Middle East respiratory syndrome coronavirus (MERS-CoV)

WHO MERS-CoV Global Summary and Assessment of Risk

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WHO/MERS/RA

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Global summary

Between 2012 and 21 July 2017, 2040 laboratory-confirmed cases of Middle East respiratory syndrome-coronavirus (MERS-CoV) infection were reported to WHO, 82% of whom were reported by the Kingdom of Saudi Arabia (Figure 1). In total, cases have been reported from 27 countries in the Middle East, North Africa, Europe, the United States of America, and Asia (Table 1). Males above the age of 60 with underlying conditions, such as diabetes, hypertension and renal failure, are at a higher risk of severe disease, including death. To date, at least 710 individuals have died (crude CFR 34.8%).

Since the last global update published on 5 December 2016, 199 laboratory-confirmed cases of MERS-CoV from four countries were reported to WHO (190 from Saudi Arabia, three from Qatar, four from the United Arab Emirates, one from Lebanon and one from Oman), of whom 58 (29.2%) have died. Among these cases, 72.9% were male and the median age was 54 years old (IQR 39-65). At the time of writing, 59 of 199 (29.6%) patients were reported as asymptomatic or having mild disease and 80 (40.2%) had severe disease and/or died. At least one underlying condition was reported in 114 cases (57.3%) since the last update, including chronic renal failure (11.4%), heart disease (12.3%), diabetes mellitus (71.0%), and hypertension (67.5%). One pregnant woman was also reported and, at the time of writing, had lost her baby and was on mechanical ventilation in an ICU.

Overall, the epidemiology, transmission patterns, clinical presentation of MERS patients and viral characteristics reported since the last update are consistent with past patterns described in previous WHO risk assessments: MERS-CoV is a zoonotic virus that has repeatedly entered the human population via direct or indirect contact with infected dromedary camels in the Arabian Peninsula. Limited, non-sustained human-to-human transmission in health-care settings continue to occur, primarily in the Kingdom of Saudi Arabia, due to the non-specificity of MERS symptoms resulting in late diagnosis of MERS. The risk of exported cases to areas outside of the Middle East due to travel remains significant.

While there have been significant improvements in surveillance for MERS, especially in the Kingdom of Saudi Arabia, and in reacting to suspect clusters, early identification in the community and in health-care systems, compliance with the infection prevention and control measures and contact follow up remain major challenges for MERS outbreak prevention and control.

The continued importance of MERS-CoV in health-care settings

Since the last global update of 5 December 2016, approximately 31% of cases reported to WHO were associated with transmission in a health-care facility. These cases included health-care workers (40 cases), patients sharing rooms/wards with MERS patients, or family visitors.

Though not unexpected, these transmission events continue to be deeply concerning, given that MERS-CoV is still a relatively rare disease about which medical personnel in health-care facilities have low awareness. Globally, awareness for MERS-CoV is low and, because symptoms of MERS-CoV infection are non-specific, initial cases are sometimes easily missed. With improved compliance in infection prevention and control, namely adherence to the standard precautions at all times, human-to-human transmission in health-care facilities can be reduced and possibly eliminated with additional use of transmission-based precautions.

Since the last update, several health-care-associated MERS outbreaks have occurred, including the following:

- An outbreak of MERS occurred in a hospital in Riyadh City, Riyadh in June 2017. From 1 June-3 July 2017, 34 laboratory-confirmed cases were reported to WHO. The initial case was a 47-year-old male who required emergency intubation in the emergency department, prior to identification of being infected with MERS-CoV. Prior to diagnosis, more than 220 health-care workers, patients and visitor contacts were identified for follow-up from contact with this patient. Extensive contact tracing, follow-up and laboratory testing identified an additional 33 cases during this outbreak. Overall, the cases associated with this outbreak had a median age of 34.5-years-old (IQR 30-54), are predominantly male (58.8%) and half were health care workers (50.0%). Eleven patients were classified as having severe disease, of whom 7 died, and 22 were asymptomatic.

- One case from the cluster described above also sought treatment (renal dialysis) at a second health-care facility in Riyadh City, Riyadh in June 2017. Within this health-care facility, 5 additional cases were identified. Transmission occurred among three household contacts, one patient contact in the hospital, and one health-care worker contact.

- Also in June 2017, an unrelated MERS cluster occurred in a hospital in Riyadh City, Riyadh. This cluster involved nine cases: the first case who reported direct contact to dromedary camels (occupational exposure as a butcher) and eight health-care worker contacts (4 were reported as asymptomatic and 4 reported mild disease).

- In March and April 2017, two unlinked clusters of MERS occurred at the same hospital in Wadi Aldwaser city, Riyadh Region.

  – A cluster of MERS occurred in March 2017. This cluster included 10 laboratory-confirmed patients, 40% of whom were male, 20% of whom were health-care workers and 40% of whom were reported as asymptomatic. The source of infection in the initially-identified patient was under investigation and transmission occurred in a renal dialysis unit within this hospital and between household contacts.

  – A cluster of MERS occurred in April 2017. This cluster involved five laboratory-confirmed cases: the initial case, three household contacts and one health-care worker.

The apparent increase in the number of asymptomatic contacts identified in health-care settings are being identified due to a policy change by the Ministry of Health of the Kingdom of Saudi Arabia, in which all high-risk contacts are tested for MERS-CoV regardless of the development of symptoms.

Drivers of transmission and the exact modes of transmission in health-care settings have not been articulated and are currently the focus of collaborative scientific research. From observational studies, transmission in health-care settings is believed to have occurred before adequate infection prevention and control procedures were applied and cases were isolated. Investigations at the time of the outbreaks indicate that aerosolizing procedures conducted in crowded emergency departments or medical wards with sub-optimal infection prevention and control measures in place resulted in human-to-human transmission and environmental contamination.

Community-acquired cases and reported links to dromedary camels

Since the last update, 56 human cases are believed to have been infected in the community. Of these 56 reported cases, 47 (89.9%) reported direct or indirect contact with dromedaries in Saudi Arabia (45 cases), Qatar (one case) and the United Arab Emirates (one case).

Improvement in multi-sectoral investigation of community-acquired cases is evident, including testing of dromedary animals/herds in the vicinity of community-acquired cases and follow-up of human contacts of laboratory-confirmed cases. The Ministries of Health in affected countries notify the Ministries of Agriculture when human cases report a link with animals. Investigations in animals are carried out by officials from the Ministries of Agriculture and results, if positive for MERS-CoV, are reported to OIE.

Exported cases identified outside the Middle East

Since the last update, no cases have been reported outside of the Middle East.

Summary – information available from 2012 to date

Thus far, no sustained human-to-human transmission has occurred anywhere in the world, however limited non-sustained human-to-human transmission in health-care facilities remains a prominent feature of this virus. WHO continues to work with health authorities in the affected countries. WHO understands that health authorities in affected countries, especially those in the most affected countries, are aggressively investigating cases and contacts, including testing for MERS-CoV among asymptomatic contacts, and applying mitigation measures to stop human-to-human transmission in health-care settings.

Of all laboratory-confirmed cases reported to date (n=2040), the median age is 52 (IQR 36-65; range >1-109 years old) and 66.4% are male.

At the time of reporting, 21.5% of the 2040 cases were reported to have no or mild symptoms, while 46.8% had severe disease or died. Overall, 19.6% of the cases reported to date have been in health-care workers.

Since 2012, 27 countries have reported cases of MERS-CoV infection. In the Middle East: Bahrain, Egypt, Iran, Jordan, Kuwait, Lebanon, Oman, Qatar, the Kingdom of Saudi Arabia, the United Arab Emirates and Yemen; in Africa: Algeria and Tunisia; in Europe: Austria, France, Germany, Greece, Italy, the Netherlands, Turkey and the United Kingdom; in Asia: China, the Republic of Korea, Malaysia, the Philippines and Thailand; and in the Americas: the United States of America (Table 1).

The majority of cases (approximately 82%) have been reported from Saudi Arabia (Figure 1).

Populations in close contact with dromedaries (e.g. farmers, abattoir workers, shepherds, dromedary owners) and health-care workers caring for MERS-CoV patients are believed to be at higher risk of infection. Healthy adults tend to have mild subclinical or asymptomatic infections. To date, limited human-to-human transmission has occurred between close contacts of confirmed cases in household settings.

More efficient human-to-human transmission occurs in health-care settings due to inadequate and/or incomplete compliance with the infection prevention and control measures and delay in triage or isolation of suspected MERS patients.

Health-care-associated transmission has been documented in several countries between 2012-2016, including the Kingdom of Saudi Arabia, Jordan, the United Arab Emirates, France, the United Kingdom, and the Republic of Korea with varying outbreak sizes (2-180 reported cases per outbreak).

The largest outbreak outside of the Middle East occurred in the Republic of Korea resulting in 186 cases (including one case who travelled to China) and 38 deaths.

Overall, the reproduction number (R_0) of MERS-CoV is <1 with significant heterogeneity in specific contexts. Specifically, outbreaks in health-care settings can have R>1, but they can be brought under control (R<1) with proper application of infection prevention and control measures and early isolation of subsequent cases.

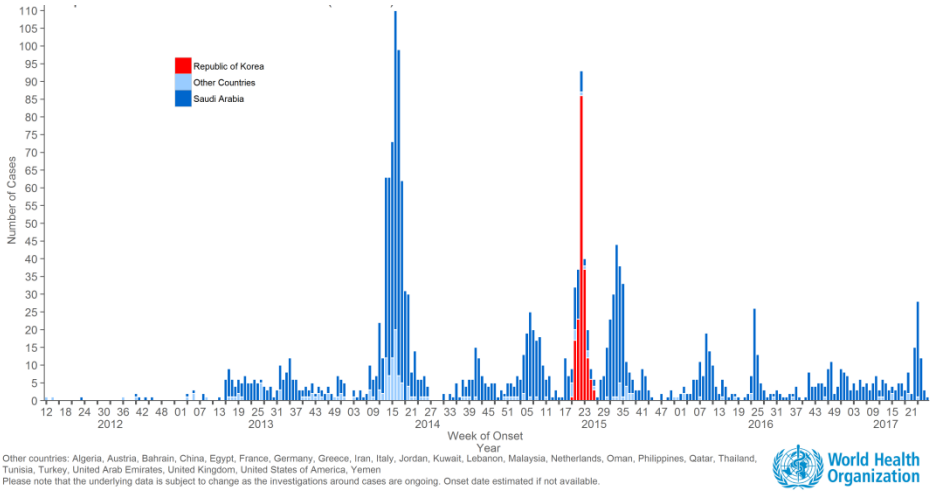

Figure 1. Epidemic curve of MERS-CoV human cases* as of 21 July 2017

*Symptomatic cases are plotted by date of symptom onset; asymptomatic cases are plotted by date of notification to WHO.
**Red = Republic of Korea; blue = Kingdom of Saudi Arabia; light blue = all other countries reporting MERS-CoV cases to date including Algeria, Austria, Bahrain, China, Egype, France, Germany, Greece, Iran, Italy, Jordan, Kuwait, Lebanon, Malaysia, the Netherlands, Oman, theyPhilippines, Qatar, Thailand, Tunisia, Turkey, United Arab Emirates, the United Kingdom, the United States, Yemen.

Table 1. Number of laboratory-confirmed MERS cases reported by countries, by year, since 2012 *

Country reporting	Number of laboratory-confirmed MERS-CoV cases reported
Algeria	2
Austria	2
Bahrain	1
China	1
Egypt	1
France	2
Germany	3
Greece	1
Iran	6
Italy	1
Jordan	28
Kuwait	4
Lebanon	2
Malaysia	1
Netherlands	2
Oman	8
Philippines	2
Qatar	19
Republic of Korea	185
Saudi Arabia	1672
Thailand	3
Tunisia	3
Turkey	1
United Kingdom	4
United Arab Emirates	83
United States of America	2
Yemen	1
Total	2,040

* Data as of 21 July 2017.

WHO MERS-CoV activities and guidance

- WHO Regional Office for the Eastern Mediterranean (EMRO) conducted a training workshop in Riyadh aimed at initiating the sentinel site surveillance system for Severe Acute Respiratory Illness (SARI) and Influenza-Like Illness (ILI) in Saudi Arabia. The training took place on 15 -19 January 2017 and included collecting and handling the respiratory specimens, laboratory testing and reporting of respiratory illnesses, including MERS-CoV.

- On 13-14 March 2017, WHO and The University of Hong Kong co-hosted an informal meeting to bring together public health and academic professionals to discuss previously conducted studies of respiratory virus persistence and plan for future observational and experimental studies of environmental and air sampling of MERS-CoV. The participants in this meeting discussed the potential role of environmental contamination and airborne transmission of MERS-CoV in health-care settings based on their own research and developed a plan for future research to be conducted experimentally and observationally where MERS patients are treated.

- In May and June 2017, WHO updated the following information products and guidance materials:

  - Middle East respiratory syndrome coronavirus (MERS-CoV) Fact Sheet. Updated May 2017

  - Frequently asked questions on Middle East respiratory syndrome coronavirus (MERS-CoV) Updated 15 May 2017

  - Online Q&A Middle East respiratory syndrome coronavirus (MERS-CoV) Updated May 2017

  - Initial Interview questionnaire for MERS-CoV cases Updated 24 May 2017. This updated form takes into account current understanding of potential exposures and risk factors for MERS-CoV infection and severe MERS-CoV outcomes. The interview form is designed to gather initial information about the potential exposures of a suspected or confirmed case of MERS-CoV infection in the 14 days prior to symptom onset. The form is intended for public health professionals.

  - Interim Case Summary Form for rapid reporting of probable and confirmed cases of MERS-CoV infection to WHO Updated 24 May 2017. This updated form allows for the systematic reporting of case-based information to WHO for risk assessment purposes.

  - Travel advice on MERS-CoV for pilgrimages Updated 1 June 2017

- In May 2017, WHO launched a new introductory course on MERS-CoV. The course is hosted on the new OpenWHO learning platform and consists of four interactive models featuring video lectures, presentations and self-tests. The free course aims to provide information about what is known about MERS-CoV, the diseases it causes and the ways to prevent, respond to and control outbreaks of MERS-CoV. Access to the training course is available here: https://openwho.org/courses/introduction-to-mers

- In May 2017, WHO published Target Product Profiles (TPPs) for MERS-CoV Vaccines. The TPPs describe the minimum acceptable standards for vaccines in development for MERS-CoV: one vaccine intended to prevent transmission from dromedaries to humans and two vaccines for use in outbreaks of MERS-CoV. The TPPs for MERS-CoV vaccines were developed through a consultation process with key stakeholders in human and animal health, scientific, funding and manufacturing communities. It is intended that they will guide and prioritize the development of MERS-CoV vaccines. As new scientific evidence is generated, these TPPs may require review and revision.

- WHO EMRO supported a technical mission of Ministry of Health officials from Saudi Arabia to Egypt in May 2017. The focus of the mission was to share surveillance and laboratory experiences with those officials who are responsible for respiratory surveillance and laboratory services in the Ministry of Health for Saudi Arabia.

- WHO EMRO conducted a review mission to Qatar to assess the existing preparedness and response to epidemics including MERS-CoV outbreaks. The Mission took place from 9 to 15 May 2017.

Risk assessment

WHO is continuing to work with ministries of health in all affected countries and with international partners to better understand transmission patterns and risk factors of MERS-CoV infection in community and health-care settings and to develop improved measures to prevent human infections. WHO's global risk assessment of MERS-CoV remains unchanged from the last publication, on 5 December 2015.

The continued occurrence of health-care-associated outbreaks is deeply concerning and is the result of low awareness and early suspicion of MERS-CoV infections. The non-specificity of MERS-CoV symptoms complicates surveillance activities for the virus, often resulting in early missed cases, including the index case, in outbreaks and thereby providing the opportunity for human-to-human transmission in health-care settings.

Investigations are ongoing into transmission within health-care facilities and more comprehensive scientific studies are underway to better understand the drivers of transmission, including more detailed studies of surface and air survival and persistence. Secondary cases have reported varying levels of contact with confirmed patients, ranging from direct contact (e.g., health-care workers providing direct care to infected patients before diagnosis with MERS) to no

clear contact (e.g., patients sharing wards with infected patients, but without sharing health-care workers or rooms). At present, it is unclear which exposures result in transmission of the virus in health-care settings or what the role of environmental contamination may play in such transmissions. Several studies from the Republic of Korea have identified MERS-CoV virus on surfaces inside patient rooms and on equipment during patient stays and after discharge or death. These findings highlight the importance of adequate cleaning and disinfection of patient rooms.

During the March 2017 WHO-led meeting to further evaluate the role of environmental contamination in MERS-CoV transmission, participants outlined critical scientific experimental and observational studies that need to be conducted. Some of these collaborative studies are currently underway.

WHO has updated its surveillance guidance for MERS-CoV and has specifically stated that any individuals presenting with respiratory symptoms who have recently visited the Middle East must be asked whether they have visited any health-care facility there or had any direct or indirect contact with dromedary camels.

WHO is currently in the process of reviewing and updating, as necessary, all WHO information products and guidance materials. Updates are done in collaboration with our international partners and will be posted online as they become available. (See also the previous list of updated materials in this assessment, p. 4.)

WHO stresses that it is a person's activities and exposures while in the Middle East that are relevant for MERS-CoV rather than the fact that he or she may have visited a particular country. The movement of patients between hospitals within countries and between countries for treatments and/or surgery (medical tourism) complicates the epidemiologic picture. Genetic sequencing of samples collected from confirmed patients should be a routine part of investigations into MERS-CoV clusters to better understand transmission patterns between patients and to help identify the source of the infection.

Since July 2015, WHO recommends that, in documented cases of human-to-human transmission in a health-care setting, all health-care contacts (e.g., health-care workers and patients sharing space with a confirmed case), household contacts, and social contacts should be tested for MERS-CoV, regardless of whether they display symptoms. Among contacts who are at higher risk of infection are those who are in direct physical contact with the patient or the patient's biological fluids before MERS-CoV was diagnosed (e.g., treating physicians, health-care professionals who performed intubation, cleaning staff). For these people, multiple specimens, including lower-respiratory specimens whenever possible, should be collected and tested for MERS-CoV within the 14-day incubation period.

In 2017, the epidemiologic patterns of MERS-CoV remain the same: multiple introductions from dromedary camels in the Middle East to humans and secondary transmission in health-care settings. Transmission among close family members within households remains limited for unclear reasons. What is different, however, is that the health-care-associated outbreaks in the Middle East are occurring more frequently and, often, though not always, are small in size and can affect several hospitals. The large outbreaks in Jeddah/Riyadh in 2014, in the Republic of Korea in June 2015 and in Riyadh in August 2015, remind us that MERS-CoV, if not adequately controlled, can cause explosive outbreaks with substantial socio-economic consequences.

Until zoonotic transfer of the virus from infected dromedary camels into the human population is halted, the risk remains that further health-care-associated outbreaks will occur. The repeated and ongoing health-care-associated outbreaks in the Middle East are concerning and more work is needed to better understand the reasons behind these outbreaks and what is necessary to prevent them. Cases have been exported to a number of countries outside of the Middle East and could happen again anywhere. The combination of factors that has previously been described illustrates that low awareness and the inability to rapidly limit exposure to MERS-CoV patients can lead to large outbreaks.

The WHO missions to affected countries have provided an opportunity to fully evaluate the ongoing challenges to tackling MERS-CoV. Control of this virus requires national leadership, coordination between animal and human sectors (and others), public trust, frequent and clear communication to all hospitals and hospital staff on measures to limit human-to-human transmission, thorough investigation of all cases and rapid dissemination of knowledge gained during outbreak investigations and research on MERS-CoV. WHO is pleased that affected countries have improved their responses to MERS-CoV and is also encouraged by the sharing of information on individual cases and investigations of clusters.

Have MERS-CoV transmission patterns changed?

There is no evidence of sustained human-to-human transmission in the community nor is there evidence of airborne transmission as main routes of transmission from all information available from recent MERS-CoV cases.

Therefore, the overall transmission patterns previously observed remain unchanged. WHO bases this assessment on the evidence that:

1. The clinical picture seen in recent outbreaks appears to be similar to that observed throughout previous outbreaks; secondary cases in the absence of comorbidities tend to present with milder disease than primary cases; and many of the recently reported secondary cases have been mild or were in patients whose tests were positive for MERS-CoV, but were reported to be asymptomatic;

2. The cases recently exported to countries outside of the Middle East have not resulted in sustained onward transmission to persons in close contact with these cases in the community;

3. Intensive screening of MERS-CoV contacts has revealed few instances of household transmission and no transmission has been identified thus far on airplanes or other forms of transportation;

4. There has been no increase in the size or number of observed household clusters; and

5. While there is variation of the R_0 number in different settings, the overall R_0 of MERS-CoV is < 1. The R_0 can be higher in health-care settings, as has been seen in several health-care associated outbreaks in Saudi Arabia and the Republic of Korea. Experiences in Austria, China, Saudi Arabia, Thailand, and the United Arab Emirates, have shown that the R_0can be brought to <1 with early isolation of cases and adequate infection prevention and control measures.

Can we expect additional cases of MERS-CoV infection in the Middle East? Can we expect additional cases exported to other countries?

WHO expects that additional cases of MERS-CoV infection will be reported from the Middle East and that occasional spillover will continue to occur in other countries by individuals who might acquire infection after exposure to an animal (e.g., while visiting farms or markets or consuming raw dromedary products such as milk, urine) or human source (possibly in a health-care setting for planned or emergency treatment).

Until more is understood about mode of transmission and risk factors for infection, cases resulting from animal to human (zoonotic) transmission will continue to occur and will eventually lead to limited community transmission within households and possibly significant health-care-associated outbreaks such as those seen in the Republic of Korea and Saudi Arabia. Consistent application of adequate infection prevention and control measures has been used to end transmission in previous clusters.

Investigation into the exported cases who reported performing Umrah in Saudi Arabia revealed that all of them had visited a health-care facility, had come into contact with dromedary camels or had consumed raw camel products while in Saudi Arabia.

Recommendations

A number of epidemiologic investigations into the transmission patterns of MERS-CoV have been conducted and published and more studies are planned or are underway. WHO hopes that these investigations can be shared with affected countries dealing with MERS-CoV and published quickly. The most urgent needs remain:

- a better understanding of how humans become infected from animal or environmental source(s) in the community;
- identification of risk factors for infection from humans or the environment in occupational settings and health-care settings;
- and enhancement of community studies and surveillance for community-acquired pneumonia.

WHO has developed a MERS-CoV research agenda to address key unknowns for this virus focusing on five major areas of research: i) virus origin and characteristics, ii) epidemiology and transmission, iii) clinical management and infection prevention and control measures, iv) product development and implementation, and v) impact of interventions and operational research.

Collaboration between human and animal health sectors in affected countries is essential to understanding the risk of transmission of MERS-CoV between animals and humans, whether there is any seasonal variation in the circulation of the virus in animals and the natural reservoir(s) of MERS-CoV. It is also important to work towards limiting the spread of infection in animal populations (through development of vaccines and better management of infected animals/herds) so as to reduce the opportunity for further human exposure.

In addition, a better understanding of transmission in health-care settings, especially the exposures that result in human-to-human transmission, the potential role of asymptomatic infected health-care workers and the possible role of environmental contamination, is urgently needed.

Enhancing infection prevention and control awareness and implementation measures is critical to preventing the possible spread of MERS-CoV in health-care facilities. It is not always possible to identify patients with MERS-CoV early because some have mild or non-specific symptoms. For this reason, it is important that all health-care facilities establish and implement clear triage policies for rapid screening and assessment of potential MERS-CoV cases and all cases with acute respiratory symptoms. It is also important for health-care workers to apply standard precautions consistently with all patients, regardless of their diagnosis, in all work practices all of the time. Droplet precautions should be added to the standard precautions when providing care to any patient with symptoms of acute respiratory infection.

Health-care facilities that provide care for patients suspected of or confirmed to be infected with MERS-CoV should take appropriate measures to decrease the risk of transmission of the virus from an infected patient to other patients, health-care facility workers (medical and service personnel) and visitors. These measures involve interventions at the patient-carer interface and other general measures such as linen management, cleaning and disinfection and waste management. Contact precautions and eye protection should be added when caring for probable or confirmed cases of MERS-CoV infection and airborne precautions should be applied when performing aerosol-generating procedures. Hospital cleaning staff should also be informed of and trained to take proper precautions when cleaning rooms of MERS-CoV patients.

Until more is understood about MERS-CoV, people at high risk of developing severe disease (any person who is older, has diabetes, renal failure, chronic lung disease, or is immunocompromised), should take precautions when visiting farms or markets where dromedary camels are present (especially in the Middle East and Africa). These precautions include: avoiding contact with camels; not drinking raw camel milk or camel urine; and not eating camel meat that has not been thoroughly cooked.

Recently published studies in Qatar, Saudi Arabia and the United Arab Emirates indicate that people handling or

working with dromedary camels in these countries are at increased risk of infection with MERS-CoV compared with people who do not have contact with camels. Until more evidence is gathered, it would be prudent for camel farm workers, slaughterhouse workers, market workers, veterinarians and anyone else handling dromedary camels to practice good personal hygiene, including frequent hand hygiene. Hands should be washed with soap and water and/or alcohol gel after every contact with an animal. Workers should wear facial protection where feasible; and protective clothing, which should be removed after work (followed by hand hygiene) and washed daily.

Workers should avoid exposing family members to soiled work clothing, shoes, or other items that may have come into contact with camel secretions and excretions. These clothes and other items should remain at the workplace for daily washing and workers should have access to and use shower facilities at their workplaces before leaving the premises.

Dromedary camels infected with MERS-CoV may not show any signs of infection. It is therefore not possible to know whether an animal on a farm, in a market, at a race track or in a slaughterhouse is excreting MERS-CoV that can potentially infect humans. However, infected animals may shed MERS-CoV through nasal and eye discharge, faeces, and potentially in their milk and urine. The virus may also be found in the raw organs and meat of infected animals. Therefore, until more is known about infection in animals, the best protection is to practice good hygiene and avoid direct contact with all of these. Obviously sick animals should never be slaughtered for consumption; dead animals should be safely buried or destroyed.

Unless protected, people should avoid contact with any animal that has been confirmed positive for MERS-CoV until subsequent tests have confirmed that the animal is free of the virus.

Health officials in countries outside of the affected regions should maintain a high level of vigilance, especially those in countries with large numbers of travellers or migrant workers returning from the Middle East. Surveillance should continue to be enhanced in these countries according to WHO guidelines, along with infection prevention and control procedures in health-care facilities. WHO continues to request that Member States report all confirmed and probable cases along with information about their exposures, testing and clinical course to inform the most effective international preparedness and response.

WHO does not advise special screening at points of entry with regard to MERS-CoV nor does it currently recommend the application of any travel or trade restrictions.

WHO guidelines and tools on epidemiologic investigations can be found at http://www.who.int/csr/disease/coronavirus_infections/technical-guidance-surveillance/en/.

Selected Publications

- Researchers from Saudi Arabia and the University of Hong Kong conducted a longitudinal study in two dromedary herds in Eastern (n=80 camels) and Central (n=100 camels) Provinces in Saudi Arabia over a 7-month period from September 2014 to May 2015. Molecular, serologic and genetic testing was conducted and identified that both herds had serologic evidence of MERS-CoV infection and that some camels in the herd in Central Province had been re-infected with MERS-CoV. The full study can be found here.

- A case-control study was conducted among patients presenting with influenza-like illness at the Prince Mohammed bin Abdulaziz Hospital Emergency Department, a designated MERS-CoV referral hospital in Riyadh, Saudi Arabia. Between 1 April 2014 and 30 September 2015, 80 laboratory confirmed patients with MERS were admitted to the hospital. The researcher found that presenting symptoms were not significantly different when compared with controls matched on age, sex and the presence of underling conditions. The full study can be found here.

- A case-control study from Qatar evaluated risk factors for MERS-CoV infection among 9 serologically-positive dromedary workers compared with 43 serologically-negative dromedary workers. The researchers from Erasmus Medical Center and the Ministry of Health in Qatar found that cleaning farm equipment, assisting in camel births and milking and training animals were associated with the presence of MERS-CoV neutralizing antibodies. The full study can be found here.

- A paper from Saudi Arabian and the US Centers for Disease Control and Prevention public health professionals described surveillance and testing for MERS-CoV in Saudi Arabia over an 11-month period between April 2015 and February 2016. During this time period, public health laboratories across Saudi Arabia tested 57 363 individuals (89% of whom were suspected to have MERS. Less than 1% (384/57 363 samples) tested positive for MERS-CoV. The full article is available here.

- A study from the Republic of Korea evaluated epidemiologic and clinical features of laboratory confirmed MERS in patients and human-to-human transmission in health-care settings. The researchers found that patients who transmitted to others had more non-isolated days in the hospital, body temperature of ≥38.5C and pulmonary infiltration of ≥3 lung zones. The full paper can be found here.

- A case study of an asymptomatic laboratory-confirmed case of MERS in the Republic of Korea evaluated potential human-to-human transmission with his contact. All 82 contacts tested negative using molecular and serologic tests, suggesting no transmission occurred from the asymptomatic patient. The full study can be found here.

- A cross-sectional survey among people from six Gulf Cooperation Council countries evaluated knowledge and awareness of MERS-CoV using a smart phone application. Among the 1812 participants from Bahrain, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates, while awareness of MERS-CoV was high, 22%

believed dromedaries are the zoonotic reservoir for MERS-CoV, 79% believed that the virus can be transmitted via droplets from an infected person, 26% believe that there is little to no risk of infection from drinking raw camel milk and 42% of respondents were "not concerned at all" of being infected with MERS-CoV. The full study can be found here.

- In a study of 12 healthy male common marmosets, lopinavir/ritonavir and interferon-beta1b demonstrated potent anti-MERS-CoV activity. The study found less severe clinical presentation, less weight loss, fewer pulmonary infiltrates and lower mean viral loads in necropsied lung tissues in lopinavir/ritonavir and inferon-beta1b treatment groups compared to the control group. In contrast, animals treated with mycophenolate mofetil (MMF) developed severe and/or fatal disease with higher viral loads than untreated animals. Mortality post inoculation at 36 hours was 67% among untreated/MMF, 0% for lopinavir/ritonavir and 33% for interferon-beta1b. The full study is available here

- In a study of mice treated intraperitoneally with m336, MERS-CoV-infected mice with treatment showed no signs of clinical symptoms, whereas control mice exhibited 100% mortality by day 8. Lower levels of virus were also found within mice treated with m336 when compared with controls and pathology revealed less damage to type II pneumocytes, one of the principal targets of MERS-CoV. The study is available here.

- Researchers from China have demonstrated decreased viral load in lung, trachea and oropharyngeal swabs in Rhesus macaques vaccinated with a vaccine made from the receptor binding domain of the MERS-CoV virus compared to control animals. The full study is available here.

- Three clinical trials underway to evaluate antiviral treatment of MERS: a convalescent therapy treatment trial at stage 2 set to complete in June 2017 (www.clinicaltrials.gov, NCT02190799), an anti-spike protein antibody safety and pharmacokinetics study set to complete in April 2018 (www.clinicaltrials.gov, NCT02788188), and a lopinavir/ritonavir and interferon beta1b trial that is still recruiting (www.clinicaltrials.gov, NCT02845843). WHO is not involved in these clinical trials.