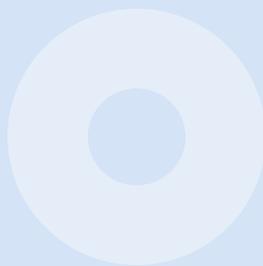
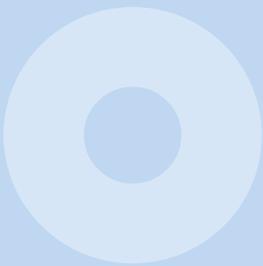


How to conduct a cross-sectional study of Middle East respiratory syndrome coronavirus infection in populations occupationally exposed to dromedary camels

Protocol, tools and implementation guidance



Unity Studies



World Health
Organization

How to conduct a cross-sectional study of Middle East respiratory syndrome coronavirus infection in populations occupationally exposed to dromedary camels

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Background

Middle East respiratory syndrome coronavirus (MERS-CoV), which was first identified in 2012, is considered an emerging virus. The emergence of a new virus means that understanding transmission patterns, severity, clinical features and risk factors for infection are limited. To address these unknowns, WHO has provided a number of protocols for MERS-CoV investigations. Data collected using these investigation protocols will be critical to refine recommendations for case definitions and surveillance, characterize key epidemiological features of MERS-CoV, help understand the geographical extent of MERS-CoV, its severity, the spectrum of the disease and its impact on the community; and to inform guidance for application of countermeasures such as case isolation and contact tracing. These protocols are designed to rapidly and systematically collect and share data in a format that facilitates comparison across different settings globally.

They are available on the WHO website here: <https://www.who.int/initiatives/mers-cov-investigations-and-studies>

MERS-CoV investigation and study protocols, tools and implementation guidance currently available include:

How to conduct surveillance and investigations of human infection with Middle East respiratory syndrome coronavirus using WHO's Investigations and Studies (Unity Studies 2.0) protocols;

How to investigate the first few X cases and contacts of human infection with Middle East respiratory syndrome coronavirus;

How to conduct a case-control study to assess the potential risk factors related to human illness caused by Middle East respiratory syndrome coronavirus;

How to conduct a cohort study to assess the potential risk factors of Middle East respiratory syndrome coronavirus infection among health and care workers in a health-care setting;

How to sample surfaces in health-care settings for Middle East respiratory syndrome coronavirus; and

How to conduct a cross-sectional study of Middle East respiratory syndrome coronavirus infection in populations occupationally exposed to dromedary camels.

Please contact MERSHQ@who.int for further information.

All WHO protocols for MERS-CoV are available on the [WHO website](#) together with technical guidance documents.

This protocol incorporates elements of previously published interim guidance entitled, *Cross-sectional seroepidemiologic study of MERS-CoV infection in high risk populations in contact with dromedary camels* – Version 2, July 2018 (available at: <https://www.who.int/publications/m/item/cross-sectional-seroepidemiologic-study-of-mers-cov-infection-in-high-risk-populations-in-contact-with-dromedary-camels-2>), highlighting the importance of a One Health approach and other additional objectives and details. It reflects updated scientific knowledge about MERS-CoV, the results and experiences of similar studies conducted in several countries, and input from the FAO and the animal sector. The protocol was also adapted from and supplemented by protocols developed and used during the COVID-19 pandemic through **WHO’s Investigations and Studies (Unity Studies): a standardized preparedness framework for an effective and proportionate response**, as well as experiences and lessons learned during the COVID-19 pandemic.

Protocol summary

Cross-sectional seroepidemiological and virological study of MERS-CoV infection in occupationally-exposed populations in contact with dromedary camels

Study population	Individuals with an occupational risk for MERS-CoV infection – those whose work requires direct and prolonged contact with dromedary camels <i>Highly recommended: inclusion of these individual's dromedary camels</i>
Potential output and analysis	Estimate or inform estimates of: <ul style="list-style-type: none"> • Seroprevalence and its geographical extent in occupationally exposed populations • Current infection (prevalence) and viral ribonucleic acid (RNA) shedding, and its geographical extent, in occupationally exposed individuals • Modifiable risk factors for infection • <i>Highly recommended: Seroprevalence and its geographical extent in dromedary camels of occupationally exposed populations</i> • <i>Highly recommended: Current infection and viral RNA shedding, and its geographical extent, in dromedary camels of occupationally exposed populations</i>
Study design	<ul style="list-style-type: none"> • One-time cross-sectional investigation, (<i>highly recommended</i>) with a One Health approach
Study duration	The study can be conducted as a “one time “cross-sectional investigation. The study duration will therefore depend upon the geographical extent of sampling, number of participants you decide to include, and your available resources.
Minimum information and specimens to be obtained from participants	<p>Data: Multiple questionnaires at one point in time for occupationally-exposed individuals collect information on demographics, medical history, clinical symptoms, epidemiological exposures.</p> <p>Specimens:</p> <ul style="list-style-type: none"> • Serum sample for occupationally-exposed individuals • Nasopharyngeal swab and oropharyngeal swab for occupationally-exposed individuals • <i>Highly recommended: Serum samples and posterior nasal swabs for dromedary camels of occupationally-exposed individuals</i>

Implementation tips are provided in boxes throughout the document.

This is a *protocol template* – the user should read through the template and guidance and then modify (and make choices about) the methods according to the local context in which this study will be carried out. If being adapted for use as the investigation protocol, the user should remove any non-relevant sections and modify the language appropriately (e.g. change “The geographic scope of the investigation should be defined.” to “This investigation will take place in [country] in [regions] in [# health facilities].”).

Background information referenced in this document should be checked for updates by investigators at the time of protocol implementation.

ONE HEALTH APPROACH – tip boxes

It is highly recommended to carry this investigation out with a One Health approach, including dromedary camel sampling and testing at sites where occupationally-exposed persons are recruited. Tip boxes in the format seen here are included throughout this protocol to facilitate inclusion of this aspect. You are also encouraged to reach out to MERSHQ@who.int and NSA-Director@fao.org for further support.

1. Scientific background and rationale





In late 2012, a novel coronavirus was identified for the first time in a resident of Saudi Arabia (1). As of April 2024, the virus, now known as Middle East respiratory syndrome coronavirus (MERS-CoV), has caused over 2600 reported laboratory-confirmed cases of human infection (2). The majority of human cases have been reported from Saudi Arabia (2). MERS-CoV is a zoonotic virus and dromedary camels are the single known maintenance host and primary reservoir (3-8), but the route of transmission to humans is unknown (8). MERS-CoV nucleic acid has been identified in dromedary camels in Burkina Faso, Egypt, Ethiopia, Islamic Republic of Iran, Jordan, Kenya, Nigeria, Oman, Pakistan, Qatar, Saudi Arabia, Senegal, Tunisia and the United Arab Emirates. Additionally, sera from dromedary camels (Bangladesh, Israel, Morocco and Uganda), Bactrian camels (Mongolia, United Arab Emirates), hybrid camels (United Arab Emirates), llama and alpaca (both Israel) have been found to have antibodies to MERS-CoV (7). Investigations in other livestock (e.g. cattle, sheep) and wild animals (e.g. birds) have not shown any evidence of MERS-CoV (9, 10).

The initial routes of transmission of MERS-CoV from animal sources (i.e. dromedary camels and possibly other camelids) to humans are not well understood. Currently, direct exposure to dromedary camels and drinking their unpasteurized milk are known to be risk factors for primary infection (3, 11). Spatial associations of human primary MERS-CoV infections with season, dromedary camel density and dromedary camel age and sex have also been found and need further investigation (12). MERS-CoV ribonucleic acid (RNA) has frequently been detected in dromedary camel respiratory tract specimens, rectal specimens and milk (7), but has also been detected in dromedary camel seminal fluid, conjunctival samples, saliva and breath (13-15). There is a need to further investigate the routes and mode of transmission to humans from dromedary camels, the types of exposures that result in infection and to understand how this may vary in different regions.

The non-specificity of clinical case definitions for MERS-CoV and the tendency of surveillance to focus on severe cases mean that rates of infection cannot be estimated from case-based clinical surveillance. Yet, this information is critical to understanding the overall morbidity, mortality and population-level severity of a novel virus. Representative serological studies will inform the extent of, and identify risk factors for, MERS-CoV infection among human populations and help inform the appropriate intensity and targeting of mitigation policies.

In the study protocol outlined here, we provide the methods to conduct a cross-sectional sero-epidemiological and virological study of populations that are believed to be at a higher risk of infection due to prolonged direct contact with dromedary camels, hereafter referred to as 'occupationally-exposed' individuals (e.g., camel farm workers, abattoir workers). The aim of the study is to estimate the seroprevalence of, and detect current infection with, MERS-CoV in these specific populations at one point in time. The information gathered in this study will be useful to refine and update recommendations for surveillance and case definitions, help understand MERS-CoV spread and its impact on occupationally-exposed communities, and will help to better understand the risk of infection among people who are likely to be more frequently exposed to the animal reservoir, i.e. dromedary camels.



1.1 Study objectives

1.1.1 Primary objectives

The primary objectives of this study are to:

1. Estimate the seroprevalence of MERS-CoV among persons with occupational exposure to dromedary camels – by sex, age group and types of exposure*
2. Identify MERS-CoV infection and shedding status of persons with occupational exposure to dromedary camels
3. Determine the geographical extent of MERS-CoV past and present infection in occupationally-exposed individuals, in areas with high densities of dromedary camels.
4. *Highly recommended: estimate the seroprevalence of MERS-CoV among dromedary camels of occupationally-exposed persons included in the study – by camel age and sex and other factors of interest (e.g. lactation status)*
5. *Highly recommended: identify MERS-CoV infection and shedding status of dromedary camels of occupationally-exposed persons included in the study – by camel age and sex and other factors of interest (e.g. lactation status)*

* E.g. occupation type and/or activities performed, camel contact type and duration

1.1.2 Secondary objectives

This investigation can provide rich data to assess secondary objectives, including, but not limited to:

6. Explore risk factors for infection by comparing the exposures of infected and non-infected occupationally-exposed individuals and (highly recommended) their dromedary camels
7. Conduct genomic analysis to explore the genetic relationship of the viruses detected in occupationally-exposed humans or their dromedary camels with other MERS-CoV isolates.

Implementation tip Conducting this cross-sectional survey among occupationally exposed persons provides an ideal opportunity to launch sub studies which may contribute valuable understanding with regards to risk factors for primary MERS-CoV infection. For example, assessment of Knowledge Attitudes and Practice (KAP), which may identify additional modifiable risk factors, to MERS-CoV in persons with occupational exposure to dromedary camels, by sex and age.

2. Methods



2.1 Study design and duration

This is a cross-sectional seroepidemiological and virological investigation of MERS-CoV, in populations with occupational exposure to dromedary camels, with possible stratification by key epidemiological factors (e.g. age, sex, occupational exposure type). Because MERS-CoV has not yet achieved sustained human-to-human transmission, this study utilizes a *one-time* cross-sectional design, i.e., the study of a population at one point in time, rather than a serial cross-sectional study in which sera were collected from two time periods (pre and post) in which cumulative incidence could be estimated (such as is done for influenza).

As the study has a one-time cross-sectional design, its duration is determined by the time it will take investigators to perform recruitment, data collection and specimen sampling at each chosen study location (e.g. 2 days per site) as well as the number of sites and participants the study plans to include, human resources, logistics and other factors. For the full length of time it will take to conduct this study, the mentioned duration would then be added to the time it takes to set-up the study (approvals, training), process specimens, perform data analysis and generate reports.

Implementation tip – seasonality considerations

Serological test results obtained through this study will be minimally, if at all, affected by the season in which the study is done. However, detection of active infection will vary by season. There is some evidence to suggest that MERS-CoV circulates and spills over (from dromedaries to humans) more frequently at certain times of the year when human contact with camels increases. This is often linked temporally to camel rearing seasons (e.g. during or immediately after calving or weaning), and periods of camel migrations. In some MERS-CoV high-risk regions, dromedaries may be on a yearly rearing cycle, whereas in other regions, they may be on a biyearly rearing cycle. Therefore, we do not recommend any specific months of the year to perform this study; however, we do suggest that investigators are mindful of their own regional camel rearing and migration seasonal cycles and their proximity to timing of data collection for the study. Particularly, if molecular testing will be a key component of your study, aim to perform data and sample collection during or immediately after camel calving or weaning seasons.

2.2 Study population and recruitment

There are several options for the selection of study participants, and these are described below. The target population for this study is individuals with occupational exposure to MERS-CoV meaning that study participants will be chosen from populations in regular direct



contact with dromedary camels (e.g. dromedary camel handlers on farms, in live animal markets, at abattoirs, etc.).

2.2.1 Study population – geographical scope of recruitment

The geographic scope of the investigation should be defined. This may be limited to a local or regional investigation (e.g. in a specific area of the country known to have high camel density), or may be conducted as a national investigation (including all, or a representative sample of all, persons occupationally exposed to dromedary camels in the country). The region(s) of interest for the study could be informed by any of:

- a. the investigation's objectives in terms of which occupationally-exposed populations the results should be generalizable to
E.g. if specifically trying to gain an understanding of the risk of past or present MERS-CoV infection in animal market workers specifically, include a representative sample of animal market workers from the region of study.
- b. the latest information on human MERS-CoV circulation from the Ministry of Health (or equivalent)
E.g. enroll occupationally-exposed persons of various types in an area with known circulation to gather more information on risk factors; alternatively or in addition, enroll occupationally exposed persons of various types in an area with unknown circulation in order to gain information on human MERS-CoV circulation in the country (detection of MERS-CoV is more likely in this sample than with a general population serosurvey)
- c. information from the Ministry of Agriculture (or equivalent) on dromedary camel density and areas with many persons occupationally exposed to dromedary camels
E.g. enroll occupationally-exposed persons of various types in an area with high camel density; alternatively stratify inclusion by camel density in order to understand MERS-CoV past and present infection in occupationally-exposed persons by camel density.

2.2.2 Recruitment of study participants

The following groups of individuals would be considered as occupationally-exposed for MERS-CoV due to occupational exposure to dromedary camels.

- Individuals working on dromedary camel farms
 - This could also be general livestock farms that include dromedary camels
- Individuals working at dromedary camel markets
 - This could also be a general livestock or animal market that includes dromedary camels
- Camel handlers, veterinarians and other individuals working at racing venues (i.e. camel racing tracks)



- Individuals working at dromedary camel abattoirs
 - This could also be a general livestock or animal abattoir that includes dromedary camels
- Individuals working at dromedary camel quarantine sites

The method to recruit the investigation population will depend on the study objectives, feasibility and the resources available to conduct the study.

Implementation tip This protocol specifically assesses seroprevalence of MERS-CoV in persons occupationally exposed to the virus through contact with dromedary camels (i.e. working with these animals); however, the same protocol could be used to evaluate seroprevalence in human populations living in proximity to camels (e.g. persons working or living on camel farms). If expanding inclusion criteria to include this group, investigators should make necessary adaptations through the protocol and questionnaires.

To recruit participants, sampling can be either by:

- **Sampling of the entire occupationally-exposed population:** In countries or regions with a limited number of individuals with occupational exposure to dromedary camels, it may be feasible and necessary (to achieve a sufficient sample size) to attempt recruitment of *all* eligible persons at *all* identified study sites.

Sampling Steps:

1. Within the defined geographical scope of the study and as per the occupationally-exposed population of interest for the specific study, as decided by investigators, identify all eligible recruitment sites (sites may include any or all of farms, markets, racing venues, abattoirs, or quarantine sites).
 2. *Attempt* recruitment of all individuals at each identified site (if feasible) or a random sample of persons (see below section on “Selection of participants within selected study sites” for more guidance on how to randomly select participants) from each identified site; however, which of these strategies will be employed, and in which circumstances, should be determined *prior* to visiting selected sites.
- **Random Sampling:** In situations where it is not feasible (or necessary to achieve sufficient sample size) to enroll all eligible persons of the occupationally exposed population in a given country or region of the study, random sampling can be considered.

Sampling Steps:

1. Identify all eligible recruitment sites (sites include any or all of farms, markets, racing venues and abattoirs). Within the defined geographical scope of the study and as per the occupationally-exposed population of interest for the specific study, both as decided by investigators.
2. Assign each eligible recruitment site a study code or number.
 - If you are using more than one type of study site (e.g. farms, abattoirs and markets), the assigning of a unique identifier to each site should be done separately for each type of site included. Ex. Camel farm #1, Camel farm #2, Camel farm #3, etc; Abattoir #1, Abattoir #2, Abattoir #3, etc.
 - If you have a key stratification characteristic of interest and would therefore like *equal representation* (Note: this does not imply representativeness, but rather, a sufficient sample size in each of your eventual stratified categories), then the assigning of a unique identifier to each site should be done separately for each of these groups. Stratification characteristics of interest may include areas with different camel densities, difference in practices, or other.

Implementation tip Below is a hypothetical example of study site numbering with various strata.

Investigators implementing the study in Country Z are including participants across two different regions, from camel farms and abattoirs; there are many camel farms and abattoirs in these regions, so investigators do not need to include all of them. They would like to eventually stratify results by occupational exposure type and region. They identify all camel farms and abattoirs in the study regions and number them as follows in preparation for random selection: Region #1 Camel farm #1, Region #1 Camel farm #2 and so on; Region #2 Camel farm #1, Region #2 Camel farm #2 and so on; Region #1 Abattoir #1, Region #1 Abattoir #2 and so on; Region #2 Abattoir #1, Region #2 Abattoir #2 and so on.

3. Use a randomization matrix, statistical software or an online randomizing tool to determine for which of the sites recruitment will be attempted.
 - It is important that investigators and study personnel do not influence the randomization. In this instance, determination of all study regions, site eligibility and assigned site codes prior to doing the randomization technique, should assure this. There should be no changes to selected sites based on feasibility or investigator preference following randomization (without rerunning the entire randomization).
4. Attempt recruitment of all individuals at each identified site (if feasible) or a random sample of persons (see below for guidance on how to randomize participants) from each identified site; however, which of these strategies will be employed, and in which circumstances, should be determined prior to visiting selected sites.

Selection of participants within selected study sites: Following identification and randomization (if applicable) of eligible study sites, study personnel will visit the selected farms or markets or abattoirs or racing venues or quarantine sites to identify the number of individuals with occupational exposure eligible for inclusion (see [section 2.2.3](#) Eligibility Criteria).

Participant selection steps:

1. The investigators should decide whether or not ALL eligible persons will be approached for inclusion (regardless of number of exposed persons per site), or a maximum number of participants will be approached for inclusion per site (according to resources allocated and feasibility).

Implementation tip Whether or not all eligible persons OR a maximum amount per site, will be enrolled in the study, should be decided prior to visiting study sites for the first time. For example, investigators implementing the study in Country X decide that if a farm or market or abattoir or racing venue has less than or equal to 20 occupationally exposed persons, then recruitment will be attempted for all persons. However, if the site has >20 occupationally exposed persons, a random selection of 20 individuals will be approached for inclusion.

2. Randomization of participants (if applicable)
 - Study personnel will visit the selected study site and find out the number of eligible participants. A list of participants will be made, and each participant given a number or code.
 - Use a randomization matrix, statistical software or an online randomizing tool to determine for which of the eligible participant numbers recruitment will be attempted.

Implementation tip Upon approaching selected study sites for the first time, study personnel should explain the study to the farm or market or abattoir or racing venue manager and seek their approval to conduct the study there. This will also facilitate finding out the number, and making a list, of potentially eligible participants at each site.

Recruitment procedures: Eligible (and randomized, if applicable) participants should be approached and be asked for informed consent (see [section 2.5.1](#) for more information on informed consent). The number of eligible participants who refuse to participate or who are not eligible for another reason should be recorded. Only following informed consent should data collection and sampling be performed.

ONE HEALTH APPROACH – selection of dromedary camels to sample

It is highly recommended to include testing the dromedary camels and their byproducts to determine if there is active shedding or past circulation at the study locations. More information on which samples to collect can be found in [section 2.3.1 Specimen collection](#). Sampling from dromedary camels at the study sites where human participants are recruited can be collected at the same time as the human biological sampling.

Based on our understanding of MERS-CoV risk factors in dromedary camels, sampling of younger camels could be prioritized, particularly during the time of the year when young camels are weaned from their mothers. However, depending on the study objectives, the investigators may wish to collect a representative random sample of all dromedary camels at each site. Further details about camel sampling strategies and how to sample dromedary camels to gather a representative sample can be found in the One Health Approach box in [section 3.1 Sample Size Considerations](#).

Sampling of dromedary camels will need to be conducted by the Ministry of Agriculture or relevant national and/or sub-national authorities as determined by each country.

2.2.3 Eligibility criteria

Inclusion criteria: All individuals identified for recruitment into the investigation (i.e. fitting the description of ‘occupationally-exposed’ by working at any of the identified study sites), irrespective of age, irrespective of previous MERS-CoV suspected or known infection, should be considered for participation in the investigation.

Exclusion criteria: Refusal to give informed consent, or contraindication to venipuncture.

All eligible individuals, regardless of whether or not they are well or unwell should be considered for participation in the investigation, and their health status recorded. The participation in another study should also not preclude inclusion in this investigation. Being an individual with suspected or confirmed acute or prior MERS-CoV infection is not an exclusion criteria. Excluding them would underestimate the extent of infection in the population. For individuals currently receiving medical care for MERS-CoV, a family member or proxy may be used to complete the questionnaire ([Annex 2](#)) on their behalf. However, some sites may decide to exclude those with severe disease who are unable to complete the questionnaire. In either case, the exclusion criteria need to be clearly stated in the adapted protocol, and in the reporting of the results.

2.2.4 Data collection

Each participant who provides informed consent or assent and who is recruited into the investigation will be asked to complete a questionnaire which covers demographic, clinical and exposure information; the questionnaire will differ according to the occupation of the participant. [Annex 2](#) provides examples of questionnaires that may be used for camel farm workers, live animal market workers, abattoir workers, racing venue workers and quarantine workers.

2.3 Specimen collection and laboratory evaluations

Full details for laboratory testing, specimen collection, biosafety, sample shipment and reporting of test results for MERS-CoV can be found here: <https://www.who.int/publications/i/item/10665-259952>

If any participants return a positive polymerase chain reaction (PCR) test for MERS-CoV, they should be reported to the national health authorities under the requirements of the International Health Regulations. Authorities will also conduct the identification and follow-up investigation of all contacts for 14 days. See: <https://www.who.int/publications/i/item/10665-178252>

Implementation tip This section gives details on biological sampling and specimen testing. However, study investigators should use the serological and molecular assays that are available and feasible in their setting; any specifications (e.g. volume of blood needed, etc.) of the assays eventually used, as well as of the specific study population (e.g. appropriate volume by age of participants) should supersede any guidance given here. We do however recommend that investigators clearly define which tests will be used in their study planning, and that the tests used on humans and dromedaries are validated for those populations, respectively.

2.3.1 Specimen collection

Occupationally-exposed participants: 5 to 10 mL of blood will be collected in a serum tube according to standard procedures and labeled with a coded identification number that will also be recorded on the interview questionnaire ([Annex 2](#)); this sample will be tested for evidence of past MERS-CoV infection. All participants will also have a nasopharyngeal and oropharyngeal swab collected; these samples will be tested for evidence of current infection. When collecting nasopharyngeal and oropharyngeal specimens, swabs specifically designed for collecting specimens for virology must be used. These swab kits



should contain virus transport medium. The nasopharyngeal and oropharyngeal swabs should be placed in the same tube to increase the viral load.

Time of collection, location and name of person collecting the specimens will also be recorded. Specimen tubes will be stored temporarily on cool packs carried by the study teams until they can be transported to the laboratory. All those involved in the collection and transportation of specimens should be trained in appropriate personal protection, safe handling practices and spill decontamination procedures.

Note: for participants who test positive for MERS-CoV via molecular testing of nasopharyngeal and oropharyngeal swabs, repeat specimen collection and testing is recommended in order to understand duration of viral presence and shedding. Any participant who tests positive in PCR should be immediately isolated, treated as a confirmed case of MERS-CoV and be managed as such, according to the national or local guidelines.

Two aliquots of sample should be made and at least one kept for future analysis. See [Annex 1](#) for more background information about MERS-CoV serological testing methods. And see the interim laboratory guidance for MERS-CoV, here: <https://www.who.int/publications/i/item/10665-259952?sequence=1>

Implementation tip Only a limited number of laboratories have the facilities for MERS-CoV serologic testing and therefore collaboration between countries without current capacity and designated reference laboratories is possible. Collaboration is at the discretion of Member States carrying out the investigation, but WHO strongly supports such collaboration and would willingly facilitate collaboration and possible shipment elsewhere for testing. For serologic testing, if capacity for performing ELISA and/or microneutralization does not exist in country, WHO is able to facilitate coordination and collaboration with an external laboratory.

ONE HEALTH APPROACH – sampling in dromedary camels

It is highly recommended to collect any or all of blood (for serum), nasal swab samples, milk, urine, feces (or rectal swabs), as well as meat and/or organ and/or other byproducts (in the case of a slaughterhouse) from dromedary camels at the study sites where human participants are recruited. Serial collection of samples for dromedary camels who are MERS-CoV positive will also allow for inferences in terms of viral shedding.



All those involved in the collection and transportation of specimens should be trained in appropriate personal protection, safe handling practices and spill decontamination procedures. Full details for swab and tissue sample collection procedures enhancing MERS-CoV detection in dromedary camels can be found here: <https://www.fao.org/3/ca7428en/CA7428EN.pdf>

Biological sampling and testing of specimens collected from dromedary camels will need to be conducted by the Ministry of Agriculture or relevant national and/or sub-national authorities as determined by each country. Test methods for diagnosis of MERS-CoV in camels and their purposes are available on the WOAHP website: https://www.woah.org/fileadmin/Home/eng/Health_standards/tahm/3.05.02_MERS-CoV.pdf

2.3.2 Specimen transportation

For each biological sample collected, the date and time of collection, the conditions for transportation and the date and time of arrival at the study laboratory will be recorded.

Serum. Samples collected in the field should be stored on cool packs (approximately 4°C) until they arrive at the laboratory for testing. At the local laboratory, the whole blood should be allowed to clot and the serum separated; if needed, whole blood samples can be stored for a few days at 4°C before serum separation. If not being tested at the local laboratory, serum can be stored at -20 to -40°C (normal freezer temperature) until shipment to a central laboratory. Shipment to the central laboratory can be done on ice-packs (approximately 4°C). If the specimen is not likely to reach the laboratory where serological testing will take place within 72 hours, specimens should be frozen, preferably at -80 °C, and shipped on dry ice. It is, however, important to avoid repeated freezing and thawing of specimens. It is recommended to aliquot samples prior to freezing, to minimize freeze thaw cycles. Aliquot volumes should be determined according to the requirements of the assay being used; aliquots should typically be between 0.5 and 1ml.

Nasal, oropharyngeal, or other swabs. In field settings, if needed, swabs can be stored at 4°C for a few days until transport to the central laboratory for testing. If not tested immediately, swabs should be frozen, at -80C or in liquid nitrogen for long term storage.

Transport of specimens within national borders should comply with applicable national regulations. International transport of MERS-CoV specimens should follow applicable international regulations as described in the WHO Guidance on Regulations for the Transport of Infectious Substances 2021-2022 available at: <https://www.who.int/publications/i/item/9789240019720>. Appropriate Material Transfer Agreements will need to be signed if samples are to be transported between laboratories within or outside the country.



Implementation tip For labeling and shipping of specimens – it is key to use a basic triple packaging system, correct marking and labeling of specimens and use of appropriate shipping documents. The receiving laboratory should always be contacted before specimens are shipped.

2.3.3 Laboratory evaluations

A MERS case may be laboratory confirmed by detection of viral nucleic acid or by paired serology. WHO case definitions for MERS-CoV can be found here: <https://www.who.int/emergencies/outbreak-toolkit/disease-outbreak-toolboxes/mers-outbreak-toolbox>

The following laboratory testing recommendations are subject to further updates as diagnostic tests and approaches become available. Please check the [Middle East respiratory syndrome coronavirus \(MERS-CoV\) \(who.int\)](#) for updates.

Serologic testing: Serological testing can be carried out in collaboration with an external laboratory partner as needed. Serological assays may include fluorescent antibody testing, enzyme linked immunosorbent assay (ELISA), neutralization (live virus or pseudovirus) assay, or other. ELISA testing will be conducted for antibodies against MERS-CoV specific proteins of the spike S1 domain. Neutralization assays are considered the gold standard and positive results from ELISA assays should ideally be confirmed by neutralization assays. At least two aliquots of sample will be made and one kept for future analysis. See [Annex 1](#) for more background information about MERS-CoV serological testing methods. see the interim laboratory guidance for MERS-CoV, here: <https://www.who.int/publications/i/item/10665-259952?sequence=1>

Implementation tip Only a limited number of laboratories have the facilities for MERS-CoV serologic testing and therefore collaboration between countries without current capacity and designated reference laboratories is possible. Collaboration is at the discretion of Member States carrying out the investigation, but WHO strongly supports such collaboration and would willingly facilitate collaboration and possible shipment elsewhere for testing. For serologic testing, if capacity for performing ELISA and/or neutralization does not exist in country, WHO is able to facilitate coordination and collaboration with an external laboratory. Please contact MERSHQ@who.int

Molecular testing: Three real-time reverse transcription (rRT)-PCR assays for routine detection of MERS-CoV have been developed and their details published; assays targeting upstream of the E protein gene (upE) and assays targeting the open reading frame 1a (ORF 1a) are considered equally sensitive and are recommended for screening. To date, these rRT-PCR assays have shown no cross-reactivity with other respiratory viruses including



human coronaviruses and are all suitable to detect all known MERS-CoV strains in humans and dromedary camels. See [Annex 1](#) for more background information about MERS-CoV molecular testing methods, other assays and complimentary confirmation methods.

Implementation tip – genome sequencing

Where possible, MERS-CoV full genome sequencing from PCR-positive biological samples may provide further details on the genetic relationship of the viruses detected with other viral isolates. A RT-PCR assay for MERS-CoV targeting a 615 bp spike fragment may already provide a phylogenetic clustering of MERS-CoV variants comparable to that of full-length genomes, but this may often be insufficient for detailed molecular epidemiological investigations. Full genomes obtained by Next Generation Sequencing (NGS) using sets of specific primers to amplify the full genome for instance delivers a more detailed picture of genetic differences between viruses. Virus grown in culture may be used as an alternative source of the viral RNA.

Acquired sequence information should be shared and reported via publicly available databases; doing so will contribute valuable information to the global effort to understand MERS-CoV epidemiology and perform risk assessment.

Material and more detailed methods for MERS-CoV sequencing are described in the following publications:

1. Corman VM, Muller MA, Costabel U, et al. Assays for laboratory confirmation of novel human coronavirus (hCoV-EMC) infections. *Euro Surveill* 2012;17(49):20334
2. Cotten M, Watson SJ, Kellam P, et al. Transmission and evolution of the Middle East respiratory syndrome coronavirus in Saudi Arabia: a descriptive genomic study. *Lancet* 2013;382:1993-2002.
3. Cotten M, Watson SJ, Zumla AI, et al. Spread, circulation, and evolution of the Middle East respiratory syndrome coronavirus. *mBio* 2014;5.
4. Smits SL, Raj VS, Pas SD, et al. Reliable typing of MERS-CoV variants with a small genome fragment. *J Clin Virol* 2015;64:83-7.

ONE HEALTH APPROACH – laboratory testing of dromedary camel specimens

The World Organisation for Animal Health (WOAH) provides an overview of available tests for MERS-CoV antigen or antibody detection in dromedary camels: https://www.woah.org/fileadmin/Home/eng/Health_standards/tahm/3.05.02_MERS-CoV.pdf

It is important to note that the assays used and licensed for MERS-CoV testing for human and camel samples are different and cannot be used interchangeably.

2.3.4 Sample storage

In the case that serum samples cannot be processed immediately they can be stored for up to 5 days at 2 to 8 °C after which they should be stored at -80 °C (see [section 2.3.1](#) on Specimen collection and [section 2.3.2](#) Specimen transportation above for more details). If -80 °C storage is not available the samples can be stored at -20 °C. It is recommended to aliquot samples prior to freezing, to minimize freeze thaw cycles. The storage of serum specimens in domestic frost-free freezers should be avoided, owing to their wide temperature fluctuations.

Implementation tip – future use of samples

In some cases, where ethical approval allows (and where seeking ethical approval for this aspect does not delay the study start significantly), the investigators may wish to store samples and reuse them for future investigations on infectious diseases. If this is the case, the information for the participant and the informed consent or assent forms must include additional provisions for the storage and future use of samples for future investigations that will be approved by a research ethics committee, in accordance with national regulations. The information for the participant and the informed consent or assent forms also need to anticipate how participants will be informed of the results of any future investigations. Participants will be asked if their samples may be kept for future studies of other infectious pathogens and will be informed regarding how the samples and data are going to be stored, where they are going to be stored and who is going to be responsible for ensuring the security of that data. Participants will have the right to refuse the storage of their sample for future use, in which case their data and samples will be destroyed upon completion of the investigation. This needs to be detailed in the information for the participant and the informed consent or assent forms.

The investigators may already decide on potential future use of specimens and the time-frame for destruction of specimens. This should also be detailed in the informed consent or assent forms.

2.4 Data management

Demographic, occupational exposure and behavioral data should be stored in a secure, password-protected database in the country where it is collected. Participant identity will be protected and only aggregate summary data released publicly in reports, media updates (and similar). Original data collection forms will be kept in locked storage.



Implementation tip Ethical approval may be obtained from relevant ethical or institutional review boards in advance using a generic protocol such as this one before an outbreak occurs. If an outbreak occurs, the study design, questionnaires, sampling and consent forms can be modified rapidly to reflect the current outbreak situation. This will likely have to be resubmitted for ethical approval, but if the generic protocol has already been approved, the process is possible that second review may be more rapid, minimizing delays to the start of investigations. Investigators should consider formulating a detailed data management and sharing plan prior to beginning the study. For example, where ethical regulations and approvals allow, investigators may consider the possibility of sharing de-identified data collected as part of the study with WHO or other international organizations; pooling of MERS data is crucial in efficiently advancing the global understanding of this disease. See also the following link: [Sharing and reuse of health-related data for research purposes: WHO policy and implementation guidance \(https://www.who.int/publications/i/item/9789240044968\)](https://www.who.int/publications/i/item/9789240044968)

2.5 Ethical considerations

Ethical requirements will vary by country. In all cases, national and local regulations need to be followed. Investigators should confirm the requirements before implementation which may cover national ethics review only, or national and institutional review.

Implementation tip Ethical approval may be obtained from relevant ethical or institutional review boards in advance using a generic protocol such as this one before an outbreak occurs. If an outbreak occurs, the study design, questionnaires, sampling and consent forms can be modified rapidly to reflect the current outbreak situation. This will likely have to be resubmitted for ethical approval, but if the generic protocol has already been approved, the process is possible that second review may be more rapid, minimizing delays to the start of investigations.

WHO guidelines on ethical issues in public health surveillance can be found here: <https://www.who.int/publications/i/item/9789241512657>

2.5.1 Informed consent

Investigations and studies for MERS-CoV and related pathogens may involve testing of samples from humans and animals as well as environmental samples. Collection of



samples from humans typically requires individual consent (although not necessarily formal informed consent). However, there are no well-established ethical norms for collection of samples from animals and environments.

The purpose of the investigation needs to be explained to all individuals identified for recruitment into the investigation. Informed consent will be obtained from all individuals willing to participate in the investigation before any procedure is performed as part of the investigation, by a trained member of the investigation team.

Consent, or assent for children under the legal age of consent, will be obtained according to the country's national ethical requirements and thus need to comply with local regulations:

- **Consent** for:
 - adults; and
 - children under the legal age of consent (usually this is 18 years but it will vary from country to country) from a parent or legal guardian.

Implementation tip The age of consent may vary by country. Check the requirements of local, regional or national authorities.

- **Assent** from:
 - children and adolescents under the legal age of consent, but who can understand the implications of informed consent and go through the necessary procedures. This is usually children over the age of 12 to 13 years, but this will vary from country to country. A consent form from a parent or legal guardian will also be collected.

All eligible individuals, regardless of whether or not they are well or unwell, or receiving medical care for confirmed or suspected MERS, should be considered for participation in the investigation. For individuals who lack the decisional capacity to consent at the time of the investigation, consent or assent by proxy (parent or guardian or spouse or family member) may be considered so as to not unduly exclude individuals from participating in the investigation. However, some sites may decide to exclude those with severe disease who are unable to complete the questionnaire ([Annex 2](#)) **if** it is not possible to find a proxy. In either case, the exclusion criteria need to be clearly stated in the adapted protocol, and in the reporting of the results.

An appropriately trained member of the investigation team will need to explain to each participant that participation in the investigation is voluntary and that they are free to withdraw, without justification, from the investigation at any time without consequences and without affecting professional responsibilities. A member of the investigation must also be able to answer any questions individuals may have related to the procedures of the investigation.



The processes related to withdrawal of a participant need to be described both in the protocol and in the information for the participant. In this description it must be made clear that a participant can withdraw from the investigation, without justification, at any time by informing one of the members of the investigation team. The contact details of one of the members of the investigation need to be provided in the information for the participant. If any participant decides to withdraw during the investigation, the samples collected and data should be discarded, except if the participant indicates that these can be kept for the purpose of conducting the investigation, or for future studies of other infectious pathogens.

Informed consent will seek approval to collect: blood, a nasopharyngeal and oropharyngeal sample, demographic data, information related to dromedary camel exposure and other epidemiological data (e.g. behaviors) intended for the purpose of this investigation. It will also seek approval that samples may be shipped outside of the country for additional testing and, in accordance with national regulations, that samples may be used for future research purposes. The investigators will need to describe in the consent or assent forms how data and specimens will be securely stored. Informed consent will also indicate that any suspected or confirmed MERS-CoV infection may be notified to the national health authorities under the requirements of the International Health Regulations.

Examples of animal testing may include testing of wild animals or testing of privately-owned animals. Many jurisdictions may not have well-established ethics or governance mechanisms for the testing of animals for public health purposes. Consent from owners may be required for the collection of samples from privately-owned animals, although this may also be legally permitted under local public or animal health powers. Any harm to animals involved in sampling should be minimized and appropriate restraining of the animal during sampling is critical (see camel swab and tissue sample collection guidance by FAO here: <https://www.fao.org/3/ca7428en/CA7428EN.pdf>).

Implementation tip Additional consent forms may need to be developed by the country, according to national laws and regulations, if the investigation calls for storage and future use of samples.

2.5.2 Risks and benefits for participants

This investigation poses minimal risk to participants, involving the collection of a small amount of blood as well as a nasopharyngeal and oropharyngeal swab. The direct benefit to the participant is the possibility of identifying evidence of MERS-CoV infection, which, if the infection were acute, would allow for early monitoring and treatment. Additional benefits of the study are indirect in that data collected will help improve and guide efforts to understand the geographical extent of MERS-CoV infection, understand transmission and assist efforts to reduce further spillover and spread of MERS-CoV.



Implementation tip If local Institutional Review Board (IRB) regulations permit, participants may be offered reimbursement for reasonable out of pocket expenses related to the investigation; however, the level of compensation should not be such that participants are unduly influenced into consenting to participate.

2.5.3 Reporting of serious adverse events, including death of a participant

Any serious adverse event, including death, of a participant during the investigation period, needs to be immediately (within 24h) reported to the Principal Investigator and the institution responsible for the investigation. The contact details for reporting serious adverse events needs to be provided to each member of the investigation team.

In accordance with national regulations, any serious adverse event, may also have to be reported to the local ethical review committee, if the adapted protocol was not deemed exempt from local ethical review committee.

2.5.4 Confidentiality

National laws and regulations for data protection requirements must be followed.

Participant confidentiality needs to be maintained throughout the investigation. All subjects who participate in the investigation should be assigned a study identification number by the investigation team for the labelling of questionnaires ([Annex 2](#)) and specimens. The link of this identification number to individuals will be maintained by the investigation team and the Ministry of Health (or equivalent), separately from the investigation files, and will not be disclosed elsewhere.

Data and specimens will be securely stored nationally. If the data are shared by the implementing organization with WHO or any agency or institution providing support for data analysis, data shared will include only the investigation identification number and not any identifiable information. Data sharing outside the country will be managed according to national laws and regulations, as appropriate.

Article 45 of the IHR (2005) describes the “treatment of personal data”. Person identifiable data collected under the IHR should be kept confidential and processed anonymously, as required by national law. However, such data may be disclosed for assessments and management of public health risks, provided the data are processed fairly and lawfully.



2.5.5 Prevention of infection

Participants. As part of the recruitment process, all eligible participants should be provided information as to how MERS-CoV spreads and what measures can be taken to avoid infection. This should include information as to where to seek medical advice related to the investigation, the symptoms associated with MERS-CoV infection and what to do if symptoms develop during the investigation.

Investigation personnel. All personnel involved in the investigation need to be trained in infection prevention and control procedures (IPC; standard contact and droplet precautions, as determined by national or local guidelines). These procedures should include proper hand hygiene and the correct use of personal protective equipment (PPE; such as surgical or respiratory face masks, gloves, etc.), as per national or local guidelines, provided to members of the investigation team, not only to minimize their own risk of infection when in close contact with individuals with occupationally-exposed for MERS-CoV, but also to minimize the risk of spread among other participants in the investigation. Any investigation personnel who develop symptoms consistent with MERS-CoV should be immediately isolated, tested with a nasopharyngeal and oropharyngeal swab and managed as a suspect case of MERS-CoV according to the national or local guidelines.

Implementation tip Where possible, to mitigate infection risk, investigation personnel may consider administering questionnaires for participants over telecommunications (e.g. phone, videoconferencing, etc.). The feasibility of this strategy would depend on logistical factors (e.g. study personnel available and investigation partners) as well as local context (likelihood that all participants have phones or computers).

For example, an initial in-person visit by a study team member may include informed consent and biological sampling (for both occupationally-exposed individuals and their dromedary camels), with a phone-interview for the anthropological questionnaires (see [Annex 2](#)) the following day. This will work particularly well if, in any case, the study personnel doing biological sampling is not the same as the one doing the questionnaires.

Investigation members collecting blood samples should wear a medical mask and gloves, and follow all other IPC measures, as per national and local guidelines.

WHO technical guidance on IPC specific to MERS-CoV can be found here: <https://www.who.int/publications/i/item/10665-174652>

2.5.6 Mitigation of stigmatization of participants

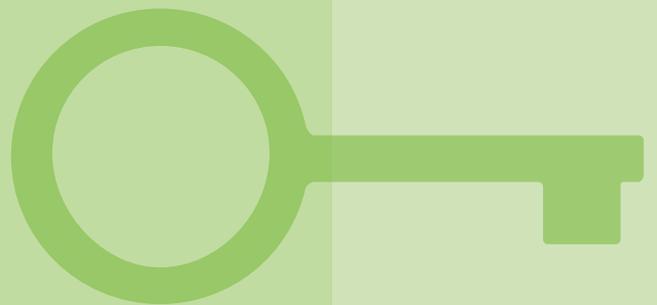
Stigma during MERS-CoV outbreaks involves negative social effects on a person or group due to the (real or perceived) presence of infection and/or risks of infection to others. Stigma can be particularly significant for pathogens such as MERS-CoV that are associated with large potential risks to individuals and communities and therefore significant negative social effects during outbreaks.

Individuals enrolled in MERS-CoV investigations or studies may face risks of stigma. Investigators, along with the relevant national or regional public health authorities, should therefore consider the stigma-related risks faced by individuals and weigh these against the benefits of the investigation. Enrolment of individuals in investigations and studies requires an ethical judgement that the likely public health benefits of enrolment outweigh additional risks specifically associated with the investigation, including those related to stigma. Measures to reduce stigma may include anonymity of enrolment to protect participants. However, full anonymity may not be possible due to the presence of staff involved in the investigations and public health measures (e.g., isolation). Public engagement regarding the disease and/or the investigation taking place, if carefully conducted, may also help to reduce stigma (e.g., by clarifying that infected individuals do not pose risks to others after the resolution of acute infection). For more reading on this subject, please consult the following resources:

- Collective Service (International Federation of Red Cross and Red Crescent Societies (IFRC), United Nations Children's Fund (UNICEF), World Health Organization (WHO) and Global Outbreak Alert and Response Network (GOARN) project): <https://www.rcce-collective.net/>
- Guidance for managing ethical issues in infectious disease outbreaks. Geneva: World Health Organization; 2016 (<https://apps.who.int/iris/handle/10665/250580>)
- WHO community engagement framework for quality, people-centred and resilient health services. Geneva: World Health Organization; 2017 (<https://apps.who.int/iris/handle/10665/259280>)

The investigators will need to provide specific information on how the risks of stigmatization will be mitigated as part of the implementation of the investigation and the communication of the findings.

3. Statistical analysis





The following section discusses sample size considerations, the epidemiological indicators that can be calculated with the data collected through this study (sometimes called ‘study endpoints’) and the statistical analyses that should be performed to do so.

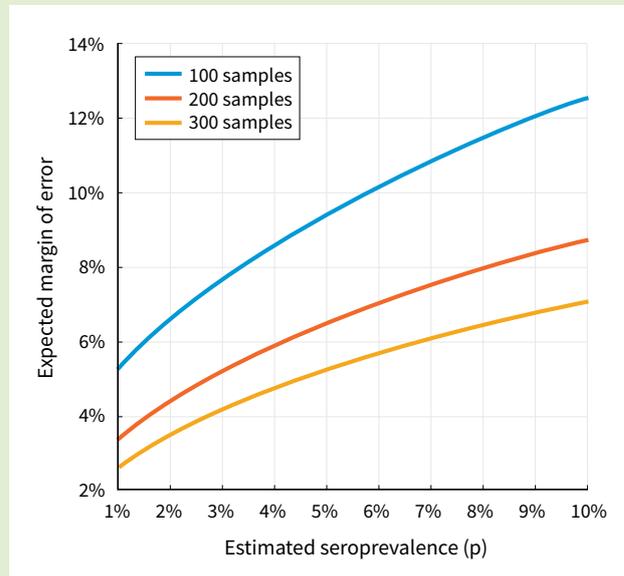
3.1 Sample size considerations

The study-specific sample size will be determined by the estimated number of ‘occupationally-exposed’ individuals of interest (i.e. those persons in contact with dromedary camels that the investigators have decided to recruit), the specific objectives you would like to complete and by feasibility considerations as per resources allocated. Past studies have found it difficult to recruit large numbers of occupationally exposed persons in individual countries. In areas where this is suspected to be an issue (i.e. limited ‘occupationally-exposed’ population size), then every effort should be made to include all participants who are routinely in contact with dromedary camels as part of their occupational duties to maximize the statistical power of the investigation. Note that:

- Sample sizes are calculated for each stratum of analysis (e.g. age, sex or occupation)
- As sampling will be conducted for participant clusters at farms or markets or racing venues or abattoirs, the design effect is likely to increase the required sample size of the study.

Implementation tip Although the sample size of this specific study is typically outside the control of the investigators (unless the number of “occupationally-exposed” individuals is expected to be very high), it will still be useful for study planning and for local administrative procedures to provide an estimate of the expected number of participants, and an example(s) of what margins of error may be present around the study outcome estimates.

Figure 1: Expected margins of errors at different seroprevalences for investigations of 100, 200 or 300 sample sizes. Note, this figure does not account for the sensitivity and specificity characteristics of the serologic test.



The Figure 1 above provides estimates of margin of error as a function of seroprevalence for 100, 200 and 300 samples per population group (e.g. overall study population, occupationally-exposed group, age-groups within occupationally-exposed groups) included in the study. For a given seroprevalence percentage p and sample size N , the expected margin of error corresponds to the expected width of the 95% confidence interval associated with the point estimate of p obtained using binomial likelihood.

For example, a study in Country X aims to understand the seroprevalence of MERS-CoV in camel herders. Investigators enroll 200 camel herders, 100 of whom are in the age group 18 to 49 years and 100 of whom are in the age group 50+ years. The study finds a seroprevalence of 6% across the entire study population ($N=200$), with a 95% confidence interval of approximately 3%-10% (as you see this confidence interval is 7 percentage points wide, or in other words, a 7% margin of error). After age stratification, the study finds that among the 18 to 49 year-old participants, the seroprevalence is 8% (95%CI: 3.5–15.2); as per Figure 1 – if seroprevalence $p = 8%$ and $N=100$, then the margin of error = ~11.5%. Among the 50+ year-old participants, the seroprevalence is 4% (95%CI: 1.1–9.9); as per Figure 1 – if seroprevalence $p=4%$ and $N=100$, then the margin of error = ~8.5%.

Margins of error and other sample size estimates can be calculated using statistical formulas or tools available online (e.g. <https://www.calculator.net/sample-size-calculator.html>) or in standard statistical packages.

ONE HEALTH APPROACH – sample size considerations for dromedary camel sampling

Different value chain nodes (such as farms, markets, abattoirs, racetracks etc.) are considered different camel populations and each node type should therefore be treated as a separate sample size calculation. For example, one sample size can be calculated for markets, one for slaughterhouses, one for primary herds, etc.. If possible, more than one site should be included from each node type. Sample size calculations for prevalence estimation should be used (see EPITOOLS sample size calculator developed by Ausvet <https://epitools.ausvet.com.au/samplesize>). It is recommended to determine how many camels should be sampled for each node type and divide this number proportionally by node type site, i.e. according to the number of camels present in each site. Camel selection at each site should be based on representative, equal-probability sampling (i.e. random sampling; see EPITOOLS by Ausvet <https://epitools.ausvet.com.au/randomsampling>).

3.2 Epidemiological indicators (study outcome measures)

Table 1 below provides an overview of the epidemiological characteristics that can be measured as part of this investigation. Not all of these will be a resulting outcome of each specific study using this protocol – this will depend on which aspects of this protocol are implemented.

Table 1: Investigation objectives and epidemiological characteristics that can be estimated from it

Objective	Epidemiological characteristics	Definition	Data source to calculate characteristics	Comments, limitations
1. Estimate the seroprevalence (presence of antibodies) of MERS-CoV in populations with occupational exposure to dromedary camels	Seroprevalence (according to type of occupational exposure, age specific*, sex specific*)	The proportion of individuals per strata who show seropositivity for MERS-CoV	<ul style="list-style-type: none"> • Seropositivity • Occupational exposure type • Age group* • Sex* • Other characteristics* 	The numerator is the total (or per strata) number of persons testing positive for MERS-CoV antibodies, and the denominator is all persons tested (or total per strata). Note that this is subject to underestimation due to the fact that not all persons infected with MERS-CoV will seroconvert, especially in instances of mild disease. Almost all persons with severe MERS will seroconvert; however, such persons will not comprise many (or any) of the persons included in this specific study.



Objective	Epidemiological characteristics	Definition	Data source to calculate characteristics	Comments, limitations
<p>2. Identify MERS-CoV infection and shedding (presence of viral RNA) status in populations with occupational exposure to dromedary camels</p>	<p>Infection prevalence and prevalence of viral shedding (according to type of occupational exposure, age-specific*, sex specific*)</p>	<p>Proportion of individuals (<i>per strata, if applicable</i>) who are positive for MERS-CoV as per a molecular test and proportion of those who are identified as having viral shedding</p>	<ul style="list-style-type: none"> • MERS-CoV molecular test results (and results of repeat testing for those positive) from swabs • Viral load quantification for positive tests • Occupational exposure type • Age group* • Sex* • Other characteristics* 	<p>For infection prevalence (or viral shedding prevalence), the numerator is the total (or per strata) number of persons testing positive for MERS-CoV (or with viral shedding identified) via molecular testing, and the denominator is all persons tested (or total per strata). Note that this is subject to underestimation because upper respiratory tract specimens (if used) are less sensitive than lower respiratory tract specimens.</p>
<p>3. Determine the geographical extent of MERS-CoV infection, both past and present, in occupationally-exposed individuals, in areas with high densities of dromedary camels</p>	<p>Geographical extent of MERS-CoV seropositivity or active infection in region of study – output will depend on analysis method</p>	<p>Various possibilities: proportion of a country or region, with evidence of any past or present MERS-CoV infection; square kilometers of the region of study with any evidence of past or present infection; infection density by subregion within region of study</p>	<ul style="list-style-type: none"> • Geographic location (e.g. district and/ or town name or detailed coordinates) of each included site where participant or dromedary testing was conducted • Seropositivity and active infection and/or shedding results from objectives #1, #2, #3 	<p>Various options are possible to describe and visualize geographic extent: seropositivity or infection prevalence by site location can be ‘drawn’ or indicated (via computer) onto a scaled map outline of the country or region of study, or if geographical information system data and expertise is available more complex maps and analyses can be conducted using software. Note: Mapping of past (seropositivity) and present (positivity in molecular test) infection should be conducted separately or distinguished within the map of choice. Also note that the length of time individuals remain seropositive is not currently certain (though it estimated to be at least 7 years) and the proportion of infected persons who seroconvert is also not known. This should be considered when interpreting findings.</p>



Objective	Epidemiological characteristics	Definition	Data source to calculate characteristics	Comments, limitations
<p>4. Highly recommended: estimate the seroprevalence of MERS-CoV among dromedary camels of occupationally-exposed persons included in the study – by camel age, sex, husbandry type and other factors of interest (e.g. site, region of origin, season)</p>	<p>Seroprevalence (according to camel age and sex) and other factors of interest (e.g. husbandry type, site, region of origin, season)</p>	<p>The proportion of dromedary camels per strata who show seropositivity for MERS-CoV</p>	<ul style="list-style-type: none"> • MERS-CoV seropositivity • Dromedary camel age • Dromedary camel sex • Other characteristics of interest (e.g. husbandry type, site, region of origin, season) 	<p>The numerator is the total (or per strata) number of camels testing positive for MERS-CoV antibodies, and the denominator is all dromedary camels (or total per strata) tested.</p>
<p>5. Highly recommended: to identify MERS-CoV infection and shedding (presence of viral RNA) status of dromedary camels of occupationally-exposed persons included in the study – by camel age and sex</p>	<p>Infection prevalence and average shedding time duration (according to any strata of interest*)</p>	<p>Proportion of dromedary camels (<i>per strata, if applicable</i>) who are positive for with MERS-CoV as per a molecular test. For shedding duration, average length of time testing positive among those positive</p>	<ul style="list-style-type: none"> • MERS-CoV molecular test results (and results of repeat testing for those positive) from swabs • Viral load quantification for positive tests • Other characteristics (e.g. camel density, site such as market or racing venue, other) 	<p>See comments and limitations for #2 above.</p>



Objective	Epidemiological characteristics	Definition	Data source to calculate characteristics	Comments, limitations
<p>6. Determine modifiable risk factors for infection by comparing the exposures of infected and non-infected occupationally-exposed individuals and dromedaries</p>	<p>Adjusted or unadjusted odds ratios or risk ratios, or unadjusted risk differences for each modifiable risk factor of interest</p>	<p>Odds or risk ratio: odds or risk of a positive test in those with the risk factor vs odds or risk of a positive test in those without the risk factor. Regression models including other factors of interest or key baseline characteristics will give an adjusted (preferable) risk or odds ratio.</p> <p>Risk difference: Risk of past or present infection in those with the risk factor subtracted by risk of past or present infection in those without the risk factor.</p>	<ul style="list-style-type: none"> • Seropositivity • Current infection status • Type of occupational exposure • Age group • Sex • Other modifiable risk factors or confounding factors of interest* 	<p>If the number of participants testing either positive for current or prior infection is ≥ 10 and depending on how many explanatory variables you wish to include, an adjusted analysis model may be considered for odds or risk ratios. The number of risk factors included is generally limited by the number of persons with the outcome of interest (roughly 1 additional risk factor per 10 persons with the outcome, but other methods for model selection and optimized fit should be considered if a trained statistician is included as a collaborator or study team member.</p> <p>Note: Analysis of past (seropositivity) and present (molecular positivity) infection should be conducted separately. Model of choice should adjust for within-site clustering.</p>

* Optional – if of interest for stratification.

Implementation tip Depending on the study sample size, any of the above epidemiological indicators may be reported as overall or by subgroup (e.g. occupational group or job duty, age, gender, etc.).

3.3 Interpretation of results

The following considerations are needed when interpreting the results of this investigation:

- The occupationally-exposed populations included and the biases inherent with the selection of the study population – do the findings apply to all types of occupationally exposed persons, or only for example, camel farm and market workers? Were any further exclusion criteria implied in the specific study (e.g. an age requirement)? What proportion of eligible participants refused to participate? What was the timing of the study relative to seasonal events that may affect MERS transmission?



- The region of study globally – was the study performed in the Middle-East region, African region, or Central Asia, where different strains may be present?
- The areas of sampling within the study country – was the sample representative of the whole country or was the sample a convenience sample? Were only high dromedary camel density areas sampled?
- The serologic assay used – what are the specificity and sensitivity characteristics of the assay itself?
- The molecular assay used – what are the specificity and sensitivity characteristics of the molecular assay used to detect active infection and shedding?

Increasing our understanding of MERS-CoV epidemiology, risk factors and severity.

The findings of this investigation will increase our global understanding of the geographical extent of MERS-CoV, risk factors for MERS-CoV infection within occupationally-exposed populations and the spectrum of MERS-CoV disease. These findings will aid in creating local and international policies for preventing MERS-CoV transmission and will inform infection control in the case of eventual outbreaks.

ONE HEALTH APPROACH – interpretation of dromedary camel test results

The following considerations are needed when interpreting the camel-specific results of this investigation:

- The camel populations included and the biases inherent with the selection of the study population – do the findings apply to all types of camel value chain nodes, or only for example, camel farm and market? Were any further exclusion criteria implied in the specific study?
- The region of study globally – was the study performed in the Middle-East region, African region, or Central Asia, where different strains may be present?
- The areas of sampling within the study country - was the sample representative of the whole country or was the sample a convenience sample? Were only high dromedary camel density areas sampled?
- The serologic assay used – what are the specificity and sensitivity characteristics of the assay itself?
- The molecular assay used - what are the specificity and sensitivity characteristics of the molecular assay used to detect active infection and shedding in camels?

4. Dissemination of results





Recruitment method allowing, all participants should be informed of their individual results using the contact information collected as part of the investigation. The communities in which the investigation is implemented also need to receive a report on the overall findings of the investigation. This should include reporting on the following information:

1. The study design and specific procedures used (e.g. sampling method, eligibility criteria, laboratory techniques, etc.);
2. A map or other depiction of the regions and/or communities that were selected for this study;
3. The number of study sites and the number of individuals approached and included, the age and sex of all individuals included is also ideally reported if this has been collected;
4. The number of dromedary camels sampled;
5. The timing of sample collection relative to camel calving or weaning timing or other relevant seasonal risk factors.
6. Seroprevalence, as well as the raw numbers of individuals with serologic evidence of MERS-CoV infection. If sample size permits, these estimates should be reported by your strata of interest;
7. Proportion of individuals, and dromedary camels, found with active infection and shedding (presence of viral RNA), as well as the raw numbers of individuals with molecular testing evidence of MERS-CoV infection. If sample size permits, these estimates should be reported by your strata of interest;
8. Any other key findings, as per the specific study objectives chosen (e.g. geographical extent and mapping, KAP results, successful virus isolation, genomic analysis, etc.).

An integrated approach which engages both researchers and stakeholders should be used for conducting dissemination activities in joint efforts by the researchers involved and advisory committee members.

Dissemination activities could include:

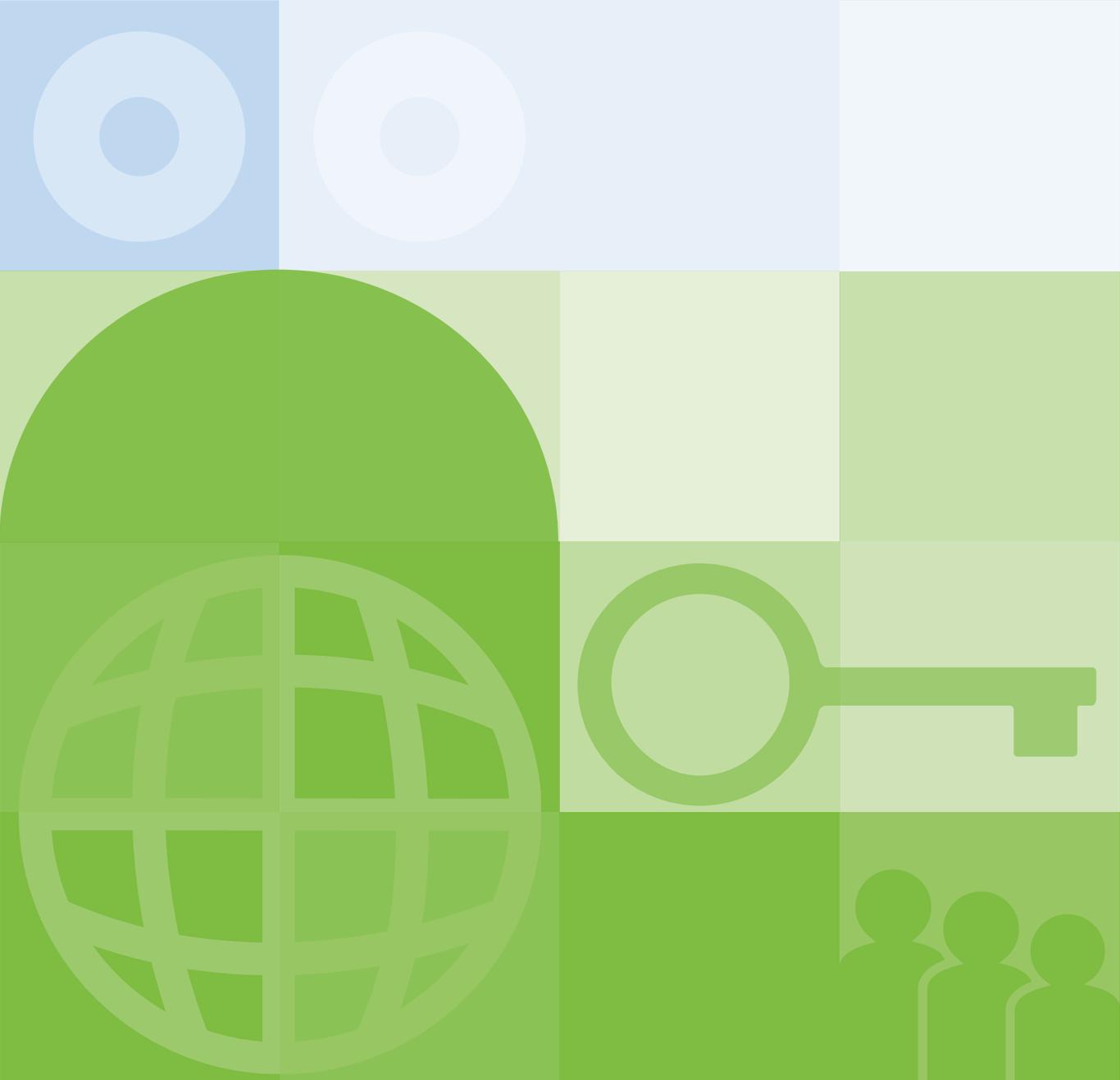
- Submitting progress and final research reports to national Ministries of Health and Agriculture and to WHO.
- Publishing the research findings as preprints and subsequently in peer-reviewed journals and making them available in open access format. The STROBE guidelines for cross-sectional studies should be used for reporting of this study <https://www.equator-network.org/reporting-guidelines/strobe/>
- Organizing meetings, seminars and workshops involving a panel of the research team beside other research experts (from human and animal health) to discuss the research findings and how they may influence public health interventions and policies.
- Developing policy briefs for national human and veterinary health authorities.



- Submitting genome sequence information into international databases and (where appropriate and allowed according to local ethics regulations) sharing data in international repositories to facilitate collating of studies to further health research on larger sample sizes. If doing so this will need to be specified in the consent form to allow use of data for other research purposes.

Implementation tip The timely dissemination of the results of this study are critical in understanding transmission of the MERS-CoV virus to inform guidance for policy to direct national and international public health responses.

5. Composition of study team



The proposal calls for a One Health approach with a multi-disciplinary research study team to undertake this study. The composition of the study team will be determined by each country. It is recommended that members from the Ministries of Health and Agriculture, national laboratories for animals and humans and other partners are included in the implementation and interpretation of this investigation.

Using a One Health approach, national veterinary and public health services should jointly develop and agree on the study design, based on the protocol proposed here. The protocol should be used as guidance, adapting some aspects to country specific contexts as well as existing procedures and legislation. The One Health coordination mechanism, if present in the country, will play an important coordination role by facilitating timely information sharing between public health authorities, e.g. the Ministry of Health (MoH), and veterinary services, the Ministry of Agriculture and/or Livestock (MoA), as well as other relevant One Health partners. Epidemiologists, veterinarians, modelers, virologists, statisticians, clinicians and public health experts will all be necessary to include in this study that will help define key clinical, epidemiological and virological characteristics of MERS-CoV. Importantly, these specialists should all be included from an early stage to ensure that the study protocol and procedures adhere to best practices; e.g. making sure to include statisticians early on in the design of the study and not only after all data collection has been conducted as this may lead to having data which is not amenable to analysis.

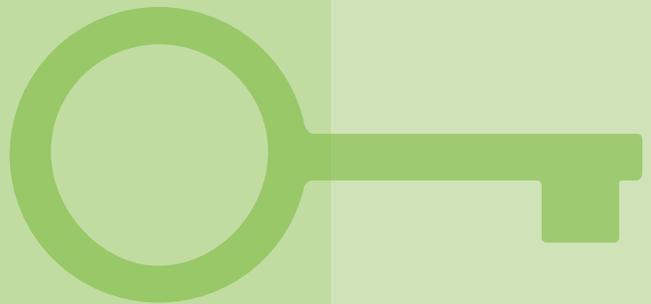
Implementation tip A table such as the one below may be useful for designating roles and responsibilities, and identifying study partners, during the planning stage of this investigation.

Coordination matrix of roles and responsibilities in Country X

What?	Who?
Overall coordination of the investigation	[Cite institution and/or body and/or person(s)]
Identification of study population	[Cite institution and/or body and/or person(s)]
Input on dromedary camel sampling strategy	[Cite institution and/or body and/or person(s)]
Recruitment, informed consent, enrolment	[Cite institution and/or body and/or person(s)]
Data and sample collection from enrolled participants	[Cite institution and/or body and/or person(s)]
Laboratory testing and storage of samples	[Cite institution and/or body and/or person(s)]
Data and sample collection from dromedary camels enrolled	[Cite institution and/or body and/or person(s)]
Laboratory testing and storage of camel samples	[Cite institution and/or body and/or person(s)]
Analysis of data and reporting	[Cite institution and/or body and/or person(s)]
Data management	[Cite institution and/or body and/or person(s)]
IT management	[Cite institution and/or body and/or person(s)]
Informing participants of their individual results and the results of their camels (if tested) and communication of overall findings of investigation	[Cite institution and/or body and/or person(s)]
[add more roles, as per country context]	[Cite institution and/or body and/or person(s)]

Once the study team has been identified, a workshop and training should be conducted to familiarize the team with the objectives and organize the implementation of the study.

6. References



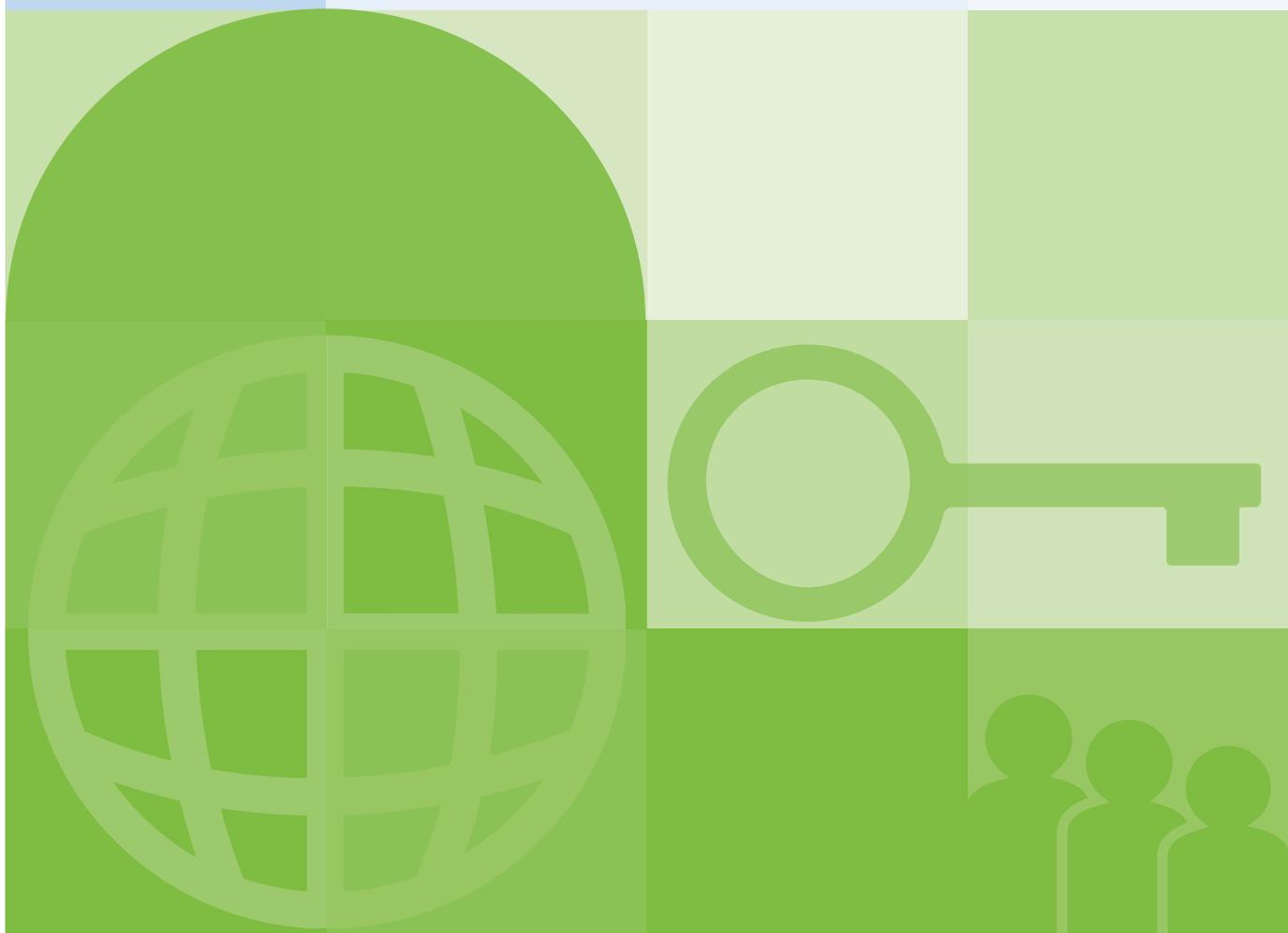
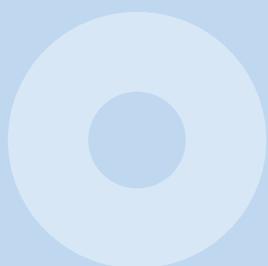


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5. Drosten C, Kellam P, Memish ZA. Evidence for camel-to-human transmission of MERS coronavirus. *N Engl J Med*. 2014;371(14):1359-60.
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8. Food and Agricultural Organization of the United Nations. Global technical meeting on MERS-CoV and other emerging zoonotic coronaviruses - meeting summary. 2021. Available from: <https://www.who.int/publications/m/item/global-technical-meeting-on-mers-cov-and-other-emerging-zoonotic-coronaviruses-meeting-summary>
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12. Al-Ahmadi K, Alahmadi M, Al-Zahrani A. Spatial association between primary Middle East respiratory syndrome coronavirus infection and exposure to dromedary camels in Saudi Arabia. *Zoonoses Public Health*. 2020;67(4):382-90.
13. Hemida MG, Ali M, Alhammadi M, Alnaeem A. The Middle East respiratory syndrome coronavirus in the breath of some infected dromedary camels (*Camelus dromedarius*). *Epidemiol Infect*. 2020;148:e247.
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7. Annexes



Annex 1: Additional information and references

MERS-CoV molecular testing

Currently described tests are an assay targeting upstream of the E protein gene (upE) and assays targeting the open reading frame 1b (ORF 1b) (1) and the open reading frame 1a (ORF 1a) (2). The assay for the upE target is considered highly sensitive and is recommended for screening, with the ORF 1a assay considered of equal sensitivity. The ORF 1b assay is considered less sensitive than the ORF 1a assay. An alternative approach involving two rRT-PCR assays targeting the MERS-CoV nucleocapsid (N) protein gene, which can complement upE and ORF 1a assays for screening and confirmation has also been published (3).

References:

1. Corman VM, Eckerle I, Bleicker T, et al. Detection of a novel human coronavirus by real-time reverse-transcription polymerase chain reaction. *Euro Surveill* 2012;17(39):20285
2. Corman VM, Muller MA, Costabel U, et al. Assays for laboratory confirmation of novel human coronavirus (hCoV-EMC) infections. *Euro Surveill* 2012;17(49):20334
3. Lu X, Whitaker B, Sakthivel SK, et al. Real-time reverse transcription-PCR assay panel for Middle East respiratory syndrome coronavirus. *J Clin Microbiol* 2014;52:67-75.

MERS-CoV serological testing

A number of different technical approaches for confirming MERS-CoV infection using serology have been developed. Details of two immunofluorescence assays to detect antibodies to MERS-CoV have been published (1), and these assays, along with a serum neutralization test, were used in a 2 to 3 stage procedure to screen contacts of a case in Germany and determine population seroprevalences in Saudi Arabia (2-5). An assay for detection of MERS-CoV antibodies using protein microarray technology has also been developed and its details published (6,7). Another two-stage approach with a screening test using a recombinant nucleocapsid (N) and spike (S) protein-based indirect enzyme-linked immunosorbent (ELISA), followed by a confirmatory microneutralization has also been described (8). Details of a neutralization test based on retroviral pseudoparticles which also demonstrates high levels of specificity to MERS-CoV have also been published (9). A commercial ELISA assay based on the spike S1 region is available for screening. Positive ELISA results should be confirmed by neutralization assays.

References:

1. Corman VM, Muller MA, Costabel U, et al. Assays for laboratory confirmation of novel human coronavirus (hCoV-EMC) infections. *Euro Surveill* 2012; 17(49):20334
2. Corman VM, Eckerle I, Bleicker T, et al. Detection of a novel human coronavirus by real-time reverse-transcription polymerase chain reaction. *Euro Surveill* 2012; 17(49):20334
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8. Trivedi S, Miao C, Al-Abdallat MM, et al. Inclusion of MERS-spike protein ELISA in algorithm to determine serologic evidence of MERS-CoV infection. *J Med Virol* 2018;90:367-71
9. Perera RA, Wang P, Gomaa MR, et al. Seroepidemiology for MERS coronavirus using microneutralisation and pseudoparticle virus neutralisation assays reveal a high prevalence of antibody in dromedary camels in Egypt, June 2013. *Euro Surveill* 2013;18:pii=20574.

Annex 2: Questionnaires



Questionnaire 1: Occupational exposure facility and facility owner questionnaire

Comment: before beginning, each facility owner should be allocated a unique identification number. This form can be used for all types of occupational-exposure facilities in this study regardless of facility type. However, you will notice a few questions which are facility specific and should be filled in (or skipped) depending on the current facility being investigated.

Note: the questionnaire's first page should be kept securely and separately from the rest of the questionnaire

Implementation tip As part of study implementation, it is important to allocate time and study funds for translation and field-testing of the questionnaires and other data collection tools. Investigators are encouraged to adapt the questionnaires to local contexts to maximize the relevance of the study's results.

Facility Owner Unique Participant ID

1. Data collector and interview information

Name of data collector	
Data collector institution	
Data collector profession	
Data collector telephone number	
Data collector email	
Place of interview (region, city, further details if applicable)	
Interview start date (dd/mm/yyyy)	___/___/_____
Form completion date (dd/mm/yyyy)	___/___/_____
Language used for interview	

2. Facility owner personally identifying information

(Note: personally identifying data should be stored securely and separately from other parts of this form)

First name	
Family name	
Date of birth (dd/mm/yyyy)	___/___/_____ <input type="checkbox"/> Unknown
Address (if multiple residences, give addresses for all)	
Telephone (mobile) number	
Email	
National identifier or social number [optional]	
Responsible health centre, if applicable (name, address, contact information):	

Questionnaire 1: Occupational exposure facility and facility owner questionnaire (continued)**3. Facility owner demographic and exposure information**

Sex	<input type="checkbox"/> Male <input type="checkbox"/> Female <input type="checkbox"/> Not known <input type="checkbox"/> Prefer not to answer
Age (years, months)	____ years ____ months <input type="checkbox"/> Unknown
Nationality	
How long have you worked at this facility?	_____ years _____ months

4. Facility information ('facility' here may mean any of: abattoir, farm, market, quarantine, racetrack)

In which country is this facility?	
Which animals are [slaughtered or farmed or sold or quarantined or raced]* at this facility (check all that apply)? Please give typical number of animals hosted at facility (if abattoir, number slaughtered per day) <small>*answer according to type of facility</small>	<input type="checkbox"/> Dromedary camels, # _____ <input type="checkbox"/> Goats, # _____ <input type="checkbox"/> Sheep, # _____ <input type="checkbox"/> Cattle, # _____ <input type="checkbox"/> Horses, # _____ <input type="checkbox"/> Donkeys, # _____ <input type="checkbox"/> Other 1, specify: _____, # _____ <input type="checkbox"/> Other 2, specify: _____, # _____ <input type="checkbox"/> Other 3, specify: _____, # _____
IF ABATTOIR What operations occur at this abattoir? Which of the operations is (are) the owner's primary job(s)?	<input type="checkbox"/> Slaughtering of animals <input type="checkbox"/> Cleaning <input type="checkbox"/> Flaying <input type="checkbox"/> Evisceration <input type="checkbox"/> Product (e.g. meat) storage <input type="checkbox"/> Other, specify: Specify:
IF FARM What operations occur at this farm outside of animal rearing and animal care? Which of the operations at the farm is (are) the owner's primary job(s)?	Specify: Specify:
IF MARKET What operations occur at this market outside of animal buying and selling? (e.g. slaughter or admin) Which of the operations at the market is (are) the owner's primary job(s)?	Specify: Specify:
IF QUARANTINE What operations occur at this quarantine facility? At what age are camels brought to this facility? Are camels and other animals kept in the same areas? Are there any treatments or vaccinations required prior to arrival at the facility?	<input type="checkbox"/> Sampling animals <input type="checkbox"/> Animal vaccination <input type="checkbox"/> Animal care <input type="checkbox"/> Other, specify: Age: _____ <input type="checkbox"/> Yes <input type="checkbox"/> No Treatment and/or vaccine 1: Treatment and/or vaccine 2: Treatment and/or vaccine 3:
IF RACETRACK What operations occur at this racetrack outside of animal racing? Which of the operations is the owner's primary job?	Specify: Specify:
Are there certain days, weeks or periods of the year when this facility operates more or less? (e.g. holidays or festivals)	Please describe:

**Questionnaire 1: Occupational exposure facility and facility owner questionnaire** (continued)

Have you seen other animals (that do not belong there) rodents or pests at the facility?	<input type="checkbox"/> No <input type="checkbox"/> Yes, (<i>check all that apply</i>): <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Rats <input type="checkbox"/> Mice <input type="checkbox"/> Bats <input type="checkbox"/> Other, specify:
Are there specific handwashing facilities at this facility? If yes, please specify number and locations* <small>*interviewer should ideally make a map of the facility</small>	<input type="checkbox"/> Yes <input type="checkbox"/> No
What personal protective equipment is used regularly (daily) by persons working at the facility?	<input type="checkbox"/> Gloves <input type="checkbox"/> Coveralls <input type="checkbox"/> Dust masks <input type="checkbox"/> Boots or boot covers <input type="checkbox"/> Respirators <input type="checkbox"/> Eye protection <input type="checkbox"/> Other, specify:
If dromedary camels are regularly introduced to this facility, where are they coming from? (fill in as required)	Location 1 (city, province, country): Location 2 (city, province, country): Location 3 (city, province, country): Location 4 (city, province, country): Location 5 (city, province, country):

5. End of questionnaire and status of form completion

Is the participant ok with being contacted again with further questions or clarifications?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Form completed	<input type="checkbox"/> Yes <input type="checkbox"/> No or partially If No or partially, reason: <input type="checkbox"/> Missed <input type="checkbox"/> Not attempted <input type="checkbox"/> Not performed <input type="checkbox"/> Refusal <input type="checkbox"/> Other, specify:



Questionnaire 2: Occupationally exposed participant questionnaire

Comment: before beginning, each participant should be allocated a unique identification number. This form can be used for all participants included in this study (the entire form can be printed and brought to the interview) – regardless of occupational exposure type. However, for section 7 of this questionnaire, do the following sections only depending on occupation.

- Abattoir worker: section 7a
- Camel or animal farm worker: section 7b
- Camel or animal market worker: section 7c
- Camel quarantine worker: section 7d
- Camel racetrack worker: section 7e

Note: the questionnaire's first page should be kept securely and separately from the rest of the questionnaire

Implementation tip As part of study implementation, it is important to allocate time and study funds for translation and field-testing of the questionnaires and other data collection tools. Investigators are encouraged to adapt the questionnaires to local contexts to maximize the relevance of the study's results.

Unique Participant ID

1. Data collector and interview information

Name of data collector	
Data collector institution	
Data collector profession	
Data collector telephone number	
Data collector email	
Place of interview (region, city, further details if applicable)	
Interview start date (dd/mm/yyyy)	___/___/_____
Form completion date (dd/mm/yyyy)	___/___/_____
Language used for interview	

2. Participant personally identifying information

(Note: personally identifying data should be stored securely and separately from other parts of this form)

First name	
Family name	
Date of birth (dd/mm/yyyy)	___/___/_____ <input type="checkbox"/> Unknown
Address (if multiple residences, give addresses for all)	

**Questionnaire 2: Occupationally exposed participant questionnaire** (continued)

Telephone (mobile) number	
Email	
National identifier or social number [optional]	
Responsible health centre, if applicable (name, address, contact information):	

3. Participant demographic information and living situation data

Sex	<input type="checkbox"/> Male <input type="checkbox"/> Female <input type="checkbox"/> Not known <input type="checkbox"/> Prefer not to answer
Age (years, months)	____ years ____ months <input type="checkbox"/> Unknown
Nationality	
Ethnicity [optional, at discretion of study investigators. If using, please input checkbox style options with relevant ethnicities in the right-hand column]	
Country of residence	
Type of housing for primary residence(s) [options to the right should be adjusted to apply to local setting]	<input type="checkbox"/> Apartment <input type="checkbox"/> House <input type="checkbox"/> Villa <input type="checkbox"/> Other (specify):
Number of people living in the household (including participant, <i>note</i> : a household is defined as having one shared kitchen)	Children less than 18 years of age: _____ Adults 18 years of age and above: _____
Highest level of education completed	<input type="checkbox"/> None or not finished primary school <input type="checkbox"/> Primary school (approximately 6 years) <input type="checkbox"/> Secondary school (total of approximately 12 years) <input type="checkbox"/> College or university undergraduate degree or postsecondary diploma <input type="checkbox"/> Graduate studies (e.g. Masters, PhD)
Household income level [enter local context specific options in the right-hand column]	<input type="checkbox"/> Level 1 [specify] <input type="checkbox"/> Level 2 [specify] <input type="checkbox"/> Level 3 [specify] <input type="checkbox"/> Level 4 [specify] <input type="checkbox"/> [add or remove as appropriate for local setting]
Occupation (select all that apply and specify location and/or facility)	<input type="checkbox"/> Abattoir worker → proceed to section 7a <input type="checkbox"/> Camel or animal farm worker → proceed to section 7b <input type="checkbox"/> Camel or animal market worker → proceed to section 7c <input type="checkbox"/> Camel quarantine worker → proceed to section 7d <input type="checkbox"/> Camel racetrack worker → proceed to section 7e <input type="checkbox"/> Other, specify:



Questionnaire 2: Occupationally exposed participant questionnaire (continued)

4. Participant current symptoms(today) and history of symptoms (last six months)

Are you sick today with fever or respiratory symptoms?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	
Did you experience any fever or respiratory signs or symptoms during the last six months?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	
If Yes, did you seek medical care?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If Yes, specify location (address):	
If Yes, were you hospitalized during your illness?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If Yes, when? (dd/mm/yyyy): ____/____/_____ If Yes, which hospital (address):	
If you answered yes to either of the first two questions, please indicate which symptoms.	Today	Last six months
Fever	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Dry cough	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Productive cough	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Phlegm	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Sore throat	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Runny nose	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Shortness of breath	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Chest pain	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Chills	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Vomiting	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Nausea	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Diarrhoea	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Headache	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Fatigue	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Other symptoms	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If Yes, specify:

5. Participant medical history

5a. Pre-existing conditions and chronic illnesses

Obesity	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Cancer If Yes, specify (timing and specific cancer): If cancer treatment in the last year:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown <input type="checkbox"/> Chemotherapy <input type="checkbox"/> Radiation <input type="checkbox"/> Other, specify:
Diabetes If Yes, do you use insulin?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
HIV and/or other immune deficiency If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown

Questionnaire 2: Occupationally exposed participant questionnaire (continued)

Heart disease If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Asthma (requiring medication) Which medication has been used for treatment of asthma in the past month?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown <input type="checkbox"/> Handheld inhalers <input type="checkbox"/> Oral medications to open airways <input type="checkbox"/> Oral steroids <input type="checkbox"/> Home nebulizer treatment to open airways <input type="checkbox"/> None in the past month <input type="checkbox"/> Other, specify:
Chronic lung disease (non-asthma) If Yes, specify: Specify any medication used for treatment:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Chronic liver disease If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Chronic hematological disorder If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Chronic kidney disease If Yes, are you currently receiving dialysis?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Chronic neurological impairment or disease If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Organ or bone marrow recipient	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Pregnancy	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If Yes, specify number of weeks:
Recent pregnancy – if female and not currently pregnant, was the participant pregnant in the last six months?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Familial hereditary illness If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Other pre-existing condition(s) If Yes, specify:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown

Questionnaire 2: Occupationally exposed participant questionnaire (continued)

5b. Other medical history

Participant currently smokes tobacco (e.g. cigarettes, cigars, shisha)	<input type="checkbox"/> Daily <input type="checkbox"/> A few days a week <input type="checkbox"/> Not at all <input type="checkbox"/> Unknown
If participant currently smokes tobacco, do they share their tobacco? (e.g. shisha)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown <input type="checkbox"/> Not applicable (does not smoke)
If participant does not currently smoke tobacco daily, have they smoked tobacco daily in the past?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown <input type="checkbox"/> Not applicable (currently smokes daily)
If participant smoked tobacco in the past (but not currently), at what frequency was it?	<input type="checkbox"/> Daily <input type="checkbox"/> A few days a week <input type="checkbox"/> Unknown
Participant takes medications regularly (within the last six months)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
If Yes, taking corticosteroids:	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
If Yes, list medications:	
Participant has seen a traditional healer in the last six months	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Participant has taken traditional medications within the last six months	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown <input type="checkbox"/> If Yes, list traditional medications:

6. Travel and other exposures in the last six months

Participant travelled domestically within the last 6 months If Yes, dates of travel and locations (list all, add extra entries as needed)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown D1. Dates of travel (dd/mm/yyyy): ____/____/____ to ____/____/____ Region(s) and cities visited: D1. Dates of travel (dd/mm/yyyy): ____/____/____ to ____/____/____ Region(s) and cities visited: D1. Dates of travel (dd/mm/yyyy): ____/____/____ to ____/____/____ Region(s) and cities visited:
Have you been in contact with a known MERS case within the last six months?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If yes, date of contact & location(s): (dd/mm/yyyy): ____/____/____, location _____
Have you attended a mass gathering event (wedding, festival, religious pilgrimage, auction) at this location?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If yes, specify event(s) type & location(s):

**Questionnaire 2: Occupationally exposed participant questionnaire** (continued)

<p>Participant travelled internationally within the last six months</p> <p>Have you attended a mass gathering (wedding, festival, religious pilgrimage, auction) at any of these locations?</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown</p> <p>Int1. Dates of travel (dd/mm/yyyy): ____/____/____ to ____/____/____ Country(s) and cities visited:</p> <p>Int2. Dates of travel (dd/mm/yyyy): ____/____/____ to ____/____/____ Country(s) and cities visited:</p> <p>Int3. Dates of travel (dd/mm/yyyy): ____/____/____ to ____/____/____ Country(s) and cities visited:</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If Yes, specify event(s) type & location(s):</p>
<p>Participant visited anyone in the hospital in the last six months</p> <p>If Yes, was the person sick with respiratory (cough, breathing problems)?</p> <p>If Yes, at what hospital (regions, city, district)?</p> <p>If Yes, what was your relationship to the person in the hospital?</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown</p> <p><input type="checkbox"/> Close family <input type="checkbox"/> Extended family <input type="checkbox"/> Friend <input type="checkbox"/> Other, specify below:</p>

7. Occupational exposures by occupation type**7a. ABATTOIR WORKER – Occupational exposures****ONLY to use if interviewing someone working at an abattoir**

Note: In the questionnaire that follows, a time frame of six months is frequently used when asking participants about high-risk exposures (e.g. close contact with dromedary camels). If the regional season(s) of interest (e.g. camel weaning season) do not overlap with the six-month exposure window, the time-frame in the questionnaire should be extended (e.g. 8 or 12 months).

How long have you worked at this abattoir?	_____ years _____ months
Which animals are slaughtered at this abattoir? (check all that apply)	<input type="checkbox"/> Dromedary camels <input type="checkbox"/> Goats <input type="checkbox"/> Sheep <input type="checkbox"/> Cattle <input type="checkbox"/> Horses <input type="checkbox"/> Donkeys <input type="checkbox"/> Other, specify:
<p>What is (are) your job(s) at this abattoir?</p> <p>Of the jobs you selected, which is your primary job?</p>	<input type="checkbox"/> Slaughtering of animals <input type="checkbox"/> Cleaning <input type="checkbox"/> Flaying <input type="checkbox"/> Evisceration <input type="checkbox"/> Product (e.g. meat) storage <input type="checkbox"/> Other, specify: Specify:
Which days does the abattoir operate?	<input type="checkbox"/> Monday <input type="checkbox"/> Tuesday <input type="checkbox"/> Wednesday <input type="checkbox"/> Thursday <input type="checkbox"/> Friday <input type="checkbox"/> Saturday <input type="checkbox"/> Sunday
Are there certain weeks or periods of the year when you work more or less at this slaughterhouse? (e.g. holidays or festivals)	Please describe:



Questionnaire 2: Occupationally exposed participant questionnaire (continued)

Do you hold other jobs aside from working at the slaughterhouse?	<input type="checkbox"/> Yes, specify: <input type="checkbox"/> No																																																
Have you seen other animals, rodents or pests at the slaughterhouse?	<input type="checkbox"/> No <input type="checkbox"/> Yes, (check all that apply): <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Rats <input type="checkbox"/> Mice <input type="checkbox"/> Bats <input type="checkbox"/> Other, specify:																																																
Do you live or sleep regularly (at least once per week) within the slaughterhouse facility?	<input type="checkbox"/> Yes <input type="checkbox"/> No																																																
<p>On average, over the last six months, how often do you do the following activities? Using the following scale, circle number closest to the frequency that you perform this activity <i>1 = Never 2 = Rarely (less than once per month) 3 = Monthly (≥ once per month) 4 = Weekly (≥ once per week) 5 = Daily</i></p> <table border="0"> <tr> <td>Kiss camels</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>Clean camel housing</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>Handle camel waste (e.g. feces, urine)</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>Clean slaughterhouse equipment</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>Slaughter camels</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>Assist in the birth of camels</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>Administer vaccines and/or medicines</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>Milk camels</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> </table>		Kiss camels	1	2	3	4	5	Clean camel housing	1	2	3	4	5	Handle camel waste (e.g. feces, urine)	1	2	3	4	5	Clean slaughterhouse equipment	1	2	3	4	5	Slaughter camels	1	2	3	4	5	Assist in the birth of camels	1	2	3	4	5	Administer vaccines and/or medicines	1	2	3	4	5	Milk camels	1	2	3	4	5
Kiss camels	1	2	3	4	5																																												
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Slaughter camels	1	2	3	4	5																																												
Assist in the birth of camels	1	2	3	4	5																																												
Administer vaccines and/or medicines	1	2	3	4	5																																												
Milk camels	1	2	3	4	5																																												
Are there other activities that you do frequently concerning camels at the slaughterhouse that were not mentioned above?	<input type="checkbox"/> No <input type="checkbox"/> Yes, specify:																																																
<p>In the last six months, are you aware of being in contact with any sick animals?</p> <p>If Yes, what types of animals? (check all that apply)</p> <p>If Yes, did any of the animals die of the illness?</p> <p>If Yes, did you personally handle (touch) the sick or dead animals?</p>	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Camels <input type="checkbox"/> Goats <input type="checkbox"/> Sheep <input type="checkbox"/> Cattle <input type="checkbox"/> Horses <input type="checkbox"/> Donkeys <input type="checkbox"/> Chickens <input type="checkbox"/> Pigeons <input type="checkbox"/> Rabbits <input type="checkbox"/> Ducks <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Other, specify _____ <input type="checkbox"/> Other, specify _____ <input type="checkbox"/> Yes, specify which: <input type="checkbox"/> No <input type="checkbox"/> Yes, specify which: <input type="checkbox"/> No																																																
Do you ever wear personal protective equipment while working at the abattoir?	<input type="checkbox"/> Yes <input type="checkbox"/> No																																																
What personal protective equipment do you usually (daily) wear when working at the abattoir? (check all that apply)	<input type="checkbox"/> Gloves <input type="checkbox"/> Coveralls <input type="checkbox"/> Dust masks <input type="checkbox"/> Boots or boot covers <input type="checkbox"/> Respirators <input type="checkbox"/> Eye protection <input type="checkbox"/> Other, specify:																																																
How often do you usually wash your hands while working at the slaughterhouse? (check all that apply)	<input type="checkbox"/> At mealtimes <input type="checkbox"/> At bathroom times <input type="checkbox"/> Before and after each animal related task <input type="checkbox"/> At the beginning and end of each day <input type="checkbox"/> Rarely (no regular pattern or specific activity before or after which washes hands)																																																

Questionnaire 2: Occupationally exposed participant questionnaire (continued)**7b. CAMEL OR ANIMAL FARM WORKER – Occupational exposures**

ONLY to fill in if interviewing someone working at either a camel farm or other animal farm

Note: 'farm' may be any of a farm, barn, ranch, or other similar workplace, and persons 'working' at this farm may also live at the farm (e.g. owner, household members) or not (i.e. external employee).

Note: In the questionnaire that follows, a time frame of six months is frequently used when asking participants about high-risk exposures (e.g. close contact with dromedary camels). If the regional season(s) of interest (e.g. camel weaning season) do not overlap with the six-month exposure window, the time-frame in the questionnaire should be extended (e.g. 8 or 12 months).

How long have you worked at this farm?	_____ years _____ months
What animals do you raise on your farm? (check all that apply, and add approximate number of animals to right)	<input type="checkbox"/> Camels <input type="checkbox"/> Goats <input type="checkbox"/> Sheep <input type="checkbox"/> Cattle <input type="checkbox"/> Horses <input type="checkbox"/> Donkeys <input type="checkbox"/> Chickens <input type="checkbox"/> Pigeons <input type="checkbox"/> Rabbits <input type="checkbox"/> Ducks <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Other, specify _____, # _____ <input type="checkbox"/> Other, specify _____, # _____ <input type="checkbox"/> Other, specify _____, # _____ <input type="checkbox"/> Other, specify _____, # _____ (if needing more 'other' options, add on back of page)
What is (are) your job(s) at this farm? [additional options may be added and finalized after initial visit to location]	<input type="checkbox"/> Animal care <input type="checkbox"/> Housework (not animal care) <input type="checkbox"/> Field work <input type="checkbox"/> Other, specify:
Of the jobs listed above that you selected, which is your primary job?	Specify:
Which days do you work at the farm?	<input type="checkbox"/> Monday <input type="checkbox"/> Tuesday <input type="checkbox"/> Wednesday <input type="checkbox"/> Thursday <input type="checkbox"/> Friday <input type="checkbox"/> Saturday <input type="checkbox"/> Sunday
Are there certain weeks or periods of the year when you work more or less at this farm? (e.g. holidays or festivals)	Please describe:
Do you hold other jobs aside from working at the farm?	<input type="checkbox"/> Yes, specify: <input type="checkbox"/> No
Is this farm your residence?	<input type="checkbox"/> Yes <input type="checkbox"/> No
How many nights per week do you sleep there?	_____ nights per week
Have you ever noticed any camel feces or urine in or around your living quarters in the last month?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Have you seen other animals, rodents or pests at the farm?	<input type="checkbox"/> No <input type="checkbox"/> Yes, (check all that apply): <ul style="list-style-type: none"> <input type="checkbox"/> Cats, not owned by farm or household <input type="checkbox"/> Dogs, not owned by farm or household <input type="checkbox"/> Rats <input type="checkbox"/> Mice <input type="checkbox"/> Bats <input type="checkbox"/> Other, specify:

Questionnaire 2: Occupationally exposed participant questionnaire (continued)

On average, over the last six months, how often do you do the following activities? Using the following scale, circle number closest to the frequency that you perform this activity

1 = Never 2 = Rarely (less than once per month) 3 = Monthly (\geq once per month) 4 = Weekly (\geq once per week) 5 = Daily

Kiss camels	1	2	3	4	5
Clean camel housing	1	2	3	4	5
Handle camel waste (e.g. feces, urine)	1	2	3	4	5
Clean farm equipment	1	2	3	4	5
Slaughter camels	1	2	3	4	5
Assist in the birth of camels	1	2	3	4	5
Administer vaccines and/or medicines	1	2	3	4	5
Milk camels	1	2	3	4	5

Are there other activities that you do frequently concerning camels on your farm that were not mentioned above?

- No
 Yes, specify:

In the last six months, are you aware of being in contact with any sick animals?

- Yes No

If Yes, what types of animals? (check all that apply)

- Camels Goats Sheep Cattle
 Horses Donkeys Chickens Pigeons
 Rabbits Ducks Cats Dogs
 Other, specify _____
 Other, specify _____

If Yes, did any of the animals die of the illness?

- Yes, specify which:

No

If Yes, did you personally handle (touch) the sick or dead animals?

- Yes, specify which:

No

Do you ever wear personal protective equipment while working at the farm?

- Yes No

What personal protective equipment do you usually (daily) wear when working at the farm? (check all that apply)

- Gloves Coveralls
 Dust masks Boots or boot covers
 Respirators Eye protection
 Other, specify:

How often do you usually wash your hands while working at the farm? (check all that apply)

- At mealtimes At bathroom times
 Before and after each animal related task
 At the beginning and end of each day
 Rarely (no regular pattern or specific activity)

7c. MARKET WORKER – Occupational exposures

ONLY to use if interviewing someone working at a camel or animal market

Note: In the questionnaire that follows, a time frame of six months is frequently used when asking participants about high-risk exposures (e.g. close contact with dromedary camels). If the regional season(s) of interest (e.g. camel weaning season) do not overlap with the six-month exposure window, the time-frame in the questionnaire should be extended (e.g. 8 or 12 months).

How long have you worked at this market?

_____ years _____ months

What animals are sold there?

- Camels Goats Sheep Cattle
 Horses Donkeys Chickens Pigeons
 Rabbits Ducks Cats Dogs
 Other, specify _____
 Other, specify _____

What is (are) your job(s) at this market?	<input type="checkbox"/> Selling/buying of animals <input type="checkbox"/> Animal care <input type="checkbox"/> Slaughtering animals <input type="checkbox"/> Administrative staff <input type="checkbox"/> Other, specify:
Of the jobs you selected, which is your primary job?	Specify:
Which days do you work at this market?	<input type="checkbox"/> Monday <input type="checkbox"/> Tuesday <input type="checkbox"/> Wednesday <input type="checkbox"/> Thursday <input type="checkbox"/> Friday <input type="checkbox"/> Saturday <input type="checkbox"/> Sunday
Are there certain weeks or periods of the year when you work more or less there? (e.g. holidays or festivals)	Please describe:
Do you hold other jobs aside from the market?	<input type="checkbox"/> Yes, specify: <input type="checkbox"/> No
Have you seen other animals, rodents or pests at the market?	<input type="checkbox"/> No <input type="checkbox"/> Yes, (check all that apply): <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Rats <input type="checkbox"/> Mice <input type="checkbox"/> Bats <input type="checkbox"/> Other, specify:
Do you live or sleep regularly (at least once per week) within the market?	<input type="checkbox"/> Yes <input type="checkbox"/> No
<p>On average, over the last six months, how often do you do the following activities? Using the following scale, circle number closest to the frequency that you perform this activity</p> <p>1 = Never 2 = Rarely (less than once per month) 3 = Monthly (≥ once per month) 4 = Weekly (≥ once per week) 5 = Daily</p>	
Kiss camels	1 2 3 4 5
Clean camel housing	1 2 3 4 5
Handle camel waste (e.g. feces, urine)	1 2 3 4 5
Clean market equipment	1 2 3 4 5
Slaughter camels	1 2 3 4 5
Assist in the birth of camels	1 2 3 4 5
Administer vaccines and/or medicines	1 2 3 4 5
Milk camels	1 2 3 4 5
Are there other activities that you do frequently concerning camels at your market that were not mentioned above?	<input type="checkbox"/> No <input type="checkbox"/> Yes, specify:
In the last six months, are you aware of being in contact with any sick animals?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If Yes, what types of animals? (check all that apply)	<input type="checkbox"/> Camels <input type="checkbox"/> Goats <input type="checkbox"/> Sheep <input type="checkbox"/> Cattle <input type="checkbox"/> Horses <input type="checkbox"/> Donkeys <input type="checkbox"/> Chickens <input type="checkbox"/> Pigeons <input type="checkbox"/> Rabbits <input type="checkbox"/> Ducks <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Other, specify _____
If Yes, did any of the animals die of the illness?	<input type="checkbox"/> Yes, specify which: <input type="checkbox"/> No
If Yes, did you personally handle (touch) the sick or dead animals?	<input type="checkbox"/> Yes, specify which: <input type="checkbox"/> No
Do you ever wear personal protective equipment while working at the market?	<input type="checkbox"/> Yes <input type="checkbox"/> No
What personal protective equipment do you usually (daily) wear when working at the market? (check all that apply)	<input type="checkbox"/> Gloves <input type="checkbox"/> Coveralls <input type="checkbox"/> Dust masks <input type="checkbox"/> Boots or boot covers <input type="checkbox"/> Respirators <input type="checkbox"/> Eye protection <input type="checkbox"/> Other, specify:

Questionnaire 2: Occupationally exposed participant questionnaire (continued)

How often do you usually wash your hands while working at the market? (check all that apply)	<input type="checkbox"/> At mealtimes <input type="checkbox"/> At bathroom times <input type="checkbox"/> Before and after each animal related task <input type="checkbox"/> At the beginning and end of each day <input type="checkbox"/> Rarely (no regular pattern or specific activity)
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7d. QUARANTINE WORKER – Occupational exposures

ONLY to use if interviewing someone working at a dromedary camel quarantine facility or site

Note: In the questionnaire that follows, a time frame of six months is frequently used when asking participants about high-risk exposures (e.g. close contact with dromedary camels). If the regional season(s) of interest (e.g. camel weaning season) do not overlap with the six-month exposure window, the time-frame in the questionnaire should be extended (e.g. eight or 12 months).

How long have you worked at this quarantine facility?	_____ years _____ months
What animals are quarantined there?	<input type="checkbox"/> Camels <input type="checkbox"/> Goats <input type="checkbox"/> Sheep <input type="checkbox"/> Cattle <input type="checkbox"/> Horses <input type="checkbox"/> Donkeys <input type="checkbox"/> Chickens <input type="checkbox"/> Pigeons <input type="checkbox"/> Rabbits <input type="checkbox"/> Ducks <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Other, specify _____ <input type="checkbox"/> Other, specify _____
What is (are) your job(s) at this quarantine facility?	<input type="checkbox"/> Sampling animals <input type="checkbox"/> Animal vaccination <input type="checkbox"/> Animal care <input type="checkbox"/> Other, specify:
Of the jobs you selected, which is your primary job?	Specify:
Which days do you work at this quarantine facility?	<input type="checkbox"/> Monday <input type="checkbox"/> Tuesday <input type="checkbox"/> Wednesday <input type="checkbox"/> Thursday <input type="checkbox"/> Friday <input type="checkbox"/> Saturday <input type="checkbox"/> Sunday
Are there certain weeks or periods of the year when you work more or less at this quarantine facility? (e.g. holidays or festivals)	Please describe:
Do you hold other jobs aside from working at the quarantine facility?	<input type="checkbox"/> Yes, specify: <input type="checkbox"/> No
Have you seen other animals, rodents or pests at the quarantine facility?	<input type="checkbox"/> No <input type="checkbox"/> Yes, (check all that apply): <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Rats <input type="checkbox"/> Mice <input type="checkbox"/> Bats <input type="checkbox"/> Other, specify:
Do you live or sleep regularly (at least once per week) within the quarantine facility?	<input type="checkbox"/> Yes <input type="checkbox"/> No

Questionnaire 2: Occupationally exposed participant questionnaire (continued)

On average, over the last six months, how often do you do the following activities? Using the following scale, circle number closest to the frequency that you perform this activity

1 = Never 2 = Rarely (less than once per month) 3 = Monthly (\geq once per month) 4 = Weekly (\geq once per week) 5 = Daily

Kiss camels	1	2	3	4	5
Clean camel housing	1	2	3	4	5
Handle camel waste (e.g. feces, urine)	1	2	3	4	5
Clean equipment	1	2	3	4	5
Slaughter camels	1	2	3	4	5
Assist in the birth of camels	1	2	3	4	5
Administer vaccines and/or medicines	1	2	3	4	5
Milk camels	1	2	3	4	5

Are there other activities that you do frequently concerning camels at the facility that were not mentioned above?

- No
 Yes, specify:

In the last six months, are you aware of being in contact with any sick animals?

- Yes No

If Yes, what types of animals? (check all that apply)

- Camels Goats Sheep Cattle
 Horses Donkeys Chickens Pigeons
 Rabbits Ducks Cats Dogs
 Other, specify _____

If Yes, did any of the animals die of the illness?

- Yes, specify which:
 No

If Yes, did you personally handle (touch) the sick or dead animals?

- Yes, specify which:
 No

Do you ever wear personal protective equipment while working at the quarantine facility?

- Yes No

What personal protective equipment do you usually (daily) wear when working at the quarantine facility? (check all that apply)

- Gloves Coveralls
 Dust masks Boots or boot covers
 Respirators Eye protection
 Other, specify:

How often do you usually wash your hands while working at the quarantine facility? (check all that apply)

- At mealtimes At bathroom times
 Before and after each animal related task
 At the beginning and end of each day
 Rarely (no regular pattern or specific activity)

7e. RACETRACK WORKER – Occupational exposures

ONLY to use if interviewing someone working at a dromedary camel racetrack

Note: In the questionnaire that follows, a time frame of six months is frequently used when asking participants about high-risk exposures (e.g. close contact with dromedary camels). If the regional season(s) of interest (e.g. camel weaning season) do not overlap with the six-month exposure window, the time-frame in the questionnaire should be extended (e.g. eight or 12 months).

How long have you worked at this racetrack?

_____ years _____ months

What is (are) your job(s) at this racetrack?

- Quarantine officer
 Animal caretaker
 Veterinarian
 Other, specify:

Of the jobs you selected, which is your primary job?

Specify:


Questionnaire 2: Occupationally exposed participant questionnaire (continued)

Which days do you work at this racetrack?	<input type="checkbox"/> Monday <input type="checkbox"/> Tuesday <input type="checkbox"/> Wednesday <input type="checkbox"/> Thursday <input type="checkbox"/> Friday <input type="checkbox"/> Saturday <input type="checkbox"/> Sunday
Are there certain weeks or periods of the year when you work more or less at this racetrack? (e.g. holidays or festivals)	Please describe:
Do you hold other jobs aside from working at the racetrack?	<input type="checkbox"/> Yes, specify: <input type="checkbox"/> No
Have you seen other animals, rodents or pests at the racetrack?	<input type="checkbox"/> No <input type="checkbox"/> Yes, (check all that apply): <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Rats <input type="checkbox"/> Mice <input type="checkbox"/> Bats <input type="checkbox"/> Other, specify:
Do you live or sleep regularly (at least once per week) at the racetrack?	<input type="checkbox"/> Yes <input type="checkbox"/> No
<p>On average, over the last six months, how often do you do the following activities? Using the following scale, circle number closest to the frequency that you perform this activity 1 = Never 2 = Rarely (less than once per month) 3 = Monthly (\geq once per month) 4 = Weekly (\geq once per week) 5 = Daily</p>	
Kiss camels	1 2 3 4 5
Clean camel housing	1 2 3 4 5
Handle camel waste (e.g. feces, urine)	1 2 3 4 5
Clean equipment	1 2 3 4 5
Slaughter camels	1 2 3 4 5
Assist in the birth of camels	1 2 3 4 5
Administer vaccines and/or medicines	1 2 3 4 5
Milk camels	1 2 3 4 5
Are there other activities that you do frequently concerning camels at the racetrack that were not mentioned above?	<input type="checkbox"/> No <input type="checkbox"/> Yes, specify:
In the last six months, are you aware of being in contact with any sick animals?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If Yes, what types of animals? (check all that apply)	<input type="checkbox"/> Camels <input type="checkbox"/> Goats <input type="checkbox"/> Sheep <input type="checkbox"/> Cattle <input type="checkbox"/> Horses <input type="checkbox"/> Donkeys <input type="checkbox"/> Chickens <input type="checkbox"/> Pigeons <input type="checkbox"/> Rabbits <input type="checkbox"/> Ducks <input type="checkbox"/> Cats <input type="checkbox"/> Dogs <input type="checkbox"/> Other, specify _____
If Yes, did any of the animals die of the illness?	<input type="checkbox"/> Yes, specify which: <input type="checkbox"/> No
If Yes, did you personally handle (touch) the sick or dead animals?	<input type="checkbox"/> Yes, specify which: <input type="checkbox"/> No
Do you ever wear personal protective equipment while working at the racetrack?	<input type="checkbox"/> Yes <input type="checkbox"/> No
What personal protective equipment do you usually (daily) wear when working at the racetrack? (check all that apply)	<input type="checkbox"/> Gloves <input type="checkbox"/> Coveralls <input type="checkbox"/> Dust masks <input type="checkbox"/> Boots or boot covers <input type="checkbox"/> Respirators <input type="checkbox"/> Eye protection <input type="checkbox"/> Other, specify:
How often do you usually wash your hands while working at the racetrack? (check all that apply)	<input type="checkbox"/> At mealtimes <input type="checkbox"/> At bathroom times <input type="checkbox"/> Before and after each animal related task <input type="checkbox"/> At the beginning and end of each day <input type="checkbox"/> Rarely (no regular pattern or specific activity)

**Questionnaire 2: Occupationally exposed participant questionnaire** (continued)**8. Dromedary camel exposures in or around the home**

Participant has had any livestock living in or around their home in the last six months	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown If yes, which animals: <input type="checkbox"/> Dromedary camels <input type="checkbox"/> Goats <input type="checkbox"/> Sheep <input type="checkbox"/> Horses <input type="checkbox"/> Cattle <input type="checkbox"/> Other, specify:
In the last six months, did you have any contact with any carcasses, body fluids, secretions, urine or excrement of dromedary camels in or around your home?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
In the last six months, did you have any contact with any dromedary camel bedding, stray of feed in or around your home?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
At your home, in the last six months did you do any of the following activities with dromedary camels ?	Feed them - <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Clean their housing - <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Clean camel-farm equipment - <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Slaughter them - <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Assist with their birth - <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Milk them - <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Kiss and/or hug them - <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown Other tasks - <input type="checkbox"/> Yes (specify below) <input type="checkbox"/> No <input type="checkbox"/> Unknown

Exposures to other livestock within the last 14 days (tick all that apply)	Number of animals	What are they used for? (check all that apply)	Do you have direct contact (i.e. touch) with these animals?	Any illness affecting animals in the last six months?
Dromedary camels	<input type="checkbox"/> None <input type="checkbox"/> < 10 animals <input type="checkbox"/> 10 to 50 animals <input type="checkbox"/> > 50 animals	<input type="checkbox"/> Income <input type="checkbox"/> Food <input type="checkbox"/> Work <input type="checkbox"/> Racing <input type="checkbox"/> Pets <input type="checkbox"/> Festival <input type="checkbox"/> Auction <input type="checkbox"/> Other: specify	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Sheep	<input type="checkbox"/> None <input type="checkbox"/> < 10 animals <input type="checkbox"/> 10 to 50 animals <input type="checkbox"/> > 50 animals	<input type="checkbox"/> Income <input type="checkbox"/> Food <input type="checkbox"/> Work <input type="checkbox"/> Racing <input type="checkbox"/> Pets <input type="checkbox"/> Festival <input type="checkbox"/> Auction <input type="checkbox"/> Other: specify	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown


Questionnaire 2: Occupationally exposed participant questionnaire (continued)

Goats	<input type="checkbox"/> None <input type="checkbox"/> < 10 animals <input type="checkbox"/> 10 to 50 animals <input type="checkbox"/> > 50 animals	<input type="checkbox"/> Income <input type="checkbox"/> Food <input type="checkbox"/> Work <input type="checkbox"/> Racing <input type="checkbox"/> Pets <input type="checkbox"/> Festival <input type="checkbox"/> Auction <input type="checkbox"/> Other: specify	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Cattle	<input type="checkbox"/> None <input type="checkbox"/> < 10 animals <input type="checkbox"/> 10 to 50 animals <input type="checkbox"/> > 50 animals	<input type="checkbox"/> Income <input type="checkbox"/> Food <input type="checkbox"/> Work <input type="checkbox"/> Racing <input type="checkbox"/> Pets <input type="checkbox"/> Festival <input type="checkbox"/> Auction <input type="checkbox"/> Other: specify	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Horses	<input type="checkbox"/> None <input type="checkbox"/> < 10 animals <input type="checkbox"/> 10 to 50 animals <input type="checkbox"/> > 50 animals	<input type="checkbox"/> Income <input type="checkbox"/> Food <input type="checkbox"/> Work <input type="checkbox"/> Racing <input type="checkbox"/> Pets <input type="checkbox"/> Festival <input type="checkbox"/> Auction <input type="checkbox"/> Other: specify	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown
Other members of the participant's household (e.g. relatives or domestic help) frequently have had direct contact with dromedary camels?		<input type="checkbox"/> Yes, in the last six months <input type="checkbox"/> Yes, in the last 14 days <input type="checkbox"/> No <input type="checkbox"/> Unknown		
Other members of the participant's household (e.g. relatives or domestic help) frequently visit or work on a camel farm, market, or other venue where dromedary camels are kept or sold?		<input type="checkbox"/> Yes, in the last six months <input type="checkbox"/> Yes, in the last 14 days <input type="checkbox"/> No <input type="checkbox"/> Unknown		

9. Food or medicinal exposures to dromedary camels

Participant uses camel products for medicinal purposes

 Yes No Unknown

If Yes, which products:

 Camel milk (to drink)

 Camel urine (to drink)

 Medication (e.g. pills, poultice) containing camel products

 Other, specify: _____

If Yes, describe further details of use

(e.g. method of ingestion or use, illness being treated):

**Questionnaire 2: Occupationally exposed participant questionnaire** (continued)

In the last 6 months, select the frequency at which you consumed the following:

	Daily	At least once per week	Less than once a week but more than once a month	Less than once per month but several times in the last six months	Never	Unknown
Raw camel milk						
Boiled camel milk						
Camel urine						
Raw camel meat						
Cooked camel meat						
Other camel products (specify)						



Questionnaire 2: Occupationally exposed participant questionnaire (continued)

10. Testing methods and results:

10a. Molecular testing methods and results:

Complete a new line for each specimen collected and each type of test conducted:

Laboratory identification number	Date sample collected (dd/mm/yyyy)	Date sample received (dd/mm/yyyy)	Type of sample	Type of test	Result	Result date (dd/mm/yyyy)	Specimens shipped to other laboratory for confirmation
	___/___/___	___/___/___	<input type="checkbox"/> Nasal swab <input type="checkbox"/> Throat swab <input type="checkbox"/> Nasopharyngeal swab <input type="checkbox"/> Other, specify:	<input type="checkbox"/> Polymerase chain reaction (PCR) <input type="checkbox"/> Whole genome sequencing <input type="checkbox"/> Partial genome sequencing <input type="checkbox"/> Other, specify	<input type="checkbox"/> positive for MERS-CoV <input type="checkbox"/> negative for MERS-CoV <input type="checkbox"/> inconclusive <input type="checkbox"/> positive for other pathogens Please specify which pathogens: Results of phylogenetic analysis: _____ _____ _____	___/___/___	<input type="checkbox"/> No <input type="checkbox"/> Yes If Yes, specify date ___/___/___ If Yes, name of the laboratory: _____ _____ Genomic sequencing <input type="checkbox"/> No <input type="checkbox"/> Yes (locally) <input type="checkbox"/> Yes (shipped to external laboratory) <i>If Yes to shipped externally, specify date</i> ___/___/___ <i>If Yes to shipped externally name of the laboratory:</i> _____ _____



Questionnaire 2: Occupationally exposed participant questionnaire (continued)

10b. Serology testing methods and results:

Complete a new line for each specimen collected and each type of test conducted:

Laboratory identification number	Date sample collected (dd/mm/yyyy)	Date sample received (dd/mm/yyyy)	Type of sample	Type of test	Result (MERS-CoV antibody titres)	Result date (dd/mm/yyyy)	Specimens shipped to other laboratory for confirmation
	___/___/___	___/___/___	<input type="checkbox"/> Serum <input type="checkbox"/> Other, specify:	Specify type (enzyme linked immunosorbent assay – ELISA, indirect fluorescent antibody assay – IFA, neutralization assay, etc.):	<input type="checkbox"/> positive If positive, titre: <input type="checkbox"/> negative <input type="checkbox"/> inconclusive	___/___/___	<input type="checkbox"/> Yes If Yes, specify date ___/___/___ If Yes, name of the laboratory: ___ <input type="checkbox"/> No

**Questionnaire 2: Occupationally exposed participant questionnaire** (continued)**11. End of questionnaire and status of form completion**

Is participant ok with being contacted again with further questions or clarifications?

Yes No

Form completed

Yes No or partially

If No or partially, reason:

Missed

Not attempted

Not performed

Refusal

Other, specify:

Emerging Diseases and Zoonoses Unit

Epidemic and Pandemic Preparedness and Prevention Department

20, Avenue Appia

1211 Geneva 27

Switzerland

Email: MERSHQ@who.int

Website: <https://www.who.int/initiatives/mers-cov-investigations-and-studies>