
USAID
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PREDICT
EGYPT & JORDAN
One Health in action (2015-2019)

EGYPT & JORDAN

Globally, there have been more than 2,250 confirmed human cases of Middle East Respiratory Syndrome (MERS) Coronavirus causing more than 800 deaths. The majority of human MERS infections have been detected in the Middle East, including the first known human cases in Jordan. Dromedary camels are the presumptive source of primary human MERS infections. The PREDICT project in Egypt and Jordan worked with existing public and animal health surveillance systems by exploring the incidence of priority viral families in rarely studied hosts such as bats and camels. PREDICT Egypt and Jordan teams played an integral part in the study of MERS-CoV at the human-animal interface by looking at evidence of MERS infection in camels, humans exposed to camels, and bats. Together with host country governments and our local partners, we also looked into viruses that are not commonly studied as part of the routine public and animal health surveillance in Jordan or Egypt such as filo- and paramyxoviruses.

In Egypt, there are significant camel-human interfaces, and dromedary camel herds in Greater Giza were found to have evidence of infection with MERS coronavirus. These sites are also high tourist areas where camels are used for tourists to ride or have their pictures taken with the animals. In Al Khatatbah, a natural area in Egypt, there are significant bat populations which are distributed directly along camel trade routes connecting camel markets to camel abattoirs.

In collaboration with Food and Agriculture Organization (FAO) of the United Nations, the PREDICT team in Jordan investigated zoonotic spillover risk at interfaces between humans, bats, and camels. Working with ministry partners and FAO, sites along the camel value chain such as abattoirs, live animal markets, and farms were identified for biological surveillance and behavioral risk characterization. The first known human cases of MERS were in Middle Jordan, and through our work we found camel herds in Middle Jordan with MERS virus. Camel herds in Northern Jordan were also found to have MERS virus.

Surveillance for Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in North Africa and the Middle East

EGYPT

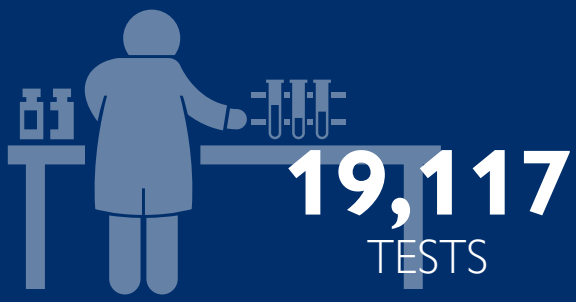
Global Health Security Agenda

DEVELOPED the One Health Workforce by training 18 people in Egypt.

OPERATIONALIZED One Health surveillance and sampled over 2.1K animals and people, helping minimize the spillover of zoonotic disease threats from animals into human populations.

LABORATORY STRENGTHENING

· Center of Scientific Excellence for Influenza Viruses



DETECTED 11 unique viruses in both animal and human populations.

AHMED KANDEIL

Researcher
National Research Centre

"PREDICT enhanced our lab capacity by making use of the viral testing protocols."

MOKHTAR GOMAA

Assistant Researcher
National Research Centre

"I enjoyed the multiple field trips collecting samples from bats and humans."

ACHIEVEMENTS

- Conducted surveillance on bats and applying the PREDICT influenza testing protocols on the collected samples led to the discovery of a new influenza virus in Egyptian fruit bats. This virus was isolated and characterized rendering it the first and only wildtype bat flu isolate globally. The virus was distinct from any previously discovered influenza A virus suggesting that it is potentially a novel H19N12 subtype.
- Closely coordinated and cooperation between PREDICT/Egypt and PREDICT/Jordan was mutually beneficial. Members of PREDICT/Jordan visited the laboratory in Cairo to familiarize themselves with the work process. Members of PREDICT/Egypt assisted with training the Jordanian team members on the conduct of human subject research. The lab in Cairo assisted PREDICT/Jordan by conducting serological analysis for MERS-CoV antibodies on human sera collected in Jordan.
- Trained and used PREDICT laboratory diagnostic protocols to expand the lab's capacity beyond influenza and coronavirus testing to include paramyxovirus, flavivirus, and filovirus capacities.

LOCAL PARTNERS

- Ministry of Health
- Ministry of Environment

JORDAN

>20

DEVELOPED the One Health Workforce by training more than 20 people in Jordan.

>2.1K

OPERATIONALIZED One Health surveillance and sampled over 2.1K animals and people, helping minimize the spillover of zoonotic disease threats from animals into human populations.

LABORATORY STRENGTHENING

· Jordan University of Science and Technology

>49,395
TESTS

5
PREDICT

8
KNOWN

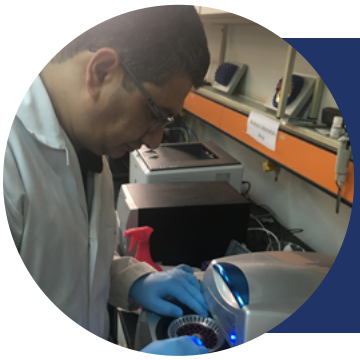
DETECTED 13 unique viruses in both animal and human populations.

Global Health Security Agenda

EHAB ABU-BASHA

Jordan University of Science & Technology (JUST)

"PREDICT has provided me with an opportunity to become deeply involved in zoonotic disease research and health capacity building in Jordan. Our contributions to the PREDICT project will have a lasting impact on One Health implementation in Jordan."



MUSTAFA ABABNEH

Jordan University of Science & Technology (JUST)

"Discovering whether a detected virus has the potential to infect humans and to cause illness is a central part of the project. We may find a multitude of viral RNA in our samples, so prioritizing which findings are of greater importance helps us sort through the data."

ACHIEVEMENTS

- Trained 25 individuals, including two graduate students in One Health skills
- Sampled >2,100 individuals (animals and people)
- Interviewed >1,000 people on behavior and practices associated with viral transmission and spread, specifically MERS-COV
- Strengthened one major research lab and two additional labs critical for surveillance and detection of zoonotic disease threats
- Detected six unique viruses and conducted the first ever reporting to OIE of MERS-COV in camels
- Empowered ministry partners to establish and operationalize Jordan's first ever national One Health platform

LOCAL PARTNERS

- Food and Agriculture Organization (FAO)
- Jordan Ministry of Agriculture
- Jordan Ministry of Environment
- Jordan Ministry of Health
- Jordan University of Science and Technology
- Princess Haya Biotechnology Center
- Royal Scientific Society
- The Hashemite Fund for Development of Jordan (Badia Fund)
- The Royal Society for the Conservation of Nature
- USAID/Jordan
- World Health Organization (WHO)
- World Organization for Animal Health (OIE)

VIRUS DETECTION

The PREDICT project's strategy for viral detection included screening samples using broadly reactive consensus PCR (cPCR) for priority viral families, including corona-, filo-, flavi-, and paramyxo- families, and influenza virus. Positives detected using these assays were sequenced to identify the viruses and compare their relationship to known pathogens, and viruses were prioritized for further characterization. This approach allows for detection of both known and novel viruses and improves our understanding of the presence and diversity of viruses, as well as potential pathogens, in humans and animals.

In Egypt, PREDICT project protocols were implemented at the laboratory of the Center of Scientific Excellence for Influenza Viruses, part of the Egyptian National Research Centre in Giza. This is a governmental virology lab which specializes in conducting research on emerging viruses at the human-animal interface, particularly coronaviruses and influenza viruses. Sampling efforts led to the accumulation of more than 6,700 biological samples safely collected from both humans and bats. After conducting more than 17,000 tests on 2,388 bat samples and 363 human nasal swab samples, the team detected 11 unique viruses, all within bat hosts. These include five known viruses (three coronaviruses, one paramyxovirus, and one influenza virus) and six novel paramyxoviruses.

In Jordan, the PREDICT project's partner laboratory at Jordan University of Science and Technology (JUST) tested animal and human samples for coronaviruses to capture the viral diversity present in the family that includes MERS-CoV, in addition to testing for the other priority viral families. Our team established a biobank of over 15,000 (>7,500 human and >7,500 bat) samples including whole blood, oral and nasal swabs, urine, feces, and serum. Over 16,000 PCR tests were conducted, resulting in the detection of 13 unique viruses (eight known coronaviruses, four novel coronaviruses, and one novel paramyxovirus).

VIRUS TABLE (EGYPT)

VIRAL FAMILY	VIRUS	SPECIES	SAMPLING LOCATION	# OF POSITIVE INDIVIDUALS TOTAL	WET SEASON	DRY SEASON
Coronavirus	Bat coronavirus HKU9	Egyptian Fruit Bat	Al Khatatbah, Banha	9	9	0
	Rousettus bat coronavirus /NRC-1	Egyptian Fruit Bat	Banha	4	4	0
	Rousettus bat coronavirus /NRC-2	Egyptian Fruit Bat	Al Khatatbah, Banha	8	8	0
Paramyxovirus	PREDICT_PMV-113	Egyptian Fruit Bat	El Mansoria	1	0	1
	PREDICT_PMV-114	Egyptian Fruit Bat	Banha	1	1	0
	PREDICT_PMV-115	Egyptian Fruit Bat	Banha	1	1	0
	PREDICT_PMV-116	Egyptian Fruit Bat	Banha	1	1	0
	PREDICT_PMV-118	Egyptian Fruit Bat, Kuhl's Pipistrelle	Birqash, El Mansoria	14	0	14
	PREDICT_PMV-119	Egyptian Slit-Faced Bat	El Mansoria	1	0	1
	Bat paramyxovirus R_aeg_UPE766/525/122	Egyptian Fruit Bat	Al Khatatbah	1	1	0
Influenza virus	Influenza A	Egyptian Fruit Bat, Egyptian Tomb Bat, Kuhl's Pipistrelle	Al Khatatbah, Banha, Birqash, El Mansoria, El Shohada	157	116	41
Total				**198**	**141**	**57**

VIRUS TABLE (JORDAN)

VIRAL FAMILY	VIRUS	SPECIES	SAMPLING LOCATION	# OF POSITIVE INDIVIDUALS TOTAL	WET SEASON	DRY SEASON
Coronavirus	Betacoronavirus 1 (OC43)	Human	Aljoun, Wadi Alseer	5	5	0
	PREDICT_CoV-65	Greater Horseshoe Bat, Lesser Mouse-Tailed Bat, Mediterranean Horseshoe Bat, Mehely's Horseshoe Bat, Schreiber's Long-Fingered Bat, Unidentified Insectivorous Bat	Aljoun, Wadi Alseer	14	3	11
	PREDICT_CoV-91	Unidentified Insectivorous Bat	Aljoun	1	0	1
	PREDICT_CoV-112	Mehely's Horseshoe Bat	Aljoun	1	1	0
	PREDICT_CoV-113	Unidentified Insectivorous Bat	Aljoun	1	1	0
	Bat alphacoronavirus/ GS2013/HuB2013	Blasius's Horseshoe Bat, Egyptian Fruit Bat, Lesser Mouse-Tailed Bat, Mediterranean Horseshoe Bat, Mehely's Horseshoe Bat, Unidentified Bat, Unidentified Insectivorous Bat	Aljoun, Wadi Alseer 54	13	41	
	Bat coronavirus 1	Unidentified Bat	Aljoun	1	1	0
	Bat coronavirus BM48-31/ BGR/2008	Chinese Rufous Horseshoe Bat, Egyptian Fruit Bat, Lesser Mouse-Tailed Bat, Mediterranean Horseshoe Bat, Mehely's Horseshoe Bat, Schreiber's Long-Fingered Bat, Unidentified Bat, Unidentified Insectivorous Bat, Unidentified Rhinopomatidae Bat	Aljoun, Wadi Alseer	52	16	36
	Bat coronavirus HKU9	Egyptian Fruit Bat, Lesser Mouse-Tailed Bat, Mediterranean Horseshoe Bat, Unidentified Insectivorous Bat	Aljoun, Wadi Alseer	6	4	2
	Betacoronavirus 1 (Bat)	Unidentified Insectivorous Bat	Aljoun	1	0	1
	Rousettus bat coronavirus/ NRC-1	Egyptian Fruit Bat, Unidentified Insectivorous Bat	Aljoun, Wadi Alseer	3	3	0
	Rousettus bat coronavirus/ NRC-2	Egyptian Fruit Bat	Wadi Alseer	2	2	0
Paramyxovirus	PREDICT_PMV-176	Lesser Mouse-Tailed Bat	Wadi Alseer	1	0	1
Total				**138***	**48***	**90***

*Numbers do not total as four bats were co-infected with two viruses

FINDINGS IN PEOPLE

The PREDICT team in Egypt safely tested 2,541 nasal swab samples from humans, an effort which resulted in no positive virus detections. These results indicate that none of the participants sampled had active infections at the time, but do not preclude the possibility for previous exposure to viruses, as the PREDICT project's cPCR assays are only capable of detecting active viral infections.

In Jordan, the only virus detected in humans (n = 5) was Betacoronavirus 1 (OC43), a human coronavirus known to cause mild to moderate respiratory illness. Although belonging to the same genus as SARS-CoV-2, the novel betacoronavirus causing the current COVID-19 pandemic, OC43 is not closely related to SARS-CoV-2. OC43 is an established human coronavirus first detected in the 1960s and one of seven coronaviruses known to infect humans (229E, NL63, OC43, HKU1, SARS, SARS-2, and MERS).

FINDINGS IN BATS

In total, the PREDICT team in Egypt tested 2,388 bat samples (oral, rectal, and oropharyngeal swabs, and blood) collected from 1,003 individual bats. One hundred ninety eight (198) of these specimens tested positive for a corona-, paramyxo-, or influenza virus. Paramyxovirus diversity was the highest, as seven unique viruses were detected in three different bat species. A novel paramyxovirus, PREDICT_PMV-118, was detected in 14 individuals; one frugivorous bat, the Egyptian fruit bat (*Rousettus aegyptiacus*), and 13 insectivorous bats, Kuhl's pipistrelle (*Pipistrellus kuhlii*). All other detected paramyxoviruses were only found in one individual, each. Although PREDICT_PMV-118 was the most commonly detected paramyxovirus by the PREDICT team in Egypt, there is no evidence to suggest that this virus, nor any other paramyxovirus detected, pose a threat to human health.

All three coronaviruses detected are known bat viruses and were found within a single species, the Egyptian fruit bat, from two independent sites. Each of the 21 coronavirus detections occurred during the wet season despite a relatively even sampling effort across the wet and dry seasons at Al Khatatbah and Banha. Although just a single influenza virus, Influenza A, was detected within bats, it was the most commonly detected virus (infecting 157 individual bats), infected the greatest diversity of bat hosts (three species; fruit-eating and insect-eating), and was the most widely distributed (found at five independent sites). In addition, Influenza A was more commonly detected in the wet season (74%) than dry season (26%).

A similar testing effort from the PREDICT team in Jordan for bats was observed; 2,160 bat samples representing 1,080 unique bats were analyzed, of which 133 individuals were positive for coronavirus and/or paramyxovirus infections. Twelve unique viruses (11 coronaviruses and one paramyxovirus) were detected in at least eight bat species from two sites in northwestern Jordan. Of the four novel coronaviruses detected, none are believed to pose a threat to human health. The other seven coronaviruses detected are known bat coronaviruses belonging to the alphacoronavirus and betacoronavirus genera, of which three betacoronaviruses were also detected in Egypt in the same species, Egyptian fruit bats.

Three individual insect-eating bats from Aljoun belonging to the *Rhinolophus* genus were co-infected with two coronaviruses, Bat Alphacoronavirus/GS2013/HuB2013 and Bat Coronavirus BM48-31/BGR/2008. These two known coronaviruses were also the most commonly detected viruses in Jordan, together representing approximately 75% of the total virus detections in bats. An additional *Rhinolophus* sp. from this site was also co-infected with two coronaviruses, the known Bat Coronavirus BM48-31/BGR/2008 and novel PREDICT_CoV-113. The single paramyxovirus detected was a novel virus, PREDICT_PMV-176, in one lesser mouse-tailed bat (*Rhinopoma hardwickii*). This is the sole detection of PREDICT_PMV-176 in the entire PREDICT project, suggesting that this is not a prevalent virus.

TABLE 2. VIRAL FAMILIES DETECTED IN BAT SAMPLES IN EGYPT (TOP) AND BY HIGH-RISK ANIMAL-HUMAN INTERFACE (BOTTOM)

Viral Test Type

	Coronaviruses	Filoviruses	Flaviviruses	Influenzas	Paramyxoviruses
Nycteris (bats)	0% (100)	0% (50)	0% (50)	0% (100)	2% (50)
Pipistrellus (bats)	0% (376)	0% (188)	0% (188)	0.8% (376)	6.9% (188)
Rousettus (bats)	0.7% (3496)	0% (2130)	0% (2130)	7.9% (3496)	0.3% (1748)
Taphozous (bats)	0% (40)	0% (20)	0% (20)	2.5% (40)	0% (20)

	Coronaviruses	Filoviruses	Flaviviruses	Influenzas	Paramyxoviruses
crop production	0.8% (2808)	0% (1786)	0% (1786)	9.7% (2808)	0.3% (1404)
natural areas	0% (1204)	0% (602)	0% (602)	0.7% (1204)	2.7% (602)

TABLE 3. VIRAL FAMILIES DETECTED IN BAT SAMPLES IN JORDAN (TOP) AND BY HIGH-RISK ANIMAL-HUMAN INTERFACE (BOTTOM)

Viral Test Type

	Coronaviruses	Filoviruses	Influenzas	Paramyxoviruses
Miniopterus (bats)	18.8% (16)	0% (8)	0% (8)	0% (8)
Pipistrellus (bats)	0% (8)	0% (4)	0% (4)	0% (4)
Rhinolophus (bats)	6.5% (1896)	0% (948)	0% (948)	0% (948)
Rhinopoma (bats)	2.1% (676)	0% (338)	0% (338)	0.3% (338)
Rousettus (bats)	0.8% (840)	0% (420)	0% (420)	0% (420)
Unknown (bats)	2.4% (884)	0% (442)	0% (442)	0% (442)

	Coronaviruses	Filoviruses	Influenzas	Paramyxoviruses
animal production; crop production	1.3% (620)	0% (310)	0% (310)	0% (310)
crop production	1.1% (1252)	0% (626)	0% (626)	0.2% (626)
natural areas	6% (2448)	0% (1224)	0% (1224)	0% (1224)

Building from Table 1 (the virus detection tables above), these heatmaps provide more granular information about sampling effort and detection rates across the five priority viral families: coronaviruses, filoviruses, flaviviruses, influenza viruses, and paramyxoviruses. First, data are summarized at the host genus level, and broader taxonomic groups are shown in parentheses. Next, data are summarized by reported disease transmission interfaces at the sampling sites. Data within the heatmaps show the percentage of viral detections that were confirmed positive (%) and the number of PCR tests conducted (in parentheses). The intensity of red color within the heatmaps scales with viral detection rate. Host taxa or interfaces that never yielded positive viral tests for a given viral group are shown in white, while red coloration indicates increasingly higher rates of viral detection.

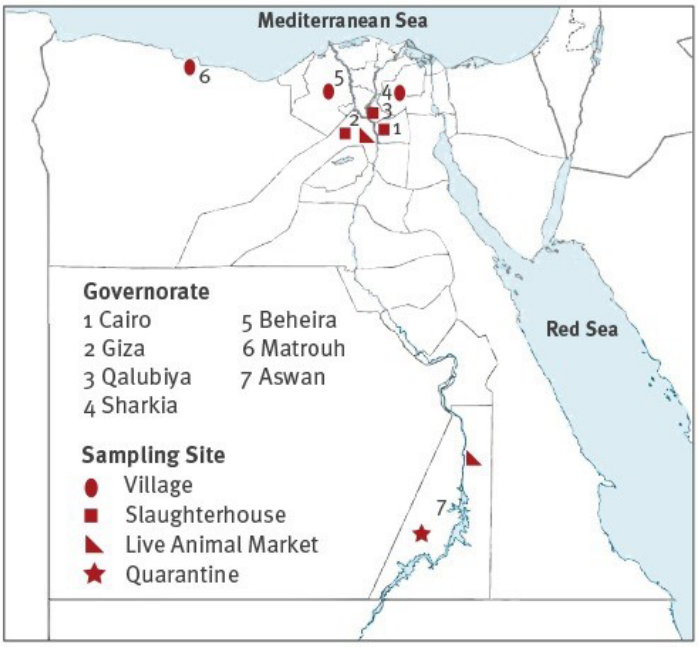
ISOLATION & CHARACTERIZATION OF A DISTINCT INFLUENZA A VIRUS FROM EGYPTIAN FRUIT BATS

As part of surveillance efforts, the PREDICT project safely collected samples from four bat species in Egypt. Samples were tested for influenza virus and our team detected, isolated, and characterized a novel subtype of Influenza A virus in Egyptian fruit bats. Out of 1,202 swabs analyzed, 105 swabs collected from a single roosting site tested positive by real time PCR (RT-PCR). The roosting site was in an abandoned house within a village in a densely inhabited agricultural area in the Nile Delta region. Bats from the roost likely fed on fruits in nearby village orchards. Genetic analysis of the virus suggested ancestry with other H9 viruses, and the virus showed a low level of cross-reactivity with serum raised against H9N2 viruses. The virus had an affinity to avian-like receptors and may have originated from an avian host. In controlled laboratory experiments, the virus was also shown capable of infecting mice. To explore exposure to the virus in bats in the roost, we collected additional serum a few weeks after the initial detection of the virus. Antibody testing showed that bats were seropositive for the isolated viruses, though no signs of disease were noted in the roost. Viruses such as this novel subtype of influenza may have the potential to infect across taxa, including domestic birds, mammals, and potentially humans. We recommend further surveillance in bats for disease threats to better understand the distribution, diversity, and potential risks of spillover. This work was published in the Journal of Virology in January 2019 (Kandeil et al. 2019).

EPIDEMIOLOGICAL & BEHAVIORAL RISK

TRANSBOUNDARY MERS-CoV RISK ALONG THE CAMEL-MARKET VALUE CHAIN

Our team in Egypt partnered with FAO to investigate the prevalence of MERS-CoV in imported and resident camels along with the prevalence of the virus among other domestic animals in country. Between August 2015 and January 2016, 1,176 sera and 1,223 nasal swabs were collected from 1,223 animals: 1,078 dromedary camels (339 resident and 739 imported) and 145 other domestic animals (cattle, sheep, goats, donkeys, buffalo, and horses) from quarantine posts, live animal markets, slaughterhouses and villages across seven governorates of Egypt. Samples were also collected from 24 fruit bats (*Rousettus aegyptiacus*) and 85 insectivorous bats (*Pipistrellus kuhlii, Nycteris thebaica,* and *Taphozous perforates*) from Abo Rawash, Giza governorate. Serologic and molecular testing for MERS-CoV was performed on the samples using serological neutralization assays and real-time reverse transcription-PCR (rtRT-PCR). Of the 1,031 camels serologically tested, 871 (84.5%) had MERS-CoV neutralising antibodies in their sera and the seroprevalence was significantly higher in imported (614/692; 88.7%) than in resident camels (75.8%). Seroprevalence varied significantly among camels originating from East Africa, Sudan, and Egypt. Additionally, we found significant differences between camels sampled from live animal markets, quarantine facilities, slaughterhouses, and villages. Adult camels had significantly higher seroprevalence (87.3%) than young camels (51.8%). Forty-one (3.8%) camels tested positive for MERS-CoV using MERS-CoV PCR tests, indicating the presence of active or passive viral infection. Four of these camels originated from East Africa, 35 from Sudan, and the other two from the study sites in Egypt. None of the 91 tested bats were positive for MERS-CoV neutralising antibodies and all genetic tests performed on bat samples were also negative. This study clearly shows that MERS-CoV is ubiquitous in camels in Egypt and highlights the role camels play as intermediate hosts for MERS-CoV especially in the transboundary camel value chain. While no human cases have been reported from the countries of origin in Sudan and East Africa, additional surveillance and monitoring is critical to follow camels from their country of origin until they reach the slaughterhouses to better understand the risks and epidemiology of the disease along the camel market chain.

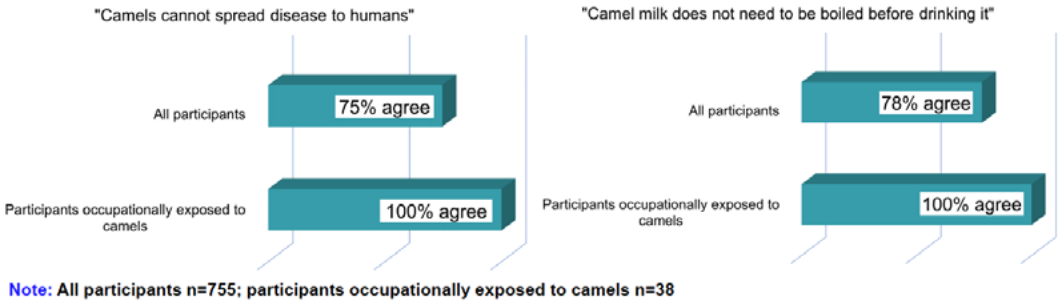


Map of the collected samples from dromedary camels and domestic animals in Egypt. Credit: Ali et al. 2017, *EuroSurveillance.*

KNOWLEDGE, ATTITUDES, BELIEFS, AND PRACTICES PERTAINING TO CAMEL-TO-HUMAN DISEASE RISKS IN JORDAN

Even the most efficacious behavioral interventions require overcoming knowledge, attitudinal, belief, cultural, and practical barriers in order to be effective, sustainable, and successful. In Jordan, the PREDICT team worked with a population occupationally exposed to camels to characterize the knowledge, attitudes, and beliefs pertaining to camel-to-human disease risks and to identify potential barriers to implementing protective practices such as use of personal protective equipment (PPE) and frequent handwashing. From February 2018 to August 2018, 755 participants were enrolled and interviewed using a focused questionnaire designed to assess knowledge, attitudes, and beliefs about camel-to-human disease risks. For those reporting working with camels or camel products, or within camel living environments, another interview was conducted using a separate questionnaire assessing PPE and handwashing practices as well as attitudes and beliefs about using various types of PPE at work.

FIGURE 2. KNOWLEDGE, ATTITUDES, & BELIEFS ON CAMEL-TO-HUMAN DISEASE RISKS IN JORDAN



Note: All participants n=755; participants occupationally exposed to camels n=38

FIGURE 3. SELF-REPORTED BIOSECURITY BEHAVIORAL PRACTICES AMONG THOSE OCCUPATIONALLY EXPOSED TO CAMELS IN JORDAN

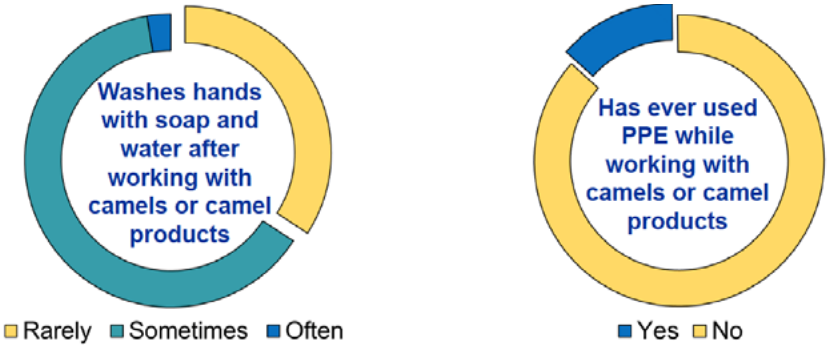
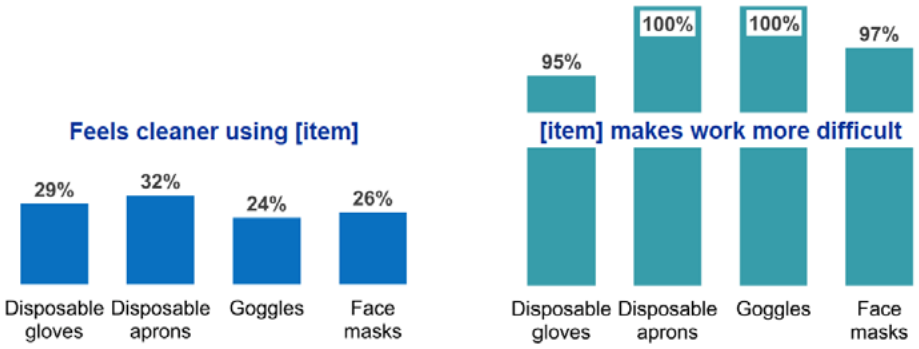


FIGURE 4. ATTITUDES & BELIEFS ABOUT PPE USE AMONG THOSE OCCUPATIONALLY EXPOSED TO CAMELS IN JORDAN



Our results clearly show barriers to implementing protective practices that could reduce risks for disease transmission in at-risk individuals that have frequent contact with camels. In this population there is a widespread belief that camels cannot spread disease to humans, particularly among those who are routinely occupationally exposed to camels. Current PPE use and frequent handwashing among those working with camels is minimal, and use of PPE such as gloves, protective clothing, and face coverings is widely perceived as burdensome. We recommend addressing these barriers through a multifaceted risk reduction and behavioral change communication intervention that promotes knowledge about camel-to-human disease risk, provides PPE and handwashing stations, provides training on PPE and handwashing practices, and normalizes PPE use and handwashing among those working with camels or camel products.

SPECIAL FEATURES

THE FIRST NATIONAL COMMITTEE FOR ONE HEALTH IN THE MIDDLE EAST

In Jordan, the PREDICT team was instrumental in the development of a national One Health platform. Through multisectoral engagement including representation from a variety of relevant institutions along with outreach and partnership building, the PREDICT project established points of contact within the Ministry of Agriculture (MOA), Ministry of Health (MOH), Ministry of Environment (MOE), USAID/Jordan, World Health Organization (WHO), Food and Agriculture Organization (FAO), World Health Organization (OIE) and Royal Scientific Society (RRS) to serve on the first interdisciplinary One Health committee. This committee met regularly and served as a platform for future implementation of One Health approaches in-country. This collaboration is novel and serves as the first national committee for One Health in the area. Inspired by the PREDICT project's achievements, the committee is currently focused on progress, legacy, and the future of One Health in the country as the project has transferred leadership to the Jordanian Ministry of Health to lead future endeavors.

CAPACITY STRENGTHENING

As part of the PREDICT project's strategic regional south-south training exchanges to share knowledge and develop communities of practice, we promoted collaboration between Egypt's National Research Centre's Center of Scientific Excellence for Influenza Viruses and the Jordan University of Science and Technology through joint training and sample/data sharing. The PREDICT Egypt team traveled to Jordan for hands-on training in safe bat capture and sampling. In turn, the PREDICT Jordan team assisted with safe and effective implementation of One Health surveillance in at-risk Jordanian communities. In addition, PREDICT lab teams worked together to better understand exposure to Middle East Respiratory Syndrome Coronavirus (MERS-CoV). Human samples from both countries were screened for MERS-CoV-neutralizing antibodies and data was shared across institutions. This allowed for regional insights on MERS exposure in the North Africa and Middle East regions.

The PREDICT team in Egypt received rigorous laboratory and field training as part of their involvement in project activities. Many were early career stage scientists that significantly benefited from the training. PREDICT's work on MERS assisted both the animal and public health sectors to detect MERS-CoV in camels in Egypt thus providing critical information in real time as testing of the received samples was completed within a very short period of time and data shared as soon as they were compiled. Through PREDICT project investments, a total of 18 individuals were trained (9 men and 9 women) in Egypt, all were members of the National Research Center.

In Jordan, the PREDICT project played a critical role in the development of a state-of-the-art molecular and virology laboratory at the Faculty of Veterinary Medicine-JUST. The JUST Molecular and Virology Laboratory is now considered an important hub for training and preparing future scientists as many graduate students are being trained in the laboratory to perform various techniques from safe sample handling to DNA extraction, cDNA synthesis, performing different PCR protocols, cloning, plasmid purification, and sequence analysis. The team also benefited from the hard work of two Master's graduate students (Ola Ababneh and Ghadeer Alzghoul) who worked with PREDICT project scientists as part time research assistants in the laboratory. Ola and Ghadeer earned their Master's degrees and continue to work with the project's JUST team in technical support roles. Through PREDICT project investments, a total of 25 individuals were trained in Jordan, including 10 students, two staff members from the Ministry of Agriculture, and one representative from FAO.

"Your efforts in Jordan to track and monitor emerging viruses kept us all safer in an ever-changing world of infectious disease risk. I admire your team's dedication to this critically important mission. Time and again, I saw the excellent relationships you built with counterparts and communities to expand our global knowledge of disease risk. You and the team exemplified some of USAID's very best work, and I am honored to have played a part in this strong partnership."

–ANDREA HALVERSON

Deputy Director, *Population & Family Health Office, USAID Jordan*

Our team in Jordan also strengthened disease detection at the Ministry of Agriculture Veterinary Services by providing needed infrastructure and training to two diagnostic laboratories in the South of Jordan (Ma'an and Karak). Both laboratories were equipped with biosafety cabinets, hematology and chemistry analyzers, ELISA readers and washers, incubators, centrifuges and microcentrifuges, balances, microscopes, autoclaves, and other essential tools to strengthen disease detection capacity and stand ready to tackle disease threats such as COVID-19.

CHILDREN'S MUSEUM OUTBREAK EXHIBIT

World Health Day was celebrated on April 4 and 5, 2019. On this occasion, The Children's Museum, Jordan (CMJ) opened "Outbreak: Epidemics in a Connected World", an exhibition that ran from April 7 to December 2019. The aim of the exhibit was to promote the One Health message and communicate the importance of interdisciplinary responses to stop outbreaks. The messaging also centered around the impact outbreaks have on communities. The Museum partnered with the PREDICT team in Jordan, which provided expertise and consultations to develop locally relevant content, specifically related to JUST's work on new emerging infectious diseases that could become a threat to human health. Our team was actively engaged with children and their families and was tasked with communicating the role of wild animals in transmitting diseases to human populations. An animated short on disease outbreaks was also developed for the CMJ exhibit and featured the PREDICT project's One Health surveillance activities.

PRACTICAL IMPLICATIONS

Egyptian and Jordanian institutions have the capacity and capabilities to effectively conduct surveillance and identify risk factors for infectious disease emergence and contribute to pandemic prevention at national and regional scales that can now be utilized and expanded upon by national authorities and other stakeholders.

>30 early and mid-career professionals received long-term training and support in surveillance, community engagement, and policy development.

Based on the project's findings from working with local communities, successful implementation of protective practices that could reduce risks for disease transmission in at-risk individuals will require educational efforts to enhance individual understanding of disease risk factors.

The creation of the first interdisciplinary One Health platform in Jordan served as the starting point for future implementation of collaborative approaches to reducing emerging disease risk and as the foundation of a national One Health Committee.

FURTHER READING

- Ali M, El-Shesheny R, Kandeil A, et al. Cross-sectional surveillance of Middle East respiratory syndrome coronavirus (MERS-CoV) in dromedary camels and other mammals in Egypt, August 2015 to January 2016 [published correction appears in Euro Surveill. 2017 May 11;22(19):]. Euro Surveill. 2017;22(11):30487. doi:10.2807/1560-7917.ES.2017.22.11.30487
- Kandeil A, Gomaa MR, Shehata MM, et al. Isolation and Characterization of a Distinct Influenza A Virus from Egyptian Bats. J Virol. 2019;93(2):e01059-18. Published 2019 Jan 4. doi:10.1128/JVI.01059-18

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