International Journal of Community Medicine and Public Health
Bala MO et al. Int J Community Med Public Health. 2017 Jul;4(7):2202-2207
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20172806

Review Article

MERS: an emerging disease of the 21st century

Mohamed Osman Bala[1]*, Mohamad Abdel Halim Chehab[1], Nagah Abdel Aziz Selim[2]

[1]Community Medicine Residency Program, Hamad Medical Corporation, Doha, Qatar
[2]Faculty of Medicine, Cairo University, Cairo, Egypt

Received: 14 May 2017
Accepted: 05 June 2017

***Correspondence:**
Dr. Mohamed Osman Bala,
E-mail: Mohamed.Bala@outlook.com

ABSTRACT

Between September 2012 and March 2017, the Middle East Respiratory Syndrome (MERS), caused by an infection with the MERS coronavirus (MERS-CoV), has been responsible for 1,931 laboratory-confirmed cases and at least 741 related-deaths. Despite the paucity of knowledge on the source and route of transmission, the evidence currently points to dromedary camels. Moreover, the incubation period for this disease ranges from two to sixteen days. The symptomatology of MERS-CoV is non-specific and cases are easily misdiagnosed. As most respiratory illnesses, no specific anti-viral therapies have been effective to date for the treatment of MERS. Currently, the WHO does not advise any travel or trade restrictions regarding MERS-CoV. However, the poor practice of infection control has reflected the association between the healthcare setting and the spike of disease occurrence, especially among patients. Interestingly, the adoption of the "one health" approach is critical to establish a more holistic understanding of this epidemic. Additionally, implementing strategies aimed at risk reduction of animal-to-human transmission, rapid case finding, adequate infection control, and contact tracing are key in the control and prevention of MERS-CoV.

Keywords: Emerging, Coronavirus, Epidemic, Travel

INTRODUCTION

The year of 2012 witnessed the birth of a new infectious disease on Earth, and that was the Middle East Respiratory Syndrome (MERS), caused by an infection with the MERS coronavirus (MERS-CoV). MERS-CoV is a zoonotic virus that has likely invaded human beings through the human-animal interface; that is through contact with infected Arabian camels and thus leading to a respiratory illness and possibly death. According to the World Health Organization (WHO), an emerging zoonotic disease is one that has been documented recently, or that has occurred previously but increased in incidence or geographic coverage, host or vector array. Additionally, these zoonoses are the manifestation of the capability of microorganisms, harbored by animal reservoirs, to adapt onto human hosts such as: Ebola virus, SARS-CoV, Nipah virus, West Nile Virus, and HIV.[1]

As the country of emergence, the Kingdom of Saudi Arabia (KSA) was the first to report the disease to the WHO on September 2012. Since then, MERS has been responsible for 1,931 laboratory-confirmed cases and at least 741 related-deaths (percentage of fatal cases, 38%).[2] Interestingly, the majority of the cases (80%) were stemming from Saudi Arabia. However, the disease managed to spread from the Arabian Peninsula to cover 27 countries across four continents globally.[3] Moreover, the widest outbreak of MERS, away from the Middle Eastern geographic context, was that of South Korea. The index case was a traveler returning from the Arabian Peninsula; who was diagnosed on May 20th, 2015. Consequently, about 200 cases were diagnosed later on as

a result of caregiver and hospital-acquired transmission, with multiple hospital-based clusters being implicated.[4] In spite of that, the International Health Regulations Emergency Committee, unlike the Zika situation, did not escalate the MERS to a public health emergency of international concern (PHEIC).

Significant effort has been made over the past five years with many endeavors directed at yielding scientific evidence about the novel Coronavirus. However, our understanding of this new disease is yet to mature as many causes are still vague and the organism itself has not been fully comprehended.

DISCOVERY OF MERS-COV

Interestingly, the actual birthplace of the Middle East respiratory syndrome (MERS) was Jordan that retrospectively reported cases of the disease in 2012. However, a 60 year old man from Bisha, a city in the southwest of Saudi Arabia, was the first publicly reported case of MERS-CoV in the same year.[5] Furthermore, Dr. Ali Zaki who was a virologist at a private hospital, Dr Soliman Fakeeh Hospital, in Jeddah, first isolated the culprit organism. After which, the doctor sent two patient samples to Erasmus Medical center in the Netherlands, where the novel virus would be first sequenced and named human Coronavirus-EMC (for Erasmus Medical Center).[6] However, a controversy soon ensued after EMC claimed patency of the two samples; bringing the scientific community into a brawl over research rights as well as endangering the health of the global population; thus triggering the intervention of the WHO director general.

THE AGENT

MERS-CoV is a betacoronavirus found in human being as well as camels and related to multiple bat coronaviruses.[7] The source and route of transmission of this novel disease is yet to be fully understood; however, the evidence currently points to dromedary camels as a possible source and bats have also been incriminated as reservoirs.[8,9] Furthermore, epidemiological studies have revealed multiple possible routes of transmission, as camel-to-human and human-to-human propagation especially in the healthcare setting, either through droplet or contact transmission.[10-13] Furthermore, genomic studies have clarified that viral genomes originating from humans as well as camels have fused; strengthening the possibility of camel-to-human transmission.[14] Additionally, laboratory investigations have shown the tropism of MERS-CoV to multiple human cell lines, including renal, hepatic, intestinal, lower (but not upper) respiratory, and histiocytes.[15] In addition to that, the virus has been easily isolated from samples of patients' lower respiratory tract (tracheal aspirates, sputum, or bronchoalveolar lavage fluid), and this shedding might occur for numerous weeks and exceed by load that from other routes of exit (stool, serum).[16] The incubation period for this disease ranges from two to sixteen days, with a mean of five to six days. Also, after studying the natural history of the disease, the communicability period has been established at 13 to 14 days after an individual becomes symptomatic.[17] However, the infectivity of the virus has yet to be defined, but the case-fatality rate has ranged significantly depending on certain demographic characteristics, presence of comorbidities, and geographic locality.[18] Similarly, a study by Alsahafi et al revealed a variation of fatality from 12.5% in patients ≤19 years up to about 86% in those aged 80 years or more.[19] While, another paper by Kim et al discussed the MERS-CoV outbreak of South Korea revealing that the fatality rate was about 20%, almost half the global rate of 38.7% and significantly less than the rate recorded in Saudi Arabia (36.5%).[20] Also, the epidemic potential of this novel coronavirus was evaluated by Breban et al, where it was found that the reproduction number (R_0; defined as the mean count of infected individuals as a result of one diseased individual in a susceptible community) ranged between 0.60 and 0.69. This denoted that MERS-CoV is yet to possess a pandemic potential because its $R_0 < 1$.[21]

THE HOST

It is well known that bats are the natural host of most coronaviruses, including MERS-CoV. However, it is still unclear whether camels are natural reservoirs or intermediate hosts of MERS-CoV, despite the finding of specific antibodies in the sera of camels, archived for more than 20 years in KSA.[22] Furthermore, the virus has been isolated from the camels' upper respiratory tract, explaining the possible route of exit to infect human beings through direct contact.[23] On the other hand, the virus has been found to colonize the lower respiratory tract in humans; explaining why the clinical picture is also variable between the two species. Furthermore, there is evidence regarding other causes of infection, such as consuming camel raw meat and unpasteurized milk, remedial utilization of camel urine, and zoonosis from other species.[24]

Regarding the human host, an epidemiological study conducted by Alsahafi et al. that included the total reported cases of MERS-CoV in KSA between 2012 and 2015, has revealed that two-thirds of patients were males and that one third of them were elderly (>60 years old). Interestingly, the gender difference was reversed when considering the healthcare workers, where about 60% of the affected were females.[25] A similar study conducted by Alraddadi et al, has elaborated that patient cases were more likely to have one or more comorbidities, namely diabetes, heart disease, and chronic pulmonary disease. Additionally, infected people were more likely to have had direct contact with dromedaries through visiting a camel farm, milking a camel, or even contact with a visitor of a camel farm; however, there was no significant difference between cases and controls regarding consumption of unpasteurized camel milk or urine.[26] The urbanization of many Gulf cooperation council (GCC)

countries has helped fuel the practice of camel herding and racing; as transport and travel across borders has been facilitated. Thus, this might have paved the way for possible spillover events between camels and human being; which manifested as a zoonosis like MERS.[27]

A review of the South Korean outbreak in 2015, by Majumder et al revealed findings similar to those generated in KSA, but the case-fatality rate as discussed earlier was nearly half that of the Saudi's.[28] Nevertheless, it is important to mention here the concept of "super spreaders", where the literature has established the 20/80 rule in which a small percentage of individuals in any community is noted to direct most transmission occurrences. Therefore, "super-spreaders" are those individuals who disproportionately infect more secondary contacts, when compared to others within a population who are assumed to possess equal chances of transmitting the disease.[29] A clear example of this was the index case in the South Korean outbreak, who acted as super spreader when he infected 82 individuals while staying at a tertiary-care hospital, Samsung medical center, in Seoul during May of 2015.[30] Interestingly, the outbreak described above witnessed a third generation transmission of MERS-CoV with the emergence of quaternary cases, where a study by Nishiura et al. calculated a secondary transmission event risk of 22.7%, distributed among generations 2, 3 and 4 at 10.5%, 6.1% and 3.9%, respectively.[31]

THE ENVIRONMENT

The environment is a key player in the occurrence and propagation of communicable diseases. Many factors influence the human environment, both physical and socio-cultural. Moreover, the former include air, water, temperature, sanitation, and pollution; while the latter encompass poverty, crowdedness, and social norms.[32] MERS-coronavirus has the potential to survive in the environment from 24 up to 48 hours depending on the ambient temperature and degree of humidity, thus making possible the transmission through direct contact with infected surfaces or fomites.[33] Furthermore, a case-control study conducted in Saudi Arabia by Alraddadi et al has revealed that environmental exposure to dromedary camels, either through direct physical contact or indirectly through having camels within or near the household, was significantly associated with the illness. In addition, the study revealed that having contacts, in the household, who have been exposed to dromedaries was also significantly associated with developing MERS.[34] Moreover, a comparative study between MERS and SARS has shown that the healthcare setting was a risk factor for patients to acquire MERS and for healthcare workers to acquire SARS.[35] Similarly, an original article by Oboho et al has made clear that the risk of acquiring MERS as a nosocomial infection was higher for patients than healthcare professionals (who represented only 20.9% of the cases); thus shedding light on the interplay between host characteristics and environmental exposure in the disease etiology.[36] In addition to that, many researchers have attempted to clarify this association between the healthcare setting and the spike of disease occurrence, especially among patients; where some have explained that the poor practice of infection control procedures is a major obstacle and Balkhy et al have even described the situation as the "Achilles heel" of the healthcare system.[37,38]

On the other hand, some cultural and social norms have been suggested to be culprits in the emergence and transmission of MERS-CoV. A recent review article by Ali M. has explored the role of religious, social, and cultural habits in MERS, such as wearing of the veil, shisha smoking, and livestock management.[39] The review showed that "hookah" smoking has become a socializing event in the Middle Eastern countries, where sharing of the shisha further exacerbates the issue; making this cultural norm an enabling environment for the transmission of infectious respiratory diseases.[40] Furthermore, the practice of dromedary camel husbandry is regarded as a vital aspect of the nomadic lifestyle culture in the GCC region, where camels are used as a source of food, folk remedies, garments, transport, trade, and for racing, a multi-million dollar industry.[41] All the aforementioned findings strengthen the belief in the socio-cultural model, which emphasizes that social and cultural variables inexorably interact with biology to affect the health of human beings.

MERS AND TRAVEL HEALTH

The WHO does not advise any travel or trade restrictions regarding MERS-CoV. However, it has shed light on certain mass gathering events that might serve as a ground zero for a large-scale outbreak of the disease, as the annual Muslim pilgrimage or "Hajj". Similarly, the centers for disease control and prevention (CDC) have designated the MERS travel threat as an alert (level 2), where only special precautions will be provided to travelers to the Arabian Peninsula. The European centre for disease prevention and control (ECDC) has recommended all travelers to the Peninsula to avoid interaction with camels, attending camel farms, eating unpasteurized milk or undercooked meat of camel, with stress on the importance of hand and food hygiene.[42] Additionally, in-flight propagation of MERS has yet to be documented; however, it is mathematically estimated to range from one new case during a first class five-hour trip up to fifteen infections from a "super spreader" in a thirteen-hour flight on coach class.[43]

ONE HEALTH APPROACH TO MERS-COV

The one health approach is a conceptual framework, where human beings, animals, and their respective environment share an intricate relationship that defines their health. Thus, when controlling and preventing zoonotic diseases, this approach serves as a platform for the establishment of a multidisciplinary team. In addition

to that, the ultimate aim of such a comprehensive team with a broad range of expertise, as: public health, clinical medicine, animal husbandry, veterinary medicine, ecology, and entomology, will be to establish a more holistic understanding of these outbreaks.[44] A practical application of this theory was noted in many countries across the world, including the state of Qatar where the national outbreak control taskforce (NOCT) established a national multidisciplinary joint investigation team that allowed for prompt surveillance and timely response to control any outbreak.[45]

GLOBAL LESSONS LEARNED FROM MERS-CoV'S COUSIN, SARS

There is no doubt that the global community handled the MERS-CoV epidemic quite differently than that of SARS. In 2002, when the SARS outbreak began in China, the latter condemned it a "state secret" and thus information was withheld from the Chinese public from November 2002 till February 2003; and the Chinese government didn't share information with the WHO till early April 2003.[46] However, the MERS-CoV emergence proved that lessons were learned from its predecessor and that effective and transparent risk communication while utilizing a robust surveillance system are critical for the control of any outbreak.[47] A clear example of this would be that the Ministry of Health in KSA is reporting on a daily basis through its official website any new MERS-CoV cases. Interestingly, the most recent of these cases reported online on March 18, 2017 was a case of a 20-years-old male expat from the city of Hafr Albatin who had direct contact with camels and has died.[48] SARS provided the health community with a rich experience in the epidemiologic management of an emerging respiratory viral disease; an experience that would later be utilized to help control MERS.[49] Despite the ERASMUS controversy, the scientific community has collaborated and provided enormous evidence on MERS-CoV where as of December 31st, 2015, about 900 MERS-CoV research journals were published globally, stemming from more than 90 nations.[50] On the other hand, SARS has been the focus of 3379 publications, given the wider time frame of these studies when compared with those of MERS-CoV as a crude explanation.[51] Moreover, the awareness of the global community to the importance of research in controlling and preventing novel infectious diseases was clearly manifested in WHO's list of top emerging diseases with epidemic potential; in which MERS ranked 5th and SARS ranked 6th.[52]

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO) & World Organization for Animal Health (OIE) (2004). – Report of the WHO/FAO/OIE joint consultation on emerging zoonotic diseases, 3 to 5 May, Geneva. WHO, Geneva.
2. Communicable Disease Threats Report, CDTR, Week 10, 5-11 March 2017. European Centre for Disease Prevention and Control.
3. Middle East respiratory syndrome coronavirus (MERS-CoV), WHO MERS-CoV Global Summary and risk assessment, 2016.
4. MERS-CoV infection advice with regard to travelling, Statement of the Health Security Committee (HSC)* based on scientific input by the European Centre for Disease Prevention and Control (ECDC), 2015.
5. Mackay IM, Arden KE. MERS coronavirus: diagnostics, epidemiology and transmission. Virol J. 2015; 22;12:222.
6. de Groot R, Baker S, Baric R, Brown C, Drosten C, Enjuanes L, et al. Middle East Respiratory Syndrome Coronavirus (MERS-CoV): Announcement of the Coronavirus Study Group. J Virol. 2013;87(14):7790-2.
7. Middle East respiratory syndrome coronavirus: Virology, pathogenesis, and epidemiology. Uptodate.com. 2017. Available at: http://www.uptodate.com/contents/middle-east-respiratory-syndrome-coronavirus-virology-pathogenesis-and-epidemiology. Accessed on 7 March 2017.
8. Chan R, Hemida M, Kayali G, Chu D, Poon L, Alnaeem A, et al. Tropism and replication of Middle East respiratory syndrome coronavirus from dromedary camels in the human respiratory tract: an in-vitro and ex-vivo study. Lancet Respir Med. 2014;2(10):813-22.
9. Memish ZA, Mishra N, Olival K, Fagbo S, Kapoor V, Epstein J, et al. Middle East Respiratory Syndrome Coronavirus in Bats, Saudi Arabia. Emerg Infect Dis. 2013;19(11):1819-23.
10. Azhar E, El-Kafrawy S, Farraj S, Hassan A, Al-Saeed M, Hashem A, et al. Evidence for Camel-to-Human Transmission of MERS Coronavirus. N Engl J Med. 2014;370(26):2499-505.
11. Updated information on the epidemiology of Middle East respiratory syndrome coronavirus (MERS-CoV) infection and guidance for the public, clinicians, and public health authorities, 2012-2013.Centers for Disease Control and Prevention (CDC) MMWR Morb Mortal Wkly Rep. 2013;62(38):793.
12. Drosten C, Muth D, Corman V, Hussain R, Al Masri M, HajOmar W, et al. An Observational, Laboratory-Based Study of Outbreaks of Middle East Respiratory Syndrome Coronavirus in Jeddah and Riyadh, Kingdom of Saudi Arabia, 2014. Clin Infect Dis. 2014;60(3):369-77.
13. Centers for Disease Control and Prevention. Health Alert Network. Notice to health care providers: updated Guidelines for Evaluation of Severe

Respiratory Illness Associated with Middle East respiratory syndrome coronavirus (MERS-CoV). http://emergency.cdc.gov/HAN/han00348.asp Accessed on 3 March 2017.
14. Wernery U, Lau S, Woo P. Genomics and zoonotic infections: Middle East respiratory syndrome. Revue Scientifique et Technique de l'OIE. 2016;35(1):191-202.
15. Chan J, Chan K, Choi G, To K, Tse H, Cai J, et al. Differential Cell Line Susceptibility to the Emerging Novel Human Betacoronavirus 2c EMC/2012: Implications for Disease Pathogenesis and Clinical Manifestation. J Infect Dis. 2013;207(11):1743-52.
16. Corman V, Albarrak A, Omrani A, Albarrak M, Farah M, Almasri M, et al. Viral Shedding and Antibody Response in 37 Patients With Middle East Respiratory Syndrome Coronavirus Infection. Clin Infect Dis. 2015;62(4):477-83.
17. Assiri A, Al-Tawfiq JA, Al-Rabeeah AA, Al-Rabiah FA, Al-Hajjar S, Al-Barrak A, et al. Epidemiological, demographic, and clinical characteristics of 47 cases of Middle East respiratory syndrome coronavirus disease from Saudi Arabia: a descriptive study. Lancet Infect Dis. 2013;13:752–61.
18. WHO Risk Assessment, Middle East respiratory syndrome coronavirus (MERS-CoV), 2014.
19. Alsahafi A, Cheng A. The epidemiology of Middle East respiratory syndrome coronavirus in the Kingdom of Saudi Arabia, 2012–2015. Int J Infect Dis. 2016;45:1-4.
20. Kim K, Tandi T, Choi J, Moon J, Kim M. Middle East respiratory syndrome coronavirus (MERS-CoV) outbreak in South Korea, 2015: epidemiology, characteristics and public health implications. J Hospital Infect. 2017;95(2):207-13.
21. Breban R, Riou J, Fontanet A. Interhuman transmissibility of Middle East respiratory syndrome coronavirus: estimation of pandemic risk. Lancet. 2013;382(9893):694.
22. Alagaili A, Briese T, Mishra N, Kapoor V, Sameroff S, de Wit E, et al. Middle East Respiratory Syndrome Coronavirus Infection in Dromedary Camels in Saudi Arabia. MBio. 2014;5(2):e00884-14.
23. Khalafalla AI, Lu X, Al-Mubarak AI, Dalab AH, Al-Busadah KA, Erdman DD. MERS-CoV in Upper Respiratory Tract and Lungs of Dromedary Camels, Saudi Arabia, 2013–2014. Emerg Infect Dis. 2015;21:1153–8.
24. Gossner C, Danielson N, Gervelmeyer A, Berthe F, Faye B, Kaasik Aaslav K, et al. Human-Dromedary Camel Interactions and the Risk of Acquiring Zoonotic Middle East Respiratory Syndrome Coronavirus Infection. Zoonoses and Public Health. 2014;63(1):1-9.
25. Alsahafi A, Cheng A. The epidemiology of Middle East respiratory syndrome coronavirus in the Kingdom of Saudi Arabia, 2012–2015. Int J Infect Dis. 2016;45:1-4.
26. Alraddadi B, Watson J, Almarashi A, Abedi G, Turkistani A, Sadran M, et al. Risk Factors for Primary Middle East Respiratory Syndrome Coronavirus Illness in Humans, Saudi Arabia, 2014. Emerg Infect Dis. 2016;22(1):49-55.
27. Gossner C, Danielson N, Gervelmeyer A, Berthe F, Faye B, Kaasik Aaslav K, et al. Human-Dromedary Camel Interactions and the Risk of Acquiring Zoonotic Middle East Respiratory Syndrome Coronavirus Infection. Zoonoses and Public Health. 2014;63(1):1-9.
28. Majumder M, Kluberg S, Mekaru S, Brownstein J. Mortality Risk Factors for Middle East Respiratory Syndrome Outbreak, South Korea, 2015. Emerg Infect Dis. 2015;21(11):2088-90.
29. Stein R. Super-spreaders in infectious diseases. Int J Infect Dis. 2011;15(8):e510-3.
30. Cho S, Kang J, Ha Y, Park G, Lee J, Ko J, et al. MERS-CoV outbreak following a single patient exposure in an emergency room in South Korea: an epidemiological outbreak study. Lancet. 2016;388(10048):994-1001.
31. Nishiura H, Miyamatsu Y, Chowell G, Saitoh M. Assessing the risk of observing multiple generations of Middle East respiratory syndrome (MERS) cases given an imported case. Euro Surveill. 2015;20(27):21181.
32. Bonita R, Beaglehole R, Kjellström T. Basic epidemiology. 2nd ed. Geneva: WHO Press; 2006.
33. van Doremalen N, Bushmaker T, Munster V. Stability of Middle East respiratory syndrome coronavirus (MERS-CoV) under different environmental conditions. Euro Surveill. 2013;18(38):20590.
34. Alraddadi B, Watson J, Almarashi A, Abedi G, Turkistani A, Sadran M, et al. Risk Factors for Primary Middle East Respiratory Syndrome Coronavirus Illness in Humans, Saudi Arabia, 2014. Emerg Infect Dis. 2016;22(1):49-55.
35. Chowell G, Abdirizak F, Lee S, Lee J, Jung E, Nishiura H, et al. Transmission characteristics of MERS and SARS in the healthcare setting: a comparative study. BMC Med. 2015;13:210.
36. Oboho I, Tomczyk S, Al-Asmari A, Banjar A, Al-Mugti H, Aloraini M, et al. 2014 MERS-CoV Outbreak in Jeddah — A Link to Health Care Facilities. N Engl J Med. 2015;372(9):846-54.
37. Zumla AHui D. Infection control and MERS-CoV in health-care workers. Lancet. 2014;383(9932):1869-71.
38. Balkhy H, Perl T, Arabi Y. Preventing healthcare-associated transmission of the Middle East Respiratory Syndrome (MERS): Our Achilles heel. J Infect Public Health. 2016;9(3):208-12.
39. Ali M. Gender Dynamics and Socio-Cultural Determinants of Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in Saudi Arabia. University Toronto Med J. 2017;91(1):32-7.

40. Aslam H, Saleem S, German S, Qureshi W. Harmful effects of shisha: literature review. Int Arch Med. 2014;7(1):16.
41. Hemida M, Elmoslemany A, Al-Hizab F, Alnaeem A, Almathen F, Faye B, et al. Dromedary Camels and the Transmission of Middle East Respiratory Syndrome Coronavirus (MERS-CoV). Transboundary Emerg Dis. 2015;64(2):344-53.
42. MERS-CoV infection advice with regard to travelling, Statement of the Health Security Committee (HSC)* based on scientific input by the European Centre for Disease Prevention and Control (ECDC), 2015.
43. Coburn Blower S. Predicting the potential for within-flight transmission and global dissemination of MERS. Lancet Infect Dis. 2014;14(2):99.
44. Zumla A, Dar O, Kock R, Muturi M, Ntoumi F, Kaleebu P, et al. Taking forward a 'One Health' approach for turning the tide against the Middle East respiratory syndrome coronavirus and other zoonotic pathogens with epidemic potential. Int J Infect Dis. 2016;47:5-9.
45. Farag E. Qatar experience on MERS-CoV One Health Surveillance and Response, 2012-2015. International Society for Disease Surveillance; 2015.
46. Huang Y. The Sars Epidemic And Its Aftermath In China: A Political Perspective. In: Institute of Medicine (US) Forum on Microbial Threats; Knobler S, Mahmoud A, Lemon S, et al., editors. Learning from SARS: Preparing for the Next Disease Outbreak: Workshop Summary. Washington (DC): National Academies Press (US); 2004. Available at: https://www.ncbi.nlm.nih.gov/books/NBK92479/ Accessed on 4 April 2017.
47. Saeed A, Abedi G, Alzahrani A, Salameh I, Abdirizak F, Alhakeem R, et al. Surveillance and Testing for Middle East Respiratory Syndrome Coronavirus, Saudi Arabia, April 2015–February 2016. Emerg Infect Dis. 2017;23(4):682-5.
48. Command and Control Center . Ministry of Health. 2017. Available at: http://www.moh.gov.sa/en/CCC/PressReleases/Pages/statistics-2017-03-18-001.aspx Accessed on 6 April 2017.
49. Cheng V, Chan J, To K, Yuen K. Clinical management and infection control of SARS: Lessons learned. Antiviral Res. 2013;100(2):407-19.
50. Zyoud S. Global research trends of Middle East respiratory syndrome coronavirus: a bibliometric analysis. BMC Infect Dis. 2016;16(1):255.
51. Sweileh W. Global research trends of World Health Organization's top eight emerging pathogens. Global Health. 2017;13(1):9.
52. Blueprint for R&D preparedness and response to public health emergencies due to highly infectious pathogens. Available at: http://www.who.int/medicines/ebola-treatment/WHO-list-of-top-emerging-diseases/en/ Accessed on 7 April 2017.

Cite this article as: Bala MO, Chehab MAH, Selim NAA. MERS: an emerging disease of the 21st century. Int J Community Med Public Health 2017;4:2202-7.