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# PREDICT MYANMAR

One Health in action (2014-2020)



*Creating the first major framework for the incorporation of environmental and wild animal health at the forefront of infectious disease emergence, and implementing One Health across Myanmar's community, university, and government sectors*



# MYANMAR

**A**t the crossroads between South and Southeast Asia paired with its developing status as a nation, Myanmar is a hotspot for zoonotic disease emergence. Multiple avian influenza outbreaks since 2009 have underscored this concern, which has prompted the creation of a national One Health program involving members from the Ministry of Health and Sports (MOHS) and the Ministry of Agriculture, Livestock, and Irrigation (MOALI).

Recent democratization, rapid development and commercialization have led to significant land-use change and an increased demand for alternative resources such as wildlife and their products. Owing to the country's unique geography with limited access, partial self-governance at the northern borders,

and an enforcement infrastructure in its infancy, the wildlife-human interface remains under-evaluated and a source of concern for zoonotic disease emergence.

PREDICT created the first major One Health surveillance framework in Myanmar. Through coordinated surveillance of people and wildlife at high-risk disease transmission interfaces, PREDICT worked across Myanmar's community, university, and government sectors to strengthen mechanisms to detect and respond to zoonotic disease threats and build capacity in both the field and laboratory for the next generation of Myanmar's One Health workforce.

## LOCAL PARTNERS

- Department of Medical Research (DMR), Ministry of Health and Sports
- Livestock Breeding and Veterinary Department (LBVD), Ministry of Agriculture, Livestock and Irrigation
- Forestry Department of Ministry of Natural Resources and Environmental Conservation



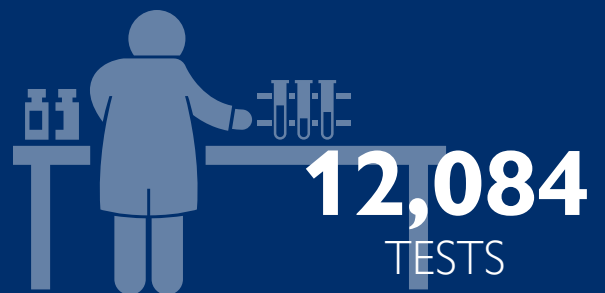
**DEVELOPED** the One Health Workforce by training more than 480 people in Myanmar.



**OPERATIONALIZED** One Health surveillance and sampled over 3.6K animals and people, to identify ways to help minimize the spillover of zoonotic disease threats from animals into human populations.

## LABORATORY STRENGTHENING

- Livestock Breeding & Veterinary Department
- Department of Medical Research



PREDICT



KNOWN

**DETECTED** 10 unique viruses in both animal and human populations.



## OHNMAR AUNG

Country Coordinator & Medical Surveillance Officer  
Smithsonian Conservation Biology Institute's Global Health Program

*“After almost 20 years of experience as a public health and health social scientist, this is the first time I have seen the conceptualization of public health issues related to wildlife, livestock and human interfaces in Myanmar. As a doctor and public health professional, it has been an incredible experience to partake in studying communicable disease transmissions and viral outbreaks while understanding it from the animal and environmental health perspective. It was a great opportunity working for PREDICT, obtaining a comprehensive scope of the One Health Concept and studying zoonotic diseases at their source.”*



## KYAW YAN NAING TUN

Veterinary Field Surveillance Officer  
Smithsonian Conservation Biology Institute's Global Health Program

*“As a veterinarian in Myanmar, I became very knowledgeable about wildlife health and potential disease transmission among wildlife, livestock, and humans from the experiences working for PREDICT. I have limited expertise about wildlife health and wildlife medicine in our University of Veterinary Science. I can apply these experiences and knowledge of PREDICT implementations in my future career while also providing education to the community and my junior colleagues.”*

# ACHIEVEMENTS

- PREDICT conducted the first major study incorporating concurrent wildlife, human and livestock viral disease surveillance activities in Myanmar.
- 150 trainees (50 males, 100 females) in over 30 conducted training sessions in all relevant One Health surveillance and diagnostic elements for a strong local One Health capacity.
- Detected six novel coronaviruses in bats and one novel paramyxovirus in a rodent at high-risk disease transmission interfaces including bat caves used for ecotourism, guano collection and religious ceremonies.
- Advised on the National One Health Strategic Plan resulting in the inclusion of zoonotic diseases originating in wildlife as a primary focus.
- Through PREDICT project guidance, the Ministry of Natural Resources and Environmental Conservation was invited to participate in designing of the National One Health Strategic Plan, which provided invaluable environmental context for the first time in planning for public and animal health.
- With local partners, DMR and LBVD, the PREDICT team convened a symposium on “One World One Health—PREDICT Myanmar” during the 47th Myanmar Health Research Congress in 2019. This marked the first time the congress set aside a section to offer a major focus on health related to wildlife and the environment for over 150 participants in the health field.
- Adapted the Smithsonian’s National Museum of Natural History’s mobile “Outbreak!” DIY exhibition materials to Myanmar specific content and used it during ministry and community engagement meetings as well as at the US Embassy to communicate the success of the PREDICT project and share strategies for public health interventions and disease prevention. Multiple exhibitions have been printed and shared for long-term display at the three ministry headquarters (MOHS, MOALI, MONREC) in NayPyiTaw as well as the University of Medicine and University of Veterinary Sciences.

# ONE HEALTH SURVEILLANCE

## STRATEGY FOR NATIONALLY RECOGNIZED PRIORITY ZOOONOTIC DISEASES

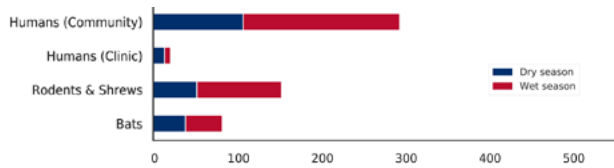


*PREDICT conducted One Health surveillance to detect priority zoonoses and emerging diseases in wildlife and people at high-risk human-animal interfaces. At the same time, PREDICT conducted interviews with local community members to better understand the social and behavioral factors associated with zoonotic disease transmission. By facilitating dialogue and sharing information between interdisciplinary partners, PREDICT strengthened One Health platforms and knowledge exchange between animal and public health sectors.*

*To enable assessment of potential trends in virus spillover and spread across space, time and season, the PREDICT team conducted surveillance activities at three key sites in Hpa-An in Kayin State, North Yangon in Yangon Region, and Shwebo in Sagaing Region over a three-year period from May 2016 to September 2018. These sites were identified by stakeholders as locations of national importance due to their dynamic human-wildlife-livestock interfaces and potential zoonotic disease exposure.*

*During ten seasonal surveillance trips over two years, the PREDICT team collected over 20,000 specimens from bats, rodents and people at previously investigated interfaces, where there was a high level of interaction between humans and animals.*

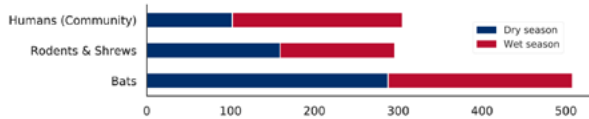
## HPA-AN



Numbers of individuals sampled by taxa group in Hpa-An

A rural agricultural community characterized by crop production and free-roaming livestock, Hpa-An features extensive, sacred bat caves that are used by people for guano harvesting, religious pilgrimages, and ecotourism. These caves house roosting colonies of approximately 300,000-500,000 bats during high season. Additionally, one cave complex maintains a resident colony of 200 macaques that regularly and directly interact with visitors through hand-feeding and physical contact. Each cave hosts between 100-500 local and international tourists daily. Traditional and religious practices of these communities include wildlife consumption and removal of footwear to visit sacred caves, respectively. Concurrent surveillance of bats, rodents, and macaques was conducted at the cave interface, alongside behavioral risk assessments and sampling of at-risk residents living near and using the bat caves for religious and livelihood purposes.

## NORTH YANGON



Numbers of individuals sampled by taxa group in North Yangon

Occupying 1,540 acres, Hlawga National Park is home to more than 2,000 free-roaming macaques (*Macaca mulatta* and *M. nemestrina*), which interact with ecotourists. Other wildlife in the park include bats, deer, boar, gaur, birds, and rodents, while domestic species including cattle, chickens, ducks, and dogs range nearby. The park receives between 200-1,000 tourists and visitors every day. PREDICT's One Health surveillance strategy targeted bats and rodents in and surrounding the National Park, as well as residents of nearby villages that may be exposed to wildlife through their work in animal and crop production, and hunting. The PREDICT team also conducted syndromic surveillance of patients at Hmawbi Hospital which provides basic health services to the local community, most of whom live in and around the Hlawga National Park.

## SHWEBO



Numbers of individuals sampled by taxa group in Shwebo

Shwe Zay Ti Monastery Compound is a rural 4,300 square meter area located between Shwebo and Yangon in central Myanmar. It is a large monastery with about 100 monks and locals residing in close contact with wildlife like rodents and bats as well as farm-raised domestic animals. Surveillance targeted bat guano after the PREDICT team identified several high-risk interfaces with people in the region.

*Laboratory testing of samples was conducted in PREDICT partner laboratories at the Ministry of Health and Sports (MOHS) Department of Medical Research for human samples, and the Ministry of Natural Resources and Environmental Conservation (MOALI) Livestock Breeding and Veterinary Department for animal samples. Both laboratories used standardized PREDICT protocols to screen for both priority zoonotic viruses of national public health concern, along with other novel and emerging viral threats.*

# HUMAN SURVEILLANCE



DEMOGRAPHICS OF PARTICIPANTS ENROLLED IN NORTH YANGON & HPA-AN DISTRICTS

	CLINIC-BASED SURVEILLANCE	COMMUNITY-BASED SURVEILLANCE			
DISTRICT	North Yangon				Hpa-An
SITE ENROLLED	Hmawbi Hospital (n=20)	Hlawga National Park (n=38)	Hmawbi villages (n=332)	Oakkan (n=12)	Hpa-An villages (n=306)
GENDER					
MALE	11 (55%)	22 (58%)	179 (54%)	3 (25%)	139 (45%)
FEMALE	9 (45%)	16 (42%)	153 (46%)	9 (75%)	167 (55%)
AGE GROUP					
CHILD (<18)	10 (50%)	0 (0%)	25 (8%)	2 (17%)	27 (9%)
ADULT	10 (50%)	38 (100%)	307 (92%)	10 (83%)	279 (91%)
AGE					
MEDIAN [MIN, MAX]	18 [3,62]	42 [18,67]	37 [2,79]	29 [3,54]	45 [2,77]

Through the PREDICT project's multidisciplinary One Health surveillance approach, our team worked with local communities to better understand social and behavioral factors associated with risks of zoonotic disease transmission, focusing on the "how" and "why" of risk. Using data-driven methods, the PREDICT team identified potential policies and intervention strategies that might be effective in preventing

or mitigating zoonotic viral spillover and spread. Insights into behavior help direct efforts to raise public awareness of personal and occupational zoonotic disease risks.

Between July 2017 and August 2018, 688 people from the community and 20 patients at the hospital completed questionnaires about their behaviour and livelihoods at high risk animal-human interfaces and provided samples for virus

testing. Participants were community members from townships in and surrounding two regions: Hmawbi, near Hlawga National Park in North Yangon, and Hpa-An. Of the respondents, 50% were female, and 50% male. The average age of participants was 40 years old, ranging from 2 to 79 years old. The majority (67%) were long term residents, living in their community for over ten years.



# EPIDEMIOLOGICAL & BEHAVIORAL RISK

Among 708 interviewed respondents, 82% were either directly exposed to wildlife and livestock through their livelihoods, or indirectly exposed by using animal products for crop production. Primary practices leading to exposure to wildlife and their byproducts included rodent and bat consumption and guano harvesting.

## SANITATION IN THE COMMUNITY

Basic food, water and sanitation hygiene practices are commonplace within the households in all communities. Preventative measures such as treating water, covering food, and using dedicated areas for human waste are highly prevalent. However, nearly half the people have observed animal feces, or animal bite marks in their food in the last year, suggesting the current measures being used are insufficient, thus presenting a disease transmission risk. Awareness of disease risks associated with open wounds while butchering was lacking, despite reporting appropriate wound care in daily life.

## PERCEPTION OF DISEASE RISK FROM ANIMALS

Knowledge of the risks of disease transmission associated with animal contact were low within the communities. Over 98% of surveyed respondents reported being exposed to live animals (small scale and household livestock in most of their residences) through daily practices, working, and living conditions, including handling, raising, petting, and sharing of dwellings.

Among 708 interviewees, 67% reported experiencing some kind of illness within the previous year. Of these, the majority had fever associated with Influenza-like Illness, Severe Acute Respiratory Illness, or Flu-like Symptoms. Most respondents were unable to link their clinical signs to possible etiologies, and only a third

speculated that the source of transmission was from animals or sick people. However, people who were exposed to live and dead animals through their livelihoods, households, and consumption practices were more likely to have experienced fever symptoms in the previous year.

Interestingly, 96% of people did not report contact with bats despite close proximity and observations of people entering bat caves at both sites. Field observations suggest contact is likely more prevalent than declared and possibly because the question was misunderstood. Of the 31 people who reported contact, bats living in houses and fecal contamination of food were the most common routes. Rodents were most frequently found in the home, with some people hunting, slaughtering, or consuming them. Of concern, people were keeping bats, primates and rodents as pets, an activity with very intimate interactions and high-risk for disease transmission.

Interactions with non-human primates were largely limited to workers in a protected area or zoo/sanctuary, with handling and or being scratched/bitten being the most frequent type of interaction reported. People that were scratched by animals were twice as likely to have reported falling ill in the last year. Conversely, respondents who practiced good hygiene following animal-related scratches and bites were 60% less likely to have fallen ill in the previous year, thus suggesting that practicing good hygiene protects against contracting disease.

High-risk behaviors such as consumption of raw meat and sick animals was commonly reported. Our survey identified that the respondents who consumed animals (when found deceased) were more likely to report an illness in the previous year. Nearly all respondents had direct contact with poultry / fowl, which are also the most common taxa to be eaten raw or when sick. These intimate and risky behaviors may facilitate transmission of viruses such as avian-origin influenza into people, especially during a disease outbreak.



## OCCUPATIONAL DISEASE RISKS

The agricultural sector consisting of agricultural, livestock, fisheries, and forestry industries comprised more than 29.8% of Myanmar's 2014-2015 gross domestic product and served as the primary source of livelihood for 61.2% of the population<sup>1</sup>. The communities we surveyed reflected this demographic with over 50% of people working in

crop or animal production. Despite reported concerns about livestock health due to their importance for food and financial security, we found a generally poor awareness of disease association between human and animal health.

At one site, a local family has been collecting guano for commercial purposes from a cave system for over three generations. Practices for collection are similar to other areas around the region with little to no skin or respiratory

protection nor any standards for washing after handling guano. Because the collection site is also a religious temple, family members are required to remove all footwear prior to entering the cave. All participants in the routine guano extraction often take refuge in the cave, eating lunch and taking short naps. Reports of poor health following guano collection is common but transient and medical attention is rarely sought after.

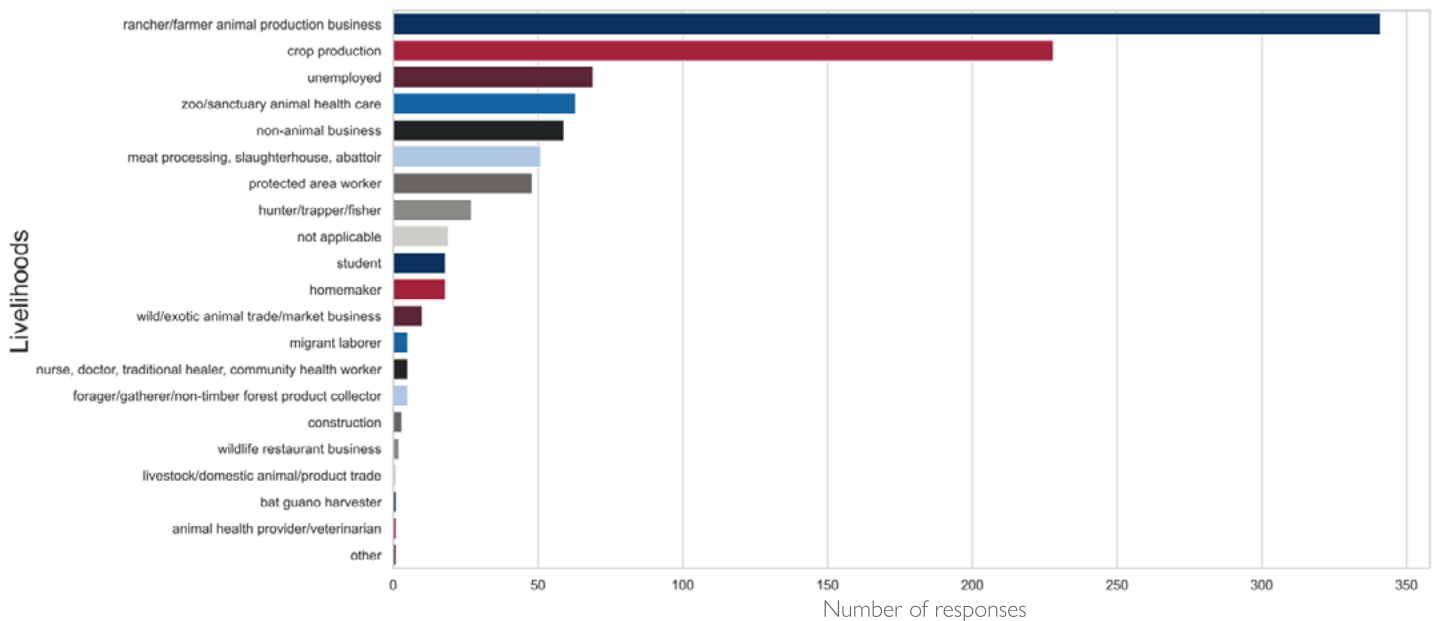


Fig. 1 Livelihoods of participants from townships in and surrounding two regions: Hmawbi, near Hlawga National Park in North Yangon, and Hpa-An

## VIRUS FINDINGS IN PEOPLE

PREDICT partner laboratory MOHS's Department of Medical Research safely tested oral swabs from 607 people, including 20 from Hmawbi Hospital in North Yangon, and 587 from members of the community (305 Hpa-An, 280 North Yangon). A total of 3,642 individual tests were conducted to detect priority viral families (Coronaviridae, Filoviridae, Orthomyxoviridae, and Paramyxoviridae) using consensus PCR. All tests for Coronaviridae, Filoviridae, and Paramyxoviridae were negative suggesting no one had an active infection for these viruses at the time of sampling.

Influenza A virus was detected in 16 oral samples from participants at two study sites; 11 in Hpa-An and 5 in North Yangon. One person was a male patient at the Hmawbi Hospital, while the rest were apparently healthy community members, comprising 10 females and 5 males. Age of positive participants ranged from 5 to 63 years old with a median age of 41. Influenza A virus is known to infect birds and mammals and is a common cause of flu like symptoms in people, including fever, cough, sore throat, muscle aches, conjunctivitis, and in severe cases pneumonia. Severity of infection is dependent on the virus subtype and immune response of the person infected. Most people (12/16) infected with Influenza A virus at the

time of PREDICT surveillance reported having a fever in the previous year, of which eight had an influenza like illness. Influenza A virus was detected in both the wet and dry seasons, and all those who tested positive had had direct contact with animals for their livelihoods, especially for females who reported direct exposure to animals and their products for cooking, meat processing and raising animals at home. Further investigation is required to subtype the Influenza A viruses detected, which would give insight into the source of the virus.

# WILDLIFE SURVEILLANCE

PREDICT tested 1,305 samples from 907 individual animals (443 rodents, 464 bats), and 155 bat guano samples from high risk human-animal disease transmission interfaces in North Yangon, Hpa-An and Shwebo. Samples collected from macaques are to be tested at a later date. Specifically, our PREDICT partner laboratory at MOALI's Livestock Breeding and Veterinary Department (LBVD) tested 8,442 rectal swabs, oral swabs and guano samples for priority viral families (Coronaviridae, Filoviridae, Orthomyxoviridae, Paramyxoviridae, and Flaviviridae) using consensus PCR which tests for active virus infection at the time of capture and sampling.



## ANIMALS TESTED FOR PRIORITY VIRAL FAMILIES AT HIGH-RISK DISEASE TRANSMISSION INTERFACES IN NORTH YANGON & HPA-AN

DISTRICT	NORTH YANGON				HPA-AN			SHWEBO	TOTAL
SITE	Hlawga National Park	Hlawga Village	Hmawbi Village	Oakkan	Cave 1	Cave 2	Hpa-An Village	Monastery Compound	
TAXA (no. positive/tested)									
BATS	3/47	1/3	0/1	0/28	3/116	0/252	0/17	-	7/464
BAT GUANO	-	-	-	-	36/86	4/73	-	0/32	40/191
RODENTS	0/111	0/36	-	-	0/2	1/291	0/3	-	1/443

## VIRUS FINDINGS IN WILDLIFE

Novel coronaviruses and paramyxoviruses were detected in bats, bat guano and rodent samples in caves near communities in Hpa-An, and in bats at Hlawga National Park in North Yangon (Table 2). Viruses were detected in animals in both the wet and the dry seasons. There is no evidence at this time to suggest that these novel viruses pose a threat to human health. These findings prompted a direct response from the LBVD Director General, Dr. Ye Tun Win: “the identification of new viruses from bats and rats in Myanmar is due to the efforts of the PREDICT project and addressed the need for long-term collaboration across the three ministries (the MOHS, MOALI and

MONREC) in strengthening the capacity for disease surveillance and laboratory testing to identify new pathogens which could potentially be transmitted between animals and humans.”

### BAT GUANO

Four novel coronaviruses (PREDICT\_CoV-47, PREDICT\_CoV-82, PREDICT\_CoV-92, PREDICT\_CoV-96) and one paramyxovirus (PREDICT\_PMV-48) were found in bat guano from caves in Hpa-An.

The types of virus found differed by site; PREDICT\_CoV-92, PREDICT\_CoV-96 and PREDICT\_PMV-48 were detected in guano samples from roundleaf bat colonies (*Hipposideros species*) in Hpa-An Cave 1, while PREDICT\_CoV-82

and PREDICT\_CoV-47 were found in samples from wrinkle-lipped free-tailed bat colonies (*Chaerephon plicatus*) in Hpa-An Cave 2. Several samples were positive for more than one virus which is not surprising given that the samples are pooled fecal/urine (guano) from many individuals and a bat can be infected with more than one virus. All bat guano samples were negative for additional priority viral families (Filoviridae, Orthomyxoviridae, and Flaviviridae).

### BATS

Only 2% (7/464) of bats captured and sampled tested positive for viruses, all of which were novel coronaviruses. The majority of positive samples were from rectal swabs, with only one oral swab testing positive for PREDICT\_CoV-96.

All bat samples were negative for the other priority viral families Paramyxoviridae, Filoviridae, Orthomyxoviridae, and Flaviviridae).

Coronaviruses were detected in bats sampled at both Hpa-An and North Yangon. Three roundleaf bats (*Hipposideros* species) in Hpa-An Cave 1 were positive for two novel coronaviruses PREDICT\_CoV-93 and PREDICT\_CoV-96, the latter having also been detected in bat guano collected from the same cave. Three greater Asian house bats

(*Scotophilus heathii*) bats in Hlawga National Park, North Yangon, were positive for the novel PREDICT\_CoV-35, one of which also tested positive for novel PREDICT\_CoV-90. Interestingly, PREDICT\_CoV-35 was also detected in an unidentified tomb bat (*Taphozous* sp.) in Hlawga Village which is adjacent to Hlawga National Park.

## RODENTS

The majority (84%) of rodents were rats belonging to the *Rattus* genus (*Rattus exulans*, *Rattus norvegicus*, *Rattus*

*rattus*, *Rattus tanezumi*), while the lesser bandicoot rat (*Bandicota bengalensis*), the Chinese white bellied rat (*Niviventer confucianus*) and Asian house shrews (*Suncus murinus*) were also sampled. Out of 443 animals tested, one Oriental house rat (*Rattus tanezumi*) in Hpa-An Cave 2 tested positive for a novel paramyxovirus PREDICT\_PMV-132 in both its rectal and oral swabs. All rodents were negative for other priority viral families (Coronaviridae, Filoviridae, Orthomyxoviridae, and Flaviviridae).



## VIRUS TABLE

VIRAL FAMILY	VIRUS	SPECIES	SAMPLING LOCATION	# OF POSITIVE INDIVIDUALS		
				TOTAL	WET SEASON	DRY SEASON
Coronavirus	PREDICT_CoV-35	Greater Asian House Bat, Unidentified Taphozous Bat	Hmawbi	4	3	1
	PREDICT_CoV-47	Wrinkle-Lipped Free-Tailed Bat	Hpa-An	1	1	0
	PREDICT_CoV-82	Wrinkle-Lipped Free-Tailed Bat	Hpa-An	3	3	0
	PREDICT_CoV-90	Greater Asian House Bat	Hmawbi	1	1	0
	PREDICT_CoV-92	Intermediate/Grand Roundleaf Bat Species Complex	Hpa-An	36	0	36
	PREDICT_CoV-93	Intermediate/Grand Roundleaf Bat Species Complex	Hpa-An	3	0	3
	PREDICT_CoV-96	Intermediate/Grand Roundleaf Bat Species Complex	Hpa-An	4	0	4
Paramyxovirus	PREDICT_PMV-48	Intermediate/Grand Roundleaf Bat Species Complex	Hpa-An	4	0	4
	PREDICT_PMV-132	Oriental House Rat	Hpa-An	1	0	1
Influenza virus	Influenza A	Human	Hpa-An, Hmawbi, Hmawbi Hospital	16	9	7
<b>Total</b>				<b>73</b>	<b>17</b>	<b>56</b>

# COMMUNITY ENGAGEMENT & RISK COMMUNICATION

The PREDICT team was committed to community engagement and worked with local villages and partners to raise awareness of zoonotic disease threats and strengthen capacity for prevention, surveillance, and detection. Sensitization meetings were held in all PREDICT project sites over the life of the project. At these meetings, our team worked with local communities to create a dialogue and build trust for implementation of surveillance activities and a platform to communicate One Health approaches.

Implementation of outreach and engagement activities provided a forum for PREDICT to empower community members to make the most informed decisions regarding their own health security on an individual level and from a community perspective. Direct community engagement in our concurrent surveillance sites of Hpa-An and North Yangon involved project introduction, permission requests, progress reporting, and involvement in surveillance activities. In 2017, the PREDICT team organized a One Health day event at Hlawga National Park that was very well attended, offering an opportunity to further engage with the community at large.

Through behavioral risk characterization, PREDICT was able to identify risk factors and to target zoonotic disease risk mitigation at the local scale. In community meetings, the PREDICT team provided summaries of project findings and shared resources to raise awareness of disease. Key visual education tools were provided to support specific public health recommendations, including a mobile “Outbreak” DIY panel exhibition developed in conjunction with Smithsonian’s National Museum of Natural History, and PREDICT’s behavior change picture book *Living Safely with Bats* (available at [www.predict.global](http://www.predict.global)) that is designed to minimize risks of infection to bat-borne viruses such as Ebola, Marburg, and MERS Coronavirus.



# STRENGTHENING CAPACITY



The PREDICT team targeted sustainable, lasting health impacts through training, education, outreach and capacity-strengthening with in-country partner institutions. The team trained 150 individuals in the One Health field, provided professional development for over 400 students, and educated and empowered local communities to make informed decisions that benefit community health. PREDICT strengthened and developed capacity through hands-on skill training, didactic lectures, development of supply chains, and laboratory equipment procurement, and distribution of educational resources at the community, university, and government levels. Cross-training and updates were also provided to relevant international counterparts including FAO, WHO, and CDC representatives for further collaboration.

The PREDICT team has been regarded by the ministries as an integral partner in developing plans for zoonotic infectious disease control and response, and as such PREDICT actively participated in the development of Myanmar's inclusive One Health National Strategic Plan (2017-2022) in close collaboration with relevant government departments, three universities, and international partners (WHO, FAO, CDC). This activity effectively bridged the gap between advocacy and action related to wildlife and environmental health policy. The PREDICT project played

key facilitation and coordination roles in bringing representatives together from three different ministries for coordinated One Health planning and activities. Specifically, the PREDICT team involved representatives from the three relevant ministries for animal, human and environmental health in all activities and provided training on zoonotic disease surveillance. Through the PREDICT project's activities in Myanmar, representatives from the Ministry of Natural Resources and Environmental Conservation (MONREC) were invited to participate in national One Health implementation meetings, marking the first time MONREC began participating in the protection of human health.

Community health workers and forestry department officials sought to improve their identification skills of high-risk interfaces and assisted in the selection of sites for PREDICT project activities. By training these key workers, they are now better equipped to identify and address potential sources of zoonotic disease exposure and behavioral risk factors in the community. Their newfound knowledge is being disseminated amongst the community members and is being passed on to neighboring community health workers, creating a network of trained One Health professionals, especially with regard to disease investigation and treatment therapy for hospitalized patients.

Beyond the direct community involvement, PREDICT established relationships to develop the higher education curriculum for the next generation of One Health professionals by offering lectures to three major universities including the University of Medicine, the University of Veterinary Sciences, and the University of Yangon's Zoology Department. Additionally, cross-training presentations on the PREDICT One Health strategy were offered to the scientific and physician communities through the Department of Medical Research.

Additionally, the PREDICT project enhanced Myanmar's national laboratory systems capability to conduct zoonotic disease detection in two facilities including the Ministry of Health and Sports' Department of Medical Research as well as the Ministry of Livestock, Agriculture, and Irrigation's Livestock Breeding and Veterinary Department. Scientists from both facilities were sent to the University of California, Davis as well as the Pasteur Institute in Cambodia, respectively, for advanced training in PREDICT diagnostic protocols. Through PREDICT, both facilities received deep freezers, thermocyclers, gel electrophoresis units, and all of the necessary items to conduct PREDICT project testing. Supply chains were created that benefitted local suppliers in Myanmar which continue to be used by the respective labs post-PREDICT.

# PRACTICAL IMPLICATIONS & KEY BEHAVIORAL INTERVENTIONS

In Myanmar, the PREDICT project's activities have benefited national and community zoonotic disease surveillance, preparedness and response. With the discovery of novel coronaviruses in Myanmar's bat populations, the One Health network was strengthened by incorporating wildlife and the environment into national planning for the prevention of emerging infectious diseases. PREDICT's lasting impact has created a road map for coordination and support between the three ministries for human and animal health and the environment, which together have a basis to conduct continued research and capacity building for further surveillance activities beyond the PREDICT project.

Through community engagement and participation across the project, PREDICT identified a desire of at risk-communities to learn how to protect themselves while appreciating the ecological benefit of coexisting with wildlife. For most, the PREDICT project's disease risk communication and strategies for living safely with animals was the first public health education they had received.

Although no evidence of exchange or sharing of viruses was identified between wildlife and humans, the discovery of novel viruses from priority high-risk viral families in bats and rodents in caves frequently visited by people, including tourists, demonstrates a potential and

previously unrecognized risk for disease transmission in Myanmar.

By investigating community behavior, the PREDICT team identified high-risk routine practices that correlate with human illness. Interventions emphasizing practical behaviors in industries with frequent and intimate interactions such as animal production, hunting and sanctuaries should be explored. Provision and use of protective gear or clothing (e.g. gloves, face masks) to prevent wounds and contact with infected animals would be effective recommendations to reduce occupational exposures.

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