Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Journal of Infection and Public Health 13 (2020) 843–848

Contents lists available at ScienceDirect

Journal of Infection and Public Health

journal homepage: http://www.elsevier.com/locate/jiph

Review Article

SARS, MERS and COVID-19 among healthcare workers: A narrative review

Jian Xiao[a,b,1], Min Fang[c,1], Qiong Chen[a,b,*], Bixiu He[a,b,*]

[a] National Clinical Research Center for Geriatric Disorders, Xiangya Hospital, Central South University, Changsha 410008, Hunan, China
[b] Department of Respiratory and Critical Care Medicine, Geriatrics, Xiangya Hospital, Central South University, Changsha 410008, Hunan, China
[c] Department of Quality Management, Xiangbei Branch, Lbx Pharmacy Chain Joint Stock Company, Changsha 410008, China

ARTICLE INFO

Article history:
Received 1 April 2020
Received in revised form 19 May 2020
Accepted 20 May 2020

Keywords:
Healthcare worker
SARS
MERS
COVID-19

ABSTRACT

In the recent two decades, three global viral infectious diseases, severe acute respiratory syndrome (SARS), middle east respiratory syndrome (MERS), and coronavirus disease (COVID-19), have occurred worldwide. SARS occurred in November 2002, causing 8096 infected cases, as well as 774 deaths. MERS occurred in June, 2012, causing 2519 confirmed cases, along with 866 associated deaths. COVID-19 occurred in December 2019, as of 30 April 2020, a total of 3,024,059 clinical cases have been reported, including 208,112 deaths. Healthcare workers (HCWs) need to be in close contact with these virus-infected patients and their contaminated environments at work, thus leading to be infected in some of them, even a few of them are died in line of duty. In this review, we summarized the infection status of HCWs during the outbreak of SARS, MERS and COVID-19, with in-depth discussion, hoping to provoke sufficient attention to the HCWs infection status by more people.

Contents

Introduction

Viral infectious diseases have always been a threat to human survival. In the recent two decades, three global viral infectious diseases, severe acute respiratory syndrome (SARS), middle east respiratory syndrome (MERS), and the current coronavirus disease (COVID-19) [1–3], have occurred worldwide, and all the pathogens are the types of coronavirus [4].

The pathogen of SARS is named as severe acute respiratory syndrome coronavirus (SARS-CoV) [5]. It first occurred in November 2002, and originated from Guangdong province, southern China [6]. According to the aggregate data of WHO, a total of 8096 cases were reported, resulting in 774 deaths (the case-fatality ratio is 9.56%) in 26 countries on 5 continents during the SARS epidemic [7].

The pathogen of MERS is named as middle east respiratory syndrome coronavirus (MERS-CoV) by the Coronavirus Study Group (CSG) [8]. The virus was first isolated from a patient that died of the disease in June, 2012, in Jeddah, Saudi Arabia [9]. According

* Corresponding authors at: National Clinical Research Center for Geriatric Disorders, Xiangya Hospital, Central South University, Changsha 410008, Hunan, China.
E-mail addresses: xyqiongchen@163.com (Q. Chen), bixiuhe@csu.edu.cn (B. He).
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.jiph.2020.05.019

Table 1
SARS infection status among HCWs in different countries.

Country	Number of total cases	Number of HCW affected	Percent
China	7429	1456	19.60
Canada	251	109	43.43
France	7	2	28.57
Germany	9	1	11.11
Philippines	14	4	28.57
Singapore	238	97	40.76
Thailand	9	1	11.11
Vietnam	63	36	57.14
Total	8020	1706	21.27

to the summary of WHO, at the end of January 2020, a total of 2519 confirmed MERS cases, including 866 associated deaths (the case-fatality rate is 34.38%), have been reported globally [10].

COVID-19 was initially identified in December 2019, in Hubei province, central China [11]. Soon afterwards, based on phylogeny, taxonomy and established practice, the CSG named the pathogen of COVID-19 as SARS-CoV-2 [12]. As of 30 April 2020, a total of 3,024,059 confirmed cases have been reported globally, including 208,112 deaths (the case-fatality ratio is about 6.88%) [13].

Healthcare workers (HCWs) are defined as personnel responsible for direct treatment, care, service or help of patients, mainly consisting of doctors and nurses, as well as physiotherapists, laboratory technicians, respiratory therapists, housekeepers, or even medical waste handlers [14–16]. HCWs need to be in close contact with these virus-infected patients and their contaminated environments at work, so they are at great risk of job exposure. In this study, we aim to review the infection status of HCWs in the past battles of SARS and MERS, and to summarize the infection status of HCWs during the outbreak of COVID-19, expecting to provoke sufficient attention to the HCWs infection status in patients, hospital managers, public, government administrators and HCWs themselves.

SARS among HCWs

WHO had reported 1706 HCW infected cases during the SARS outbreak [7]. As is shown in Table 1, eight countries (China, Canada, France, Germany, Philippines, Singapore, Thailand, and Vietnam) have reported SARS-infected cases among HCWs, which account for 21.27% (1706/8020) of the total infections in these countries. However, the total number of HCW infections accounts for 21.07% (1706/8096) of all SARS confirmed cases in the worldwide [7]. In addition, to a certain extent, it can be seen that countries with more SARS cases have more absolute numbers of corresponding HCWs infections (Table 1).

In China (included the mainland, Hong Kong, Macao, and Taiwan), 1456 HCWs have been infected with SARS, accounting for 19.60% (1456/7429) of total infection cases and 85.35% (1456/1706) of all HCW infections (Table 1). Of all the above countries, Vietnam has the highest percent of HCW infection on total SARS cases, reaching 57.14% (36/63) (Table 1). There are also many SARS infections among HCWs in Canada and Singapore, and their proportions of infections to total are also high, accounting for 43.43% (109/251) and 40.76% (97/238) respectively (Table 1).

Because Beijing has the highest number of SARS cases in China, its corresponding HCW also has the largest number of infections. SARS occurred in HCWs in more than 70 hospitals in Beijing [17], including there have four hospitals, each of them, with more than 20 cases of SARS infection among HCWs, and for which one large hospital has 41 probable HCW cases [17]. In total, 395 probable SARS cases occurred in HCWs, and the attack rate of SARS among HCWs in Beijing was estimated as 465 per 100,000 [17]. Hong Kong and Guangdong are the other two regions in China where more than one thousand SARS cases occurred. Based on the report of WHO, 386 HCWs were infected with SARS in Hong Kong, accounting for 21.99% (386/1755) of its total infection cases [7]. In Guangdong, 343 HCWs were reported to have been infected with SARS, 75.1% of whom were women [18].

Most of the probable SARS cases (57.14%, 36/63) identified in the Vietnam outbreak were HCWs, all of which occurred in a private hospital in Hanoi [19], and lack of SARS transmission among the public HCWs [20]. L Clifford McDonald and colleagues [21] reported that 164 HCWs in the greater Toronto area were infected with SARS, which is more than the total number of infected HCW in Canada as summarized by WHO (Table 1). However, the reason for the inconsistency in the total number of these reports may be that the former involved suspected cases [21]. In Singapore, the most severe nosocomial outbreak of SARS among HCWs occurred in Tan Tock Seng Hospital, with a total of 44 HCWs infected [22].

It is widely known that SARS caused 774 deaths [7], but what is unknown is the exact number of HCWs that died of SARS infection worldwide. However, by analyzing the SARS mortality rate reported by the WHO [7], it can be concluded that approximately 164 (multiplying 1706 by 0.096) HCWs might die of SARS. But we speculate that the actual number of deaths of HCWs should be far lower because the HCWs fighting against SARS in front line were basically young people with good autoimmunity. However, according to statistics (maybe incomplete) from Wikipedia, about 39 HCWs died worldwide in the battle against SARS [23].

Table 2
MERS infection status among HCWs in Saudi Arabia and South Korea.

Country	Number of total cases	Number of HCW affected	Percent
Saudi Arabia	2121	405	19.1%
South Korea	186	25	13.44%
Global Total	2519	450[a]	17.86%[a]

[a] Speculative data.

MERS among HCWs

Unlike SARS, of which no new cases have been reported worldwide since 2004, new cases of MERS have always been arising since 2012. The WHO regularly summarizes and reports on new cases of MERS, and the latest MRES summary report currently released by WHO summarizes all cases that before February 2020 [24]. WHO's statistics on new cases of MERS in different time periods reveal that the number of infections among HCWs between different months or seasons has a large fluctuation in their corresponding total number of MERS cases, which accounts for 0–32% from 2013 to 2020 [24].

More than 84.2% (2121/2519) of MERS cases worldwide occur in Saudi Arabia. According to the latest WHO report (MERS situation update, January 2020), in Saudi Arabia, 19.1% of these 2121 MERS cases are HCWs, which means 405 HCW MERS-infected cases [24] (Table 2). Based on epidemiological data of confirmed MERS cases reported to the WHO from September 2012 to 2 June 2018, Amgad A Elkholy and colleagues [25] found there were 415 HCW MERS cases globally by conducting a retrospective analysis. Therefore, it can be speculated that the current number of HCW cases infected with MERS may be more than 450 (Table 2).

South Korea has the largest number of MERS infections outside Saudi Arabia in the world, with 186 confirmed cases [26]. Among them, 25 cases were occupationally acquired by HCWs, accounting for 13.44% (25/186) of total infection cases in South Korea [27] (Table 2). The super-spreader of MERS-CoV is the main cause of MERS outbreak and infection of HCW in South Korea. Having followed a single patient exposure in a hospital in South Korea, Sun Young Cho and colleagues [28] found 82 individuals were infected with MERS-CoV from a super-spreader, and 8 of them were HCWs.

The case fatality rate of MERS is 34.38% (866/2519) according to the latest WHO MERS situation update report as of January 2020 [24]. By conducting a retrospective analysis based on the epidemiological data of confirmed MERS cases reported to the WHO from September 2012 to 2 June 2018, Elkholy and colleagues [25] reported the fatality rate of HCW MERS cases is 5.78% (24/415), which is far lower than that of the non-HCWs. That is because the death of secondary case of MERS is the highest in the age group 70–79, while most of the HCWs are not in this range for younger age [24,25].

COVID-19 among HCWs

China has 84,369 COVID-19 cases with of 4643 deaths as of 30 April 2020 [13]. Since the outbreak of COVID-19, the infection among HCWs has been reported gradually in China. By extracting data regarding 1099 patients with laboratory-confirmed COVID-19, Guan and colleagues found a total of 3.5% (about 38 of 1099) confirmed cases are HCWs [29]. Wang and colleagues reported that 40 HCW infected cases among 138 hospitalized patients [30]. In early February, the China CDC reported 1716 confirmed cases of COVID-19 among HCWs [31]. On February 24, 2020, members of the China-WHO coronavirus team announced that 3387 HCWs of 476 medical institutions in China were infected with COVID-19 (2055 confirmed cases, 1070 clinically diagnosed cases and 157 suspected cases), and more than 90% of them (3062 cases) came from Hubei Province [32].

According to the WHO COVID-19 situation report-82, as of 8 April 2020, 22,073 HCW infected cases from 52 countries had been reported globally [33]. Meanwhile, the COVID-19 cases among HCWs are still on the increase. In the United States, it has almost 10,000 HCWs have been infected with COVID-19 according to the Centers for Disease Control and Prevention in early April [34]. More recently, according to the COVID-19 situation update for the WHO European Region-Data for the week of 13–19 April 2020 (Epi week 16) [35], among the 339,657 COVID-19 cases with available characteristic records data, 54,749 of them were HCWs. Because the current reported data are incomplete and dynamic, it is difficult to estimate how many HCWs worldwide have been infected with COVID-19.

As of 30 April 2020, COVID-19 has caused 208,112 deaths worldwide [13]. Despite relatively lower case fatality rate, COVID-19 has killed far more people than SARS and MERS combined [36]. These deaths caused by COVID-19 include some HCWs. China CDC analysis of epidemiological characteristics of COVID-19 cases as of February 11, 2020, found that 5 HCWs died of COVID-19 [31]. According to relevant news reports collected and summarized by Wikipedia, as of March 27, 2020, at least a total of 88 HCWs have died of COVID-19, of which 36 are in China, 31 in Italy, 13 in Iran, 5 in France and 3 in United States [37]. However, some of them died of COVID-19 epidemic prevention and control work rather than COVID-19 infection [37].

Although the COVID-19 epidemic in China has now been basically under control, it is still spreading in many other countries outside China. It is unclear how many HCWs have been infected with COVID-19 due to work, and how many HCWs have died in line of duty. It is foreseeable that despite the best protection, there also will be more HCWs infections. To know the specific situation of HCWs infection with COVID-19, further statistics and analysis are needed for subsequent studies after the epidemic is under control.

Discussion

Hospital is the important place for secondary transmission of SARS, MERS and COVID-19 [14,38,39]. Densely staffed, and packed with public facilities and people with compromised immunity, hospitals provide objective conditions for the secondary transmission of these infectious diseases. Generally, emergency department, infectious disease department, fever clinic, intensive care unit and respiratory medicine department are the main departments that cause the spread of these diseases. Therefore, HCWs in these departments may well be infected with SARS, MERS and COVID-19 at work.

As is known, 3 ophthalmologists in the Central Hospital of Wuhan, Hubei died of COVID-19 [40], which is a wake-up call that ophthalmology is also a high-risk department that can cause HCWs infection of COVID-19. It has been found that SARS-CoV-2 can be detected in tears and conjunctival secretions of patients with COVID-19 [41]. Studies suggest that when no eye protection was worn, SARS-CoV-2 could also possibly be spread by aerosol contact with conjunctiva and cause infection of HCWs [42–44]. Close proximity between patients and ophthalmologists during slit lamp examination, intraocular pressure measurement, direct ophthalmoscopy, pupillary dilatation and others may pose an infectious risk to ophthalmologists [44]. Hence these factors may increase the risk of cross-infection between HCWs and patients in the department of ophthalmology.

Nosocomial transmission of SARS, MERS and COVID-19 can be categorized as patient-to-patient, patient-to-HCW, HCW-to-patient, and HCW-to-HCW. Confirmed or suspected cases of these infectious diseases can be physically separated by setting up isolation wards or establishing isolation hospitals to avoid patient-to-patient transmission [38,45,46]. Therefore, the subsequent key issue that needs to be persistently considered, solved and prevented is how to prevent the transmission of patient-to-HCW.

Reasons for patient-to-HCW transmission involve poor institutional infection control measures, lack of awareness and preparedness in the early stage of disease outbreak, lack of training on infection control procedures, and poor compliance with personal protection equipment (PPE) use. To be specific, the recognized risk factors are close contact in physical examination and therapy, direct physical contact with body fluid and excreta from patients, airway suctioning, endotracheal intubation and cardiopulmonary resuscitation. However, the most dangerous situation is when they are facing the super-spreader, whose transmission ability is simply overwhelming [47–49]. Therefore, how to identify the super-spreaders as early as possible is of vital importance as to reducing the chance of patient-to-patient and patient-to-HCW transmission.

Hand hygiene is recognized as an easy and effective way to prevent the spread of respiratory infections that include SARS, MERS and COVID-19 [38,50–52]. Correspondingly, wearing masks is the simplest and most important PPE to prevent infection of these infectious diseases. Both surgical and N95 masks can effectively prevent HCWs from being infected with SARS, MERS and COVID-19. However, if conditions permit, wearing N95 masks maybe relatively better [53–57]. Other PPE such as gloves, hats, protective clothing, isolation clothing and others are also important for HCWs to prevent infection, depending on the working environment. Improving the compliance of using PPE and standardizing the putting on and taking off process of these PPEs can better protect HCWs.

By investigating the frontline of HCWs combating SARS, Cindy W C Tam and colleagues reported that the stress and psychological distress among HCWs were high, accounting for 68% and 57% respectively [58]. Robert Maunder also reported that a high level of distress was experienced by 29–35% of HCWs, and the relevant contextual factors were having contact with SARS patients, being a nurse and having children [59]. Similarly, study conducted by Namhee Oh and colleagues reported that high stress had also shown in HCWs engaged in patient nursing during the MERS outbreak [60].

Um and colleagues found that 26.6% doctors involved in MERS care showed symptoms of depression [61].

Recently, Li and colleagues [62] reported the prevalence of depression and anxiety was 21.3%, 19.0%, respectively among public HCWs in the frontline during the COVID-19 epidemic. Lai and colleagues [63] analyzed 1257 mental health status among HCWs exposed to COVID-19, finding 50.4%, 44.6%, 34.0% and 71.5% of them reported depression, anxiety, insomnia and distress, respectively. And frontline HCWs engaged in direct diagnosis, treatment, and care of COVID-19 patients were associated with a higher risk of depression, anxiety, insomnia and distress. HCWs were anxious regarding their safety and reported psychological effects from mortality reports from COVID-19 infection [64]. Therefore, hospital administrators need to pay sufficient attention to and ease the stress and psychological distress on frontline HCWs fighting the COVID-19 epidemic.

Previous studies have found that some HCWs developed post-traumatic stress syndrome after coping with SARS or MERS outbreaks [65–68]. Because of perceived risk of fatality from SARS, increased work stress, and affected social relationships, some HCWs were even considered switching or resigning from their job [69]. These previous evidences remind hospital managers, that during the outbreak of COVID-19, they must pay attention to the post-traumatic stress syndrome and occupational concerns of HCWs, and should temporarily invite psychologist or psychological counselor to participate in the management of the hospital if necessary.

In addition to providing as much psychological support and counseling as possible for the HCWs fighting the COVID-19 epidemic, hospital managers should also provide strong logistical support for these front-line HCWs, such as ensuring the supply of protective equipment, giving appropriate additional financial assistance, and taking care of their family difficulties. And in the future, hospitals and health administration departments may also consider giving these HCWs preferential promotion opportunities under the same conditions.

In less than two decades, humans have experienced SARS and MERS outbreaks and are currently experiencing the outbreak of COVID-19. It can be said that COVID-19 is the most severe blow to human health among the three infectious diseases, and it is not yet known how long it will last. After experiencing SARS and MERS, HCWs appeared to be more vigilant against similar infectious diseases [70–72]. However, in the battle against COVID-19, the vigilance does not seem to have played a due role in HCWs on the grounds that a large number of HCWs have been infected at work, indicating SARS-CoV-2 is more troublesome than SARS-CoV and MERS-CoV.

It has been five months since the outbreak of the COVID-19 epidemic in December 2019. The duration of this epidemic cannot be predicted, nor can the possibility be ruled out that it will cause seasonal epidemics like influenza in the future [73,74]. As for the impact of COVID-19 on HCWs, many subsequent studies can and need to be performed, such as collecting the detailed statistics of the infection status of HCWs in each country, subdividing the infection status according to their different job positions, comprehensively investigating their psychological and mental problems, and researching their possible post-traumatic stress syndrome.

The pandemic of COVID-19 gave medical students a big practical lesson. The Chinese Ministry of Education has postponed the spring start of colleges and universities and discourages medical students from returning to hospitals for internships before the outbreak is under control [75]. Italy government has announced a plan to add 20,000 new HCWs to meet the demand to fight against COVID-19, and called on students who have completed their medical degrees and are in the final year of specialist training to participate [76]. The England chief medical officer has announced that the final year medical students may have their duty rights extended [77]. Anyway, governments have made appropriate arrangements for medical students in their countries according to their own epidemic situation.

However, on the other hand, we also need to consider whether the COVID-19 epidemic has affected the future career planning of medical students, and whether it has caused a psychological burden and discouraged them from engaging in the medical industry in the future. In the face of the current global epidemic disaster, and alike major outbreaks that may also occur in the future, we should encourage medical students in a suitable way to strengthen their confidence in the medical industry, and encourage young people to choose to study medicine.

Authors' contribution

Jian Xiao and Min Fang contributed equally to this work.

Conception and design: Jian Xiao, Min Fang

Analysis and interpretation of the data: Jian Xiao, Min Fang, Bixiu He.

Drafting of the article: Jian Xiao, Min Fang, Bixiu He.

Critical revision of the article for important intellectual content: Qiong Chen, Jian Xiao.

Final approval of the article: Bixiu He, Qiong Chen.

Administrative, technical, or logistic support: Bixiu He, Qiong Chen.

Collection and assembly of data: Min Fang, Jian Xiao, Bixiu He.

Conflicts of interest

The authors disclosed no conflicts of interest.

Acknowledgments

In the face of the SARS, MERS or COVID-19 epidemic, HCWs are soldiers. Their enemies are viruses and they fight the wars without gun smoke. These soldiers are wives, mothers, and daughters, or husbands, fathers, and sons. Although, in the face of the epidemic, they are may also be worried, afraid, and anxious. However, because of the responsibility, as long as the situation needs, HCWs rush to the battlefield without hesitation. We pay tribute to frontline fighting HCWs, thank them for their great efforts. We wish to express our deepest condolences to those HCWs who have died in the fight against SARS, MERS and COVID-19.

References

[1] Gralinski LE, Menachery VD. Return of the coronavirus: 2019-nCoV. Viruses 2020;12:135.
[2] Negahdaripour M. The battle against COVID-19: where do we stand now? Iran J Med Sci 2020;45:81.
[3] Xu J, Zhao S, Teng T, Abdalla AE, Zhu W, Xie L, et al. Systematic comparison of two animal-to-human transmitted human coronaviruses: SARS-CoV-2 and SARS-CoV. Viruses 2020;12:244.
[4] Guarner J. Three emerging coronaviruses in two decades: the story of SARS, MERS, and now COVID-19. Oxford University Press US; 2020.
[5] Kuiken T, Fouchier RA, Schutten M, Rimmelzwaan GF, van Amerongen G, van Riel D, et al. Newly discovered coronavirus as the primary cause of severe acute respiratory syndrome. Lancet (London, England) 2003;362:263–70, http://dx.doi.org/10.1016/s0140-6736(03)13967-0.
[6] Zhong NS, Zheng BJ, Li YM, Poon, Xie ZH, Chan KH, et al. Epidemiology and cause of severe acute respiratory syndrome (SARS) in Guangdong, People's Republic of China, in February, 2003. Lancet (London, England) 2003;362:1353–8, http://dx.doi.org/10.1016/s0140-6736(03)14630-2.
[7] WHO. Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003. Available online: https://www.who.int/csr/sars/country/table2004_04_21/en/ [Accessed 15 March 2020].
[8] de Groot RJ, Baker SC, Baric RS, Brown CS, Drosten C, Enjuanes L, et al. Middle East respiratory syndrome coronavirus (MERS-CoV): announcement of the

Coronavirus Study Group. J Virol 2013;87:7790–2, http://dx.doi.org/10.1128/jvi.01244-13.
[9] Zumla A, Hui DS, Perlman S. Middle East respiratory syndrome. Lancet (London, England) 2015;386:995–1007, http://dx.doi.org/10.1016/s0140-6736(15)60454-8.
[10] WHO. Available online: https://www.who.int/emergencies/mers-cov/en/ [Accessed 18 March 2020].
[11] Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet (London, England) 2020;395:497–506, http://dx.doi.org/10.1016/s0140-6736(20)30183-5.
[12] Gorbalenya A, Baker S, Baric R. The species severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. Nat Microbiol 2020.
[13] WHO. Available online: https://covid19.who.int/ [Accessed 30 April 2020].
[14] 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, http://dx.doi.org/10.1186/s12916-015-0450-0.
[15] Joseph B, Joseph M. The health of the healthcare workers. Indian J Occup Environ Med 2016;20:71–2, http://dx.doi.org/10.4103/0019-5278.197518.
[16] Lee N, Sung JJ. Nosocomial transmission of SARS. Curr Infect Dis Rep 2003;5:473–6, http://dx.doi.org/10.1007/s11908-003-0089-4.
[17] Liang W, Zhu Z, Guo J, Liu Z, Zhou W, Chin DP, et al. Severe acute respiratory syndrome, Beijing, 2003. Emerg Infect Dis 2004;10:25–31, http://dx.doi.org/10.3201/eid1001.030553.
[18] Xu RH, He JF, Evans MR, Peng GW, Field HE, Yu DW, et al. Epidemiologic clues to SARS origin in China. Emerg Infect Dis 2004;10:1030–7, http://dx.doi.org/10.3201/eid1006.030852.
[19] Reynolds MG, Anh BH, Thu VH, Montgomery JM, Bausch DG, Shah JJ, et al. Factors associated with nosocomial SARS-CoV transmission among healthcare workers in Hanoi, Vietnam, 2003. BMC Public Health 2006;6:207, http://dx.doi.org/10.1186/1471-2458-6-207.
[20] Le DH, Bloom SA, Nguyen QH, Maloney SA, Le QM, Leitmeyer KC, et al. Lack of SARS transmission among public hospital workers, Vietnam. Emerg Infect Dis 2004;10:265–8, http://dx.doi.org/10.3201/eid1002.030707.
[21] McDonald LC, Simor AE, Su IJ, Maloney S, Ofner M, Chen KT, et al. SARS in healthcare facilities, Toronto and Taiwan. Emerg Infect Dis 2004;10:777–81, http://dx.doi.org/10.3201/eid1005.030791.
[22] Teleman MD, Boudville IC, Heng BH, Zhu D, Leo YS. Factors associated with transmission of severe acute respiratory syndrome among health-care workers in Singapore. Epidemiol Infect 2004;132:797–803, http://dx.doi.org/10.1017/s0950268804002766.
[23] URL. Available online: https://en.wikipedia.org/wiki/List_of_medical_professionals_who_died_during_the_SARS_outbreak [Accessed 16 March 2020].
[24] WHO. Available online: http://www.emro.who.int/health-topics/mers-cov/mers-outbreaks.html [Accessed 18 March 2020].
[25] Elkholy AA, Grant R, Assiri A, Elhakim M, Malik MR, Van Kerkhove MD. MERS-CoV infection among healthcare workers and risk factors for death: retrospective analysis of all laboratory-confirmed cases reported to WHO from 2012 to 2 June 2018. J Infect Public Health 2020;13:418–22, http://dx.doi.org/10.1016/j.jiph.2019.04.011.
[26] Ki M. 2015 MERS outbreak in Korea: hospital-to-hospital transmission. Epidemiol Health 2015;37:e2015033, http://dx.doi.org/10.4178/epih/e2015033.
[27] Kim KH, Tandi TE, Choi JW, Moon JM, Kim MS. Middle East respiratory syndrome coronavirus (MERS-CoV) outbreak in South Korea, 2015: epidemiology, characteristics and public health implications. J Hosp Infect 2017;95:207–13, http://dx.doi.org/10.1016/j.jhin.2016.10.008.
[28] Cho SY, Kang JM, Ha YE, Park GE, Lee JY, Ko JH, et al. MERS-CoV outbreak following a single patient exposure in an emergency room in South Korea: an epidemiological outbreak study. Lancet (London, England) 2016;388:994–1001, http://dx.doi.org/10.1016/s0140-6736(16)30623-7.
[29] Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020, http://dx.doi.org/10.1056/NEJMoa2002032.
[30] Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA 2020, http://dx.doi.org/10.1001/jama.2020.1585.
[31] Novel CPERE. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. Zhong Hua Liu Xing Bing Xue Za Zhi 2020;41:145.
[32] URL. Available online: http://www.chinanews.com/gn/2020/02-24/9103094.shtml [Accessed 16 March 2020].
[33] WHO. Available online: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports [Accessed 29 April 2020].
[34] URL. Available online: https://www.medscape.com/viewarticle/928770 [Accessed 29 April 2020].
[35] WHO. Available online: http://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/weekly-surveillance-report [Accessed 29 April 2020].
[36] Mahase E. Coronavirus: covid-19 has killed more people than SARS and MERS combined, despite lower case fatality rate. British Medical Journal Publishing Group; 2020.
[37] URL. Available online: https://zh.wikipedia.org/wiki/2019%E5%86%A0%E7%8B%80%E7%97%85%E6%AF%92%E7%97%85%E7%96%AB%E6%83%85%E6%9C%9F%E9%96%93%E6%AE%89%E8%81%B7%E9%86%AB%E8%AD%B7%E4%BA%BA%E5%93%A1%E5%88%97%E8%A1%A8 [Accessed 27 March 2020].
[38] Hellewell J, Abbott S, Gimma A, Bosse NI, Jarvis CI, Russell TW, et al. Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. Lancet Global health 2020;8:e488–96, http://dx.doi.org/10.1016/s2214-109x(20)30074-7.
[39] Rajakaruna SJ, Liu WB, Ding YB, Cao GW. Strategy and technology to prevent hospital-acquired infections: lessons from SARS, Ebola, and MERS in Asia and West Africa. Military Med Res 2017;4:32, http://dx.doi.org/10.1186/s40779-017-0142-5.
[40] URL. Available online: https://news.163.com/20/0310/02/F7ARQP2R0001899O.html [Accessed 16 March 2020].
[41] Xia J, Tong J, Liu M, Shen Y, Guo D. Evaluation of coronavirus in tears and conjunctival secretions of patients with SARS-CoV-2 infection; 2020, http://dx.doi.org/10.1002/jmv.25725.
[42] Zhou Y, Zeng Y, Tong Y, Chen C. Ophthalmologic evidence against the interpersonal transmission of 2019 novel coronavirus through conjunctiva. MedRxiv 2020.
[43] Lu CW, Liu XF, Jia ZF. 2019-nCoV transmission through the ocular surface must not be ignored. Lancet (London, England) 2020;395:e39, http://dx.doi.org/10.1016/s0140-6736(20)30313-5.
[44] Lai TH, Tang EW, Chau SK, Fung KS, Li KK. Stepping up infection control measures in ophthalmology during the novel coronavirus outbreak: an experience from Hong Kong. Graefe's Arch Clin Exp Ophthalmol 2020:1–7.
[45] Leung PC. The efficacy of Chinese medicine for SARS: a review of Chinese publications after the crisis. Am J Chin Med 2007;35:575–81, http://dx.doi.org/10.1142/s0192415x07005077.
[46] Zhang S, Diao MY, Duan L, Lin Z, Chen D. The novel coronavirus (SARS-CoV-2) infections in China: prevention, control and challenges. Intensive Care Med 2020:1–3.
[47] Ebrahim SH, Memish ZA. COVID-19: preparing for superspreader potential among Umrah pilgrims to Saudi Arabia. Lancet (London, England) 2020;395:e48, http://dx.doi.org/10.1016/s0140-6736(20)30466-9.
[48] Oh MD, Choe PG, Oh HS, Park WB, Lee SM, Park J, et al. Middle East respiratory syndrome coronavirus superspreading event involving 81 persons, Korea 2015. J Korean Med Sci 2015;30:1701–5, http://dx.doi.org/10.3346/jkms.2015.30.11.1701.
[49] Shen Z, Ning F, Zhou W, He X, Lin C, Chin DP, et al. Superspreading SARS events, Beijing, 2003. Emerg Infect Dis 2004;10:256–60, http://dx.doi.org/10.3201/eid1002.030732.
[50] Fung IC, Cairncross S. Effectiveness of handwashing in preventing SARS: a review. Trop Med Int Health 2006;11:1749–58, http://dx.doi.org/10.1111/j.1365-3156.2006.01734.x.
[51] Organization WH. Middle East respiratory syndrome coronavirus (MERS-CoV): summary of current situation, literature update and risk assessment. World Health Organization; 2015.
[52] Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. Am J Infect Control 2007;35:S27–64.
[53] Chung SJ, Ling ML, Seto WH, Ang BS, Tambyah PA. Debate on MERS-CoV respiratory precautions: surgical mask or N95 respirators? Singapore Med J 2014;55:294–7, http://dx.doi.org/10.11622/smedj.2014076.
[54] Li Y, Wong T, Chung J, Guo YP, Hu JY, Guan YT, et al. In vivo protective performance of N95 respirator and surgical facemask. Am J Ind Med 2006;49:1056–65, http://dx.doi.org/10.1002/ajim.20395.
[55] Loeb M, McGeer A, Henry B, Ofner M, Rose D, Hlywka T, et al. SARS among critical care nurses, Toronto. Emerg Infect Dis 2004;10:251–5, http://dx.doi.org/10.3201/eid1002.030838.
[56] Ng K, Poon BH, Kiat Puar TH, Shan Quah JL, Loh WJ, Wong YJ, et al. COVID-19 and the risk to health care workers: a case report. Ann Intern Med 2020, http://dx.doi.org/10.7326/l20-0175.
[57] Seto WH, Tsang D, Yung RW, Ching TY, Ng TK, Ho M, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet (London, England) 2003;361:1519–20, http://dx.doi.org/10.1016/s0140-6736(03)13168-6.
[58] Tam CW, Pang EP, Lam LC, Chiu HF. Severe acute respiratory syndrome (SARS) in Hong Kong in 2003: stress and psychological impact among frontline healthcare workers. Psychol Med 2004;34:1197–204, http://dx.doi.org/10.1017/s0033291704002247.
[59] Maunder R. The experience of the 2003 SARS outbreak as a traumatic stress among frontline healthcare workers in Toronto: lessons learned. Philos Trans R Soc Lond Ser B Biol Sci 2004;359:1117–25, http://dx.doi.org/10.1098/rstb.2004.1483.
[60] Oh N, Hong N, Ryu DH, Bae SG, Kam S, Kim KY. Exploring nursing intention, stress, and professionalism in response to infectious disease emergencies: the experience of local public hospital nurses during the 2015 MERS outbreak in South Korea. Asian Nurs Res 2017;11:230–6, http://dx.doi.org/10.1016/j.anr.2017.08.005.
[61] Um DH, Kim JS, Lee HW, Lee SH. Psychological effects on medical doctors from the Middle East Respiratory Syndrome (MERS) outbreak: a comparison of whether they worked at the MERS occurred hospital or not, and whether they participated in MERS diagnosis and treatment. J Korean Neuropsychiatr Assoc 2017;56:28–34.
[62] Li J, Xu J, Zhou H, You H, Wang X, Li Y. The information herein is available for unrestricted use, distribution and reproduction in any medium, provided that the original work is properly cited as indicated by the Creative Commons

Attribution 3.0 Intergovernmental Organizations licence (CC BY IGO 3.0). RECOMMENDED.
[63] Lai J, Ma S, Wang Y, Cai Z, Hu J, Wei N, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. JAMA Network Open 2020;3:e203976.
[64] Jiang Y. Psychological impact and coping strategies of frontline medical staff in hunan between january and march 2020 during the outbreak of coronavirus disease 2019 (COVID-19) in Hubei, China. Med Sci Monit 2020;26:e924171.
[65] Chan AO, Huak CY. Psychological impact of the 2003 severe acute respiratory syndrome outbreak on health care workers in a medium size regional general hospital in Singapore. Occup Med (Oxford, England) 2004;54:190–6, http://dx.doi.org/10.1093/occmed/kqh027.
[66] Lancee WJ, Maunder RG, Goldbloom DS. Prevalence of psychiatric disorders among Toronto hospital workers one to two years after the SARS outbreak. Psychiatr Serv (Washington, DC) 2008;59:91–5, http://dx.doi.org/10.1176/ps.2008.59.1.91.
[67] Lee SM, Kang WS, Cho AR, Kim T, Park JK. Psychological impact of the 2015 MERS outbreak on hospital workers and quarantined hemodialysis patients. Compr Psychiatry 2018;87:123–7, http://dx.doi.org/10.1016/j.comppsych.2018.10.003.
[68] Kim Y, Seo E, Seo Y, Dee V, Hong E. Effects of Middle East respiratory syndrome coronavirus on post-traumatic stress disorder and burnout among registered nurses in South Korea.
[69] Shiao JS, Koh D, Lo LH, Lim MK, Guo YL. Factors predicting nurses' consideration of leaving their job during the SARS outbreak. Nurs Ethics 2007;14:5–17, http://dx.doi.org/10.1177/0969733007071350.
[70] Khan MU, Shah S, Ahmad A, Fatokun O. Knowledge and attitude of healthcare workers about Middle East Respiratory Syndrome in multispecialty hospitals of Qassim, Saudi Arabia. BMC Public Health 2014;14:1281, http://dx.doi.org/10.1186/1471-2458-14-1281.
[71] Koh D, Takahashi K, Lim MK, Imai T, Chia SE, Qian F, et al. SARS risk perception and preventive measures, Singapore and Japan. Emerg Infect Dis 2005;11:641–2, http://dx.doi.org/10.3201/eid1104.040765.
[72] Loh LC, Chelliah A, Ang TH, Ali AM. Change in infection control practices and awareness of hospital medical staff in the aftermath of SARS. Med J Malaysia 2004;59:659–64.
[73] Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD. How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet (London, England) 2020, http://dx.doi.org/10.1016/s0140-6736(20)30567-5.
[74] Heymann DL, Shindo N. COVID-19: what is next for public health? Lancet (London, England) 2020;395:542–5, http://dx.doi.org/10.1016/s0140-6736(20)30374-3.
[75] Wang C, Cheng Z, Yue X-G, McAleer M. Risk management of COVID-19 by universities in China. Multidisciplinary Digital Publishing Institute; 2020.
[76] Paterlini M. On the front lines of coronavirus: the Italian response to covid-19. BMJ (Clin Res Ed.) 2020:368.
[77] Mahase E. Covid-19: 90% of cases will hit NHS over nine week period, chief medical officer warns. British Medical Journal Publishing Group; 2020.