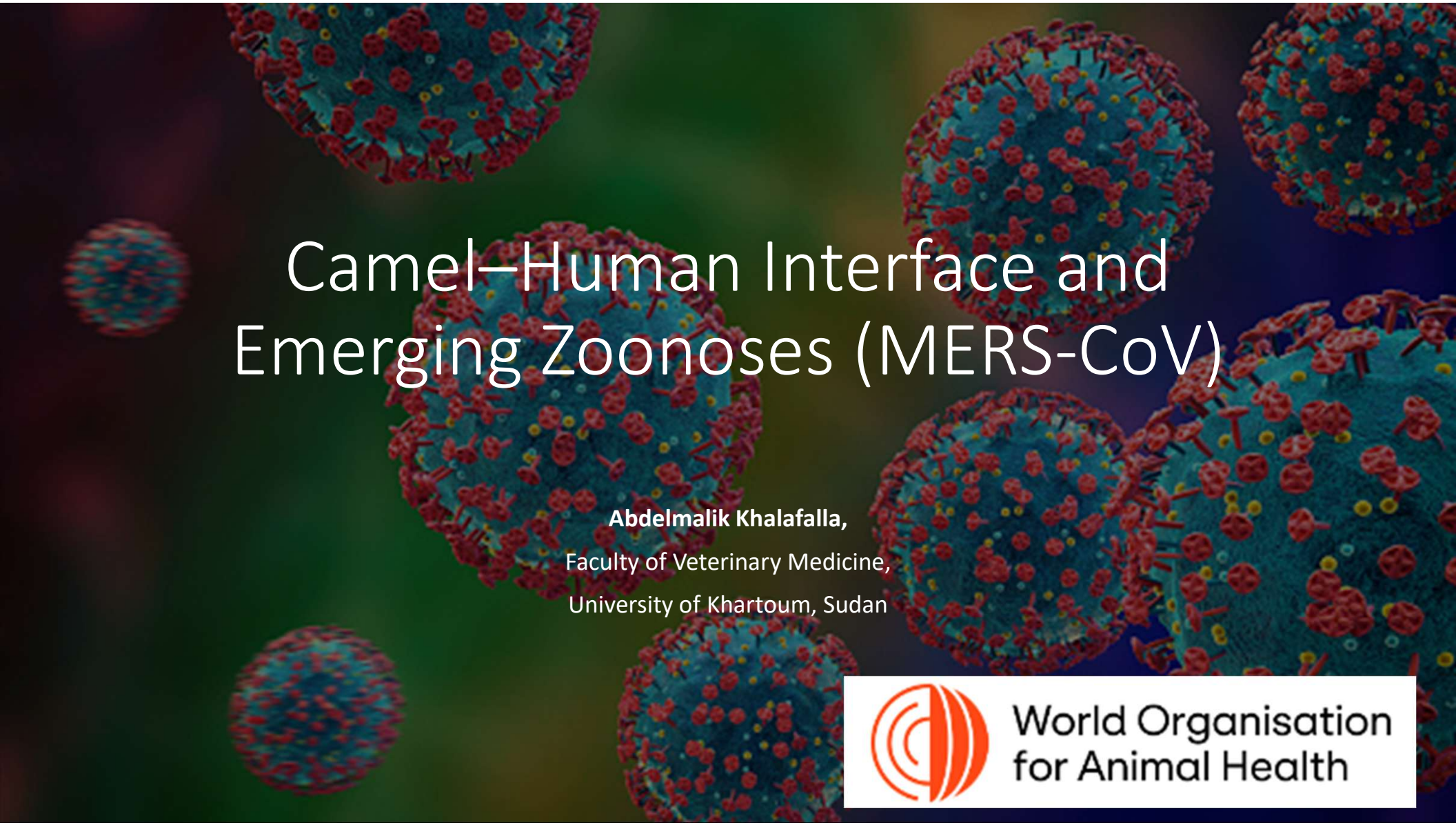


Camel–Human Interface and Emerging Zoonoses (MERS-CoV)

Abdelmalik Khalafalla,

Faculty of Veterinary Medicine,

University of Khartoum, Sudan

World Organisation for Animal Health

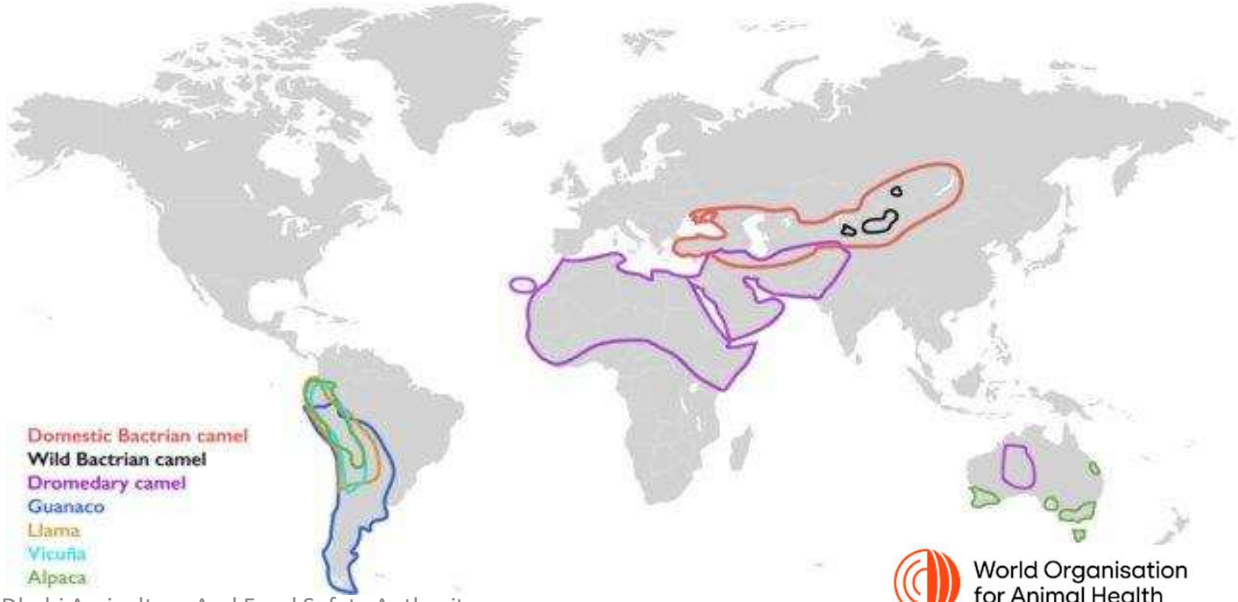
Introduction- Camelids

Classification of camelids

Class Mammalia
Order Artiodactyla
Suborder Suiformes
Suborder Tylopoda
Family Camelidae

Tribe Camelini
Old World *Camelus dromedarius (*one-humped), dromedary camel
*Camelus bacterianus (*two-humped), Bactrian came
*Camelus ferus (*wild two-humped)*, the Tartary camel*

Tribe Lamini
New World *Lama glama* – (llama)
Lama guanicoe (guanaco)
Vicugna pacos – (alpaca)
Vicugna vicuna (& two subspecies)



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What Are Zoonoses?

WHO: Diseases and infections naturally transmitted between vertebrate animals and humans.

*Over 200 foodborne diseases caused by bacteria, viruses, parasites, or toxins.

*Zoonoses account for ~60% of emerging infectious diseases globally.

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Zoonoses: Why Focus on Camels?

- Global camel population >30 million and rising.
- Increased urbanization of camel farming.
- Close human–camel interactions (milking, herding, racing, festivals).
- Cultural preference for raw milk and undercooked meat.
- Economic growth in camel milk and meat industries.

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Zoonosis: Why the camels?

- 2- **Close relationship with camels**
  - Camels are key part of the Arab heritage and their *relationship with camels* dates back to ancient times
  - Camels are very social, lovely and curious

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Zoonosis: Why the camels?

Increased consumption of camel milk and meat

International Journal of Veterinary Science and Research

Peertechz

Kula Jilo*

Jimma University College of Agriculture and Veterinary Medicine, School Of Veterinary Medicine, Ethiopia

Dates: Received: 23 March, 2016; Accepted: 02 April, 2016; Published: 07 April, 2016

***Corresponding author:** Jilo Kula, Jimma University College of Agriculture and Veterinary Medicine, School Of Veterinary Medicine, Jimma, Ethiopia, E-mail: Kula.jilo1@gmail.com

www.peertechz.com

Keywords: Camel milk; Chemical composition; Medicinal value; Protective protein

Review Article

Medicinal Values of Camel Milk

Abstract

Camel milk differs from other ruminant milk as it contains low cholesterol, low sugar, high minerals, high vitamin C and higher protective proteins like *lactoferrin, lactoperoxidase, Immunoglobulins* and lysozyme. Camel milk lacks of *β-lactoglobulin* and used as an option for the individuals intolerant to lactose of cow's milk Camel's milk is unique in terms of antioxidative factors, antibacterial, antiviral, antifungal, anti-hepatitis, anti-arthritis, treatment for *paratuberculosis*, preventies aging, remedy for autoimmune diseases and cosmetics. Insulin in camel milk is safe and efficacious in improving long-term glycemic control in diabetic patient. Camel milk reduces autism symptoms in children. *Lactoferrin* has ability to inhibit the proliferation of cancer cell. Camel milk is rich in magnesium and zinc thus endowed antiulcer properties. Camel milk has high α-hydroxyl acids which are known to plump and smoothies the skin and also used to treat skin disorders such as dermatitis, Acne, Psoriasis and Eczema. Although camel milk has such values, it's less appreciated thus its consumption is restricted to pastoral area. Further studies should be conducted on the chemical composition and medicinal value of camel milk.

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Zoonosis: Why the camels ?

1- **The recent intensification of the production, concentration of the production around cities and change to camel farming**

Kagunyu and Wanjohi *Pastoralism: Research, Policy and Practice* 2014, **4**:13
http://www.pastoralismjournal.com/content/4/1/13

Pastoralism
a SpringerOpen Journal

SHORT REPORT **Open Access**

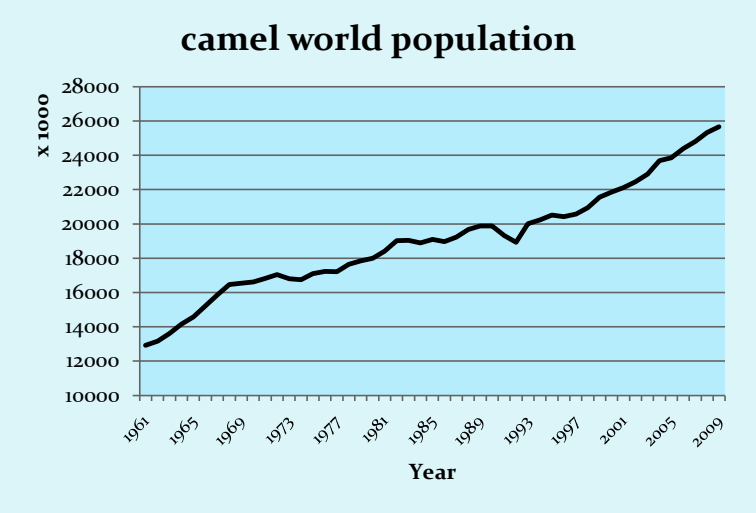
Camel rearing replacing cattle production among the Borana community in Isiolo County of Northern Kenya, as climate variability bites

Anastasia W Kagunyu[1*] and Joseph Wanjohi[2]

World Organisation for Animal Health

Zoonoses: Why camels

- The increase in global camel populations, particularly dromedaries, has raised concerns about zoonotic diseases.
- This growth, coupled with socio-cultural practices and inadequate health infrastructure,
- intensifies the risks associated with zoonoses as camel farming becomes more concentrated around urban areas.
- While camels serve as multipurpose animals offering meat and milk, their role in public health is complex due to the potential transmission of diseases.
- Camel breeding is currently observed in the north of Nigeria, Cameroon, Republic of Central Africa, Uganda and Tanzania



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Camel-human interface

- The camel–human interface is defined by sustained and multifaceted contact, providing food security, mobility, and socio-economic stability for traditional pastoralist and seminomadic groups
- Microbes exchange is facilitated through practices including:

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1- raw milk consumption,	2- cohabitation of living spaces, at farm or in the field	3-livestock and meat markets,	4- slaughterhouses

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5-racing and beauty festivals,	6-tourism (camelback leisure riding)	7- others, visitors, vets..etc
		 

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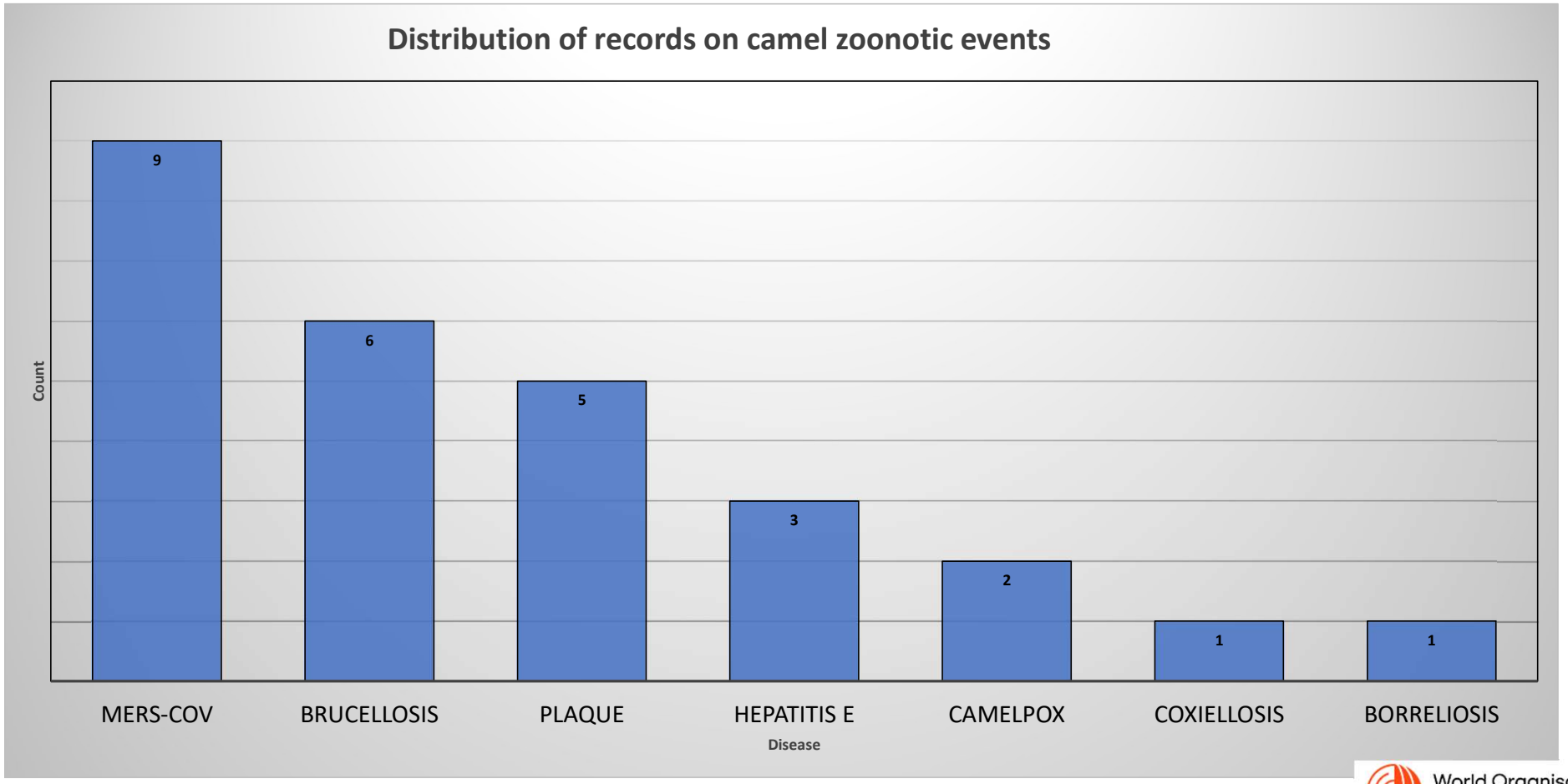
Key Zoonotic Diseases Transmitted from Camels to Humans



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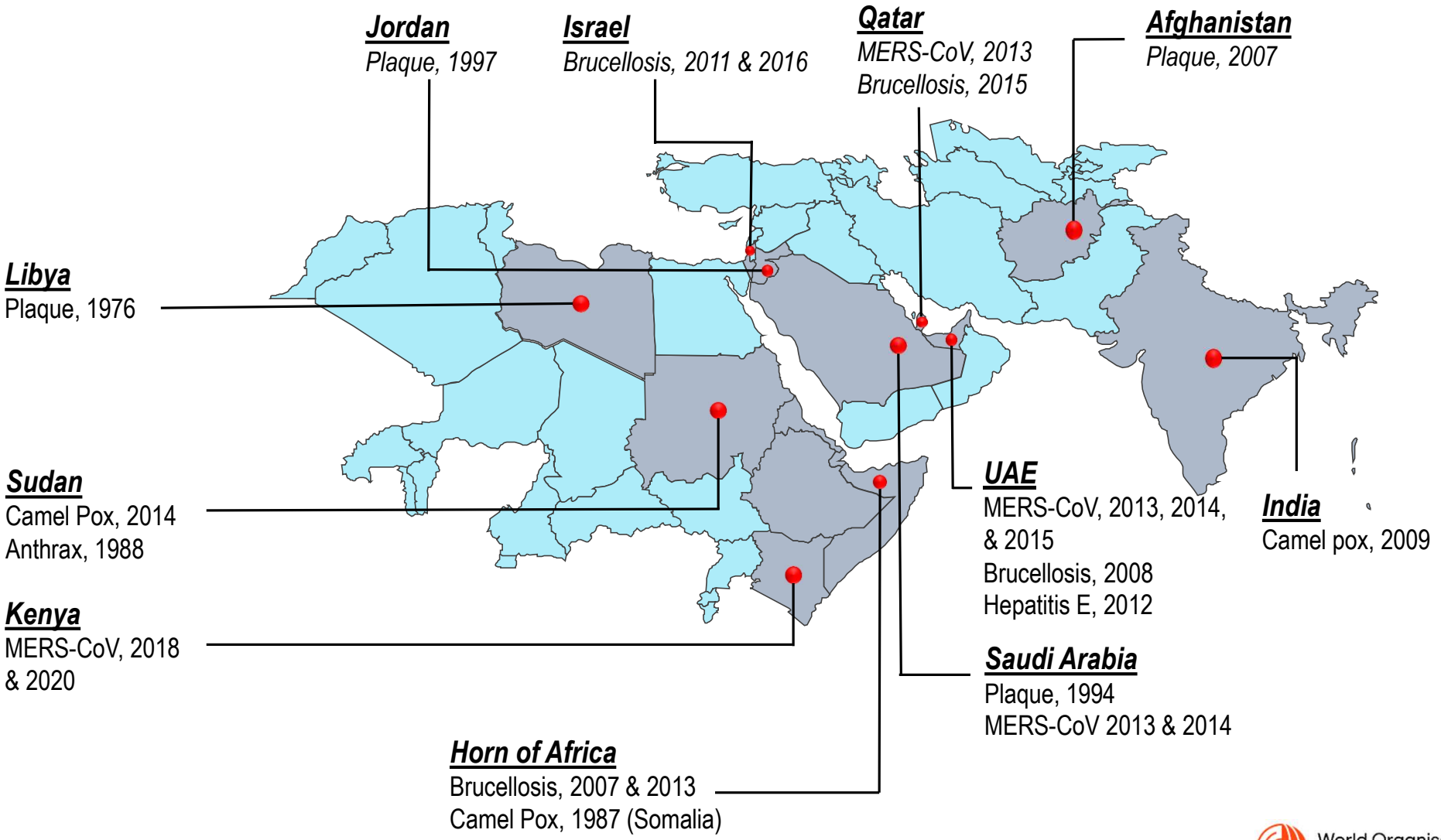

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MERS-CoV infection

- MERS-CoV emerged as the cause of severe respiratory disease in humans in 2012
- Dromedary camels (*Camelus dromedarius*) were implicated as a possible source for human infection based on presence of MERS-CoV neutralizing antibodies
- MERS coronaviruses detected in camels are genetically very similar or identical to those infecting humans
- Dromedary camels act as an important reservoir of the virus and as responsible for its transmission to humans

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Why dromedaries are central to MERS-CoV

Evidence converges across serology, virus detection and genomics

Serology

High antibody prevalence in many camel populations indicates widespread prior exposure.

Virus detection

MERS-CoV RNA and virus sequences detected in respiratory specimens; infection may be subclinical.

Genetic similarity

Camel viruses are genetically very similar to viruses infecting humans.

Epidemiology

Direct camel contact is a major risk category; exact environmental mechanisms remain incompletely resolved.

Incubation period:

- Two days, experimentally (Adney et al., 2014), naturally ~ 5-7 days
- Points regarding course of infection:

- When MERS-CoV circulates on a farm, both calves and adults can be infected WITH EVIDENCE FOR RE-INFECTION (Hemida et al., 2014)

- Prior infection or passively acquired maternal antibody might not provide complete protection from infection (Hemida et al., 2014)

- Positive samples were more commonly found among young animals (<4 years of age) than adults (Khalafalla et al., 2015)

- Considerable prevalence of MERS-CoV RNA among all dromedaries <4 years of age with increased infectivity of calves in contrast to increased antibody titers in adult dromedaries (Wernery et al., 2015)

- Excretion is short lived in individual camels (Wernery et al., 2015)

- The maximum duration of viral shedding from infected camels was 2 weeks after the first positive test result (Al Muhairi et al., 2016)

Is MERS a camel disease?

- **MERS-CoV is mostly a subclinical infection but can induce clinical in some of the affected camels**
- **These upper respiratory tract signs are not characteristic and can be due to a variety of viral, bacterial, and other pathogens.**
- **They could be due to secondary bacterial infections.**
- **Camels are affected with the respiratory disease (CRD) [*Abu Nikhairat*] which has a multifactorial etiology and develops as a result of complex interactions between environmental factors, host factors, and pathogens.**

Natural exposure:

- 1) Khalafalla et al., 2015, Emerg Infect Dis. 21(7): 1153–1158
- 2) Memish et al., 2014), Emerg Infect Dis. 20(6):1012-1015
- 3) Zuleikha et al., 2015, Emerg Infect Dis. 21(12):2197-2000

Experimental infection

- Adney et al., 2014

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Case Definition

- History:

- - OIE was drafted in May 2017;
- - In Jan 2019, the ad hoc group on MERS-CoV reviewed and made minor comments
- - The Group agreed that only PCR or antigen-positive laboratory-confirmed cases should be notifiable to the
- OIE (now WOAH) as an emerging disease and “suspected cases” need not be reported.
- - Since the virus is widely circulating in some populations of dromedary camels, resulting in high antibody
- prevalence, serological evidence does not help determine active infection or the purpose of the definition of case confirmation.

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Case Definition for reporting MERS-CoV in dromedary camels to OIE

(Update January 2019)

Introduction

Middle East respiratory syndrome (MERS) is a viral respiratory infection of humans and dromedary camels which is caused by a coronavirus called Middle East Respiratory Syndrome Coronavirus (MERS-CoV).

Dromedary camels (Camelus dromedarius) have been confirmed by several studies to be the natural host and zoonotic source of the MERS-CoV infection in humans. Other species may be susceptible to infection with MERS-CoV. However, their epidemiological significance has not been proven.

MERS-CoV has been associated with mild upper respiratory signs in some dromedary camels. While the impact of MERS-CoV on animal health is very low, human infections has a significant public health impact.

Positive RT-PCR results for MERS-CoV or isolation of the virus from dromedary camels is notifiable to the OIE because MERS is an emerging disease with a significant public health impact to human. The aims of reporting to the OIE are to mitigate the human health risk of MERS-CoV and to prevent international spread, while ensuring safe international trade of dromedary camels and their products.

Confirmed case

The following defines a laboratory confirmed case of MERS-CoV infection (with or without clinical sign

1) MERS-CoV has been isolated from a dromedary camel; OR
2) Viral nucleic acid has been identified in a sample from a dromedary camel on:
    a. at least two specific genomic targets; OR
    b. a single positive target with sequencing of a secondary target; OR
    c. a single positive target and tested positive to rapid MERS-CoV antigen test

Additional notes

A case can be suspected based on a direct epidemiological link with a confirmed human case, living together in close proximity to a MERS-CoV infected dromedary camel or sharing the same environme individual dromedary infected with MERS-CoV. If testing for MERS-CoV is unavailable, negative or in on a single inadequate specimen, the case should also be suspected. Inconclusive tests may include screening test on a single real time RT-PCR target without further confirmation. Animals with an inconclu test should undergo additional sampling and testing to determine if the animal can be classified as a confirm CoV case. Preference should be a repeat nasopharyngeal specimen. Other types of clinical specimens co considered for molecular testing if necessary, including blood/serum, and stool/rectal swab. These gen lower titres of virus than respiratory tract specimens but have been used to confirm cases when other spec inadequate or unobtainable.

CHAPTER 3.5.2.

MIDDLE EAST RESPIRATORY SYNDROME (INFECTION OF DROMEDARY CAMELS WITH MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS)

SUMMARY

Description of the disease: *Middle East respiratory syndrome (MERS) is a viral respiratory infection of humans and dromedary camels that is caused by a coronavirus called Middle East respiratory syndrome coronavirus (MERS-CoV). MERS-CoV is an enveloped, positive-sense, single-stranded RNA virus of the genus* Betacoronavirus, *first identified in 2012. Since July 2015, infection with MERS-CoV has been reported in over 21 countries and so MERS-CoV has become a great concern for public health.*

Dromedary camels (*Camelus dromedarius*) have been confirmed by several studies to be the natural host and zoonotic source of the MERS-CoV infection in humans. Other species may be susceptible to infection with MERS-CoV. However, their epidemiological significance has not been proven.

MERS-CoV has been associated with mild upper respiratory signs in some dromedary camels. While the impact of MERS-CoV on animal health is very low, human infections has a significant public health impact.

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Table 1. Test methods available for diagnosis of MERS and their purposes

Method	Purpose					
	Population freedom from infection	Individual animal freedom from infection prior to movement	Contribute to eradication policies	Confirmation of clinical cases	Prevalence of infection – surveillance	Imm in a po post
Detection of the agent						
Real-time RT-PCR	–	+++	+	+++	+++	
Antigen detection	–	+	+	++	++	
Virus isolation and identification	–	+	–	+++	–	
Detection of immune response						
Indirect IgG ELISAs	++	–	++	–	++	
Pseudo-particle neutralisation assay	+	–	+	–	+	
PRNT	+	–	+	–	+	
VNT	+	–	+	–	+	

Key: +++ = recommended for this purpose; ++ = recommended but has limitations;
+ = suitable in very limited circumstances; – = not appropriate for this purpose.
RT-PCR = reverse-transcription polymerase chain reaction; IgG ELISA = immunoglobulin G enzyme-linked immu assay; PRNT = plaque reduction neutralisation test; VN = virus neutralisation.

Camel-to-Human Transmission

- It is well-established that people can contract MERS-CoV from dromedary camels through both direct and indirect contact with infected animals.

- The primary cause of zoonotic transmission is the close interaction with camels, which includes activities such as handling, training, milking, and coming into contact with their feces.

- According to epidemiological studies, individuals who work with camels, such as camel shepherds and slaughterhouse workers, show a higher prevalence of MERS-CoV antibodies (Khudhair et al., 2019; Aljasim et al., 2020; Holloway et al., 2024).

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Potential pandemic preparedness for zoonoses transmitted by camels

- Preparedness strategies must encompass a One Health approach, integrating human, animal, and environmental health surveillance systems
- A notable example of effective collaboration is the early warning and response system in Abu Dhabi, UAE.
- This system, established by the Department of Health (which focuses on human health) and the Abu Dhabi Agriculture and Food Safety Authority (which oversees animal health), features an efficient bilateral notification process.
- The system is designed with efficient bilateral notification processes and web-based surveillance systems that facilitate the rapid sharing of epidemiological data, laboratory results, and risk assessments among relevant authorities.
- This capability enables authorities to develop and implement targeted, evidence-based control strategies, such as regulating the movement of camels

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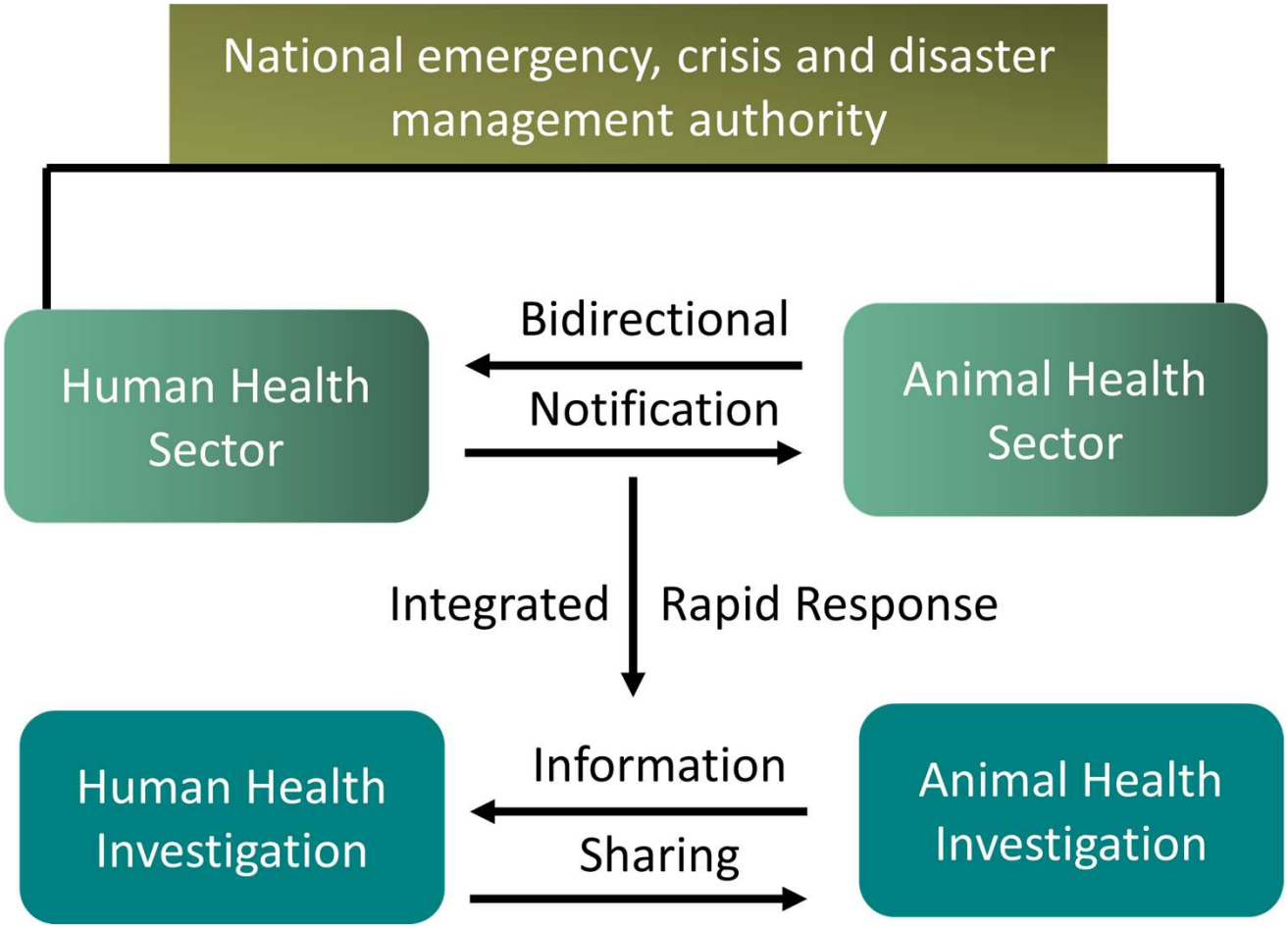
ZU1

Disease notification system



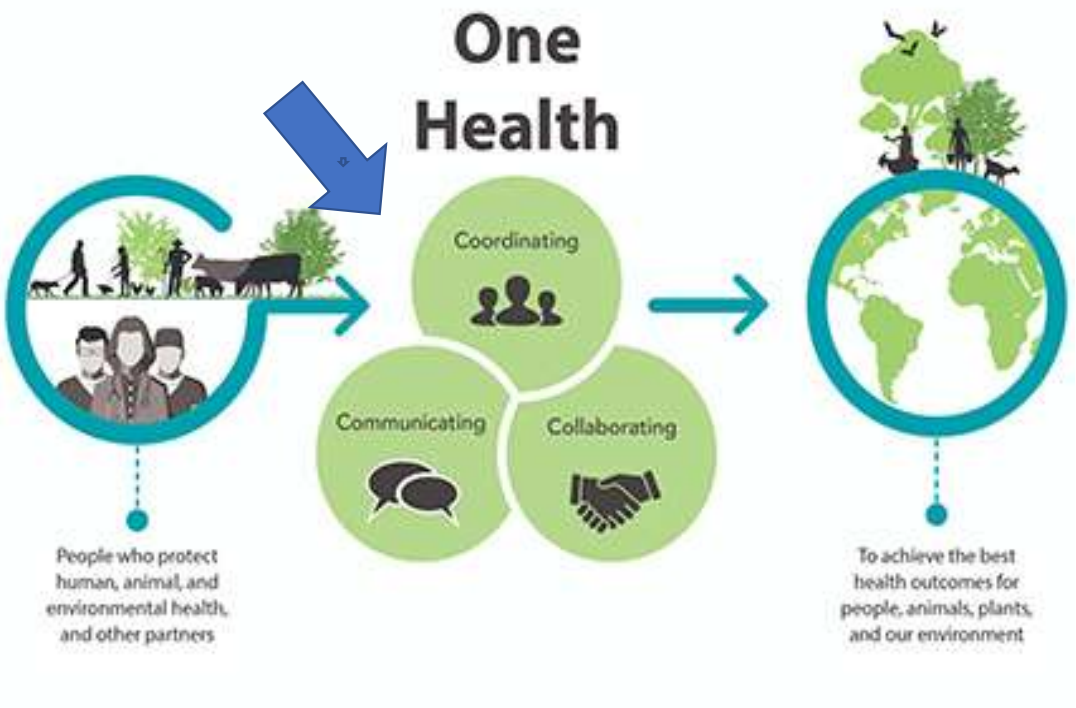
ZU1 what about the environment as we do conduct some testing on environmental samples in case of some notifications

Z UAE, 2022-01-31T06:43:40.052

“One Health” (OH)

- “One Health” (OH) is an important concept that aims to bring together human, animal, and environmental health.
- WOAH: The “ONE HEALTH” concept ensures political support in coordinated prevention of high public health and animal impact diseases at the human-animal interface

Source:
CDC (One Health | CDC)



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International coordination is also crucial

- WHO, FAO, and the World Organization for Animal Health (WOAH), through their collaborating and reference centers, can facilitate standardized reporting, rapid response mechanisms, and the sharing of epidemiological data.

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Camel Vaccination

A mathematical model (Alatawi and Gumel, 2024) indicates that MERS-CoV could be eliminated in Saudi Arabia by focusing on camel vaccination and mask use, preferably together, to lower the disease burden in the camel population.

Additionally, developing and deploying veterinary vaccines for camels could help reduce viral circulation within the animal reservoir and limit spillover events.

Epidemiological and Immunological Hurdles

- **High turnover in calves:** Young camels lose maternal antibodies quickly and become the primary drivers of new infections.
- **Asymptomatic infection:** Infected camels show little to no clinical illness, reducing urgency for owners to seek treatment or vaccination.
- **Waning immunity:** Short-lived mucosal and systemic immunity requires frequent booster shots to maintain herd protection.
- **Lack of standardized assays:** Reliable T-cell assays for monitoring camel immune responses post-vaccination are still limited.

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MERS-CoV Vaccination of Camels. Social and Cultural Acceptance

Abdelmalik Khalafalla,

Abu Dhabi Agriculture and Food Safety Authority (ADAFSA),UAE

Background

- Camels serve as a key reservoir host for MERS-CoV, posing risks for zoonotic transmission.
- Vaccination of camels is a critical control strategy to reduce spillover infections in humans.
- Understanding owners' attitudes toward vaccination is essential for policy and public health planning.

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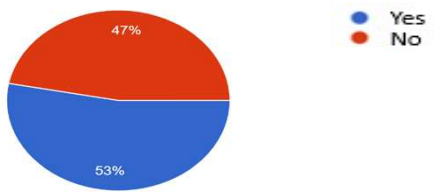
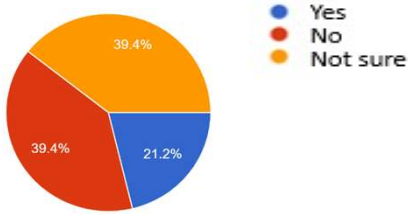
Methods: Questionnaire distributed to camel owners across **UAE, Saudi Arabia, Oman, and Qatar** via Google Forms (October 2025). A total of **66 responses** were analysed

Have you heard of MERS?



Do you believe that camels can carry or spread MERS-CoV to humans?



Key Findings:

- **Awareness:** Most respondents were aware of MERS-CoV as a camel-associated disease.
- Knowledge gaps remain regarding the zoonotic potential of MERS-CoV.
- **Perceived Risk:** Moderate concern expressed regarding transmission to humans.
- **Cultural Factors:** Some reluctance linked to traditional beliefs
- Need to conduct community-based awareness campaigns in collaboration with local leaders.

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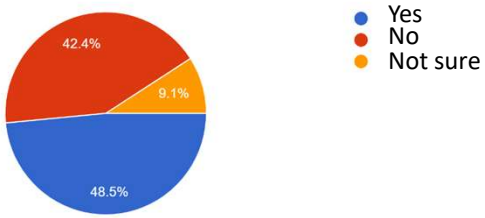
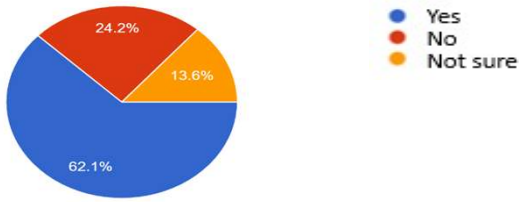
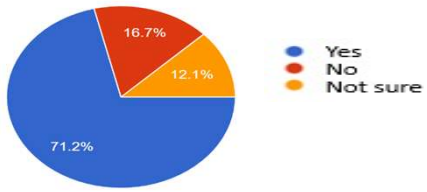
Have your camels ever received any vaccines in the past?



Would you be willing to vaccinate your camels against MERS-CoV if a safe and approved vaccine is available?



Would you be more likely to vaccinate your camels if the government or veterinary service organized a free campaign in your area?



Willingness to Vaccinate

- Camels are not commonly vaccinated animals, although this is evolving
- **Positive Acceptance:** Over half indicated readiness to vaccinate if the vaccine proved safe and effective.
- **Economic Factors:** Cost and availability were cited as major influencing factors.
- **Trust in Authorities:** Owners' trust in veterinary and governmental institutions affected willingness.
- Economic incentives and transparent communication could enhance vaccination uptake.
- Regional collaboration across Gulf states can standardize public health messaging.
- Majority of respondents support camel vaccination if safety and cost concerns are addressed.
- Involve veterinarians in awareness programs as trusted communicators.

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Challenges → mitigations

- Lack of knowledge among communities and healthcare professionals on camel diseases and their zoonotic impact. → Public health education aimed at populations that closely interact with camels, such as herders, traders, and slaughterhouse workers, is essential. Risk communication for high-risk occupational groups.

- Insufficient veterinary services and limited diagnostic capabilities. →

increase the capacity for diagnostic testing and investment in diagnostic and research infrastructure.

- Informal trading and transportation of camels, which often bypass health inspections. → enhance quarantine measures and conduct testing for zoonotic diseases in camels, particularly MERS-CoV and brucellosis.
- Vaccination logistical and cultural barriers. → Research and awareness

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The occupational risk is not uniform

It is highest when workers or veterinarians:

- Handle young, newly introduced, sick, or actively shedding camels.
- Work close to the camel's nose, mouth, or respiratory secretions.
- Perform procedures that generate splashes or aerosols.
- Handle raw milk, urine, feces, respiratory samples, or contaminated equipment.
- Work in enclosed, poorly ventilated barns, markets, slaughter areas, or transport vehicles.
- Move between camel groups without changing clothing, boots, gloves, or equipment.
- Have underlying conditions associated with severe MERS, including diabetes, chronic kidney or lung disease, cardiovascular disease, cancer, or immunosuppression.

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Conclusion

- MERS-CoV risk is best managed by recognizing that **clinically healthy camels may still be infected**, identifying practices that bring people into contact with respiratory secretions or contaminated products, and applying layered controls. Program to combines animal quarantine, safe restraint, hygiene, cleaning and disinfection, task-specific PPE, competent veterinary sampling, disease reporting, laboratory confirmation, and rapid **One Health implementation**.

- PPE, but cannot compensate for crowded barns, uncontrolled camel movement, poor ventilation, or delayed reporting. Conversely, farm-level biosecurity is incomplete if veterinarians lack respiratory protection for high-risk procedures or if symptomatic workers continue working.

- A successful program therefore treats the farm, veterinary service, market, transport network, and healthcare system as one connected occupational-health system.

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Thank you

Questions & discussion

A safer camel–human interface is a shared One Health achievement.

Abdelmalik Khalafalla · Faculty of Veterinary Medicine · University of Khartoum

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