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The Middle East Respiratory Syndrome (MERS)



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KEYWORDS

- Middle East respiratory syndrome coronavirus • MERS-CoV
- Epidemiology diagnosis • Treatment

KEY POINTS

- The Middle East respiratory syndrome (MERS) is a novel lethal zoonotic disease of humans endemic to The Middle East, caused by the MERS coronavirus (MERS-CoV).
- Humans are thought to acquire MERS-CoV through contact with camels or camel products.
- MERS carries a 35% mortality rate. There is no specific treatment for MERS. Person-to-person spread causes hospital and household outbreaks of MERS-CoV.
- Millions of visitors travel to Saudi Arabia each year from across the world, thus watchful surveillance and a high degree of clinical awareness and early diagnosis with rapid implementation of infection control measures in returning travelers is important.

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INTRODUCTION

The Middle East respiratory syndrome coronavirus (MERS-CoV) is a new zoonotic human viral pathogen endemic to the Middle East.^{1–3} It was identified in 2012 in a lung sample of a 60-year-old patient who had died of respiratory failure in Jeddah, Saudi Arabia.⁴ The disease caused by MERS-CoV is named Middle East respiratory syndrome (MERS). MERS has remained on the radar of global public health authorities because of recurrent nosocomial and community outbreaks, and its association with severe disease and high mortality rates.^{1–3} Intermittent sporadic cases, community clusters, and nosocomial outbreaks of MERS-CoV have continued to occur in Saudi Arabia.¹ MERS-CoV remains on the World Health Organization (WHO) Blueprint list of priority pathogens⁵ because it remains a persistent threat to global health security.

EPIDEMIC POTENTIAL AND GLOBAL SPREAD

Cases of MERS from outside the Middle East have been reported from all continents, and have been linked with travel to the Middle East.¹ Nosocomial outbreaks of MERS-CoV infection accounts for approximately 40% of MERS-CoV cases globally. Large health care-associated outbreaks of MERS-CoV have occurred in Saudi Arabia, United Arab Emirates, and the Republic of Korea.^{6–10} From June 1 to July 31, 2015, MERS-CoV caused the largest outbreak outside the Arabian Peninsula in the Republic of Korea, resulting in 186 confirmed MERS cases with 38 deaths.^{7–9} This occurred when a Korean traveler returning from a trip to Qatar, United Arab Emirates (UAE), Saudi Arabia, and Bahrain became ill with a respiratory illness and visited several hospitals before finally being diagnosed as having MERS-CoV infection on May 20, 2015, at Samsung Medical Center.^{7–9} This resulted in 186 people, including 25 health care workers (HCWs), contracting MERS-CoV infection; 181 of 186 cases were associated with hospital transmission. This outbreak clearly illustrated the epidemic potential of MERS-CoV, spreading person-to-person.

EPIDEMIOLOGY

The number of MERS-CoV cases reported to the WHO have steadily increased since the first report of MERS-CoV in September 2012.⁴ MERS-CoV cases continue to be reported from the community and hospitals across the Arabian Peninsula. As of July 31st 2019, 2458 cases of laboratory-confirmed MERS cases were reported to WHO. Of these, there were 848 deaths (34% mortality)¹ (Fig. 1). Approximately 80% of human cases have been reported by Saudi Arabia. Twenty-seven countries have reported cases of MERS.¹¹ Countries in or near the Arabian Peninsula that report MERS cases are Bahrain, Iran, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, UAE, and Yemen. Cases identified outside the Middle East are usually in travelers who were infected in the Middle East and then traveled to areas outside the Middle East. Countries outside the Arabian Peninsula that have reported travel-associated MERS cases are Algeria, Austria, China, Egypt, France, Germany, Greece, Italy, Malaysia, Netherlands, Philippines, Republic of Korea, Thailand, Tunisia, Turkey, United Kingdom, and the United States.¹

SOURCE OF PRIMARY HUMAN MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS INFECTIONS

The exact mode of transmission of MERS-CoV to humans is not yet accurately defined. Epidemiologic, genetic, and phenotypic studies indicate that dromedary

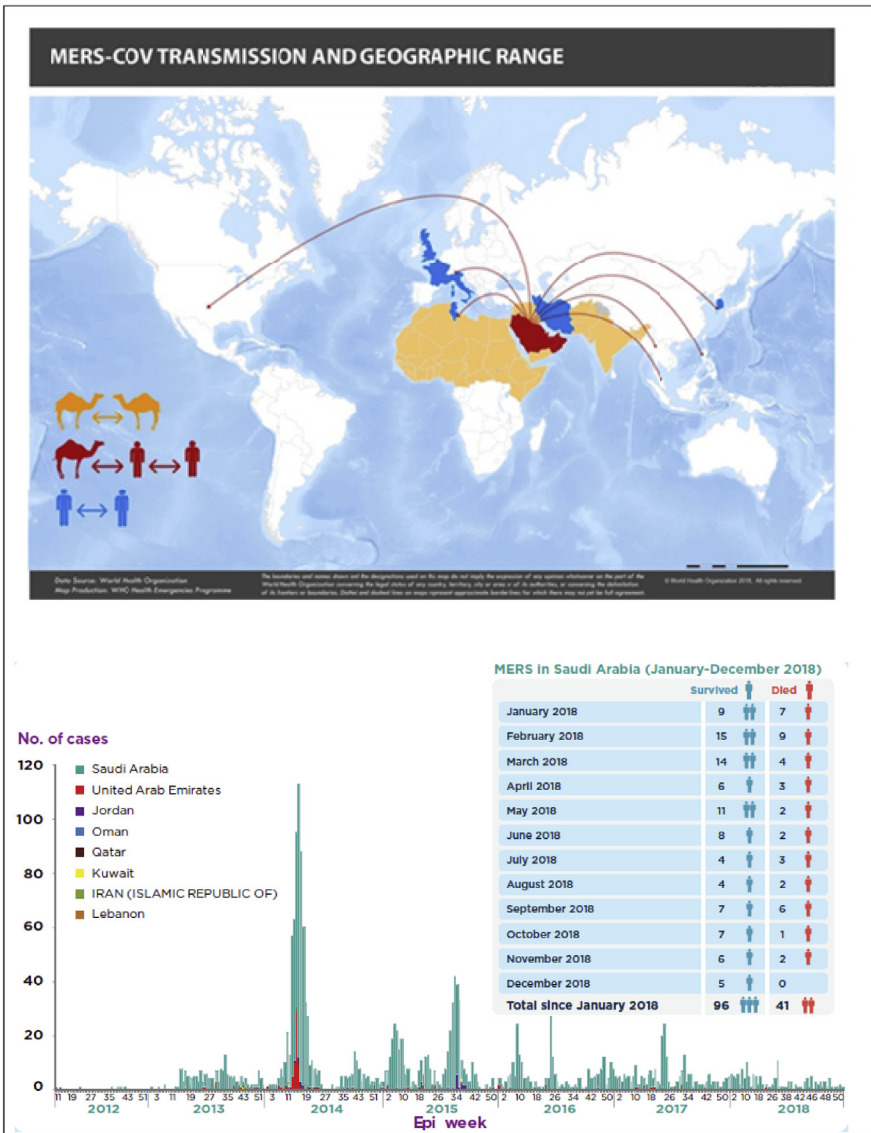


Fig. 1. Geographic distribution of MERS reported to WHO (2012–2018). (From WHO 2019. Middle East respiratory syndrome coronavirus (MERS-CoV. <https://www.who.int/emergencies/mers-cov/en/>; with permission.)

camels appear to be the main intermediary reservoirs of MERS-CoV.^{12–15} Camels are assumed to be intermediary host species for the MERS-CoV, although the exact source and the mode of transmission in many primary MERS cases remain unclear. Antibodies to MERS-CoV were detected in serum and milk collected from 33 camels in Qatar in April 2014. In one study, active virus shedding in nasal secretions and in feces was observed for 7 of 12 camels.¹³ MERS-CoV survives for prolonged periods in camel’s milk but viable virus became undetectable after pasteurization at 63°C for

30 minutes.¹⁶ MERS-CoV has been detected in camels from Kenya; 792 of 1163 camels studied had enzyme-linked immunosorbent assay (ELISA) seropositivity of which 11 camel nasal swabs were positive for MERS-CoV by quantitative reverse-transcription polymerase chain reaction (RT-PCR).¹⁷ A study of humans in Kenya detected MERS-CoV neutralizing antibodies in persons living in rural areas, although no human MERS cases have been detected yet.¹⁸

The primary source of human MERS-CoV infections remains unknown. There are no definitive data on the epidemiologic link between human MERS-CoV infections and bats. Only one fragment of MERS-CoV with close matching to a human isolate of MERS-CoV was found in a study of more than 1000 samples from *Taphozous* bats.¹⁹ Phylogenetic analysis of an MERS-related CoV identified from a *Neoromicia capensis* bat sampled in South Africa supports the hypothesis that bats are the evolutionary source of MERS-CoV but not a zoonotic reservoir.²⁰ To date, no sustained human-to-human transmission has been documented, although tertiary and quaternary spread did occur in the Korean outbreak.^{8,9}

RISK FACTORS FOR PRIMARY MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS INFECTION

Several independent risk factors for increased susceptibility to acquiring primary MERS-CoV infections have been identified: direct dromedary exposure in the fortnight before illness onset, direct physical contact with dromedary camels during the previous 6 months, diabetes mellitus, and heart disease. Risk factors for MERS-CoV infection among camel workers include milking camels, contact with camel waste, poor hand hygiene before and after animal tasks and training activities, and workers with respiratory symptoms requiring overnight stay in hospital.²¹ Viral RNA sequencing has confirmed camel to human transmission of MERS-CoV^{22–24} after known exposure to the infected camels. Recent data suggest that although MERS-CoV is widespread among dromedary camels in the Middle East and Africa, zoonotic transmission of MERS-CoV from camels to humans is relatively uncommon, and human disease is not directly proportional to potential exposure. MERS-CoV does not transmit easily from person-to-person unless there is close contact, such as occurs when providing care to a patient in the household²⁵ or nosocomial setting when the diagnosis of MERS-CoV has not yet been recognized and there are lapses in instituting infection control measures.^{2,3,6,7}

CLINICAL FEATURES

The symptoms, signs, laboratory, and imaging abnormalities associated with MERS-CoV infection are not MERS-specific and are like other respiratory tract infections (RTIs)^{2,3,7,26–28} (**Box 1, Table 1**). The clinical manifestations of MERS-CoV infections range from asymptomatic infection to mild, moderate, and severe disease, often complicated by severe pneumonia, acute respiratory distress syndrome (ARDS), septic shock, and multiorgan failure. The incubation period is between 2 and 14 days. Mild cases can have low-grade fever, chills, runny nose, dry cough, sore throat, and myalgia. Some patients have gastrointestinal symptoms, such as nausea, vomiting, and diarrhea. Fever may be absent in up to 15% of hospitalized cases. Laboratory abnormalities include cytopenias and elevated transaminases (see **Table 1**). Coinfections with other respiratory viruses and bacterial pathogens have been reported. Up to half of MERS cases can have acute kidney injury and one-third of very ill patients have gastrointestinal symptoms.

Box 1**Risk factors for nosocomial Middle East respiratory syndrome coronavirus (MERS-CoV) outbreaks**

- Lack of awareness of the possibility of MERS in febrile patients presenting to health care facilities
- Overcrowded emergency departments where patients with MERS first present
- Exposure of health care workers and other patients to symptomatic MERS patients
- Poor compliance with infection control measures: (1) hand hygiene, (2) droplet and contact precautions, (3) inadequate environmental cleaning
- Inadequate compliance with appropriate Personal Protective Equipment
- Lack of proper isolation room facilities
- Aerosol-generating procedures on patients with MERS
- Crowded inpatient wards, including nonessential staff and visitors (family and friends)

Data from Refs. ^{1–3,7,8,47,51}

Severe illness can cause respiratory failure that requires mechanical ventilation and support in an intensive care unit (ICU). There is rapid progression to ARDS and multi-system disease and organ failure with a median of 2 days from hospitalization to ICU admission.^{29,30} MERS-CoV infection appears to cause more severe disease in older people, people with weakened immune systems, and those with chronic diseases, such as renal disease, cancer, chronic lung disease, and diabetes.^{2,3}

MORTALITY AND RISK FACTORS

A case study of 660 patients with MERS in Saudi Arabia seen between December 2, 2014, and November 12, 2016, found that 3-day, 30-day, and overall mortality were 13.8%, 28.3%, and 29.8%.³¹ Patients older than 60 were more likely to die (45.2% mortality) from their infections than were younger patients (20%). Patients with preexisting medical comorbidities tend to have more severe disease and higher mortality rates.

Factors associated with poor management outcomes (severe disease or death) in patients with MERS include old age, male gender, comorbid preexisting illnesses (such as obesity, diabetes mellitus, heart and lung disease, and immunocompromised states), low serum albumin, concomitant infections, and positive plasma MERS-CoV RNA.^{27–32} DPP4 receptors have been shown to be upregulated in the lungs of smokers, and this may explain why patients with comorbid lung diseases are prone to severe illness.³³

MAKING AN EARLY DIAGNOSIS OF MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS INFECTION

Many cases of MERS-CoV can be easily missed because the presentation is that of any community-acquired pneumonia or other respiratory illness caused by influenza A and B respiratory syncytial virus, parainfluenza viruses, rhinoviruses, adenoviruses, enteroviruses (eg, EVD68), human metapneumovirus, and endemic human coronaviruses (ie, HCoV-HKU1, -OC43, -NL63, and -229E).² Most nosocomial outbreaks of MERS-CoV have been associated with a delay in diagnosis.

A history of travel to the Middle East is important for patients presenting in non-Middle Eastern countries with a febrile illness.^{1,2,33,34}

Table 1	
Clinical and laboratory features of patients with Middle East respiratory syndrome	
Clinical/Laboratory Feature(s)	
Date of first MERS case (place) (retrospective analyses)	April 2012 (Zarqa, Jordan) June 2012 (Jeddah, Kingdom of Saudi Arabia)
Incubation period	Mean: 5.2 d (95% confidence interval 1.9–14.7) Range: 2–14 d
Age group	
Adults	Adults (98%)
Children	Children (2%)
Age, y, range, median	Range:1–94; Median: 50
Gender	Male: 64.5%, Female: 35.5%
Presenting symptoms	Estimated proportion of cases, %
Fever >38°C	98
Chills/rigors	87
Cough	83
• Dry	56
• Productive	44
Shortness of breath	72
Myalgia	32
Malaise	38
Nausea	21
Vomiting	21
Diarrhea	26
Sore throat	14
Hemoptysis	17
Headache	11
Rhinorrhoea	6
Comorbidities (eg, obesity, diabetes, cardiac disease and lung disease), %	76
Laboratory results, %	
Chest radiograph and computed tomography abnormalities	90–100
Leukopenia (<4.0 × 10 ⁹ /L)	14
Lymphopenia (<1.5 × 10 ⁹ /L)	32
Thrombocytopenia <140 × 10 ⁹ /L)	36
Elevated lactate dehydrogenase	48
Elevated alanine transaminase	11
Elevated aspartate transaminase	14
Risk factors associated with poor outcome (severe disease or death)	Any immunocompromised state, comorbid illness, concomitant infections, low albumin, age ≥65 y
Mortality, %	
Case fatality rate (CFR), overall	34%
CFR in patients with comorbidities	60

Data from Refs.^{1–3,7}

RISK FACTORS FOR NOSOCOMIAL MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS OUTBREAKS

Early and accurate diagnosis of MERS-CoV infection is important for clinical management, and instituting infection control and epidemiologic control measures of MERS-CoV infections. Thus, a high degree of clinical awareness of the possibility of MERS-CoV infection is required in all health care settings so that an accurate diagnosis can be made and infection control measures instituted as soon as the diagnosis is entertained clinically.^{33,34}

CLINICAL SAMPLES FOR LABORATORY TESTING

Upper respiratory tract samples have yielded negative results in some symptomatic close contacts of confirmed cases who later developed pneumonia and tested positive on lower respiratory specimens. For laboratory testing, WHO³⁵ recommends that both upper respiratory tract specimens (nasopharyngeal and oropharyngeal) and lower respiratory tract specimens (sputum, tracheal aspirate, or lavage) are collected whenever possible. Lower respiratory specimens have a higher diagnostic value than upper respiratory tract specimens for detecting MERS-CoV infection.³⁶ Sputum, endotracheal aspirate, or bronchoalveolar lavage should be collected for MERS-CoV testing when possible. If patients do not have signs or symptoms of lower respiratory tract disease and the collection of lower tract specimens is not possible or clinically indicated, upper respiratory tract specimens, such as a nasopharyngeal aspirate or combined nasopharyngeal and oropharyngeal swabs, should be collected.

When taking nasopharyngeal and oropharyngeal specimens, Dacron or rayon 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.^{35,36} A single negative test result does not exclude the diagnosis, and repeat sampling and testing is strongly recommended. To confirm clearance of the virus, respiratory samples should be collected sequentially (every 2–4 days) over ensuing days until there are 2 consecutive negative results in clinically recovered persons. Specimens for MERS-CoV detection should reach the laboratory as soon as possible after collection and be delivered promptly to the laboratory, shipped at 4°C if possible. When there is likely to be a delay of more than 72 hours in specimens reaching the laboratory, it is recommended that the specimens are frozen at –20°C or ideally –80°C and shipped on dry ice. It is important to avoid repeated freezing and thawing of specimens.^{35,36}

LABORATORY TESTS FOR MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS

Accurate laboratory molecular diagnostic tests are available using highly sensitive and specific real-time RT-PCR (rRT-PCR). Three rRT-PCR assays for routine detection of MERS-CoV have been developed targeting upstream of the E protein gene (*upE*) and the open reading frame 1b (ORF 1b), and ORF 1a.^{35–37} The assay for the *upE* target is considered highly sensitive and is recommended for screening, with the ORF 1a assay considered of equal sensitivity. To date, these rRT-PCR assays have shown no cross-reactivity with other respiratory viruses, including human coronaviruses, and were suitable to detect all known MERS-CoV strains in humans and dromedary camels.

Laboratory confirmation of MERS-CoV infection³⁷ is obtained by detection of the virus by (1) MERS-CoV-specific nucleic acid amplification test with up to 2 separate targets and/or sequencing; (2) virus isolation in tissue culture; or (3) serology on serum

tested in a WHO collaborating center with established testing methods.^{35,36} A case confirmed by serology requires demonstration of seroconversion in 2 samples ideally taken at least 14 days apart, by a screening (ELISA, immunofluorescence assay) and a neutralization assay.

Serologic tests such as ELISAs for MERS-CoV are being developed and refined for surveillance or investigational purposes.^{36,38} An indirect ELISA has been developed for sero-epidemiological testing and surveillance purposes and requires evaluation in field studies.³⁹

MERS-CoV testing must be performed in appropriately equipped biosafety laboratories by staff trained in the relevant technical and safety procedures. National or WHO guidelines on laboratory biosafety should be followed in all circumstances.⁴⁰

CLINICAL MANAGEMENT OF MIDDLE EAST RESPIRATORY SYNDROME CASES

The management of patients with MERS is largely symptomatic and supportive and aims to reduce the risk of complications, such as secondary infections, and renal and respiratory failure.¹⁻³ Seriously ill patients should receive intensive care.

Although a range of existing and developmental treatments may be useful⁴¹ (Box 2), currently there are no specific treatments to treat MERS-CoV. A range of treatments such as lopinavir/ritonavir, pegylated interferon (IFN)- α 2a, and ribavirin have been used empirically for serious cases of MERS but there is no accurate evidence base that any of them improve treatment outcomes. Treatment with either lopinavir/ritonavir or IFN- β 1b in the marmoset model was associated with improved clinical, radiological, and pathologic outcomes with lower viral loads in comparison with no treatment, whereas mycophenolic acid alone increased viral loads and fatality.⁴² Macrolide therapy is commonly started before the patient arrives in the ICU in Saudi Arabia. A retrospective study of 136 patients with MERS found that macrolide therapy is not associated with a reduction in mortality or improvement in MERS-CoV RNA clearance.⁴³

Currently there is an ongoing randomized controlled trial in progress in the Kingdom of Saudi Arabia comparing lopinavir/ritonavir, recombinant IFN- β 1b, and standard supportive care against placebo and standard supportive care in patients with laboratory-confirmed MERS requiring hospital admission.⁴⁴ Systemic corticosteroids were shown to delay viral clearance in critically ill patients with MERS-CoV infection.³⁰ A range of anti-MERS-CoV drugs and host-directed therapies are being considered as potential therapies for MERS-CoV.⁴¹ Properly designed studies are needed to answer several knowledge gaps for us to understand the disease pathogenesis, viral kinetics, mode of disease transmission, and the intermediary source of MERS to guide infection control prevention measures and treatment responses in MERS-CoV infection.

INFECTION CONTROL MEASURES IN HOSPITALS WHEN MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS INFECTION IS SUSPECTED

The main infection prevention and control measures for managing patients with MERS are well documented from the severe acute respiratory syndrome (SARS) epidemic.⁴⁵ Early identification and isolation of suspected or confirmed cases and ongoing surveillance are key to preventing nosocomial spread. Droplet precaution (wearing a surgical mask within 1 m of the patient) and contact and droplet precautions (wearing gown, gloves, mask, and eye protection on entering the room and removing them on leaving) must be used when caring for patients with suspected MERS-CoV infection.⁴⁶ HCWs should implement airborne

Box 2**Potential treatments for MERS-CoV infection**

- Antivirals
 - Ribavirin monotherapy^a (± interferon)
 - Human immunodeficiency virus protease inhibitors (lopinavir,^b nelfinavir)
- Repurposed drugs:
 - Cyclophilin inhibitors (cyclosporin, alisporivir)
 - Chloroquine (active in vitro)
 - Mycophenolic acid
 - Nitazoxanide
- Interferons^b:
 - Interferon alfa
 - Interferon beta
- Neutralizing antibodies^b:
 - Convalescent plasma
 - Polyclonal human immunoglobulin from transgenic cows
 - Equine F(ab')₂ antibody fragments
 - Camel antibodies
 - Anti-S monoclonal antibodies
- Recombinant human mannose-binding lectin
- Small interfering RNA to key MERS-CoV genes

^a Risks likely to exceed benefits.

^b Treatment benefits likely to exceed risks.

Adapted from Zumla A, Hui DS, Perlman S. Middle East respiratory syndrome. *Lancet*. 2015;386(9997):995-1007; and Zumla A, Chan JF, Azhar EI, Hui DS, Yuen KY. Coronaviruses - drug discovery and therapeutic options. *Nat Rev Drug Discov*. 2016 May;15(5):327-47.

precautions and wear a fit-tested particulate respirator (eg, The US National Institute for Occupational Safety and Health–approved N95 filtering facepiece respirator [FFR] or an European norms [EN] approved FFP2-FFR or FFP3-FFR) when performing aerosol-generating procedures for infected and potentially infected patients. Avoiding aerosolizing procedures in crowded hospital emergency or inpatient medical wards that do not have adequate infection control measures in place may decrease MERS-CoV human-to-human spread and environmental contamination. It is also prudent to use higher levels of protection for HCWs who extend close contact with patients with MERS and those who are exposed to aerosols from high-risk procedures.

Higher levels of ventilation (more air changes, higher air flow and velocity), greater effort to prevent air dispersion beyond the point of generation (enclosure, using capture ventilation), and higher levels of personal protective equipment (more coverage, more protective types of respiratory protection) are all necessary. To reduce room contamination in the hospital setting, the application of a minimum room ventilation rate of 12 air changes per hour in a single room or at least 160 L/s per patient in facilities with natural ventilation is recommended when caring for patients receiving mechanical ventilation and during aerosol-generating procedures.

DECREASING RISK OF TRANSMISSION

Instituting appropriate infection control measures as soon as the diagnosis is considered is critical to preventing spread, especially in hospitals. Because symptoms and signs of RTIs are nonspecific, it is difficult to diagnose primary cases of patients

with MERS-CoV infection. Infection prevention and control measures are important to prevent the spread of MERS-CoV within households, the community, and in health care facilities.

TRANSMISSION IN HOSPITALS

Human-to-human transmission occurs within communities, households, and, more strikingly, within hospital settings. Health care-associated outbreaks have occurred in several countries, with the largest outbreaks seen in Saudi Arabia, UAE, and the Republic of Korea. Several outbreak studies have shown that MERS-CoV does not appear to transmit easily from person-to-person unless there is close contact, such as providing clinical care.^{2,7,47–52} MERS-CoV has been identified in clinical specimens, such as sputum, endotracheal aspirate, bronchoalveolar lavage, nasal or nasopharyngeal swabs, urine, feces, blood, and lung tissue.^{2,3} The modes of MERS-CoV transmission through direct or indirect contact, airborne, droplet, or ingestion have yet to be defined.

The upsurge in the number of human infections due to MERS-CoV over the past few years in health care facilities in the Middle East and South Korea^{2,3,47,48} were related to low awareness for MERS-CoV infection resulting in nosocomial outbreaks involving existing hospitalized patients, outpatients, visitors, and HCWs within health care facilities with overcrowding, lack of isolation room facilities, environmental contamination, and inadequate infection control measures without any significant change in the transmissibility of the virus. HCWs should always undertake standard precautions consistently with all patients with fever and symptoms of RTIs. Droplet precautions should be added to the standard precautions when providing care to these patients, and contact precautions and eye protection should be included when caring for probable or confirmed cases of MERS-CoV. Airborne precautions are important when performing aerosol-generating procedures.

HOUSEHOLD TRANSMISSION

Human-to-human transmission in the community or in those living in large households and family compounds has been described.^{25,50–54} An investigation of 280 household contacts of 26 index MERS-CoV-infected Saudi Arabian patients, with follow-up serologic analysis in 44 contacts performed in 2014 to determine the rate of “silent or subclinical” secondary infection after exposure to primary cases of MERS-CoV infection, found there were 12 probable cases of secondary transmission (4%; 95% confidence interval, 2–7).⁵¹ There have been several reports of MERS-CoV carriage after exposure to patients with MERS. Apparently healthy household contacts have been found to have MERS-CoV in their upper respiratory tract. Low levels of MERS-CoV RNA have been detected in asymptomatic HCWs from nosocomial MERS-CoV outbreaks in a Jeddah hospital.⁵² Of 79 relatives who were investigated after MERS-CoV infections affected an extended family in Saudi Arabia in 2014, 19 (24%) were MERS-CoV positive; 11 were hospitalized, and 2 died.

HEALTH CARE WORKER AND COMMUNITY EDUCATION

In MERS-CoV endemic countries where MERS-CoV cases can occur in the community and households, educational awareness of MERS-CoV and MERS prevention measures may reduce the risk of household transmission and prevent community

clusters.^{53,54} Regular hand washing before and after touching camels and avoiding contact with sick camels is advised. People should avoid drinking raw camel milk or camel urine or eating camel meat that has not been properly cooked. Persons who have diabetes, kidney disease, chronic lung disease, or cancer or are on immunosuppressive treatment are at high risk of developing severe MERS-CoV disease, thus they should avoid close contact with camels and bats.

WHO does not advise special screening for MERS-CoV at points of entry after return from the Middle East nor does it currently recommend the application of any travel or trade restrictions.¹ Persons with a history of travel from or to the Arabian Peninsula within 10 days of developing symptoms of an acute respiratory infection involving fever of 38°C or more, or cough with radiologic pulmonary changes at presentation should alert the physician to the possibility of MERS-CoV infection.⁵⁵

MIDDLE EAST RESPIRATORY SYNDROME CORONAVIRUS VACCINES

No vaccines are yet available that can protect against MERS-CoV infection. There are several groups working on developing a vaccine using a variety of platforms and some have shown efficacy in animal models.⁵⁶

SUMMARY

MERS-CoV remains an important public health risk and possible consequences of further international spread could be serious in view of the patterns of nosocomial transmission within health care facilities. With 10 million pilgrims visiting Saudi Arabia each year from 182 countries to perform the Hajj and Umrah pilgrimages,⁵⁷ watchful surveillance by public health systems and a high degree of clinical awareness of the possibility of MERS-CoV infection is essential.^{58–61} Nosocomial transmission is often due to a delayed diagnosis of MERS-CoV infection in a patient shedding MERS-CoV in a crowded health care setting such as an inpatient ward, emergency department, or renal dialysis unit. Early recognition of cases, improved compliance with internationally recommended infection control protocols, and rapid implementation of infection control measures are required to prevent health care facility-associated outbreaks of MERS-CoV.

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