Risk Factors for Fatal Middle East Respiratory Syndrome Coronavirus Infections in Saudi Arabia: Analysis of the WHO Line List, 2013–2018

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Objectives. To explore complex associations among demographic factors, risk factors, health care, and fatality rates of Middle East respiratory syndrome coronavirus (MERS-CoV) in the Kingdom of Saudi Arabia.

Methods. We based this study on analysis of a publicly accessible line listing of 1256 MERS-CoV cases (2013 to October 2018) available on the World Health Organization's Web site. For analyses of demographic factors (e.g., age, gender), access to health care, promptness of laboratory services, risk factors (comorbidity, exposure to camels and persons with MERS-CoV), occupation (health care), and outcome (fatality), we used descriptive statistics, risk ratio (RR), and the Pearson χ^2 test.

Results. Presence of comorbidity (RR = 3; 95% confidence interval [CI] = 2.2, 3.9), being male (RR = 1.6; 95% CI = 1.2, 2.1), exposure to dromedary camels (RR = 1.6; 95% CI = 1.3, 2.3), and consumption of camel milk (RR = 1.5; 95% CI = 0.9, 1.7) can significantly increase risk for fatality. Health care workers have significantly lower fatality ($P < .001$) than the rest of the persons with MERS-CoV.

Conclusions. Policies that promote health awareness for the high-risk population and their prompt seeking of health care should be considered. Publicly accessible line lists of infectious diseases such as MERS-CoV can be valuable sources for epidemiological analysis. (*Am J Public Health.* Published online ahead of print July 18, 2019: e1–e6. doi:10.2105/AJPH.2019.305186)

Middle East respiratory syndrome coronavirus (MERS-CoV) is a zoonotic virus that enters the human population via direct or indirect contact with infected dromedary camels and infected humans.[1,2] The clinical spectrum of MERS-CoV infection ranges from asymptomatic to severe pneumonia, presenting acute respiratory distress syndrome and other life-threatening complications such as septic shock and multiorgan failure. The maximum incubation period for cases is around 14 days (average ranging between 5.5 and 6.5 days).[3,4]

From 2012 to October 2018, 27 countries reported 2261 laboratory-confirmed cases of MERS-CoV infections to the World Health Organization (WHO), 83% of which were reported by the Kingdom of Saudi Arabia (KSA). Overall, 19% of the reported cases were health care workers (HCWs).[1,5] Those with community-acquired MERS were 7 times as likely as controls to have had direct exposure to dromedaries during the preceding 2 weeks. Sero-epidemiological studies indicated that infection might be associated with occupational exposure to dromedaries.[6] In the KSA, the rate of MERS-CoV seropositivity was 15 times as high in shepherds and 23 times as high in slaughterhouse workers as in the general population.[7] Household contacts evaluation in the KSA showed that 4.3% had positive results for MERS-CoV on real-time polymerase chain reaction assay or serologic assay.[8]

A nationwide, cross-sectional sero-epidemiological study conducted in the KSA in 2012 to 2013 showed that 0.15% of 10 009 participants had antibodies to MERS-CoV, thus suggesting the occurrence of more than 40 000 unrecognized or asymptomatic infections.[7] During the 2014 outbreak in Jeddah (KSA), 25% of MERS cases were reported to be asymptomatic.[9] The role of persons with asymptomatic infections in human-to-human transmission remains unclear but may be underappreciated.[6,9] Sensitive surveillance strategies and follow-up for all contacts are contributing to the increased recognition of asymptomatic cases.[9–11]

Usual treatment is supportive and based on the patient's clinical condition.[12] People with diabetes, renal failure, chronic lung disease, obesity, and immunocompromise are considered to be at high risk of severe disease from MERS-CoV infection.[12] Therefore, it has been advised that individuals with these underlying comorbidities should avoid contact with dromedaries; should not drink or handle raw dromedary milk, blood, or urine; and should not eat dromedary meat that has not been properly cooked.[13]

Despite significant improvements in MERS-CoV surveillance, there is a lack of understanding in the relationship between demographic and risk factors as well as health care. The aim of our study was to explore complex associations among age, gender, risk factors (comorbidity, exposure to camels, exposure to infected persons, consumption of camel milk, and occupation), trends in access

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to health care (duration between symptom onset and hospitalization), promptness of laboratory services (duration between hospitalization and laboratory confirmation), and fatality rates.

METHODS

We performed a cross-sectional study based on analysis of a publicly accessible line listing of MERS-CoV cases (from 2013 until the end of October 2018) available on the WHO's Web site.[14] This data set had been regularly updated and, during data pulling, we made sure that all the updates to the previous cases were incorporated. We also referred all the case reports (not included in the line list) from the same Web site and added information to the same line list we used (Appendix A, available as a supplement to the online version of this article at http://www.ajph.org). During the process of data collection, we had regular communication with the WHO for any needed clarification. We followed the WHO's definitions of laboratory-confirmed cases, exposure to animals (dromedary camels), and contact exposure to other persons with MERS-CoV (Table A, available as a supplement to the online version of this article at http://www.ajph.org).

Sample Size

Out of the total 2261 laboratory-confirmed MERS-CoV cases, 1477 cases were recorded in the line list (missing 784 cases [35%]).[14] All 1477 cases were included for initial analysis (descriptive statistics). As most of the cases were reported from the KSA, for further analysis we focused on those patients.

The WHO line list includes nationality of the persons reported to have MERS-CoV. Because we did not have any scope to verify individuals with regard to their duration of stay (travel history) in foreign countries (whether within or beyond the maximum incubation period of MERS-CoV), we listed the cases based on their background of the reporting country (i.e., KSA).

Data Preparation

Some cases in the data set had missing information on 1 or more variables, so the complete-case analysis was not possible, as it could not be ascertained that those cases with missing data had a random distribution. However, all the cases in the line list included in the analysis were standardized accordingly. We used a bootstrap-based expectation maximization method to amplify the inputs of the information missing in the data set.[15] We used a total of 100 computer-based randomized case data on the basis of the assumption that those data (missing or observed) came from a normal distribution. We formulated a data-collection tool to collect data on the variables mentioned in the WHO line list.

Data Analysis

We present descriptive statistics, the total number of cases, percentages for categorical variables, and means for continuous variables to indicate the demographic characteristics, risk factors, and outcomes. We calculated *P* values and 95% confidence intervals (CIs) assuming a Poisson distribution. For age and other continuous variables (the time [days] between the onset of symptoms and hospitalization and the time [days] between hospitalization and laboratory confirmation), we calculated the mean value and standard deviation (for normal distribution). We performed a Pearson χ^2 test to see the relationships between 2 categorical variables and a *t* test analysis to identify any significant differences between the means of 2 variables. We used a Poisson regression model with a robust variance estimator to estimate the univariate relative risk of outcomes to each potential risk factor.[16] This model is comparable to that formulated with binomial regression. Then we conducted a statistical analysis of age, gender, occupation, and year-wise correlations with risk factors and fatality rates of the cases pertaining to the KSA. We used Microsoft Excel 2013 (Microsoft, Redmond, WA) and the statistical package SPSS version 25 (IBM, Somers, NY) software for data entry, cleaning, and analysis.

Risk factors we considered during analysis were the patient's age, gender, the presence or absence of any comorbidities, reported contact with dromedary camels and camel milk consumption, employment as an HCW, and contact exposure to other persons with MERS-CoV. Outcomes of interest were whether patients were reported dead or alive at the time of initial reporting. The outcomes of the patients were mentioned as "deceased" or "alive," which was determined by the patients' status at the time of initial reporting.

RESULTS

The majority of MERS-CoV cases occurred in the KSA (1883 reported, but the line list included 1256 cases). Table 1 shows that the KSA contributed 85% of total cases reported in the line list. The gender distribution (M:F::2.5:1) and median age (53 years) were comparable with the WHO's figure (M:F::2:1; 52 years).[1] The fatality rate was 20%, which is lower than the WHO's current figure (35%).[1] However, the WHO admits that this figure might be overestimated, as mild cases of MERS-CoV may be missed by existing surveillance systems, and the case fatality rates are counted only among laboratory-confirmed cases.[12]

The ages of the cases reported from the KSA were normally distributed (Figure A, available as a supplement to the online version of this article at http://www.ajph.org). The proportions of comorbidities were higher in older age groups (> 46 years; Table 2), and an χ^2 test demonstrated significance ($P < .001$; Table B, available as a supplement to the online version of this article at http://www.ajph.org). Exposure to dromedary camels and camel milk consumption was higher in those aged 46 years or older whereas exposure to persons with MERS-CoV was lower in patients aged 36 years or older (Table 2). The fatality rate was the highest among those aged 26 to 35 years and lower in older age groups (Table 2).

We did a Pearson χ^2 statistical analysis between the presence of comorbidities and gender. It showed a significant association ($P < .001$) between gender and comorbidities (Table C, available as a supplement to the online version of this article at http://www.ajph.org). We also found the fatality rate to be significantly associated with the comorbidities of the patients (χ^2 test $P < .001$; Table D, available as a supplement to the online version of this article at http://www.ajph.org).

HCWs had a significantly lower (χ^2 test $P < .001$) fatality rate compared with the other professions (Table E, available as a supplement

TABLE 1—General Demographic Distribution of Global Middle East Respiratory Syndrome Coronavirus Cases: World Health Organization (WHO) Line List, January 2013 to September 2018

	Available Cases	Missing Cases
Other WHO report: country distribution, no.	2261	
Saudi Arabia	1883	
Other countries[a]	378	
Line list: country distribution, no. (%)	1477	784 (34.6)
Saudi Arabia	1256 (85.1[c])	627 (33.3[d])
Other countries[a]	221 (14.9[c])	157 (41.5[e])
Gender, no. (%)		12 (0.8[c])
Male	1055 (72.0[b])	
Female	410 (28.0[b])	
Age, mean years (range) or no. missing (%)	53.2 (1–109)	15 (1.0[c])
Occupational exposure: HCW, no. (%)	169 (11.9[b])	52 (3.5[c])
Risk, no. (%)		
Comorbidity	874 (75.3 [b])	317 (19.4[c])
Exposure to camel	282 (33.9[b])	647 (43.8[c])
Consumption of camel milk	196 (27.6[b])	767 (51.9[c])
Exposure to cases	371 (55.7[b])	811 (54.9[c])
Duration between symptom onset and hospitalization, mean days or no. missing (%)	4.4	411 (27.8[c])
Duration between hospitalization and laboratory confirmation, mean days or no. missing (%)	4	661 (44.8[c])
Fatality, no. (%)	286 (19.4[b])	5 (0.3[c])

Note. HCW = health care worker.
[a]Other countries in Middle Eastern region and outside.
[b]% of total cases in the line list (n = 1477) minus corresponding missing cases.
[c]% of total cases in the line list (n = 1477).
[d]% of total cases in the WHO report (n = 1883).
[e]% of total cases in the WHO report (n = 378).

to the online version of this article at http://www.ajph.org). For HCWs, mean durations (in days) between the dates of symptom onset and dates of hospitalization were significantly lower than the rest ($P < .001$; Table F, available as a supplement to the online version of this article at http://www.ajph.org). A higher level of awareness, familiarity with the health care system, confidence, and physical access to health care facilities might have allowed them to receive benefits earlier than the others.

Females had a lower median age, comorbidity rate, exposure to dromedary camels, consumption of camel milk, mean duration (in days) between the dates of symptom onset and dates of hospitalization, and fatality rate than did males (Table 3). However, a higher proportion of HCWs were females (27% of females vs 7% of males with MERS-CoV). Gender-wise analysis for non-HCWs showed lesser gaps between males and females with regard to mean age, comorbidity rate (females a little higher), and fatality rate. Non-HCW males were more exposed to camels and consumption of camel milk, and non-HCWs females were more exposed to patients with MERS-CoV (Table G, available as a supplement to the online version of this article at http://www.ajph.org). For HCWs, there were no significant associations ($P > .05$) between gender and comorbidities and fatalities (Tables H and I, available as supplements to the online version of this article at http://www.ajph.org). Region-specific analysis showed that Al-Jawf (population 440 009, total 36 cases) had the lowest median age (41 years), lowest percentage of male cases (51%), and highest proportion of HCWs (23%). We did not have any scope for further analysis; thus, further investigation is warranted.

There was no sign of decline in the exposure to camels, consumption of camel milk, exposure to persons with MERS-CoV, and fatality rate (Table 3). However, the mean durations (in days) between the dates of symptom onset and dates of hospitalization as well as the dates of hospitalization and dates of laboratory confirmation have reduced.

The estimated RRs of fatality and corresponding 95% CIs for the covariates are shown in Table 4 and Table J (available as a supplement to the online version of this article at http://www.ajph.org). Because this is an emerging communicable disease, we have analyzed some risk factors and their association with fatality in the cases from the KSA. Regression analysis demonstrated that male gender, the presence of underlying comorbidity, exposure to dromedary camels, and camel milk consumption were associated with an increased risk of fatality. Having an occupation in health care was protective against fatality, even in the male gender. The male gender was also found to be associated with comorbidity, but when occupation was considered alongside gender, male HCWs were found to be more susceptible to comorbidity and fatality.

DISCUSSION

The older population (aged > 46 years), particularly males, were more exposed to dromedary camels and consumed more camel milk, and younger people (aged < 35 years) and females were more exposed to persons with MERS-CoV. High comorbidity rates were found among the older population (aged > 46 years) with no notable differences between males and females. We found that comorbidity, being male, and exposure to camels and consumption of camel milk increased the risk for fatality. The overwhelming majority of the persons reported to have MERS-CoV were males. Those findings may be attributable to the zoonotic nature of the disease and the increased exposure of males to camels probably because of gender-selective occupation (predominantly males working in camel farms and slaughterhouses in KSA). Women played central roles in caring for sick family members, and

TABLE 2—Distribution of Comorbidities, Exposure (Camel, Milk, and Cases), and Fatalities in Middle East Respiratory Syndrome Coronavirus Cases Among Different Age Groups: Kingdom of Saudi Arabia, January 2013 to September 2018

Age Group, Years	Total No. Cases	Comorbidity,[a] No./Total No. (%)	Exposure to Dromedary Camel,[a] No./Total No. (%)	Camel Milk Consumption,[a] No./Total No. (%)	Exposure to Cases,[a] No./Total No. (%)	Fatality Rate,[a] No./Total No. (%)
< 16	12	4/7 (57.1)	1/4 (25)	0	6/7 (85.7)	10/12 (83.3)
16–25	54	17/43 (38.6)	9/28 (32.1)	6/24 (25)	24/31 (77.4)	47/54 (87)
26–35	178	31/143 (21.7)	10/116 (8.6)	9/99 (9.1)	79/101 (78.2)	163/178 (91.6)
36–45	169	76/141 (53.9)	29/101 (28.7)	21/87 (24.1)	47/88 (53.4)	150/167 (88.8)
46–55	224	159/199 (79.9)	55/133 (41.4)	46/115 (40)	56/99 (56.6)	185/224 (82.6)
56–65	281	225/245 (91.8)	63/151 (41.7)	49/135 (36.3)	48/105 (45.7)	222/279 (79.6)
66–75	183	162/165 (98.2)	52/115 (45.2)	36/95 (37.9)	19/60 (31.7)	120/182 (65.9)
≥ 76	145	125/127 (98.4)	25/83 (30.1)	19/74 (25.7)	15/49 (30.6)	90/145 (62.1)

[a]Denominators are based on number of Middle East respiratory syndrome coronavirus cases with respective responses. The cases in the line list without respective responses (either blank cells or marked as "not available") were removed from the analysis of the particular variable.

this might be the reason for a higher proportion of females exposed to the persons with MERS-CoV. However, underreporting of cases among females could not be ruled out. Significantly high hospitalization delay (symptom onset to hospitalization) and fatality rate among the non-HCWs (as compared with the HCWs) expose existing gaps with regard to access to knowledge and health care. Interestingly, cases arising in later years during the epidemic do not have any sign of decline in exposure to camels, consumption of camel milk, exposure to MERS-CoV cases, and fatality rate, which warrants an evaluation of the existing epidemic management program. However, the declines in the mean duration of hospitalization from the symptom onset and laboratory confirmation of the disease suggest some improvement in access to health care and efficiency of the diagnostic services.

The major limitation of the study was missing data, including missing cases (33.3%) and an incomplete line list for the listed cases. The majority of the missing cases were reported until 2014. From 2015, the line list captured the majority of the cases, signifying improvement of the disease surveillance. Understandably, because of missing data, the complete case analysis was not possible and it could not be ascertained that the cases with missing data would follow a random distribution. So, we used the bootstrap-based expectation maximization method to amplify the data inputs in the line list we used for analysis so that the results could be generalized for all notified MERS-CoV cases. We also referred all the case reports (not included in the line list) from the same Web sites and

TABLE 3—Gender and Year-Wise Analysis of Age, Occupation, Comorbidity, Exposure, Mean Durations, and Fatality Rate of the Persons Reported to Have Middle East Respiratory Syndrome Coronavirus: Kingdom of Saudi Arabia, January 2013 to September 2018

	No. (%) or Total No.	Mean Age, Years[a] (SD)	Occupation (HCW),[a] No./Total No. (%)	Comorbidity,[a] No./Total No. (%)	Exposure to Camel,[a] No./Total No. (%)	Camel Milk Consumption,[a] No./Total No. (%)	Exposure to Cases,[a] No./Total No. (%)	Mean Duration Between Symptom Onset and Hospitalization, Days (SD)	Mean Duration Between Hospitalization and Laboratory Confirmation, Days (SD)	Fatality Rate,[a] No./Total No. (%)
Gender										
Male	890 (71.2)	54.9 (17.4)	56/866 (6.5)	600/768 (77.5)	219/523 (41.9)	176/459 (38.3)	164/370 (44.3)	4.5 (3.6)	3.3 (4.4)	203/865 (23.4)
Female	360 (28.8)	50.2 (18.3)	94/349 (26.9)	199/291 (67.7)	25/208 (12.0)	10/172 (5.8)	133/176 (75.6)	3.8 (3.9)	3.9 (5.2)	52/349 (14.8)
Year										
2013	97	54.3 (17.4)	16/62 (25.8)	44/45 (97.8)	3/18 (16.7)	0	14/30 (46.7)	6.3 (4.9)	7.8 (11.1)	29/95 (30.5)
2014	110	52.7 (19.3)	8/110 (7.3)	62/78 (79.5)	22/88 (25.0)	8/74 (10.8)	13/75 (17.3)	4.7 (3.3)	3.5 (6.1)	23/109 (21.1)
2015	454	53.8 (17.9)	59/454 (12.9)	300/424 (70.8)	45/317 (14.2)	42/316 (13.3)	111/222 (50.0)	3.9 (4.2)	4.7 (5.7)	67/453 (14.8)
2016	226	54 (16.7)	21/226 (9.3)	147/203 (72.4)	63/118 (53.4)	60/117 (51.3)	46/84 (54.8)	4.7 (3.5)	2.5 (3.0)	25/225 (11.1)
2017	235	51.5 (17.8)	41/235 (17.4)	145/201 (72.1)	69/114 (60.5)	60/82 (73.2)	84/101 (83.2)	4.7 (3.3)	2.4 (3.4)	70/235 (29.8)
2018	128	54.6 (16.5)	5/128 (3.9)	101/119 (84.9)	42/77 (54.5)	16/33 (48.5)	29/34 (85.3)	4.1 (2.9)	1.8 (1.8)	41/128 (32.0)
Total	1250	53.5 (17.8)	150/1215 (12.3)	799/1059 (74.7)	244/731 (33.4)	186/631 (29.5)	297/546 (54.4)	4.3 (3.7)	3.4 (4.6)	255/1214 (20.9)

Note. HCW = health care worker.

[a]Denominators are based on number of Middle East respiratory syndrome coronavirus cases with respective responses. The cases in the line list without respective responses (either blank cells or marked as "not available") were removed from the analysis of the particular variable.

TABLE 4—Estimated Risk Ratio of Fatality Attributable to Middle East Respiratory Syndrome Coronavirus: Kingdom of Saudi Arabia, January 2013 to October 2018

Variables	Total No.	Fatality Risk, No. (%)	Fatality, RR (95% CI)
Comorbidity	1067		
Present	796	201 (25.3)	3.0 (2.2, 3.9)
Absent	271	23 (8.5)	
Camel exposure	730		
Present	244	65 (26.6)	1.6 (1.3, 2.3)
Absent	486	81 (16.7)	
Camel milk consumption	630		
Present	186	44 (23.6)	1.5 (0.9, 1.7)
Absent	444	72 (16.2)	
MERS-CoV cases exposure	545		
Present	297	31 (10.4)	0.4 (0.4, 1.0)
Absent	248	65 (26.2)	
Health care worker	1214		
Yes	150	2 (1.3)	0.1 (0.02, 0.2)
No	1064	236 (22.2)	
Both genders	1247		
Male	888	203 (22.9)	1.6 (1.2, 2.1)
Female	359	52 (14.5)	

Note. CI = confidence interval; MERS-CoV = Middle East respiratory syndrome coronavirus; RR = risk ratio.

added information to our line list and, thus, the number of missing data was further minimized.

Before our study, Rivers et al., Aly et al., and Yang et al. analyzed the line lists of MERS-CoV (2012–August 2015, June 2012–July 2016, and March 2012–October 2016, respectively), and all the studies encountered a similar challenge of missing data.[17–19] Rivers et al. encountered 920 cases (out of 1105) with missing information on 1 or more variables (including outcome variables). They addressed the missing data by using the same method (i.e., bootstrap-based expectation maximization method to multiply impute the missing information). Analysis showed that the results were similar to our findings such as female gender, absence of comorbidities, and employment as HCW were protective against mortality. The authors also mentioned that deficiency of data impeded any construction of mathematical models or broad-scale risk assessment and suggested to improve data quality.[17]

The analysis of Aly et al. was limited to the simple frequency and percentage distribution of country and region (for KSA only) specific cases, variables (gender, age, exposure to camels and other animals and human cases) and seasonal pattern of infection in KSA. The authors stated that a higher probability of male exposure to camel population was the reason for a much higher proportion of males (67%) than females (33%). Interestingly, they did not highlight the roles of comorbidity in the analysis.[18]

Yang et al. intended to assess the impact of comorbidity on fatality rate while simultaneously adjusting for age and gender in a Bayesian multilevel survival model. To manage the reported cases with missing onset date, the date of symptom onset was calculated by subtracting the reported date by the median of the time period between onset date and reported date. The analysis showed that cases with comorbidity had a higher fatality rate. The survival probability of cases without comorbidity at 21 days was higher than those with comorbidity. Even after adjusting age and epidemic period (initial 2 years), the effect of comorbidity on fatality rate remained significantly high.[19]

Lessler et al. analyzed the line list of laboratory-confirmed cases of MERS-CoV in the KSA, identified by the Ministry of Health through active and passive surveillance from June 2012 to July 2014 to estimate the total number of subclinical cases that had occurred up to a point.[20] The data set included information on age, gender, area of residence, the reason the case was tested for MERS-CoV, whether the cases met the case definition, and most recently reported clinical status (hospitalized, home isolation, discharged, or deceased). The authors fit a probabilistic model to the observed distribution of symptoms and mortality in MERS-CoV infections detected through active and passive surveillance. The study estimated 1528 MERS-CoV cases, more than twice as many as had been observed (n = 716). The undetected persons did not develop symptoms of the infection severe enough to trigger testing or severe but unusual clinical presentation.[20] The estimation of subclinical cases was made possible because of the availability of detailed information on patients, abstracted from multiple sources including report forms of cases and laboratories and clinical records. We suggest that WHO expand the scope for the line list and include more information on clinical status for better estimation of cases and for robust analysis.

Gardner et al. used the publicly available line list of WHO (January 2015–December 2017) to identify the meteorological factors (temperature, relative humidity, wind speed, and visibility) that may increase the risk of primary MERS-CoV infections in KSA.[21] To identify the primary cases, they selectively removed the cases that lacked confirmed exposure to camels and camel products, and excluded secondary contacts, HCWs, and the cases with symptom onset dates after hospitalization date. The variables for analysis were symptom onset date and meteorological factors. Therefore, other missing variables of the line list did not affect the outcomes. The results showed that more primary MERS-CoV cases occurred when weather conditions were relatively cold and dry.[21]

Despite several missing cases, analysis of the line list is probably the best option for global public health professionals for studying outbreaks, mainly when there is no scope for access to individual case reports. To the best of our knowledge, this study provides a comprehensive review of MERS-CoV cases by analyzing the latest available data. We have provided a detailed account of gender and occupation (health care)–based analysis and access to health (hospitalization delay) and quality of health care (promptness of laboratory services). The latest WHO report showed that by April 2019, a total of 134 new cases had already been reported[22] and the number may surpass the 2018 figure (n = 142) by the end of the year or before. Regular occurrences of MERS-CoV outbreaks in KSA and no sign of improvement in exposure to the risk factors and fatality rates indicate a serious lapse in disease control measures including health promotion and surveillance.

In conclusion, MERS-CoV is still an emerging infectious disease, and its epidemiological pattern has not changed much.[23] We recommend the improvement of disease surveillance and line listing all the cases with complete information. Similar to MERS-CoV, public access to line lists of other outbreaks can help generate new perspectives in disease-control strategies. AJPH

CONTRIBUTORS

A. Sarkar contributed to exploring the data source, study design, data analysis plan, data interpretation, literature review, and article writing. A. Rahman contributed to data collection, data analysis, and data interpretation.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

HUMAN PARTICIPANT PROTECTION

The research was based on the analysis of a publicly accessible line list, and hence it did not require any ethics approval.

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