The results are essential for Sabah Wildlife Department to make decisions on the further actions required to conserve these important animals.

For example, during an annual health screening for the SORC orangutans, the team from PREDICT and the Wildlife Health Unit collected samples from three quarantined animals, and the WHGFL facilitated the testing of these samples using published Hepatitis PCR protocols. The analysis of sequencing results by Malaysia's PREDICT project Laboratory Coordinator at WHGFL showed that the three orangutans had orangutan Hepatitis B, endemic to wild orangutans which does not pose a public health concern. Soon after that, Tiger, Rosalinda, and Yoda were released into their newly-built rehabilitation cage and began playing on the ground, enjoying the sunshine for first time ever after being quarantined. Six years later in 2018 one of these magnificent animals, Tiger, was returned to the wild thanks to the efforts of SWD, the staff at SORC, and the Wildlife Rescue Unit.



EcoHealth Alliance Malaysia Laboratory Coordinator Mei-Ho Lee loading samples into Easymag for nucleic acid extraction

PHOTO: SURAYA HAMID, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE

In 2016, three captive orphan elephants died at the rescue center located at SORC. An investigation into elephant deaths led by EcoHealth Alliance's lab coordinator, in collaboration with elephant endotheliotropic herpesvirus (EEHV) experts at WHGFL, found a new and distinct strain of EEHV that caused the infection. This knowledge can help SWD better manage orphaned elephants in captivity and improve disease surveillance in wild populations. Screening of the sun bears found a related virus to ursid herpesvirus 1 from seven sun bears that has not previously been reported in Bornean sun bears. This will help BSBCC prepare to release some of the 44 bears back into the wild. In addition, through PREDICT project activities we have not only discovered new viruses; the Deep Forest Project has allowed us to better understand the impact of land use change on species diversity and population dynamics. The genetic barcoding of sampled animals helped us to better understand the identity of and distributions of these host species.

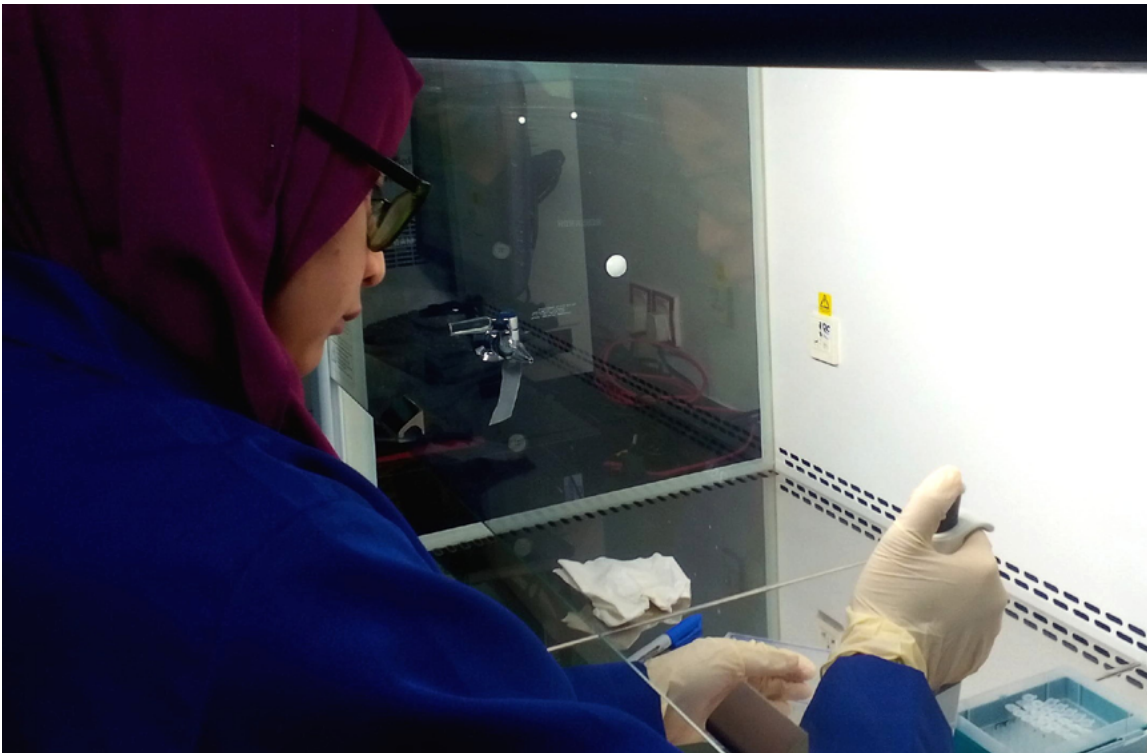
LAB CAPACITY BUILDING ACROSS MALAYSIA

The PREDICT Malaysia team built laboratory capacity in Sabah in collaboration with SWD and DGFC by establishing the Wildlife Health, Genetic and Forensic Laboratory. In August 2019 the lab was certified for the sixth year in a row as a BSL 2 biocontainment level laboratory in accordance with the Biosafety in Microbiological and Biomedical Laboratories 5th Edition (December 2009) which is the US standard used by CDC and NIH for laboratory specifications. The laboratory was the first certified BSL 2 level facility in the region dedicated to the detection of wildlife pathogens, allowing SWD to rapidly screen wildlife prior to relocation, and to engage in a variety of infectious disease research projects.

The PREDICT Malaysia team built laboratory capacity

in Peninsular Malaysia in collaboration with DWNP by establishing the Molecular Zoonosis Laboratory at the new National Wildlife Forensic Laboratory. In May 2019 the lab was certified for the third year in a row as a BSL 2 biocontainment level laboratory in accordance with the US standard used by CDC and NIH for laboratory specifications. This state of the art facility has allowed DWNP to play an even larger role in zoonotic disease research projects.

The PREDICT Malaysia team helped to improve and standardize protocols and SOPs for each partner laboratory in Malaysia, and provided reagents, primers, and a universal positive control that can be used to screen samples for 17 virus families. These primers and controls have been used by NPHL, KKPHL, UPM, and DWNP for disease surveillance outside the PREDICT project.



DWNP Research Officer Millawati adding template for a PCR screening of PREDICT samples at the National Wildlife Forensic Laboratory

PHOTO: MEI-HO LEE, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE

STRENGTHENING ONE HEALTH PARTNERSHIPS

In February 2018, PREDICT Indonesia team members from Bogor Agricultural University, Science Techno Park (IPB-STP) visited DWNP's NWFL to learn about lab design and discuss future collaborations. These individuals included Dr. Diah Iskandriati, Scientific Advisor, Dr. Dadang Syamsul Munir, MM, Director, and Dr. Meika Syahbana Rusli, President Director. IPB-STP is in the process of building an integrated laboratory facility to support its function with some funding from the Indonesian government. One of its purposes will be to provide laboratory services for wildlife. At the moment,

Indonesia does not have a centralized laboratory to support analysis for pathogen detection, genetics, and forensics. The purpose of this visit was to learn about laboratory services for wildlife from the established wildlife laboratories in the region (the NWFL being one of the best examples) to apply to their facility, as well as to see the possibility to build networking and collaboration with wildlife laboratories in the region. This visit highlights the importance of regional One Health collaborations which the PREDICT project helped facilitate.

INTEGRATING ONE HEALTH & CONSERVATION

The PREDICT Malaysia Field Manager, Jimmy Lee, was made a member of the International Union for Conservation of Nature and Natural Resources (IUCN) Pangolin Species Survival Specialist Group. In December 2017, he represented the PREDICT project in Malaysia at the One Plan Approach Conservation Planning and Formosan Pangolin PHVA Workshop at the Taipei Zoo in Taiwan. The conference was an opportunity to work with representatives from the Taipei Zoo, Taiwan Forest Bureau, Endemic Species Research Institute, the IUCN SSC, and other organizations to assess potential conservation management plans for pangolins. This opportunity highlights the key work the PREDICT project is doing in the region to strengthen links between conservation and One Health. To further strengthen these goals, he also presented a poster "Surveillance of zoonotic viruses and population genetics of confiscated Sunda pangolins (*Manis javanica*) from Malaysia" at the 5th

International One Health Congress in Saskatoon, Canada, June 2018.

In addition to managing all PREDICT project field activities in Peninsular Malaysia and Sabah, Jimmy is also enrolled in a Master's degree program at Universiti Malaysia Sabah conducting pangolin research. Pangolins are critically endangered and the most illegally traded mammal in the world; 1.1 million pangolins were traded between 2006 and 2015. Pangolins are smuggled from countries in Southeast Asia, including Malaysia, to China as a delicacy or for traditional Chinese medicine. This research will provide important information regarding the presence of zoonotic viruses in confiscated pangolins and where these animals were smuggled from. This data will help to lobby governmental agencies and the public to stop the pangolin trade and prevent disease transmission, thus protecting regional economies, public health, and pangolin populations.

PRACTICAL IMPLICATIONS

- The PREDICT project has strengthened the multisectoral platform for partnership around One Health and zoonotic disease surveillance.
- In the last 10 years, the PREDICT Malaysia team has trained 662 current and future One Health workforce individuals. This ensured everyone involved in sampling and testing were fully equipped and capable to safely carry out zoonotic disease surveillance in the field and the lab, adhering to the standards established in PREDICT project protocols.
- The creation of the WHU in Sabah and DWNP's Wildlife Disease Surveillance program guarantees that the wildlife authorities continue to be able to play an important role in zoonotic disease surveillance by identifying novel viruses before they spillover into human and livestock populations. The significant capacity building across all our partners' labs, laboratory screening, and biosafety and field training activities in Malaysia complements all of our government partners' efforts to improve One Health surveillance and capacity building among their staff.
- The establishment of the Molecular Zoonosis Laboratory at DWNP's NWFL and the Wildlife Health, Genetic and Forensic Laboratory for SWD has significantly strengthened virus surveillance capacity in wildlife and resulted in the identification of 76 novel viruses. Noteworthy mentions include the discovery of 12 novel coronaviruses in bats and rodents, some of which are genetically related to SARS CoV, 15 novel paramyxoviruses in bats and a moonrat, and 1 novel flavivirus detected in a bat. Many of these novel viruses warrant further investigations to determine their pandemic potential. This ongoing effort is a critical step in understanding the risk that wildlife viruses pose to humans and will provide actionable data for our government partners to help keep the Malaysian public safe from emerging zoonotic diseases.
- The PREDICT project has helped Malaysia fully embrace the concept of One Health and recognize the importance of ongoing zoonotic disease surveillance. The continued collaboration between EcoHealth Alliance, Conservation Medicine, and Malaysian government partners will allow for the continuation of efforts to find new viruses and strengthen human and laboratory capacity in-country.

(Back cover)

PHOTO: TOM HUGHES, ECOHEALTH ALLIANCE/CONSERVATION MEDICINE

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