**Name of journal: *World Journal of Clinical Pediatrics***

**Manuscript NO: 27398**

**Manuscript Type: Systematic Reviews**

**Middle East respiratory syndrome coronavirus disease is rare in children: An update from Saudi Arabia**

Al-Tawfiq JA *et al.* MERS-CoV Disease is Rare in Children

**Jaffar A Al-Tawfiq, Rana F Kattan, Ziad A Memish**

**Jaffar A Al-Tawfiq,** Johns Hopkins Aramco Healthcare, Dhahran 31311, Kingdom of Saudi Arabia

**Jaffar A Al-Tawfiq,** Indiana University School of Medicine, Indianapolis, IN 46202, United States

**Rana F Kattan,** Pediatric Department, King Saud bin Abdulaziz University for Health Sciences, King Abdullah Specialist Children’s Hospital, Riyadh 11514, Kingdom of Saudi Arabia

**Ziad A Memish,** Ministry of Health, Riyadh 1151, Kingdom of Saudi Arabia

**Ziad A Memish,** College of Medicine, Alfaisal University, Riyadh 11514, Kingdom of Saudi Arabia

**Author contributions:** Al-Tawfiq JA developed the research protocol; Al-Tawfiq JA performed the research and data analysis; Al-Tawfiq JA, Kattan RF and Memish ZA authored and approved the article.

**Conflict-of-interest statement:** All authors have no competing interests to declare.

**Data sharing statement:** The dataset as presented in tables is available upon request to the corresponding author.

**Open-Access:** This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

**Manuscript source:** Invited manuscript

**Correspondence to: Ziad A Memish, Professor,** College of Medicine, Alfaisal University, P.O. Box 54146, Riyadh 11514, Kingdom of Saudi Arabia. [zmemish@yahoo.com](mailto:zmemish@yahoo.com)

**Telephone:** +966-50-5483515

**Fax:** +966-11-2616464

**Received:** May 27, 2016

**Peer-review started:** May 30, 2016

**First decision:** July 6, 2016

**Revised:** August 16, 2016

**Accepted:** August 27, 2016

**Article in press:**

**Published online:**

**Abstract**

***AIM***

To summarize the reported Middle East respiratory syndrome-coronavirus (MERS-CoV) cases, the associated clinical presentations and the outcomes.

***METHODS***

We searched the Saudi Ministry of Health website, the World Health Organization website, and the Flutracker website. We also searched MEDLINE and PubMed for the keywords: Middle East respiratory syndrome-coronavirus, MERS-CoV in combination with pediatric, children, childhood, infancy and pregnancy from the initial discovery of the virus in 2012 to 2016. The retrieved articles were also read to further find other articles. Relevant data were placed into an excel sheet and analyzed accordingly. Descriptive analytic statistics were used in the final analysis as deemed necessary.

***RESULTS***

From June 2012 to April 19, 2016, there were a total of 31 pediatric MERS-CoV cases. Of these cases 13 (42%) were asymptomatic and the male to female ratio was 1.7:1. The mean age of patients was 9.8 ± 5.4 years**.** Twenty-five (80.6%) of the cases were reported from the Kingdom of Saudi Arabia. The most common source of infection was household contact (10 of 15 with reported source) and 5 patients acquired infection within a health care facility. Using rRT-PCR of pediatric patients revealed that 9 out of 552 (1.6%) was positive in the Kingdom of Saudi Arabia.

***CONCLUSION***

Utilizing serology for MERS-CoV infection in Jordan and Saudi Arabia did not reveal any positive patients. Thus, the number of the pediatric MERS-CoV is low; the exact reason for the low prevalence of the disease in children is not known.

**Key words:** Middle East respiratory syndrome-coronavirus; Pediatric; Children; Respiratory tract infection

**© The Author(s) 2016.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Core tip:** The number of the pediatric Middle East respiratory syndrome-coronavirus (MERS-CoV) is low and the exact reason for the low prevalence is not known. A total of 31 pediatric MERS-CoV cases were reported since June 2012. Of all the cases 13 (42%) were asymptomatic and the male to female ratio was 1.7:1. The mean age of patients was 9.8 ± 5.4 years**.** The most common source of infection was household contact followed by infection within a health care facility. Using rRT-PCR of pediatric patients revealed that 9 out of 552 (1.6%) was positive in the Kingdom of Saudi Arabia.

Al-Tawfiq JA, Kattan RF, Memish ZA. Middle East respiratory syndrome coronavirus disease is rare in children: An update from Saudi Arabia. *World J Clin Pediatr* 2016; In press

**INTRODUCTION**

Middle East respiratory syndrome-coronavirus (MERS-CoV) was first isolated in 2012 from a patient in the Kingdom of Saudi Arabia (KSA)[1]. As more cases were reported, the case fatality rate changed to 40% from 60%[2–5]. In addition, initially there was a predominance of males; later this ratio decreased[2,6]. MERS-CoV is characterized by three different patterns of disease: Sporadic cases, intra-familial transmission[7–9] and health care associated infection[2,3,10–16]. Despite the increased number overtime and the multiple health care associated outbreaks[17], the number of pediatric cases remained low during the study period[18]. The initial description of 47 cases included only a 14-year child[4]. The first pediatric case was a two-year old child reported from Jeddah, KSA on June 28, 2013[19]. Later an additional three asymptomatic children were reported[4]. The largest report of childhood MERS-CoV cases included eleven, of which two patients were symptomatic and nine were asymptomatic[18]. The exact reason for this low prevalence of the disease in children is not known. In this study, we summarize the reported MERS-CoV cases and the associated clinical presentation and the outcome.

**MATERIALS AND METHODS**

We searched the Saudi Ministry of Health website[20], the World Health Organization website[21], the Flutracker website[22], the medical literature and the retrieved published studies for any childhood MERS-CoV infections. We searched MEDLINE and PubMed for the keywords Middle East respiratory syndrome-coronavirus, MERS-CoV, in combination with pediatric, children, childhood, infancy and pregnancy from the initial discovery of the virus in June 2012 until April 19, 2016. The retrieved articles were also read to find other relevant articles.

***Statistical analysis***

Relevant data were placed into an excel sheet and analyzed accordingly. Descriptive analytic statistics were used in the final analysis as deemed necessary, including mean and standard deviation when applicable and frequency. The statistical review of the study was performed by a biomedical statistician. Statistical review is performed before the submission of the manuscript.

**RESULTS**

***Summary of pediatric cases***

From June 2012, to April 19, 2016, there were a total of 31 pediatric MERS-CoV cases as shown in Table 1. Of all the cases, thirteen (13) or 42% were asymptomatic, and there were 17 males, 10 females and 4 unreported (a male to female ratio of 1.7:1). The mean age of patients was 9.8 + 5.4 (0.75-17) years**.** Twenty-five cases (80.6%) were reported from KSA; the other patients were in Jordan, United Arab Emirates and the Republic of Korea (Table 1). The most common source of the infection was household contact (10 of 15 with reported source), and 5 patients acquired the infection within a health care facility. About one half of the cases were reported in 2014, and 29% were reported in 2013 and 22.6% in 2015 (Table 2).

***Screening of pediatric patients for MERS-CoV***

Screening of pediatric patients for MERS-CoV infection using rRT-PCR showed that only 9 out of 552 (1.6%) were positive in KSA[23]. However, serologic testing of pediatric patients admitted with lower respiratory tract infection in Jordan and Saudi Arabia revealed no positive tests[24,25] (Table 3).

***Pregnancy associated MERS-COV***

The effect of MERS-CoV infection on the fetus was described in eight cases[26–29] as summarized in Table 4. The mean age of the mothers was 32.25 + 3.4 years, and the mean gestational age was 28.4 + 6.3 wk. Death of the fetus was observed in 3 (37.5%) of the 8 fetuses.

**DISCUSSION**

Despite the total number of MERS cases increasing, especially in KSA, the number of pediatric cases remained low during the study period. Initially, the testing in KSA was directed towards hospitalized patients with severe pneumonia. In 2015, the Saudi Ministry of Health added a specific case definition for MERS-CoV infection in children[30]. The definition includes those ≤ 14 years, meets the adult case definition and has either a history of exposure to a confirmed or suspected MERS-CoV in the proceeding 14 d or a history of contact with camels or camel products in the proceeding 14 d[30]. The case definition also includes children with unexplained severe pneumonia[30]. The 2015 change in the case definition does not account for the low rate of childhood MERS-CoV infection as 33% of the cases were reported in 2014 before the case definition was changed. One of the reasons for an increased number of cases in 2014 during the Jeddah outbreak was increased testing of asymptomatic and mildly symptomatic patients[11].

The pattern of MERS-CoV pediatric cases was similar to the 2003 SARS outbreak. Children were less affected than adults and children less than 2 years of age had milder disease[31]. In the largest screening of contacts, the rate of MERS-CoV positive children (1.6%, 9/616) compared to 2.2% (99/4440) in adults (*P* = 0.23)[23]. Thus, in this study utilizing MERS-CoV PCR the positivity rate did not differ in children and adults.

In adults with MERS-CoV infections, three patterns of transmissions were observed: sporadic (primary) cases presumed to be due to animal exposure (mainly camels), household contacts or health care associated infections[32]. In KSA, the majority (45%) of cases were health care-associated infections, 38% were primary cases, and 13% were household contacts[32]. In contrast, in the majority of pediatric cases that reported source of acquisition (66.7% of the 15 with reported source), the disease was acquired through household contact. This pattern indicates a low exposure of children to animals and a higher rate of health care associated infections in adult wards. The male to female ratio (2.8:1 and 3.3:1) was initially high[3,4]. This apparent male predominance could be explained by the nature of hospital outbreaks[2]. Eventually the male to female ratio was reduced to 1.3:1 to 1.8:1[5,6]. Consistent with these studies, the male to female ratio in children with MERS-CoV was 1.7:1 and may indicate similar exposure of children to index cases in the household settings and differential host factors.

Possible explanations for the lower number of pediatric cases compared to adults include differential testing of adult patients and milder diseases in children; although, serologic testing of pediatric patients in KSA and Jordan did not reveal any positive cases[24,25]. In the largest sero-epidemiologic survey in KSA, the study did not include children and thus it is difficult to establish the rate of sero-positivity in children[31]**.**

The MERS-CoV infection rate in children remains low and possible explanations include: A milder disease in children, asymptomatic infection, or the presence of yet to be identified factors. The development of a shorter duration of MERS in children is another possible explanation. If this is the case, it may limit the development of a positive serology. In one study, delayed antibody responses as measured with the neutralization test was associated with severe diseases[33]. The longevity of antibodies in MERS-CoV cases might be limited as was the case with SARS[33,34]. The only study of serology among children was done among hospitalized pediatric cases who presented with lower respiratory tract infections[25]. There is no systematic screening of exposed children using serologic testing; this limited the interpretation of available serologic studies.

Little data also exist regarding the effect and the likelihood of MERS-CoV in pregnancy. Eight cases were reported[26,27,29]. The outcome was favorable in the majority of cases. The exact prevalence of MERS-CoV antibodies and exposure of pregnant women to MERS-CoV is not known.

In conclusion, the number of MERS-CoV infections in pediatric patients remains low. Possible explanations include low exposure, presence of asymptomatic, mildly symptomatic patients or the presence of yet to be identified factors. The immune system predisposing to severe disease and to fatal outcome remains unknown. An exploration of the virus-host interaction may add to the understanding of the low prevalence in this age group.

**COMMENTS**

***Background***

Middle East respiratory syndrome-coronavirus (MERS-CoV) was first isolated in 2012 from a patient in the Kingdom of Saudi Arabia (KSA). Despite the increased number of MERS-CoV cases overtime, the number of pediatric cases remained low. The exact reason for this low prevalence of the disease in children is not known. The aim of this study is to summarize the reported MERS-CoV cases and the associated clinical presentation and the outcome.

***Research frontiers***

The first pediatric case was a two-year old child reported from Jeddah, KSA on June 28, 2013. Later an additional three asymptomatic children were reported. The largest report of childhood MERS-CoV cases included eleven, including nine asymptomatic cases.

***Innovations and breakthroughs***

The number of MERS-CoV infections in pediatric patients remains low. Possible explanations include low exposure, presence of asymptomatic, mildly symptomatic patients or the presence of yet to be identified factors. The immune system predisposing to severe disease and to fatal outcome remains unknown. An exploration of the virus-host interaction may add to the understanding of the low prevalence in this age group.

***Applications***

Despite the low number of pediatric MERS-CoV cases, it is important to continue to monitor the development of this disease in this age group and to understand the risk factors.

***Terminology***

MERS-CoV is a new emerging virus that was first isolated in 2012.

***Peer-review***

This complication of all known pediatric cases is a useful contribution to the medical literature, and knowing it is possible but rare is important.

**REFERENCES**

1 **Zaki AM**, van Boheemen S, Bestebroer TM, Osterhaus AD, Fouchier RA. Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. *N Engl J Med* 2012; **367**: 1814-1820 [PMID: 23075143 DOI: 10.1056/NEJMoa1211721]

2 **Al-Tawfiq JA**, Memish ZA. Middle East respiratory syndrome coronavirus: epidemiology and disease control measures. *Infect Drug Resist* 2014; **7**: 281-287 [PMID: 25395865 DOI: 10.2147/IDR.S51283]

3 **Assiri A**, McGeer A, Perl TM, Price CS, Al Rabeeah AA, Cummings DA, Alabdullatif ZN, Assad M, Almulhim A, Makhdoom H, Madani H, Alhakeem R, Al-Tawfiq JA, Cotten M, Watson SJ, Kellam P, Zumla AI, Memish ZA. Hospital outbreak of Middle East respiratory syndrome coronavirus. *N Engl J Med* 2013; **369**: 407-416 [PMID: 23782161 DOI: 10.1056/NEJMoa1306742]

4 **Assiri A**, Al-Tawfiq JA, Al-Rabeeah AA, Al-Rabiah FA, Al-Hajjar S, Al-Barrak A, Flemban H, Al-Nassir WN, Balkhy HH, Al-Hakeem RF, Makhdoom HQ, Zumla AI, Memish ZA. 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**: 752-761 [PMID: 23891402 DOI: 10.1016/S1473-3099(13)70204-4]

5 **Penttinen PM**, Kaasik-Aaslav K, Friaux A, Donachie A, Sudre B, Amato-Gauci AJ, Memish ZA, Coulombier D. Taking stock of the first 133 MERS coronavirus cases globally--Is the epidemic changing? *Euro Surveill* 2013; **18**: pii: 20596 [PMID: 24094061]

6 **The WHO Mers-Cov Research Group**. State of Knowledge and Data Gaps of Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in Humans. *PLoS Curr* 2013; **5**: [PMID: 24270606 DOI: 10.1371/currents.outbreaks.0bf719e352e7478f8ad85fa30127ddb8]

7 **Memish ZA**, Zumla AI, Al-Hakeem RF, Al-Rabeeah AA, Stephens GM. Family cluster of Middle East respiratory syndrome coronavirus infections. *N Engl J Med* 2013; **368**: 2487-2494 [PMID: 23718156 DOI: 10.1056/NEJMoa1303729]

8 **Omrani AS**, Matin MA, Haddad Q, Al-Nakhli D, Memish ZA, Albarrak AM. A family cluster of Middle East Respiratory Syndrome Coronavirus infections related to a likely unrecognized asymptomatic or mild case. *Int J Infect Dis* 2013; **17**: e668-e672 [PMID: 23916548 DOI: 10.1016/j.ijid.2013.07.001]

9 **Memish ZA**, Cotten M, Watson SJ, Kellam P, Zumla A, Alhakeem RF, Assiri A, Rabeeah AA, Al-Tawfiq JA. Community case clusters of Middle East respiratory syndrome coronavirus in Hafr Al-Batin, Kingdom of Saudi Arabia: a descriptive genomic study. *Int J Infect Dis* 2014; **23**: 63-68 [PMID: 24699184 DOI: 10.1016/j.ijid.2014.03.1372]

10 **Oboho IK**, Tomczyk SM, Al-Asmari AM, Banjar AA, Al-Mugti H, Aloraini MS, Alkhaldi KZ, Almohammadi EL, Alraddadi BM, Gerber SI, Swerdlow DL, Watson JT, Madani TA. 2014 MERS-CoV outbreak in Jeddah--a link to health care facilities. *N Engl J Med* 2015; **372**: 846-854 [PMID: 25714162 DOI: 10.1056/NEJMoa1408636]

11 **Drosten C**, Muth D, Corman VM, Hussain R, Al Masri M, HajOmar W, Landt O, Assiri A, Eckerle I, Al Shangiti A, Al-Tawfiq JA, Albarrak A, Zumla A, Rambaut A, Memish ZA. 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* 2015; **60**: 369-377 [PMID: 25323704 DOI: 10.1093/cid/ciu812]

12 **Al-Tawfiq JA**, Memish ZA. An update on Middle East respiratory syndrome: 2 years later. *Expert Rev Respir Med* 2015; **9**: 327-335 [PMID: 25790840 DOI: 10.1586/17476348.2015.1027689]

13 **Al-Tawfiq JA**, Memish ZA. Middle East respiratory syndrome coronavirus: transmission and phylogenetic evolution. *Trends Microbiol* 2014; **22**: 573-579 [PMID: 25178651]

14 **Hijawi B**, Abdallat M, Sayaydeh A, Alqasrawi S, Haddadin A, Jaarour N, Alsheikh S, Alsanouri T. Novel coronavirus infections in Jordan, April 2012: epidemiological findings from a retrospective investigation. *East Mediterr Health J* 2013; **19** Suppl 1: S12-S18 [PMID: 23888790]

15 **Kim Y**, Lee S, Chu C, Choe S, Hong S, Shin Y. The Characteristics of Middle Eastern Respiratory Syndrome Coronavirus Transmission Dynamics in South Korea. *Osong Public Health Res Perspect* 2016; **7**: 49-55 [PMID: 26981343 DOI: 10.1016/j.phrp.2016.01.001]

16 **Seong MW**, Kim SY, Corman VM, Kim TS, Cho SI, Kim MJ, Lee SJ, Lee JS, Seo SH, Ahn JS, Yu BS, Park N, Oh MD, Park WB, Lee JY, Kim G, Joh JS, Jeong I, Kim EC, Drosten C, Park SS. Microevolution of Outbreak-Associated Middle East Respiratory Syndrome Coronavirus, South Korea, 2015. *Emerg Infect Dis* 2016; **22**: 327-330 [PMID: 26814649 DOI: 10.3201/eid2202.151700]

17 **Al-Tawfiq JA**, Memish ZA. Managing MERS-CoV in the healthcare setting. *Hosp Pract* (1995) 2015; **43**: 158-163 [PMID: 26224424 DOI: 10.1080/21548331.2015.1074029]

18 **Memish ZA**, Al-Tawfiq JA, Assiri A, AlRabiah FA, Al Hajjar S, Albarrak A, Flemban H, Alhakeem RF, Makhdoom HQ, Alsubaie S, Al-Rabeeah AA. Middle East respiratory syndrome coronavirus disease in children. *Pediatr Infect Dis J* 2014; **33**: 904-906 [PMID: 24763193 DOI: 10.1097/INF.0000000000000325]

19 **WHO**. MERS-CoV summary and literature. [update 2013 Jun 20]. Available from: URL: http://www.who.int/csr/disease/coronavirus\_infections/update\_20130620/en/

20 **Saudi Ministry of Health C and CC**. MERS-CoV Statistics. Available from: URL: http://www.moh.gov.sa/en/ccc/pressreleases/pages/default.aspx

21 **WHO**. Middle East respiratory syndrome coronavirus (MERS-CoV). Available from: URL: http://www.who.int/emergencies/mers-cov/en/

22 **Flutracker**. 2012-2016 Case List of MoH/WHO Novel Coronavirus MERS nCoV Announced Cases. Available from: URL: https://flutrackers.com/forum/forum/novel-coronavirus-ncov-mers-2012-2014/146270-2012-2016-case-list-of-moh-who-novel-coronavirus-mers-ncov-announced-cases

23 **Memish ZA**, Al-Tawfiq JA, Makhdoom HQ, Al-Rabeeah AA, Assiri A, Alhakeem RF, AlRabiah FA, Al Hajjar S, Albarrak A, Flemban H, Balkhy H, Barry M, Alhassan S, Alsubaie S, Zumla A. Screening for Middle East respiratory syndrome coronavirus infection in hospital patients and their healthcare worker and family contacts: a prospective descriptive study. *Clin Microbiol Infect* 2014; **20**: 469-474 [PMID: 24460984 DOI: 10.1111/1469-0691.12562]

24 **Khuri-Bulos N**, Payne DC, Lu X, Erdman D, Wang L, Faouri S, Shehabi A, Johnson M, Becker MM, Denison MR, Williams JV, Halasa NB. Middle East respiratory syndrome coronavirus not detected in children hospitalized with acute respiratory illness in Amman, Jordan, March 2010 to September 2012. *Clin Microbiol Infect* 2014; **20**: 678-682 [PMID: 24313317 DOI: 10.1111/1469-0691.12438]

25 **Gierer S**, Hofmann-Winkler H, Albuali WH, Bertram S, Al-Rubaish AM, Yousef AA, Al-Nafaie AN, Al-Ali AK, Obeid OE, Alkharsah KR, Pöhlmann S. Lack of MERS coronavirus neutralizing antibodies in humans, eastern province, Saudi Arabia. *Emerg Infect Dis* 2013; **19**: 2034-2036 [PMID: 24274664 DOI: 10.3201/eid1912.130701]

26 **Payne DC**, Iblan I, Alqasrawi S, Al Nsour M, Rha B, Tohme RA, Abedi GR, Farag NH, Haddadin A, Al Sanhouri T, Jarour N, Swerdlow DL, Jamieson DJ, Pallansch MA, Haynes LM, Gerber SI, Al Abdallat MM. Stillbirth during infection with Middle East respiratory syndrome coronavirus. *J Infect Dis* 2014; **209**: 1870-1872 [PMID: 24474813 DOI: 10.1093/infdis/jiu068]

27 **Alserehi H**, Wali G, Alshukairi A, Alraddadi B. Impact of Middle East Respiratory Syndrome coronavirus (MERS-CoV) on pregnancy and perinatal outcome. *BMC Infect Dis* 2016; **16**: 105 [PMID: 26936356 DOI: 10.1186/s12879-016-1437-y]

28 **Malik A**, El Masry KM, Ravi M, Sayed F. Middle East Respiratory Syndrome Coronavirus during Pregnancy, Abu Dhabi, United Arab Emirates, 2013. *Emerg Infect Dis* 2016; **22**: 515-517 [PMID: 26890613 DOI: 10.3201/eid2203.151049]

29 **Assiri A**, Abedi GR, Almasry M, Bin Saeed A, Gerber SI, Watson JT. Middle East Respiratory Syndrome Coronavirus Infection During Pregnancy: A Report of 5 Cases From Saudi Arabia. *Clin Infect Dis* 2016 [PMID: 27358348 DOI: 10.1093/cid/ciw412]

30 **Madani TA**, Althaqafi AO, Alraddadi BM. Infection prevention and control guidelines for patients with Middle East Respiratory Syndrome Coronavirus (MERS-CoV) infection. *Saudi Med J* 2014; **35**: 897-913 [PMID: 25129197]

31 **Denison MR**. Severe acute respiratory syndrome coronavirus pathogenesis, disease and vaccines: an update. *Pediatr Infect Dis J* 2004; **23**: S207-S214 [PMID: 15577575]

32 **Al-Tawfiq JA**, Memish ZA. Drivers of MERS-CoV transmission: what do we know? *Expert Rev Respir Med* 2016; **10**: 331-338 [PMID: 26848513 DOI: 10.1586/17476348.2016.1150784]

33 **Park WB**, Perera RA, Choe PG, Lau EH, Choi SJ, Chun JY, Oh HS, Song KH, Bang JH, Kim ES, Kim HB, Park SW, Kim NJ, Man Poon LL, Peiris M, Oh MD. Kinetics of Serologic Responses to MERS Coronavirus Infection in Humans, South Korea. *Emerg Infect Dis* 2015; **21**: 2186-2189 [PMID: 26583829 DOI: 10.3201/eid2112.151421]

34 **Cao WC**, Liu W, Zhang PH, Zhang F, Richardus JH. Disappearance of antibodies to SARS-associated coronavirus after recovery. *N Engl J Med* 2007; **357**: 1162-1163 [PMID: 17855683 DOI: 10.1056/NEJMc070348]

35 **Thabet F**, Chehab M, Bafaqih H, Al Mohaimeed S. Middle East respiratory syndrome coronavirus in children. *Saudi Med J* 2015; **36**: 484-486 [PMID: 25828287 DOI: 10.15537/smj.2015.4.10243]

36 **WHO**. Middle East respiratory syndrome coronavirus (MERS-CoV) update. Disease Outbreak News. [updated 2014 Apr 26]. Available from: URL: http://www.who.int/csr/don/2014\_04\_26\_mers/en/

37 **WHO**. Middle East respiratory syndrome coronavirus (MERS-CoV) update. Disease Outbreak News. [updated 2013 Dec 2]. Available from: URL: http://www.who.int/csr/don/2013\_12\_02/en/

**P-Reviewer:** Chen XL, Striker R **S-Editor:** Ji FF **L-Editor: E-Editor:**

**Table 1 Summary of reported pediatric Middle East respiratory syndrome cases**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Number | Age | Gender | Country | Sample source | Year of reporting | Symptoms | Co-morbidity | Signs | Sample type | Viral load ct value | Imaging | Intensive care | Death | Ref. |
| 1 | 2 | Male | KSA | Hospital  inpatient | 2013 | Fever, respiratory distress | Cystic fibrosis | Chest: bilateral fine crepitation | NPS | 36 | Bilateral diffused infiltrate | + | Yes | [18] |
| 2 | 14 | Female | KSA | Hospital inpatient | 2013 | Fever | Down’s syndrome |  | NPS | 37 | Bilateral diffused infiltrate | No | No | [18] |
| 3 | 7 | Female | KSA | Family contact | 2013 | asymptomatic | None | None | N+T | 37 | ND | No | No | [18] |
| 4 | 15 | Female | KSA | Family contact | 2014 | asymptomatic | None | None | NPS | 35 | ND | No | No | [18] |
| 5 | 14 | Male | KSA | Family contact | 2014 | asymptomatic | None | None | NPS | 34 | ND | No | No | [18] |
| 6 | 12 | Female | KSA | Family contact | 2014 | asymptomatic | None | None | NPS | 35 | ND | No | No | [18] |
| 7 | 16 | male | KSA | Family contact | 2013 | asymptomatic | none | none | NPS | 36 | ND | No | No | [18] |
| 8 | 7 | Female | KSA | Family contact | 2014 | asymptomatic | none | none | NPS | 37 | ND | No | No | [18] |
| 9 | 3 | Female | KSA | Family contact | 2013 | asymptomatic | none | none | NPS | 38 | ND | No | No | [18] |
| 10 | 13 | Female | KSA | Contact | 2014 | asymptomatic | none | none | NPS | 34 | ND | No | No | [18] |
| 11 | 14 | Female | KSA | Family contact | 2013 | asymptomatic | none | none | NPS | 36 | ND | No | No | [18] |
| 12 | 0.75 | Male | KSA | Not known | 2014 | ICU | nephrotic syndrome | Respiratory distress | Tracheal aspirate | NA | diffuse bilateral haziness | Yes | Yes | [35] |
| 13 | 4 | Male | KSA | NA | 2013 | Mild respiratory symptoms | None | NA |  | NA | ND | No | No | [36] |
| 14 | 8 | Male | KSA | NA | 2013 | Mild respiratory symptoms | none | NA |  | NA | ND | NA | No | [37] |
| 15 | 17 | NA | KSA | Contact | 2014 | asymptomatic | NA | NA | NA | NA | NA | NA | NA | [22] |
| 16 | 11 | NA | KSA | contact | 2014 | asymptomatic | NA | NA | NA | NA | NA | NA | NA | [22] |
| 17 | 16 | NA | KSA | NA | 2014 | symptomatic | NA | NA | NA | NA | NA | NA | NA | [22] |
| 18 | 13 | M | KSA | NA | 2014 | symptomatic | NA | NA | NA | NA | NA | NA | NA | [22] |
| 19 | 10 | M | KSA | Hospital contact | 2014 | symptomatic | NA | NA | NA | NA | NA | NA | NA | [20,22] |
| 20 | 2 | NA | KSA | NA | 2014 | symptomatic | Congenital anomalies | NA | NA | NA | NA | NA | NA | [20,22] |
| 21 | 11 | M | KSA | Hospital contact | 2014 | symptomatic | Brain tumor | NA | NA | NA | NA | NA | NA | [20,22] |
| 22 | 17 | M | KSA | NA | 2014 | symptomatic | NA | NA | NA | NA | NA | NA | NA | [20,22] |
| 23 | 16 | M | South Korea | Hospital contact | 2015 | symptomatic | NA | NA | NA | NA | NA | NA | NA | [22] |
| 24 | 2 | M | KSA | Hospital contact | 2015 | symptomatic | NA | NA | NA | NA | NA | NA | NA | [20,22] |
| 25 | 16 | M | KSA | contact | 2015 | symptomatic | NA | NA | NA | NA | NA | NA | NA | [20,22] |
| 26 | 7 | F | Jordan | Contact | 2015 | asymptomatic | None | NA | NA | NA | NA | NA | NA | [22] |
| 27 | 0.8 | F | Jordan | Contact | 2015 | symptomatic | None | NA | NA | NA | NA | NA | NA | [22] |
| 28 | 14 | M | KSA | Contact | 2015 | symptomatic | None | NA | NA | NA | NA | NA | NA | [20,22] |
| 29 | 4 | M | UAE | NA | 2014 | NA | NA | NA | NA | NA | NA | NA | NA | [22] |
| 30 | 8 | M | UAE | Family contact | 2013 | NA | NA | NA | NA | NA | NA | NA | NA | [22] |
| 31 | 11 | M | UAE | Family contact | 2015 | Asymptomatic | None | NA | NA | NA | NA | NA | NA | [22] |

 NPS: Nasopharyngeal swab; N + T: Nasal and tracheal aspirate; ND: Not done; KSA: Kingdom of Saudi Arabia; UAE: United Arab Emirates.

**Table 2 Summary of the demographic characteristics of pediatric Middle East respiratory syndrome-coronavirus**

|  |  |  |
| --- | --- | --- |
|  | **Number** | **Percentage** |
| Male:female | 17:10 (1.7:1) | 63 *vs* 37 |
| Saudi | 20 | 83.3 |
| City |  |  |
| Jeddah | 7 | 29.2 |
| Riyadh | 7 | 29.2 |
| Hafr al-Batin | 3 | 12.5 |
| Symptomatic | 12 | 50.0 |
| Death | 8 | 33.3 |
| Year of report |  |  |
| Year 2013 | 9 | 29 |
| Year 2014 | 15 | 48.4 |
| Year 2015 | 7 | 22.6 |

**Table 3 Summary of different studies examining Middle East respiratory syndrome-coronavirus infection in children**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Country** | **Testing Method** | **Population** | **Positive n/N (%)** | **Year** | **Ref.** |
| KSA | rRT-PCR | Screening of children | 9/552 (1.6%) |  | [23] |
| KSA | Neutralizing antibodies testing | Serum samples from children hospitalized for lower respiratory tract infections | 0/158 (0) | May 2010–May 2011 | [25] |
| Jordan | rRT-PCR | Hospitalized children < 2 yr of age | 0/2427 (0) |  | [24] |

rRT-PCR: Real time reverse transcriptase polymerase chain reaction; KSA: Kingdom of Saudi Arabia.

**Table 4 Summary of pregnancy associated Middle East respiratory syndrome-coronavirus infection**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Age of the patient (yr)** | **Gestational age** | **Fetal outcome** | **Diagnostic test** | **Country** | **Ref.** |
| 39 | 5 mo | Still birth | Antibody by EIA | Jordan | [26] |
| 33 | 32 wk | Healthy infant | PCR | Saudi Arabia | [27] |
| 32 | 32 wk | Healthy | PCR | United Arab Emirates | [28] |
| 34 | 34 wk | Died | PCR | Saudi Arabia | [29] |
| 32 | 38 wk | Survived | PCR | Saudi Arabia | [29] |
| 31 | 24 wk | Died | PCR | Saudi Arabia | [29] |
| 27 | 22 wk | Survived | PCR | Saudi Arabia | [29] |
| 30 | 23 wk | Survived | PCR | Saudi Arabia | [29] |

PCR: Polymerase chain reaction.