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Epidemiology of and Risk Factors for Coronavirus Infection in Health Care Workers

A Living Rapid Review

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Background: Health care workers (HCWs) are at risk for severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) infection.

Purpose: To examine the burden of SARS-CoV-2, SARS-CoV-1, and Middle Eastern respiratory syndrome (MERS)-CoV on HCWs and risk factors for infection, using rapid and living review methods.

Data Sources: Multiple electronic databases including the WHO Database of Publications on Coronavirus Disease and medRxiv preprint server (2003 through 27 March 2020, with ongoing surveillance through 24 April 2020), and reference lists.

Study Selection: Studies published in any language reporting incidence of or outcomes associated with coronavirus infections in HCWs and studies on the association between risk factors (demographic characteristics, role, exposures, environmental and administrative factors, and personal protective equipment [PPE] use) and HCW infections. New evidence will be incorporated on an ongoing basis by using living review methods.

Data Extraction: One reviewer abstracted data and assessed methodological limitations; verification was done by a second reviewer.

Data Synthesis: 64 studies met inclusion criteria; 43 studies addressed burden of HCW infections (15 on SARS-CoV-2), and 34 studies addressed risk factors (3 on SARS-CoV-2). Health care workers accounted for a significant proportion of coronavirus infections and may experience particularly high infection incidence after unprotected exposures. Illness severity was lower than in non-HCWs. Depression, anxiety, and psychological distress were common in HCWs during the coronavirus disease 2019 outbreak. The strongest evidence on risk factors was on PPE use and decreased infection risk. The association was most consistent for masks but was also observed for gloves, gowns, eye protection, and handwashing; evidence suggested a dose–response relationship. No study evaluated PPE reuse. Certain exposures (such as involvement in intubations, direct patient contact, or contact with bodily secretions) were associated with increased infection risk. Infection control training was associated with decreased risk.

Limitation: There were few studies on risk factors for SARS-CoV-2, the studies had methodological limitations, and streamlined rapid review methods were used.

Conclusion: Health care workers experience significant burdens from coronavirus infections, including SARS-CoV-2. Use of PPE and infection control training are associated with decreased infection risk, and certain exposures are associated with increased risk.

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A cluster of pneumonia cases in Wuhan, China, was first reported to the World Health Organization (WHO) on 31 December 2019 (1). The cause was identified as the novel coronavirus SARS-CoV-2 (2–4), and the disease was named "coronavirus disease 2019" (COVID-2019) (5).

Health care workers (HCWs) are at risk for SARS-CoV-2 infection (6), and reports have described COVID-19 cases in HCWs since early in the outbreak (7). Preventing HCW infections is important for reducing morbidity and potential mortality, maintaining health system capacity, and reducing secondary transmission (8, 9).

This rapid review summarizes the evidence on the burden of and risk factors for SARS-CoV-2 infections in HCWs. The report will be used by WHO to inform the development of evidence-based guidance. Because evidence is limited on SARS-CoV-2, this review also includes 2 coronaviruses associated with earlier pneumonia outbreaks: SARS-CoV-1 (causing severe acute respiratory syndrome [SARS-1]) and MERS-CoV (causing Middle East respiratory syndrome [MERS]).

METHODS

Detailed methods are available in the full report (10). The key questions were developed by WHO with input from the review authors.

Key Question 1. What is the burden of SARS-CoV-2, SARS-CoV-1, and MERS-CoV on HCWs and how do burdens vary according to age, sex, and presence of comorbidities?

Key Question 2. What are the risk factors for HCW infections with SARS-CoV-2, SARS-CoV-1, and MERS-CoV?

Key Question 3. What are the risk factors for household transmission of SARS-CoV-2, SARS-CoV-1, and MERS-CoV from HCWs?

See also:

Editorial comment 1

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Because of the urgent and ongoing need to support WHO's pandemic response, a rapid, living review approach was used (11). Rapid reviews utilize streamlined systematic review processes. For this review, modified methods included 1) protocol not posted to a systematic review registry; 2) a gray literature search limited to 1 website; 3) dual review of 25% of abstracts; 4) critical appraisal not conducted using a formal instrument; and 5) single-reviewer assessment of study limitations and data abstraction, with second reviewer verification. Living reviews use methods for continual updating, as new evidence becomes available (12).

Data Sources and Searches

A medical librarian searched PubMed, MEDLINE, and Elsevier Embase (from 2003 through 27 March 2020). Searches had no language restrictions. Search strategies are shown in Appendix Table 1 (available at Annals.org). We also searched the WHO Database on Coronavirus Disease (13) and the medRxiv preprint server (14) and reviewed reference lists. Daily MEDLINE surveillance and weekly surveillance on EMBASE, the WHO Database on Coronavirus Disease, and the medRxiv server is ongoing; this article includes surveillance through 24 April 2020.

Study Selection

Studies were selected by using predefined criteria (Appendix Table 2, available at Annals.org). The population was HCWs at risk for or with SARS-CoV-2, SARS-CoV-1, or MERS-CoV infection. For key question 1, for SARS-CoV-2, we included cohort studies and case series on incidence and severity of infection, mortality, morbidity (including mental health outcomes), and effects on family members and contacts. For SARS-CoV-1 and MERS-CoV, inclusion was restricted to cohort studies on incidence, infection severity, and mortality. For key question 2, potential risk factors were demographic characteristics, exposure history, administrative factors, health care setting/environmental factors, HCW health, and infection control and prevention factors. We included studies that reported risk estimates or infection incidence stratified by risk factor.

One investigator reviewed each citation for potential full-text review. A second investigator reviewed a 25% random sample of citations; disagreements were resolved through consensus. One investigator reviewed each full-text article for inclusion, and a second verified exclusion decisions. We included non–peer-reviewed articles for SARS-CoV-2 because the peer-reviewed literature was sparse. Chinese-language articles were translated by a review team member who was a native speaker.

Data Extraction

One investigator extracted study data into standardized tables and a second verified data: study author, year, setting (country, health care setting, dates), population characteristics (sample size, age, sex, HCW role/position, number of cases), and results. For key question 2, odds ratios were calculated if necessary and the data were available.

Quality Assessment

We did not perform formal risk for bias assessment. Instead, we noted key limitations of each study, such as potential recall, selection, or participation bias; issues regarding evaluation of outcomes and analytic methods; and confounding (15, 16).

Data Synthesis and Analysis

Results were synthesized narratively. For key question 2, unadjusted and adjusted risk estimates were presented. Quantitative synthesis was not possible owing to methodological limitations; study design variability; and heterogeneity in populations, comparisons, and analytic methods.

Living Review

Surveillance for new studies is ongoing, and study selection and quality assessment will follow the same processes described. New evidence that does not substantively change review conclusions will be briefly summarized on a monthly basis; a major update will be performed when new evidence changes the nature or strength of the conclusions.

Role of the Funding Source

The study was funded by the WHO. Staff at the WHO developed the key questions and review scope but did not have any role in the selection, assessment, or synthesis of evidence. The WHO was not involved in the decision to submit this article for publication.

RESULTS

Sixty-four studies met inclusion criteria (17–48-49–80). The Appendix Figure (available at Annals.org) summarizes the study selection process and number of included studies, by key question and coronavirus type.

Key Question 1: Burden of Coronavirus Infections on HCWs

SARS-CoV-2

One cohort study (61), 9 cross-sectional studies (28, 36, 39, 40, 46, 51, 59, 79, 80) and 5 case series (47, 48, 53, 67, 68) reported on the burden of SARS-CoV-2 in HCWs (Appendix Table 3, available at Annals.org).

Two non–peer-reviewed, retrospective cohort studies reported the proportion of exposed HCWs with polymerase chain reaction (PCR)–confirmed SARS-CoV-2 infection (39, 61). One study evaluated 1353 HCWs in the Netherlands with recent fever or mild respiratory symptoms. Infection with SARS-CoV-2 was present in 6.4% (86 of 1353) of the HCWs; 91.9% (79 of 86) of infections met the COVID-19 case definition. Two HCWs (3.7% [2 of 86]) were hospitalized, with no critical cases or deaths. A second, smaller study of 72 exposed HCWs with acute symptoms in Wuhan, China, reported a COVID-19 incidence of 38.9% (61).

Health care workers accounted for 3.8% (1716 cases) of 44 672 cases of COVID-19 (PCR-confirmed) diagnosed in China through 11 February 2020 (67). The proportion of HCW cases classified as severe or critical was 15% (247 of 1608), and the case-fatality rate was 0.3% (5 of 1716). Health care workers accounted for a higher proportion of cases from 11 to 20 January (5.7%), early in the outbreak when case numbers were increasing sharply. The proportion of cases that were severe or critical was highest from 1 to 10 January (45% [9 of 20]) and lowest after 1 February (8.7% [28 of 322]).

Another non–peer-reviewed study evaluated a large series of 25 961 patients with PCR-confirmed COVID-19 diagnosed in Wuhan, China, through 18 February 2020 (68). Health care workers accounted for 5.1% (1316 of 25 961) of cases. The overall estimated COVID-19 incidence, using epidemiologic data for denominators, was higher in HCWs than the general population (144.7 [95% CI, 137.0 to 152.8] vs. 41.7 [CI 41.2 to 42.2] per 10^6 people) (**Appendix Table 3**).

Three case series reported outcomes of COVID-19 infections in HCWs (47, 48, 53). Two separate series (50 and 64 HCWs) reported on infected HCWs in Wuhan, China (47, 48). The average age (35 years) and proportion female (~65%) were similar. In one study, one third of cases were physicians and two thirds were nurses; this was reversed in the other study. There were no deaths. In one study, 1.6% (1 of 64) of HCWs had severe illness not requiring mechanical ventilation (47). In the other study, 13.3% (4 of 30) met criteria for severe pneumonia and received noninvasive ventilation or nasal high-flow oxygen (48). A limitation of the studies is that 20% and 47% of cases remained hospitalized at outcome assessment. In addition, in 1 study, few cases (25% [7 of 30]) were PCR-confirmed (48). The third study found that 29% (50 of 167) of cases in a U.S. long-term care facility were HCWs (53). The median age was 43.5 years, and 76% were female. Six percent (3 of 50) of HCWs were hospitalized, with no deaths.

Seven cross-sectional studies (16 630 HCWs) evaluated the mental health or sleep quality of HCWs in China during the COVID-2019 outbreak (28, 36, 40, 46, 51, 59, 80). The proportion of HCWs meeting clinically relevant (that is, moderate or severe) thresholds was 14% to 15% for depression (40, 80), 12% to 24% for anxiety (40, 46, 80), 30% to 39% for psychological distress (28, 40, 80), 8% to 60% for sleep issues (40, 59), and 29% (36) for a composite mental health outcome. Female sex (28, 40, 80) and direct contact with cases (40, 46, 51, 80) were associated with increased likelihood of mental health issues; effect of HCW role on risk was inconsistent (28, 36, 80). Methodological limitations included no baseline symptom information, no non-HCW comparison groups, and not controlling for work exposures. One cross-sectional study (843 persons) found a high prevalence of anxiety (34%) and psychological distress (29%) in family members of HCWs (79).

No study reported the social or economic effects of SARS-CoV-2 infection in HCWs or the incidence of HCW transmission to close contacts.

SARS-CoV-1

Fourteen cohort studies (25, 30, 32–35, 43, 45, 50, 57, 60, 64, 69, 74), 1 cross-sectional study (27), and 1 case series (44) reported on the burden of SARS-CoV-1 in HCWs (**Appendix Table 3**). We also included WHO data (81).

The prevalence of SARS-CoV-1 seropositivity in exposed or potentially exposed HCWs ranged from 0.3% to 40% in 6 studies (25, 27, 33, 57, 60, 69), and SARS-1 incidence ranged from 1.2% to 29.4% in 14 studies (25, 30, 32–35, 43, 45, 50, 57, 60, 64, 69, 74). The highest SARS-1 incidence (29.4%) occurred in a large outbreak in Vietnam in a hospital without an isolation ward (57). In addition, infection control measures were not initiated owing to unawareness of the index SARS-1 case. Another study reporting high incidence focused on critical care nurses in Canada who cared for patients with SARS-1 with unstandardized PPE use, often before knowing patients' infection status (50).

Health care workers accounted for 21% (1706 of 8096) of all SARS-1 cases reported to WHO (**Appendix Table 4**, available at Annals.org). Among countries with at least 50 cases, HCWs accounted for 19% (China) to 57% (Vietnam). Among all (n = 1755) SARS-1 cases from Hong Kong, the case-fatality rate in HCWs was 2.0% (8 of 405), compared with 21.8% (294 of 1350) in non-HCWs (adjusted OR, 0.3 [CI, 0.1 to 0.7]) (**Appendix Table 3**) (44).

MERS-CoV

Seven cohort studies (18, 19, 21, 37, 38, 63, 71), 4 case series (17, 20, 22, 29), and 1 cross-sectional study (54) reported on the burden of MERS in HCWs (**Appendix Table 3**). We also utilized WHO data (82).

In 3 studies with at least 500 HCWs (3311 HCWs in total), the proportion with MERS-CoV infection ranged from 1.12% to 2.0% (21, 37, 54). In 5 smaller studies (9 to 283 HCWs), the proportion ranged from 0% to 7.1% (18, 19, 38, 63, 71).

As of December 2019, HCWs accounted for 19.1% (402 of 2106) of laboratory-confirmed cases of MERS in Saudi Arabia, which accounts for 84% of cases (**Appendix Table 4**) (82). Globally, among the 651 MERS cases diagnosed in July to December, 14% to 18% were HCWs in 2014 and 2015 and 0 to 4% in 2018 and 2019.

An analysis of all cases of MERS in HCWs reported to WHO found an overall case-fatality rate of 5.8% (24 of 415); excluding primary cases, mortality was slightly lower (4.7%) (29). These figures are lower than the overall MERS case-fatality rate (34.4%) (82). Two smaller case series (166 and 105 HCWs) reported HCW case-fatality rates of 3.0% and 16% (17, 20). Studies that directly compared MERS mortality in HCWs versus non-HCWs also reported lower mortality risk in HCWs (17, 20, 22). In the largest analysis (2260 HCWs), the adjusted OR was 0.07 (CI, 0.001 to 0.35) (22). Factors associated with increased mortality risk in HCWs are older age and presence of comorbid conditions (22, 29).

Key Question 2: Risk Factors for Coronavirus Infection in HCWs

SARS-CoV-2

Three retrospective cohort studies evaluated risk factors for COVID-19 in exposed HCWs (**Appendix Ta-**

ble 5, available at Annals.org) (55, 61, 70). One study evaluated risk factors for COVID-19 in 72 exposed HCWs (clinicians and nurses) in Wuhan, China, who had acute symptoms (61). The median age was 31 years, and 69% of HCWs were female; PCR-confirmed COVID-19 occurred in 38.9% (28 of 72 HCWs). Risk factors were working in a high risk versus general department (relative risk [RR], 2.13 [CI, 1.45 to 3.95]), suboptimal handwashing before or after patient contact (RR, 3.10 [CI, 1.43 to 6.73] and 2.82 [CI, 1.11 to 7.18], respectively), longer work hours (log-rank P = 0.02), and improper PPE use (RR, 2.82 [CI, 1.11 to 7.18]). Such procedures as endotracheal tube removal, cardiopulmonary resuscitation, fiberoptic bronchoscopy, and sputum suction were not associated with increased risk. Having a diagnosed family member was associated with increased risk (RR, 2.76 [CI 2.02 to 3.77]), suggesting that some HCW infections may have been acquired outside the hospital. The study was susceptible to recall bias, it was unclear whether risk estimates were adjusted, and some estimates were imprecise.

Another study evaluated 41 HCWs exposed to a patient with COVID-19 and an aerosol-generating procedure for 10 or more minutes at a distance of 2 meters or less (55). Eighty-five percent of HCWs used a surgical mask, and 15% used an N95 respirator. No COVID-19 cases occurred; therefore, it was not possible to draw conclusions about effects of mask type. One other study reported a strong association between N95 respirator use and decreased COVID-19 risk, but had serious limitations (70). Mask use was based on the department worked (not on individual use), departments varied in other infection control measures (such as handwashing), and estimates were very imprecise.

SARS-CoV-1

Seventeen cohort studies (23, 25, 30, 32–35, 43, 45, 50, 57, 60, 64, 69, 72, 75, 77), 11 case–control studies (26, 41, 49, 52, 56, 58, 62, 65, 66, 76), and one cross-sectional study (27) evaluated risk factors for SARS-CoV-1 infection in HCWs (Appendix Table 5). Seven studies evaluated risk for SARS-CoV-1 seropositivity, not necessarily meeting the SARS-1 case definition (25–27, 33, 60, 69, 72). The remainder evaluated risk for SARS-1 meeting the case definition, usually with laboratory confirmation. Ten studies reported adjusted risk estimates from multivariate models (26, 41, 49, 52, 57, 58, 60, 66, 76, 78). Of these, 2 studies evaluated correlations between risk factors (for example, between use of different types of PPE) to inform variable selection for model building (49, 76). All studies except for 1 (32) were retrospective. The studies were limited in their ability to measure and control for the amount and intensity of exposures.

Age and Sex. Six studies indicated no association between sex and risk for SARS-CoV-1 infection in HCWs (Appendix Table 6, available at Annals.org) (27, 56, 60, 66, 69). One study found no association between age and risk for SARS-CoV-1 infections after controlling for other factors (adjusted OR, 0.97 [CI, 0.90 to 1.03]) (57). Five other studies that did not control for confounders also found no association between age and risk for SARS-CoV-1 infection (27, 56, 60, 66).

Professional Profile. Twelve studies reported SARS-CoV-2 infection incidence by HCW role (Appendix Table 6) (25, 27, 30, 32, 34, 43, 52, 56, 57, 60, 69). Infections occurred in HCWs across various clinical and nonclinical (including nonpatient contact) roles. There was no consistent difference in risk between nurses and physicians, the most commonly evaluated HCW roles, based on 12 studies (25, 27, 30, 32, 34, 43, 45, 52, 56, 57, 60, 69). There were too few studies and cases to determine risks for other HCW roles relative to nurses and physicians.

Exposure History. Exposure during endotracheal intubation was strongly and consistently associated with increased risk for HCW SARS-CoV-1 infections in 6 studies (Table 1) (26, 30, 49, 50, 58, 60). Of these, 4 studies found exposure during endotracheal intubation to be independently associated with risk (26, 30, 58, 60). One study (50) found oxygen mask manipulation to be associated with increased risk for infection in a univariate analysis, but 2 other studies (60, 66) found that oxygen mask manipulation or oxygen administration were not independent predictors. Few studies evaluated risks associated with other procedures involving oxygen administration, such as noninvasive positive-pressure ventilation (30, 50, 60), high-frequency oscillatory ventilation (30), nebulizer treatment (50, 60), manual ventilation (50), high-flow oxygen (60), or mechanical ventilation (60), and estimates were often imprecise. Other procedures associated with increased risk but only evaluated in 1 or 2 studies each were electrocardiography (50, 60), chest compressions (49, 60), and suctioning before intubation (50). In most studies, direct patient contact was associated with increased risk compared with less direct contact, though some inconsistency was present (26, 33, 41, 49, 57, 58, 62, 66, 72). Other exposures associated with increased risk for infections in HCWs were exposure of eyes or mucous membranes to patient bodily fluids (60, 64), contact with more severely ill patients (60), contact with a "super spreading" patient (26), closer proximity to infected patients (58, 62, 64, 75), and contact with respiratory secretions (49, 52). Evidence on the association between duration of contact with patients and risk for infection was inconsistent (52, 60, 64, 66).

Administrative Factors. One study found administrative measures (having a crisis response team, exclusion of visitors, or provision of administrative support) and PPE use policies (requiring N95 respirator in the emergency department, within certain hospital zones, or on entering the hospital) were not associated with risk for HCW infections (Appendix Table 7, available at Annals.org) (76). Another study (with the same lead author) found a lower incidence of HCW infections in a hospital in which an integrated infection control strategy was implemented compared with 86 control hospitals, but did not control for use of infection control measures or degree of SARS-1 exposure (77).

Health Care Setting and Environmental Factors. One study of hospitals found installation of a fever screen station outside of the emergency department and alco-

Table 1. Exposure History and Risk for Infection With SARS-CoV-2, SARS-CoV-1, or MERS-CoV in HCWs*

Author, Year (Reference)	Intubation	Directness of Contact	Oxygen Administration and Related Exposures	Number or Duration of Contacts and Proximity to Patient	Other Exposures
SARS-CoV-2					
Ran et al, 2020 (61)	Endotracheal tube removal: RR, 0.63 (95% CI, 0.06–7.08)	–	–	–	CPR: RR, 0.63 (95% CI, 0.06–7.08) Fiberoptic bronchoscopy: RR, 0.63 (95% CI, 0.06–7.08)
SARS-CoV-1					
Chen et al, 2009 (26)	Performing endotracheal intubation vs. not: adjusted ***OR, 2.76 (95% CI, 1.16–6.53)***	Avoiding face to face contact (reference never) Sometimes: adjusted OR, 0.67 (95% CI, 0.36–1.24) Often: ***adjusted OR, 0.30 (95% CI, 0.10–0.90)*** Every time: ***adjusted OR, 0.30 (95% CI, 0.15–0.60)***	–	–	Caring for "super spreading" patient vs. not: ***adjusted OR, 3.57 (95% CI, 1.94-6.57)*** Performing tracheostomy (yes vs. no): ***OR, 4.15 (95% CI, 1.50-11.50)†***
Fowler et al, 2004 (30)	Any involvement in intubation vs. no involvement: ***adjusted OR, 13.29 (95% CI, 2.99–59.04)***	–	Patient treated with noninvasive positive-pressure vs. conventional ventilation: adjusted OR, 2.33 (95% CI, 0.25–21.76) Patient treated with high-frequency oscillatory vs. conventional ventilation: adjusted OR, 0.74 (95% CI, 0.11–4.92)	–	–
Ho et al, 2004 (33)	–	Exposure only vs. direct contact: RR, 2.40 (95% CI, 0.64–9.00)	–	–	–
Lau et al, 2004 (41)	–	Direct contact with SARS-1 patients (yes vs. no): OR, 0.57 (95% CI, 0.28–1.14)†	–	–	–
Liu et al, 2009 (49)	Contact: intubation (yes vs. no): ***50.0% vs. 9.7%; P < 0.001†***	Contact: physical contact (yes vs. no): 11.3% vs. 10.3%; *P* = 0.75†	–	–	Contact with respiratory secretion vs. no contact: ***adjusted OR, 3.27 (95% CI, 1.41–7.57)*** Chest compression vs. no contact: ***adjusted OR, 4.52 (95% CI, 1.08–18.81)*** Contact with sputum vs. no contact: ***18.0% vs. 8.2%; P = 0.004†*** Contact with feces vs. no contact: 12.7% vs. 10.1%; *P* = 0.45† Contact with urine vs. no contact: 11.8% vs. 10.4%; *P* = 0.66†

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Table 1—Continued

Author, Year (Reference)	Intubation	Directness of Contact	Oxygen Administration and Related Exposures	Number or Duration of Contacts and Proximity to Patient	Other Exposures
Loeb et al, 2004 (50)	Intubation (yes vs. no): ***RR, 4.20 (95% CI, 1.58–11.14)*** Suctioning before intubation (yes vs. no): ***RR, 4.20 (95% CI, 1.58–11.14)*** Suctioning after intubation (yes vs. no): RR, 0.68 (0.21-2.26)	–	Manipulation of oxygen mask (yes vs. no): RR, 9.00 (95% CI, 1.00–64.89) Nebulizer treatment (yes vs. no): ***RR, 3.24 (95% CI, 1.11–9.42)*** Manual ventilation (yes vs. no): RR, 1.19 (95% CI, 0.30–4.65) Manipulation of BiPAP mask (yes vs. no): RR, 2.60 (95% CI, 0.8–7.99)	–	Performing ECG (yes vs. no): RR, 1.67 (95% CI, 0.51–5.46) Endotracheal aspirate (yes vs. no): RR, 1.00 (95% CI, 0.29–3.45) Bronchoscopy: RR, 2.14 (95% CI, 0.46–9.90)
Ma et al, 2004 (52)	–	–	–	Accumulated contact days: ***OR, 0.83 (95% CI, 0.80–0.86)†*** Average number of patients contacted each day: ***OR, 0.73 (95% CI, 0.66–0.80)†*** Average hours working in the isolation room each day: ***OR, 0.73 (95% CI, 0.68–0.78)†***; maximum hours: ***OR, 0.79 (95% CI, 0.75–0.83)†*** Average hours working in the contaminated area each day: ***OR, 0.67 (95% CI, 0.61–0.72)†***; maximum hours: ***OR, 0.76 (95% CI, 0.71–0.80)†***	Exposure to secretions vs not: ***adjusted OR, 4.70 (95% CI, 1.84–11.97)*** Daily care with and contact with patients' secretions: ***adjusted OR, 3.02 (95% CI, 1.23–7.46)***
Nishiyama et al, 2008 (57)	–	Indirect contact with SARS patient vs. direct contact: adjusted OR, 6.06 (95% CI, 0.63–58.7)	–	–	–
Pei et al, 2006 (58)	Endotracheal intubation vs. no intubation: ***adjusted OR, 30.79 (95% CI, 7.91–119.84)***	Avoiding face to face contact with patients (yes vs. no): ***adjusted OR, 0.29 (95% CI, 0.13–0.64)†***	–	Keeping a certain distance from patients with SARS-1 (yes vs. no): ***OR, 0.45 (95% CI, 0.28–0.73)†***	–
Raboud et al, 2010 (60)	Present during intubation vs. not: ***adjusted OR, 2.79 (95% CI, 1.40–5.58)***	–	Noninvasive ventilation (yes vs. no): ***OR, 3.15 (95% CI, 1.39–7.15)†*** High-flow oxygen (yes vs. no): OR, 0.39 (95% CI, 0.09–1.66)† Mechanical ventilation (yes vs. no): OR, 0.87 (95% CI, 0.38–1.97)† Nebulizer treatment (yes vs. no): OR, 1.17 (95% CI, 0.07–20.66)† Manipulation of oxygen mask (yes vs. no): OR, 2.15 (95% CI, 0.94–4.89)† Present during manual ventilation or not, before intubation: ***OR, 2.84 (95% CI, 1.25–6.42)†***; after intubation: OR, 1.27 (95% CI, 0.50–3.24)†	Number of times entering patient's room, based on number of shifts with exposure (reference, >10 times)† • 1–2 times: OR, 0.67 (0.28–1.63) • 3–5 times: OR, 0.69 (0.39–1.23) • 6–10 times: OR, 0.41 (0.14–1.20) Duration of face-to-face contact with patient, based on number of shifts with exposure (reference, >4 h)† • <1 min: OR, 0.83 (0.11–6.27) • 1–10 min: OR, 0.98 (0.26–3.71) • 11–30 min: OR, 1.33 (0.20-8.88) • 31-60 min: OR, 2.73 (0.33–22.5) • 1-4 h: OR, 2.37 (0.41–13.6)	Eye/mucous membranes exposed to body fluids: ***adjusted OR, 7.34 (95% CI, 2.19–24.52)*** Present during ECG: ***adjusted OR, 3.52 (95% CI, 1.58–7.86)*** Present during suctioning or not, before intubation: OR, 1.71 (95% CI, 0.70–4.17)†; after intubation: OR, 1.79 (95% CI, 0.79–4.02)† Cardiac compressions (yes vs. no): OR, 2.95 (95% CI, 0.36–24.50)† Sputum sample collection (yes vs. no): OR, 2.68 (95% CI, 0.88–8.17)†

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Table 1—Continued

Author, Year (Reference)	Intubation	Directness of Contact	Oxygen Administration and Related Exposures	Number or Duration of Contacts and Proximity to Patient	Other Exposures
Reynolds et al, 2006 (62)	–	Touched index patient: OR, 2.8 (95% CI, 0.9–8.5) Spoke with index patient in his room: ***OR, 3.7 (95% CI, 1.1–12.6)***	–	Came within 1 meter of index patient: ***OR, 9.3 (95% CI, 2.8–30.9)*** Entered patient room: ***OR, 20.0 (95% CI, 4.1–97.1)*** Visited patient room when patient was not there: ***OR, 3.7 (95% CI, 1.3–10.9)***	Touched visibly contaminated surface: ***OR, 7.8 (95% CI, 2.3–25.9)*** Entered general ward: ***OR, 8.0 (95% CI, 1.7–38.4)*** Saw (viewed) index patient: ***OR, 14.0 (95% CI, 3.6–55.3)***
Scales et al, 2003 (64)	–	–	–	Contact duration: • ≤10 min: 0% (0/11) • 11–30 min: 12.5% (1/8) • 31 min–4 h: 25% (2/8) • ≥4 h: 75% (3/4)	–
Teleman et al, 2004 (66)	Performed/assisted in intubation (yes vs. no): OR, 1.5 (95% CI, 0.4–5.4)†	Touched patients (yes vs. no): OR, 1.0 (95% CI, 0.4–3.0)†	Administered oxygen (yes vs. no): OR, 1.01 (95% CI, 0.4–2.8)†	Distance to source infection <1 m vs. ≥1 m: OR, 0.9 (95% CI, 0.2–3.6)† Duration of exposure ≥60 min vs. <60 min: OR, 0.7 (95% CI, 0.3–1.6)†	Contact with respiratory secretions: ***adjusted OR, 21.8 (1.7–274.8)*** Touched patients' personal belongings (yes vs. no): OR, 0.6 (95% CI, 0.2–1.7)† Performed suction of body fluids (yes vs. no): OR, 1.01 (95% CI, 0.4–2.8)†
Wilder-Smith et al, 2005 (72)	–	–	–	Close contact with SARS-1 patient (yes or no): OR, 1.11 (95% CI, 0.23–5.26)	–
Wong et al, 2004 (75)	–	–	–	Definitely visited patient's cubicle vs. did not: RR, 7.4 (95% CI, 1.0–53.5); association between distance from patient and likelihood of infection	–
MERS-CoV					
Alraddadi et al, 2016 (19)	Intubation (yes vs. no): RR, 0.66 (95% CI, 0.27–1.63)†	Exposure to a patient with MERS-CoV (yes vs. no): RR, 1.38 (95% CI, 0.20–9.72)† Same room or <2 meters from any hospitalized patient with pneumonia or respiratory illness (yes vs. no): RR, 1.16 (95% CI, 0.28–4.80)	Manipulation of oxygen face mask or tubing (yes vs. no): RR, 0.92 (95% CI, 0.37–2.33)† Airway suction (yes vs. no): RR, 0.67 (95% CI, 0.29–1.60)† Noninvasive ventilation (yes vs. no): RR, 1.02 (95% CI, 0.43–2.41)† Manual ventilation (yes vs. no): RR, 0.53 (95% CI, 0.20–1.42)† Nebulizer treatments (yes vs. no): RR, 1.05 (95% CI, 0.45–2.50)†	Not statistically significant in univariate analyses: time spent in MERS patient's room, number of MERS patients cared for	Cardiopulmonary resuscitation (yes vs. no): RR, 0.73 (95% CI, 0.29–1.84)† Tracheostomy care (yes vs. no): RR, 1.10 (95% CI, 0.41–2.91)† Any aerosol-generating procedure (yes vs. no): RR, 1.13 (95% CI, 0.39–3.27)† Chest tube insertion or removal (yes vs. no): 0% vs. 9.3%, *P* = 0.23 Not statistically significant in univariate analyses: other clinical exposures, handling of MERS patient bedding or bodily fluids

CoV = coronavirus; CPR = cardiopulmonary resuscitation; ECG = electrocardiography; HCW = health care worker; OR = odds ratio; RR = relative risk; MERS = Middle East respiratory syndrome; SARS = severe acute respiratory syndrome.
* Values in boldface and italics indicate a statistically significant difference between groups.
† Variable not included in a multivariate model.

hol dispensers for hand sanitation to be associated with decreased likelihood of HCW SARS-1 infections (adjusted OR, 0.05 [CI, 0.004 to 0.692] and 0.043 [CI, 0.003 to 0.63], respectively) (**Appendix Table 7**) (76). One study found a higher risk for infections in the emergency department compared with hospital wards (69), and 1 study reported HCW infections in multiple hospital departments (27). Natural air ventilation was associated with decreased risk for SARS-CoV-1 infection versus artificial ventilation in 1 study (adjusted OR, 0.40 [CI, 0.18 to 0.88]) (26); another study found a well-ventilated office to be associated with a non–statistically significant decreased risk (adjusted OR, 0.32 [CI, 0.09 to 1.15]) (58). One study attempted to assess physical aspects of the hospital ward and risk for SARS-1 infection in HCWs, but only evaluated 4 wards, with many confounding factors (35).

HCW Health. Two studies found no association between presence of comorbid conditions in HCWs and SARS-CoV-1 infection risk (60, 66). One study found having an upper respiratory infection in the past 6 months to be associated with decreased risk for SARS-CoV-1 infection (62). Another study found an HCW history of to be diabetes associated with increased univariate risk for infection, but it was not an independent predictor (58).

Infection Prevention and Control Factors. The most consistent and robust evidence on PPE measures was on the association between use of masks and decreased infection risk (**Table 2**) (26, 41, 49, 50, 52, 56–58, 60, 65, 66, 72, 78). Four studies found N95 respirators to be associated with decreased risk versus surgical masks in unadjusted analyses (23, 49, 50, 60). Evidence was inconsistent on the effectiveness of multiple masks versus a single mask (26, 49). Most studies found an association between use of gloves (49, 50, 56, 58, 60, 65, 66, 72, 78), gowns (41, 50, 52, 56, 60, 65, 66, 78), eye protection (23, 26, 41, 49, 52, 58, 60, 78), or shoe covers (26, 78) and decreased risk for HCW infections (**Table 3**). In some studies, individual PPE measures were not included in multivariate models, but information on the degree of correlation between PPE measures was lacking. When evaluated as "inconsistent use of more than one type of PPE," 1 study found a strong, independent association with increased risk for HCW infection (adjusted OR 5.06, 95% CI 5.06 to 598.92) (41). Studies also found full PPE use (gloves, mask, gown, and eye protection) to be associated with reduced infection risk versus partial PPE (33, 56, 65, 78); some studies found a dose–response relationship between more frequent or consistent PPE use and decreased risk (26, 33, 41, 78). Handwashing was associated with decreased risk for SARS-CoV-1 infection in most studies (41, 52, 56, 57, 65, 66, 72), but there was no association in others (26, 56), and handwashing was not included in some multivariate models (26, 52). Nasal washing was not independently associated with decreased risk for infection in HCWs in 3 studies (26, 49, 52). No study evaluated the association between reuse of PPE and infection risk. One study found perceived inadequacy of PPE supplies associated with increased risk for HCW infections (41). Infection control training and education were consistently associated with decreased infection risk, though this finding was not always retained in multivariate models (**Table 3**) (26, 41, 49, 57, 58).

MERS-CoV

One retrospective cohort study of 283 HCWs at a Saudi Arabian hospital found participation in MERS-CoV training to be associated with decreased risk for MERS-CoV seropositivity (adjusted RR, 0.33 [CI 0.12 to 0.90]) (**Appendix Table 7**) (19). Cases occurred almost exclusively among HCWs with close contact with patients with MERS. Always using an N95 respirator was associated with a non–statistically significant decreased risk compared with some or no use (adjusted RR, 0.44 [CI, 0.15 to 1.24]). Past or current smoking was associated with a nonstatistically increased risk for infection.

Another study evaluated risk factors for MERS-CoV seropositivity in 737 HCWs who had direct contact with a patient with MERS in 31 hospitals in South Korea (37), but only reported 2 cases in HCWs (both of whom had not used appropriate PPE).

Key Question 3: Risk Factors for Transmission of Coronavirus Infection From HCWs

No study evaluated risk factors for transmission of coronavirus infections from HCWs to household or other close contacts. Four studies (24, 31, 42, 73) that did not evaluate risk factors for HCW transmission but compared SARS-CoV-1 transmission incidence from HCWs versus non-HCWs to household contacts are described in the full report (10).

DISCUSSION

This rapid, living review summarizes the evidence on the burden of and risk factors for HCW coronavirus infections. Health care workers account for a significant proportion of infections in these outbreaks. Exposed HCWs may experience a high incidence of infections, particularly for unprotected and repeated exposures, though they appear to experience less severe illness and mortality than non-HCWs, possibly related to younger age and fewer comorbid conditions. Evidence that depression, anxiety, and psychological distress are common in HCWs in the COVID-19 outbreak is consistent with findings from the SARS-1 outbreak (83–90). Evidence on risk factors for coronavirus infections in HCWs is primarily available for SARS-CoV-1, with the strongest evidence indicating an association between PPE use versus nonuse and decreased risk. The association was most consistent for masks but was also observed for gloves, gowns, and eye protection, as well as handwashing. There was evidence that more consistent and full use of recommended PPE measures was associated with decreased risk for infection, suggesting a dose–response relationship, and evidence that N95 respirators might be associated with decreased risk for infection versus surgical masks. Evidence also indicated an association between certain exposures (such as involvement in intubations, direct contact with infected

Table 2. Mask Use and Risk for Infection With SARS-CoV-2, SARS-CoV-1, or MERS-CoV in HCWs*

Author, Year (Reference)	Mask Use Versus Nonuse	Comparison of Mask Types	Consistency of Mask Use	Multiple Mask Layers Versus Single Layer
SARS-CoV-2				
Wang et al, 2020 (70)	In department with N95 mask use (yes vs. no): ***OR, 0.04 (95% CI, 0.002–0.61)†***; ***adjusted OR, 0.002 (95% CI, 0–0.21)*** (note: reversed from no vs. yes as reported in study, for which the 95% CI, was 97.73–∞)	–	–	–
Caputo et al, 2006 (23)	–	N95 or N95 equivalent vs. surgical mask: OR, 0.12 (95% CI, 0.01–1.92)*	–	–
Chen et al, 2009 (26)	–	–	–	Double-layer vs. single-layer cotton masks: ***OR, 0.40 (95% CI, 0.25–0.64)†***
Lau et al, 2004 (41)	–	–	Consistent N95 or surgical mask use vs. inconsistent use: • All HCWs: ***OR, 0.27 (95% CI, 0.08–0.95)†*** • Direct contact with SARS-1 patient: ***OR, 0.50 (95% CI, 0–20)*** (note: reversed from inconsistent vs. consistent as reported in study, 95% CI, 0.05–∞) • Direct patient contact in general: OR, 0.25 (95% CI, 0.004–4.76) • No patient contact: OR, 0.41 (0.06–2.44)† Consistent N95 mask use vs. inconsistent† • All HCWs: ***OR, 0.48 (95% CI, 0.25–0.93)†*** • Direct contact with SARS-1 patient: OR, 0.35 (95% CI, 0.07–1.43)† • Direct patient contact in general: OR, 0.78 (95% CI, 0.10–6.25)† • No patient contact: OR, 0.55 (95% CI, 0.21–1.39)†	–
Liu et al, 2009 (49)	• 12-layer cotton surgical mask (yes vs. no): OR, 0.50 (95% CI, 0.23-1.10); ***adjusted 0.22 (95% CI, 0.08–0.62)†*** • 16-layer cotton surgical mask (yes vs. no): ***OR, 0.27 (95% CI, 0.14–0.51); adjusted OR, 0.17 (95% CI, 0.07–0.41)†*** • N95 mask (yes vs. no): 0.52 (95% CI, 0.12–2.24); adjusted OR, 0.52 (95% CI, 0.12–2.24) • Disposable mask (yes vs. no): OR, 1.12 (95% CI, 0.55–2.27) *Not in model: disposable mask, glasses, gloves, goggles*	• N95 vs. 12- or 16-layer cotton surgical mask: OR, 1.05 (95% CI, 0.24–4.66) • N95 vs. disposable mask: OR, 0.49 (95% CI, 0.10–2.35) • Disposable vs. 12- or 16-layer cotton surgical mask: OR, 2.13 (95% CI, 1.00–4.54)	–	Multiple layers of masks (yes vs. no): ***adjusted OR, 0.41 (95% CI, 0.17–0.97)†***
Loeb et al, 2004 (50)	Surgical mask vs. no mask: RR, 0.45 (95% CI, 0.07–2.71)	N95 vs. surgical mask: RR, 0.50 (95% CI, 0.06–4.23)	• Consistent N95 or surgical mask vs. inconsistent mask: ***RR, 0.23 (95% CI, 0.07–0.78)*** • Consistent N95 vs. inconsistent mask: ***RR, 0.22 (95% CI, 0.05–0.93)***	–
Ma et al, 2004 (52)	Mask use vs. no mask: ***OR, 0.24 (95% CI, 0.009–0.64)***	• Disposable vs. ≤12 layer: ***OR, 0.13 (95% CI, 0.05–0.34)*** • >16 layer vs. ≤12 layer : ***OR, 0.06 (95% CI, 0.03–0.15)***	–	–

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Table 2—Continued

Author, Year (Reference)	Mask Use Versus Nonuse	Comparison of Mask Types	Consistency of Mask Use	Multiple Mask Layers Versus Single Layer
		• N95 and respirator vs. ≤12 layer: *OR, 0.00 (95% CI, 0.00–0.33)* • ≤12 layer vs. others: *adjusted OR, 76.68 (95% CI, 16.74–351.31)*		
Nishiura et al, 2005 (56)	Mask use vs. no mask: • Period 1 (26 February–4 March 2003): *OR, 0.3 (95% CI, 0.1–0.7)* • Period 2 (5–10 March 2003): *OR, 0.1 (95% CI, 0.0–0.3)*	–	–	–
Nishiyama et al, 2008 (57)	Mask use, always vs. no: *adjusted OR, 0.38 (95% CI, 0.01–0.50)*	–	Sometimes vs. always: adjusted OR, 0.34 (95% CI, 0.09–1.37)†	–
Pei et al, 2006 (58)	General cotton mask vs. no mask: *OR, 0.48 (95% CI, 0.25-0.95)* Double 12-layer cotton mask vs. no mask: *OR, 0.13 (95% CI, 0.05–0.30)*	–	–	–
Raboud et al, 2010 (60)	Surgical mask in patient room vs. no mask (reference): OR, 3.27 (95% CI, 0.72–14.79) N95 or equivalent: OR, 0.59 (95% CI, 0.17–2.08) Higher protection than N95: OR, 0.25 (95% CI, 0.01–4.98)	N95 or N95 equal vs. surgical mask: *OR, 0.18 (95% CI, 0.06–0.53)**	–	–
Seto et al, 2003 (65)	Mask use vs. nonuse: OR, *0.08 (95% CI, 0.02–0.33)*† • Paper mask use vs. nonuse: OR, 0.50 (95% CI, 0.10–2.42) • Surgical mask use vs. nonuse: OR, 0.06 (95% CI, 0.004–1.06) • N95 mask use vs. nonuse: *OR, 0.003 (95% CI, 0.002–0.59)*	Number of cases by mask type: • Paper mask: 7.1% (2/28) Surgical mask: 0% (0/51) N95: 0% (0/92)	–	–
Teleman et al, 2004 (66)	Wearing N95 mask vs. not wearing: *OR, 0.1 (95% CI, 0.03–0.4)*; *adjusted OR, 0.1 (95% CI, 0.02–0.9)*	–	–	–
Wilder-Smith et al, 2005 (72)	Mask use vs. no mask: *OR, 0.25 (95% CI, 0.09–0.69)**	–	–	–
Yin et al, 2004 (78)	Mask vs. no mask: *OR, 0.08 (95% CI, 0.01–0.43)* • Disposable mask vs. no mask: OR, 0.22 (95% CI, 0.02–1.29) • ≥12-layer mask vs. no mask: *OR, 0.07 (95% CI, 0.01–0.34)*; *adjusted OR, 0.78 (95% CI, 0.60–0.99)*	Disposable mask vs. ≥12 layer mask: *OR, 3.39 (95% CI, 1.72–6.67)*	–	–
MERS-CoV				
Alradaddi et al, 2016 (19)	–	–	Medical mask or N95 respirator, direct contact (use always vs. sometimes/never): RR, 0.69 (95% CI, 0.28–1.69) • Medical mask: RR, 2.06 (95% CI, 0.86–4.95) • N95: RR, 0.44 (95% CI, 0.17–1.12)	–

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Table 2—Continued

Author, Year (Reference)	Mask Use Versus Nonuse	Comparison of Mask Types	Consistency of Mask Use	Multiple Mask Layers Versus Single Layer
			Medical mask or N95 respirator, aerosol-generating procedure (use always vs. sometimes/never): ***RR, 0.32 (95% CI, 0.12–0.86)*** • Medical mask: RR, 0.59 (95% CI, 0.20–1.71) • N95: RR, 0.45 (95% CI, 0.16–1.29); adjusted RR, 0.44 (95% CI, 0.15–1.24) (medical mask almost always worn in sometimes or never group)	

CoV = coronavirus; HCW = health care worker; OR = odds ratio; RR = relative risk; MERS = Middle East respiratory syndrome; SARS = severe acute respiratory syndrome.
* Values in boldface and italics indicate a statistically significant difference between groups.
† Comparison was reversed.

patients, or contact with bodily secretions) and increased infection risk. Education and training in infection control measures were consistently associated with decreased risk for HCW infections.

Our findings are generally consistent with prior reviews on risk factors for respiratory infections in HCWs, including PPE use (91–96). It differs from prior reviews by including recent evidence on risk factors (including those related to SARS-CoV-2 infections), focusing on coronavirus infections, excluding surrogate markers for transmission risk, evaluating a broader array of potential risk factors, and including a more comprehensive set of relevant studies. In addition, we implemented living review processes to incorporate new evidence on an ongoing basis.

The evidence base has important limitations. The evidence on SARS-CoV-2 infections in HCWs is sparse and has methodological limitations. Many studies on the burden of SARS-CoV-2 infections are case series and epidemiologic evaluations; evaluations of clinical cohorts of exposed HCWs are lacking. Studies on SARS-CoV-2 infections in HCWs that reported mental health or sleep outcomes used a cross-sectional design, did not control for baseline status, and did not include a non-HCW comparison group. Almost all studies on risk factors were retrospective and susceptible to recall bias with regard to PPE use and other factors. Some risk factor studies did not control for confounders, and those that did had limited ability to control for exposure intensity and frequency. Few studies that analyzed risk factors in multivariate models addressed collinearity (97), complicating interpretation for potentially correlated risk factors (for example, use of different types of PPE). Case–control studies did not match cases and controls on such factors as age, sex, or HCW role. Applicability of evidence on SARS-CoV-1 and MERS-CoV infections to SARS-CoV-2 is uncertain, owing to decreased transmission propensity, greater illness severity, or variability in affected populations. Most evidence on SARS-CoV-2 in HCWs is from China; studies from other settings, including those with decreased availability or use of infection prevention and control measures, are needed.

The review process had limitations, in particular the use of streamlined rapid review methods for searching and selecting studies. We did not assess study quality by using a formal instrument, though key methodological limitations were highlighted. We included non–peer-reviewed studies on SARS-CoV-2 infection in HCWs, given the lack of peer-reviewed literature, which may reduce data quality. Meta-analysis was not attempted owing to study limitations and heterogeneity in study designs, comparisons, and analyses.

Studies are needed to better understand the proportion of exposed HCWs who are infected with SARS-CoV-2 and associated outcomes, including economic effects; ability to work; social effects (for example, need for child care); and effects on family members and other close contacts, including transmission. Studies evaluating mental health and other outcomes should control for baseline status, include non-HCW controls, and incorporate longitudinal follow-up. Recovered HCWs require evaluation to understand outcomes over time (such as after return to work). For assessing SARS-CoV-2 infection risk factors, studies that prospectively measure exposures, PPE use, and other factors would increase measurement accuracy, reduce recall bias, and enable analyses that minimize confounding. Multivariate analyses of risk factors should account for potential collinearity. Given current limitations related to PPE supply, research on effects of PPE reuse is a priority (98). Studies are needed on the association between administrative factors, environmental factors, and HCW health and risk for HCW infections.

In conclusion, HCWs experience significant burdens from coronavirus infections, including SARS-CoV-2. Use of PPE and infection control training are associated with decreased infection risk and certain exposures are associated with increased risk. Research is urgently needed on optimal methods for reducing HCW risk for SARS-CoV-2 infections.

Table 3. Infection Prevention and Control Factors (Other Than Masks) and Risk for Infection With SARS-CoV-2, SARS-CoV-1, or MERS-CoV in HCWs*

Study, Year (Reference)	Gown	Glove	Handwashing	Eye Protection	PPE
SARS-CoV-2					
Wang et al, 2020 (70)	–	–	–	–	–
Ran et al, 2020 (61)	–	–	Unqualified handwashing: ***RR, 2.64 (95% CI, 1.04–6.71)*** Suboptimal handwashing before patient contact: ***RR, 3.10 (95% CI, 1.43–6.73)*** Suboptimal handwashing after patient contact: ***RR, 2.43 (95% CI, 1.34–4.39)***	–	Improper PPE: ***RR, 2.82 (95% CI, 1.11–7.18)***
SARS-CoV-1					
Caputo et al, 2006 (23)	–	Double vs. single layer gloves: ***OR, 0.04 (95% CI, 0.002–0.78)***	–	Goggles vs. no goggles: OR, 0.10 (95% CI, 0.01–1.29) Face shield vs. no face shield: OR, 0.79 (95% CI, 0.07–9.50)	Powered air purifying respirator or Stryker suit vs. no personal protective system: OR, 0.02 (95% CI, 0.01–4.12)
Chen et al, 2009 (26)	Single vs. double gowns: ***OR, 2.12 (95% CI, 1.36–3.31)†***	Single vs. double gloves: ***adjusted OR, 4.13 (95% CI, 1.99–8.55)***	Wash hands after caring for SARS-1 patients: • Never vs. every time: OR, 0.89 (95% CI, 0.52–1.51)† • Sometimes vs. every time: OR, 1.03 (95% CI, 0.38–2.75)† • Often vs. every time: OR, 1.14 (95% CI, 0.64–2.06)†	Face shield in SARS ward: • Never vs. every time: OR, 4.05 (95% CI, 0.54–30.34)† • Sometimes vs. every time: OR, 0.22 (95% CI, 0.01–3.56)† Goggles while performing operation for SARS-1 patient: • Never vs. every time: ***OR, 7.83 (95% CI, 1.07–57.63)†*** • Sometimes vs. every time: OR, 0.84 (95% CI, 0.07–9.45)†	Shoe cover use: • Never vs. every time: ***OR, 3.80 (95% CI, 2.24–6.45)†*** • Sometimes vs. every time: ***OR, 5.04 (2.04–12.48)†*** • Often vs. every time: OR, 2.29 (95% CI, 0.96–5.67)† Cap worn: • Never vs. every time: ***OR, 1.79 (95% CI, 1.03–3.10)†*** • Sometimes vs. every time: OR 0.48 (0.14–1.67)† • Often vs. every time: OR, 0.59 (95% CI, 0.13–2.65)† Wash uncovered skin after caring for SARS-1 patients: • Never vs. every time: ***OR, 3.29 (95% CI, 1.29–8.43)†*** • Sometimes vs. every time: OR, 2.16 (95% CI, 0.77–6.05)† • Often vs. every time: OR, 1.47 (0.45–4.79)† Wash nasal cavity after caring for SARS-1 patients: • Never vs. every time: OR, 3.21 (95% CI, 0.98–10.53)† • Sometimes vs. every time: OR, 2.51 (95% CI, 0.72–8.77)† • Often vs. every time: OR, 0.82 (95% CI, 0.13–5.13)† Wash oral cavity after caring for SARS-1 patients: • Never vs. every time: OR, ***3.26 (95% CI, 1.15–9.21)†*** • Sometimes vs. every time: OR, 2.05 (95% CI, 0.67–6.33)† • Often vs. every time: OR, 0.28 (95% CI, 0.03–2.59)†
Ho et al, 2004 (33)	–	–	–	–	Use of full PPE 100% of the time vs. <100%: RR, 0.19 (95% CI, 0.02–1.49) Protected direct contact vs. unprotected direct contact: RR, 0.16 (95% CI, 0.03–1.02)

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Table 3—Continued

Study, Year (Reference)	Gown	Glove	Handwashing	Eye Protection	PPE
Lau et al, 2004 (41)‡	Inconsistent gown use vs. consistent use§: • Direct contact with SARS-1 patient: *OR, 8.85 (95% CI, 2.46–48.28)* • Direct patient contact in general: *OR, 11.54 (95% CI, 2.56–106.36)* • No patient contact: *OR, 3.42 (95% CI, 1.38–9.30*)	–	Inconsistent hand hygiene vs. consistent use§: • Direct contact with SARS-1 patient: *OR, 4.83 (95% CI, 0.38–∞)* • Direct patient contact in general: OR, 1.00 (95% CI, 0.02–19.21) • No patient contact: *OR, 6.38 (95% CI, 1.6–36.17)*	Inconsistent goggles use vs. consistent use§: • Direct contact with SARS-1 patient: *OR, 6.41 (95% CI, 2.49–19.49)* • Direct patient contact in general: *OR, 6.93 (95% CI, 2.19–28.85)* • No patient contact: *OR, 3.50 (95% CI, 1.42–9.47)* Problems with fogging of goggles (yes vs. no): OR, 0.61 (0.31–1.17)†	Inconsistent use of >1 type of PPE vs. consistent use: *adjusted OR, 5.06 (95% CI, 1.9–598.92)* Perceived inadequacy of PPE vs. no perceived inadequacy: *adjusted OR, 4.27 (95% CI, 1.66–12.54)*
Liu et al, 2009 (49)	Multiple layers of protective clothes (yes vs. no): *OR, 0.44 (0.20-0.99)†*	Gloves (yes vs. no): *OR, 0.16 (95% CI, 0.5-0.57)†*	–	Glasses (yes vs. no): *OR, 0.43 (95% CI, 0.23-0.81)†* Goggles (yes vs. no): OR, 0.54 (95% CI, 0.29-1.00)†	Nose wash (no vs. yes): adjusted OR, 2.41 (95% CI, 0.98-5.93)
Loeb et al, 2004 (50)	Gown vs. inconsistent gown: RR, 0.36 (95% CI, 0.10-1.24)	Gloves vs. inconsistent gloves: RR, 0.45 (95% CI, 0.14–1.46)	–	–	–
Ma et al, 2004 (52)	Gowns vs. no gowns: *adjusted OR, 0.02 (95% CI, 0.01-0.04)* Number of gown layers vs no gown†: • 1 layer: *OR, 0.03 (95% CI, 0.01–0.09)* • 2 layers: *OR, 0.03 (95% CI, 0.01-0.12)* • 3 layers: *OR, 0.02 (95% CI, 0.00–0.07)* • 4 layers: *OR, 0.04 (95% CI, 0.01–0.19)*	–	Handwashing vs. no handwashing: OR, 0.53 (95% CI, 0.26–1.06)† Hands in disinfectants (yes vs. no): *OR, 0.40 (95% CI, 0.19–0.81)†*	Goggles vs. no goggles: *adjusted OR, 0.27 (95% CI, 0.10–0.73)*	Nasal cleaning (yes vs. no): OR, 0.53 (95% CI, 0.26–1.06)†
Nishiura et al, 2005 (56) (reported in two periods)	*Period 1 and 2* Gowns vs. no gowns: *OR, 0.2 (95% CI, 0.0–0.8)* and not calculated (100% in controls)	*Period 1 and 2* Gloves vs. no gloves: OR, 0.7 (95% CI, 0.3–1.9) and not calculated (100% in cases)	*Period 1 and 2* Handwashing before vs. not: OR, 1.0 (95% CI, 0.4–2.3) and not calculated (100% in cases) Handwashing after vs. not: OR, 1.1 (95% CI, 0.5–2.8) and not calculated (100% in cases)	–	*Period 1 and 2* All precautionary measures vs. not: *OR, 0.2 (95% CI, 0.0–1.0)* and *OR, <0.1 (95% CI, 0.0–0.3)*
Nishiyama et al, 2008 (57)	–	–	Sometimes vs. always before patient contact: adjusted OR, 1.25 (95% CI, 0.25–6.10) No vs. always: adjusted OR, 3.69 (95% CI, 0.56–24.2)	–	–
Pei et al, 2006 (58)	At least double-layer disposable suit when caring for SARS patients vs. no suit: *adjusted OR, 0.05 (95% CI, 0.007–0.39)*	1-layer plastic gloves vs. no gloves: *adjusted OR, 0.10 (95% CI, 0.02–0.42)* 1-layer latex gloves vs. no gloves: *adjusted OR, 0.10 (95% CI, 0.03–0.42)*	Hand sanitizing with iodine vs. not: adjusted OR, 0.23 (95% CI, 0.04–1.32)	Face shield of goggles (yes vs. no): *OR, 0.50 (95% CI, 0.27–0.75)†*	Gargling (yes vs. no): OR, 0.47 (95% CI, 0.22–1.01)† Changing PPE <4 h (yes vs. no): *OR, 0.50 (95% CI, 0.31–0.82)†*

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Table 3–Continued

Study, Year (Reference)	Gown	Glove	Handwashing	Eye Protection	PPE
Raboud et al, 2010 (60)	Always wore gown in patient room (yes vs. no): ***OR, 0.35 (95% CI, 0.14–0.91)†***	Always wore gloves in patient room (yes vs. no): OR, 0.59 (95% CI, 0.17–2.06)†	Hand hygiene after removal of face protection vs. no hand hygiene (reference): OR, 0.48 (95% CI, 0.19–1.22)† Hand hygiene before removing face protection, with or without hand hygiene after: OR, 0.93 (95% CI, 0.29–3.01)†	Always wore goggles in patient room (yes vs. no): ***OR, 0.33 (95% CI, 0.15–0.72)†***	Always wore recommended PPE, based on number of shifts with exposure (yes vs. no): OR, 0.70 (0.19–2.58)† PPE removal, based on number of shifts with exposure (yes vs. no): • No hand hygiene described: OR, 0.87 (0.16–6.45)† • Hand hygiene performed once: OR, 0.67 (0.11–3.99)† • Adequate PPE removal: OR, 1.18 (0.20–6.83)†
Seto et al, 2003 (65)	Gown use vs. nonuse: ***0% in cases vs. 34% in controls, P = 0.006***	Glove use vs. nonuse: OR, 0.5 (95% CI, 0.14–1.7)	Hand-washing vs. no handwashing: OR, 0.2 (95% CI, 0.05–1)	–	All PPE measures vs. not all PPE measures: All measures ***0% in cases and 29% in controls, P = 0.02***
Teleman et al, 2004 (66)	Gowns vs. not wearing: OR, 0.5 (95% CI, 0.1-1.4)†	Gloves vs. not wearing: adjusted OR, 1.5 (95% CI, 0.3-7.2)	Hand washing after each patient (yes vs. no): ***adjusted OR, 0.07 (95% CI, 0.008–0.7)***	–	–
Wilder-Smith et al, 2005 (72)	–	Glove use vs. no glove use: ***OR, 0.40 (95% CI, 0.17–0.96)***	Handwashing vs. no handwashing: OR 0.35 (95% CI, 0.11–1.12)	–	–
Yin et al, 2004 (78)	Gown vs. no gown: ***OR, 0.22 (95% CI, 0.12–0.39)†***	Gloves vs. no gloves: ***OR, 0.30 (95% CI, 0.17-0.53)†***	Disinfect and wash hands (yes vs. no): ***OR, 0.49 (95% CI, 0.2–0.85)†***	Use of goggles vs. no use: ***adjusted OR, 0.20 (95% CI, 0.10–0.41)***	Mouth washing vs. no mouth washing: ***OR, 0.35 (95% CI, 0.13–0.93)†*** Shower and change after work (before going home) vs. not: ***OR, 0.37 (95% CI, 0.19–0.72)†*** Nose clip vs. no nose clip: OR, 0.70 (95% CI, 0.38–1.31)† Protection of nasal and eye mucosa: ***OR, 0.13 (95% CI, 0.02–0.97)†*** Shoe cover vs. no shoe cover: ***adjusted OR, 0.58 (95% CI, 0.39–0.86)***
MERS-CoV					
Alraddadi et al, 2016 (19)	Gown always vs. sometimes or never: RR, 0.89 (95% CI, 0.36–2.21)†	Gloves always vs. sometimes or never: 9.1% cases vs. 0% controls†	–	Eye protection always vs. sometimes or never • Direct contact: RR, 0.21 (95% CI, 0.03–1.51)† • During aerosol-generating procedure: RR, 0.44 (95% CI, 0.13–1.51)†	–
Kim et al, 2016 (37)	–	–	–	–	Exposure without appropriate PPE vs. never: ***0.7% (2/294) vs. 0% (0/443); P = 0.16***

CoV = coronavirus; HCW = health care worker; OR = odds ratio; RR = relative risk; MERS = Middle East respiratory syndrome; SARS = severe acute respiratory syndrome.
* Values in boldface and italics indicate a statistically significant difference between groups.
† Variable not included in a multivariate model.
‡ Study reports ORs as matched ORs, except where indicated.
§ Addressed in model as inconsistent use of >1 type of PPE item.

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Appendix Table 1. Search Strategies

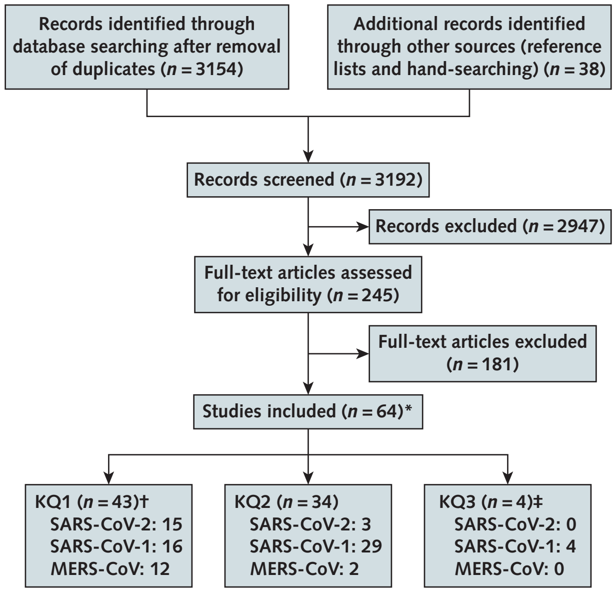
Database	Search Strategy
MEDLINE (PubMed)	((((((((COVID 19 OR “sars cov” OR “nCOV” OR “coronavirus 2”) OR ("novel coronavirus" AND (2019 : 2020[pdat]))) OR ("Severe Acute Respiratory Syndrome"[Mesh])) OR ("SARS")) OR ("Middle East Respiratory Syndrome Coronavirus"[Mesh])) OR (MERS)) OR ("severe acute respiratory syndrome coronavirus 2"[Supplementary Concept])) OR ("COVID-19"[Supplementary Concept])) AND ((("Health Personnel"[Mesh]) OR (clinician OR clinicians OR doctor OR doctors OR physician OR physician OR nurse OR nurses OR midwife OR midwives OR ambulance OR "first responder" OR "first responders" OR "EMT" OR "EMTs")) OR ((health OR healthcare OR "health care" OR clinic* OR medical OR laboratory) AND (work OR worker* OR personnel OR practitioner* OR staff OR employee*)))
Embase (Elsevier)	('covid 19' OR (covid AND 19) OR `sars cov' OR ncov OR `coronavirus 2' OR 'novel coronavirus' OR 'middle east respiratory syndrome coronavirus' OR `mers' OR 'severe acute respiratory syndrome' OR `sars') AND ('health care personnel' OR 'health workforce' OR clinician OR clinicians OR doctor OR doctors OR physician OR physician OR nurse OR nurses OR midwife OR midwives OR ambulance OR `first responder' OR `first responders' OR `EMT' OR `EMTs') AND [embase]/lim NOT ([embase]/lim AND [medline]/lim)

Appendix Table 2. Inclusion Criteria

Study Aspect	Inclusion	Exclusion
Population	KQ 1: HCW at risk for or with SARS-CoV-2, SARS-CoV-1, or MERS-CoV infection KQ 2: HCW at risk for SARS-CoV-2, SARS-CoV-1, or MERS-CoV infection KQ 3: Household contacts of HCW infected with SARS-CoV-2, SARS-CoV-1, or MERS-CoV	KQ 1, 2: Non-HCW KQ 3: Nonhousehold HCW contacts
Exposures/risk factors	KQ 1: SARS-CoV-2, SARS-CoV-1, or MERS-CoV infection KQ 2: Demographic characteristics: age, sex Exposure history: in workplace, home, or community Professional role/position Administrative factors: policies; point of care assessment; patient flow/triage; use, training, adherence, availability of personal protective equipment; hours worked, shifts; contact hours Health care setting and environment: unit worked (high-risk department e.g. ICU; lower risk, e.g. triage; etc.); institutional characteristics; use of negative pressure rooms; availability of hand hygiene stations HCW health (e.g., premorbid conditions/comorbidities) Infection prevention and control factors: policies, use (including reuse), training, adherence, availability, and type of personal protective equipment or hand washing KQ 3: Demographic characteristics, presence of symptoms, use of and type of PPE, living circumstances (e.g. crowded housing, lack of separate rooms), self-quarantine methods	Other exposures/risk factors
Outcomes	KQ 1: SARS-CoV-2 infection: Incidence, morbidity and mortality, social and economic effects of infection; and effects on family in exposed HCWs and infected HCWs SARS-CoV-1 and MERS-CoV infection: Infection and mortality in exposed and infected HCWs KQ 2: Risk estimates (relative risk, odds ratio, or hazard ratio) for incidence or prevalence for risk factors; or incidence or prevalence reported by risk factor KQ 3: Risk estimates and incidence of infections in household contacts of infected HCWs	Other outcomes
Study design	Randomized, nonrandomized, and controlled clinical trials Cohort studies Case–control studies Cross-sectional studies Case series (KQ 1).	Systematic reviews (reference lists of relevant reviews checked for primary studies) Case reports Anecdotal reports Modeling studies
Language	No restrictions	

CoV = coronavirus; HCW = health care worker; ICU = intensive care unit; KQ = key question; MERS = Middle East respiratory syndrome; SARS = severe acute respiratory syndrome.

Appendix Figure. Literature search and selection.



CoV = coronavirus; KQ = key question; MERS = Middle East respiratory syndrome; SARS = severe acute respiratory syndrome.
* Some studies were included for multiple KQs; includes 6 studies that were not peer-reviewed (28, 39, 46, 47, 59, 79) and 3 Chinese-language studies translated into English (48, 52, 78).
† Data from 2 World Health Organization websites on the incidence of SARS-1 (81) and MERS (82) were also included.
‡ Included in the full evidence review (10).

Appendix Table 3. Burden of SARS-CoV-2, SARS-CoV-1, and MERS-CoV*

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
SARS-CoV-2					
Ran et al, 2020 (61)	Retrospective cohort	China (Wuhan); 1 hospital serving outbreak; follow-up through 28 January 2020	72 HCWs with acute symptoms • Median age, 31 y • 69% female • 53% clinicians and 47% nurses	Incidence of COVID-19: 38.9% (28/72)	No information on clinical outcomes of COVID-19; selection of HCWs for testing unclear
Dai et al, 2020 (28)	Cross-sectional	China (Hubei province); HCWs from throughout province; 3–11 February 2020	4357 HCWs • Mean age, 35 y • 76.5% female • 32.6% physicians, 53.8% nurses, 10.0% technicians, 3.6% support staff • 0.9% diagnosed with COVID-19	GHQ-12 score ≥3: 39.1% (1704/4357) Adjusted OR (95% CI) for GHQ-12 score ≥ 3 • Female vs. male: ***1.53 (1.26–1.85)*** • Nurse vs. doctor: 0.97 (0.81–1.15) • Technician vs. doctor: ***0.73 (0.57–0.94)*** • Support staff vs. doctor: 0.80 (0.55–1.18) • Hospital type (reference ministerial/provincial) ○ Municipal: ***1.45 (1.17–1.81)*** ○ Country: ***1.71 (1.30–2.23)*** ○ Township/community: ***1.46 (1.08–1.98)***	*Not peer reviewed* No control for baseline symptoms; no non-HCW controls; no control for work exposures
Kang, 2020 (36)	Cross-sectional	China (Wuhan); HCWs from hospitals in Wuhan; 29 January to 4 February 2020	994 HCWs • 63.4% aged 25–40 y • 85% female • 31.1% high-risk department • 18.4% physicians; 81.6% nurses • 1.9% (19/994) positive for SARS-CoV-2 infection	Proportion classified into moderate or severe mental health disturbance clusters: • Moderate: 22.4% (223/994) ○ Mean depression (PHQ-9) score: 9.0 (SD, 3.9) ○ Mean anxiety (GAD-7) score: 8.2 (SD, 3.6) ○ Mean insomnia (ISI) score: 10.4 (SD, 4.8) ○ Mean distress (IES-R) score: 39.9 (SD, 5.4) • Severe: 6.2% (62/994) ○ Mean depression (PHQ-9) score: 15.1 (SD, 5.2) ○ Mean anxiety (GAD-7) score: 15.1 (SD, 4.3) ○ Mean insomnia (ISI) score: 15.6 (SD, 5.2) ○ Mean distress (IES-R) score: 60.0 (SD, 9.8) No association between increased risk for moderate or severe mental health disturbance and age, sex, type of HCW or department	Participation rate not reported; no control for baseline symptoms; no non-HCW controls
Kluytmans-van den Berg et al, 2020 (39)	Cross-sectional	The Netherlands; 2 hospitals; 7–12 March 2020	1853 HCWs with fever or mild respiratory symptoms in past 10 d • Median age, 49 y (cases) • 83% female (cases) • HCW role/position not reported • 6.4% (86/1353) positive for SARS-CoV-2 infection	Prevalence of SARS-CoV-2 infection (PCR): 6.4% (86/1353) • Met case definition (fever and/or coughing and/or shortness of breath): 91.9% (79/86) • Recovery (by day of interview): 23.3% (20/86), median duration of illness 8 days • Admitted to hospital (not critical): 3.7% (2/86)	*Not peer reviewed* 77% not recovered at time of interview

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Appendix Table 3–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Lai et al, 2020 (40)	Cross-sectional	China; HCWs from hospitals with COVID-19 fever clinics or wards for COVID-19; 29 January–3 February 2020	1257 HCWs • 65% aged 26–40 y • 77% female • 39% physicians and 61% nurses • Proportion diagnosed with COVID-19 not reported	Depression symptoms (PHQ-9), moderate or severe: 14.7% (186/1257) Anxiety symptoms (GAD-7), moderate or severe: 12.3% (154/1257) Insomnia symptoms (ISI), moderate or severe: 7.7% (97/1257) Distress symptoms (IES-R), moderate or severe: 35.0% (440/1257) Adjusted OR (95% CI): • Depression symptoms (PHQ-9) ○ Women vs. men: ***1.94 (1.26–2.98)*** ○ Secondary vs. tertiary hospital: ***1.65 (1.17–2.34)*** ○ Technical title: ▪ Intermediate vs. junior: ***1.77 (1.25–2.49)*** ▪ Senior vs. junior: 1.21 (0.72–2.03) ○ Frontline vs. second-line HCV: ***1.52 (1.11–2.09)*** • Anxiety symptoms (GAD-7) ○ Women vs. men: ***1.69 (1.23–2.33)*** ○ Secondary vs. tertiary hospital: ***1.43 (1.08–1.90)*** ○ Technical title: ▪ Intermediate vs. junior: ***1.82 (1.38–2.39)*** ▪ Senior vs. junior: 1.01 (0.67–1.51) ○ Frontline vs. second-line HCW: ***1.57 (1.22–2.02)*** • Insomnia symptoms (ISI) ○ Frontline vs. second-line: ***2.97 (1.92–4.60)*** • Distress symptoms (IES-R) ○ Women vs. men: ***1.45 (1.08–1.96)*** ○ Technical title: ▪ Intermediate vs. junior: ***1.94 (1.48–2.55)*** ▪ Senior vs. junior: 1.03 (0.69–1.55) ○ Frontline vs. second-line HCW: ***1.60 (1.25–2.04)*** ○ Location: Hubei outside Wuhan vs. Wuhan: 0.77 (0.57–1.06) ○ Outside Hubei vs. Wuhan: ***0.62 (0.43–0.88)***	Response rate 69%; no control for baseline symptoms; no non-HCW controls; no control for work exposures
Liu et al, 2020 (46)	Cross-sectional	China; HCWs from multiple urban and rural hospitals; 10–20 February 2020	512 HCWs • 75.4% aged 18–39 y • 85% female • 32.0% direct treatment contact of COVID-19–infected patient • 8.0% suspected COVID-19 case	Anxiety score (scale 20–80; higher score = more anxiety), direct treatment contact vs. nondirect treatment contact: ***38.8 (SD, 8.4) vs. 41.1 (SD, 9.8); P = 0.007*** Adjusted beta (95% CI) for anxiety score: • Direct contact vs. nondirect contact: 2.33 (0.65–4.00) • Contact with suspect cases vs. no suspect cases: ***4.44 (1.55–7.33)*** • Hubei province vs. other: ***3.67 (1.44–5.89)***	*Not peer reviewed* 85% response rate; sample limited to HCWs utilizing WeChat app; no control for baseline symptoms

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***Appendix Table 3*–Continued**

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Lu et al, 2020 (51)	Cross-sectional	China (Fujian Province); single provincial hospital; 25–26 February 2020	2299 (2042 direct contact workers and 257 administrative staff) • 78% aged <30-40 y • 78% female • 22% high-risk department (respiratory, emergency, ICU or infectious disease) • Proportion diagnosed with COVID-19 not reported	Medical staff vs. administrative staff • Anxiety symptoms (HAM-A), mild/moderate: 22.6% (462/2042) vs. 17.1% (44/257) • Anxiety symptoms (HAM-A), severe/extreme: 2.9% (59/2042) vs. 1.6% (4/257) • Depression symptoms (HAM-D), mild/moderate: 11.8% (241/2042) vs. 8.2% (21/257) • Depression symptoms (HAM-D), severe/extreme: 0.3% (6/2042) vs. 0% (0/257) • Fear scale (0 to 10 NRS), moderate: 43.9% (896/2042) vs. 38.9% (100/257) • Fear symptoms (0 to 10 NRS), severe/extreme: 26.7% (545/2042) vs. 19.5% (50/257) Adjusted hazard ratio (95% CI), direct contact worker vs. nonclinical: Fear, high-risk worker: ***1.41 (1.02–1.93)***; low-risk worker: 1.30 (0.99–1.72) Anxiety (HAM-A), high-risk worker: ***2.06 (1.35–3.15)***; low-risk: 1.31 (0.89–2.93) Depression (HAM-D), high-risk worker: ***2.02 (1.10–3.69)***; low-risk: 1.39 (0.80–2.43)	Response rate not reported; no non-HCW control; no control for baseline symptoms
Qi et al, 2020 (59)	Cross-sectional	China (Hubei Province); HCWs from hospitals throughout province; dates not reported	1306 HCWs (persons with sleep disturbances and treated for psychiatric conditions excluded) • Mean age, 33.1 y • 80% female • 61% frontline HCW and 39% nonfrontline • Proportion diagnosed with COVID-19 not reported	Pittsburgh Sleep Quality Index >7: 59.6% (779/1306) overall • 67.2% (538/801) frontline medical workers vs. 47.7% (241/505) nonfrontline medical workers, *P* < 0.0001 Athens Insomnia Index >6: 45.5% (594/1306) overall • ***51.7% (414/801) frontline medical workers and 35.6% (180/505) nonfrontline medical workers, P < 0.0001***	*Not peer reviewed* Response rate not reported; no non-HCW control
Ying et al, 2020 (79)	Cross-sectional	China (Ningbo); HCWs from 5 hospitals; February 2020	843 family members of HCWs • Mean age, 38 y • 47.3% female • Relationship with HCW: 65.4% spouse, 4.7% child, 5.8% parent, 24.0% other • HCW had direct contact with confirmed or suspected COVID-19–infected patient: 48.0%	Prevalence of GAD score ≥5 in family members of HCWs: 33.7% Proportion with PHQ score ≥5 in family members of HCWs: 29.4% **Adjusted OR (95% CI) for GAD score ≥5 in family members of HCWs (significant variables in model)** • Hours/day focusing on COVID-19: ***1.22 (1.06–1.39)*** • HCW in direct contact with confirmed or suspected COVID-19 patients: ***1.48 (1.07–2.04)***	*Not peer reviewed* Sample limited to family members using WeChat App; no control for baseline symptoms; no controls without HCW family members

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Appendix Table 3–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
				• Family member's self-reported safety score for PPE of HCWs: *0.81 (0.70–0.93)* Adjusted OR (95% CI) for PHQ-9 ≥5 in family members of HCWs (significant variables in model) • Occupation: ○ Enterprise worker vs. HCW: *1.75 (1.10–2.78)* ○ Government employee vs. HCW: *0.53 (0.29–0.98)* • Relationship: ○ Parent vs. spouse: *3.53 (1.61–7.73)* ○ Other next of kin vs. spouse: *1.64 (1.10–2.45)* • Hours/day focusing on COVID-19: *1.20 (1.04–1.38)* • Average working time per week for HCWs: *1.02 (1.00–1.03)*	
Zhu et al, 2020 (80)	Cross-sectional	Wuhan, China; tertiary hospital; 8–10 February 2020	5062 HCWs • 96.5% aged 19–49 y • 85% female • 20% physicians, 68% nurses, and 13% medical technicians • 3.1% with suspected or confirmed COVID-19	Depression symptoms (PHQ-9 ≥10): 13.5% (681/5062) Anxiety symptoms (GAD-7 ≥8): 24.0% (1218/5062) Distress symptoms (IES-R >33): 29.8% (1509/5062) Adjusted OR (95% CI) for psychological distress (selected factors) • Women vs. men: *1.31 (1.02–1.66)* • Nurse vs. doctor: *2.24 (1.61–3.12)* • Medical technician vs. doctor: *1.57 (1.12–2.21)* • Working >10 y vs. < 2 y: *2.02 (1.47–2.79)* • Work in isolation ward vs. nonisolation: *1.32 (1.10–1.59)* • Chronic noncommunicable disease vs. in good health: *1.51 (1.27–1.80)*; history of mental disorders vs. in good health: *3.27 (1.77–6.05)* • Satisfied with coverage with protective measures vs. not satisfied: *0.69 (0.53–0.89)* • Satisfied with work shift arrangement vs. not satisfied: *0.45 (0.33–0.63)* • Satisfied with logistic support and accommodation arranged by hospital vs. not satisfied: not significant	*Not peer reviewed* Response rate 77%; did not control for baseline symptoms; no non-HCW controls

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Appendix Table 3—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Liu et al, 2020 (47)	Case series	China (Wuhan); single hospital; diagnosed 16 January–15 February 2020	64 HCWs with COVID-19 (PCR-positive) • Median age, 35 y • 64% female • 33% doctors; 67% nurses	• Mortality: 0% • ICU admission for mechanical ventilation: 0% • Severe illness: 1.6% (1/64) • Discharge (as of 24 February): 53% (34/64) • Discharge time (median): 20 days • Nondischarge: larger BMI (≥24 kg/m±) ***(HR, 0.14 [95% CI, 0.03–0.73])***, fever ***(HR, 0.24, [95% CI, 0.09–0.60])***, increased IL-6 (>2.9 pg/mL) ***(HR, 0.31 [95% CI, 0.11–0.87])***	Small sample; 47% of patients still hospitalized at time outcomes reported
Liu et al, 2020 (48)	Case series	China (Wuhan); single hospital; diagnosed 10–31 January 2020	30 HCWs with COVID-19 (7 confirmed with PCR) • Mean age, 35 y • 66.7% female • 73.3% doctors; 26.7% nurses	• Mortality: 0% • Noninvasive ventilation or nasal high-flow oxygen: 13.3% (4/30) • Severe pneumonia (respiratory rate ≥30 breaths/min, resting oxygen saturation ≤93%; Pao_2/Fio_2 ≤300 mm Hg): 13.3% (4/30); severe pneumonia associated with higher BMI, greater number of exposures, and longer exposure times, and infections before use of PPE (10–20 January)	Small sample; 20% of patients still hospitalized at time outcomes reported; most cases not confirmed with PCR
McMichael et al, 2020 (53)	Case series	United States (Washington); 1 long-term care facility; initial resident case diagnosed 28 February 2020	50 HCWs with COVID-19 (PCR-positive) • Median age, 43.5 y • 76% female • Various (numbers not reported)	29.9% (50/167) of cases were in HCWs • Hospitalized: 6.0% (3/50) • Mortality: 0% (0/50)	No denominator for the total number of exposed HCWs; proportion recovered at time of study not reported
Novel Coronavirus Pneumonia Emergency Response Epidemiology Team, 2020 (67)	Case series (descriptive study)	China (throughout); through 11 February 2020	44 672 patients with COVID-19 (PCR-positive) • Age, sex, and role/position of infected HCWs not reported (not restricted to physicians and nurses)	• 3.8% (1716/44 672) of cases were in HCWs ○ Before 31 December: 0% (0/104) ○ 1–10 January: 3.1% (20/653) ○ 11–20 January: 5.7% (310/5417) ○ 21–31 January: 3.9% (1036/26 468) • Case-fatality rate: 0.3% (5/1716) • Mortality per 10 patient days: 0.002 • Proportion severe or critical: 14.6% (247/1608) ○ 1–10 January: 45.0% (9/20) ○ 11–20 January: 19.7% (61/310) ○ 21–31 January: 14.4% (149/1,036) ○ After 1 February: 8.7% (28/322) ○ Wuhan: 17.7% (191/1,080) ○ Hubei (outside Wuhan): 10.4% (41/394) ○ Outside Hubei: 7.0% (15/214)	No denominator for the total number of exposed HCWs; proportion recovered unclear

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Appendix Table 3–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Wang et al, 2020 (68)	Case series	China (Wuhan); through 18 February 2020	25 961 patients with COVID-19 (PCR-positive) • Age, sex, and role/position of infected HCWs not reported	5.1% (1316/25,961) of cases were in HCWs • Estimated attack rate in HCWs vs. general population: 144.7 (95% CI, 137.0 to 152.8) vs. 41.7 (95% CI, 41.2 to 42.2) per 10^6 people ○ Before 11 January: 6.1 vs. 2.2 per 10^6 people ○ 11–22 January: 275 vs. 44.9 per 10^6 people ○ 23 January–1 February: 507.4 vs. 150.9 per 10^6 people ○ 2–18 February: 116.6 vs. 54.1 per 10^6 people	*Not peer-reviewed* Attack rate in general population and HCWs estimated using the Wuhan Statistical Yearbook 2018; denominator for potentially exposed HCWs not provided
SARS-CoV-1					
Chang et al, 2004 (25)	Retrospective cohort	Taiwan; 1 hospital ED; 30 March–30 June 2003	193 HCWs • Mean age, 32.7 y • 72% female • 17% physician, 49% nurse, 8.8% radiology technician, 8.3% clerk, 6.7% sanitation worker, 6.7% administration personnel, 3.1% ambulance drivers	• Prevalence of SARS-CoV-1 seropositivity: 4.7% (9/193) • Incidence of SARS-1: 4.1% (8/193)	No major limitations noted
Fowler et al, 2004 (30)	Retrospective cohort	Toronto; 1 hospital intensive care unit; 1–22 April 2003	122 intensive care unit HCWs • Mean age, 35.1 y (cases) • Sex not reported • 54% nurse, 15% nursing aid/patient assistant, 12% physician, 15% respiratory therapist, 2.5% physiotherapist, 1.6% other HCW	Incidence of SARS-1: 8.2% (10/122)	No major limitations noted
Ho et al, 2003 (32)	Retrospective cohort	Hong Kong; 1 hospital; 25 March to 5 May, 2003	1,053 HCWs • Mean age (cases) 36 y • 78% female (cases) • 13% physician, 47% nurse, 8.4% health care assistant, 10.5% cleaner, 12.4% clerical staff	Incidence of SARS-1: 3.8% (40/1053)	No major limitations noted
Ho et al, 2004 (33)	Prospective cohort	Singapore; 1 hospital; 18 March –29 April 2003	372 HCWs • Mean age, 34.2 y • 77% female • 27.7% physician, 55.1% nurse, 17.2% allied health and clerical	• Prevalence of SARS-CoV-1 seropositivity: 2.2% (8/372) • Incidence of SARS-1: 1.6% (6/372)	No major limitations noted
Ip et al, 2004 (34)	Retrospective cohort	Hong Kong; 1 hospital; blood samples obtained after 21 May 2003	742 HCWs • Mean age, 36.2 y (HCWs with serologic testing) • 79% female (HCWs with serologic testing) • 9.0% doctor, 3% nurse, 23% allied health, 14% health care/general service assistant, 13% ancillary, 3.7% other	Incidence of SARS-1: 7.1% (53/742)	No major limitations noted
Jiang et al, 2003 (35)	Retrospective cohort	China (Guangzhou); 1 hospital; 30 January–March 2003	431 HCWs • Age, sex, role/type of HCW not reported	Incidence of SARS-1: 17.9% (77/431)	No major limitations noted
Lau et al, 2004 (43)	Retrospective cohort	Hong Kong; 16 hospitals; 4 March to 31 May 2003	∼28 000 HCWs • Age, sex, and HCW role/position not reported	Incidence of SARS-1: 1.2% (339/∼28,000)	SARS-1 criteria not reported
Li et al, 2003 (45)	Retrospective cohort	China (Beijing); 1 hospital; 24 March–13 May 2003	770 HCWs • Age, sex and health care role/position not reported	Incidence of SARS-1: 2.43% (18/770)	No major limitations noted

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Appendix Table 3–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Loeb et al, 2004 (50)	Retrospective cohort	Canada (Toronto); 1 hospital critical care units; 8–16 March 2003	43 nurses • Mean age, 41 y • 100% female	Incidence of SARS-1: 18.6% (8/50)	No major limitations noted
Nishiyama et al, 2008 (57)	Retrospective cohort	Vietnam (Hanoi); two hospitals; exposure 3–17 March 2003	146 HCWs • Age, sex, and HCW role/position not reported	Prevalence of SARS-CoV-1 seropositivity: 40.4% (59/146) Incidence of SARS-1: 29.4% (43/146)	No major limitations noted
Raboud et al, 2010 (60)	Retrospective cohort	Canada (Toronto); 20 hospitals; 5 March–12 June 2003	624 HCWs provided care to intubated SARS-1 patients • Mean age 38.5 y (cases) • 75.2% female • 12.3% staff physician, 2.6% medical resident/intern, 45.4% registered nurse, 14.3% respiratory therapist, 10.7% radiology technologist, 6.1% housekeeper, 4.2% personal service assistant, 2.2% laboratory technician/technologist, 0.5% EMT; 1.8% other	Prevalence of SARS-CoV-1 seropositivity: 4.2% (26/624)	SARS-1 diagnosis did not require laboratory confirmation
Scales et al, 2003 (64)	Retrospective cohort	Canada (Toronto); single hospital intensive care unit; exposure occurred 23 March 2003	69 HCWs with brief, unexpected exposure to SARS-1–infected patient • Age, sex, HCW role/position not reported	Incidence of SARS-1: 10.1% (7/69)	No major limitations noted
Wang et al, 2007 (69)	Retrospective cohort	Taiwan; 4 hospitals; study began 1 July 2003	2512 HCWs • Mean age, 33.4 y • 88% female • 13% physician, 83% nurse • 0.36% (9/2512) seropositive for SARS-CoV-1; 1.0% (9/882) among those reporting contact with SARS-1 patients	Prevalence of seropositivity to SARS-CoV-1: 0.3% (9/2512); 1.0% (9/882) among those reporting contact with SARS-1 patients	No major limitations noted
Wong et al, 2004 (74)	Retrospective cohort	Hong Kong; 1 hospital; 4–10 March 2003	66 medical students • Mean age, 22.3 y (cases) • 50% female (cases) • 24% (16/66) diagnosed with SARS-1	Incidence of SARS-1: 24% (16/66)	No major limitations noted
Chen et al, 2005 (27)	Cross-sectional	China (Guangzhou); 3 hospitals; May 2003	1856 HCWs (1135 worked with SARS patients) • Mean age, 30.8 y • 71.6% female • 30.7% doctor, 48.3% nurse, 5.5% health attendant, 4.0% laboratory technician, 11.5% other	• Prevalence of SARS-CoV-1 seropositivity among HCWs who worked with SARS patients: 8.3% (95/1147) • Incidence of SARS-1: 7.8% (90/1147)	10 patients with SARS-1 were SARS-CoV-1 seronegative
Leung et al, 2004 (44)	Case series	Hong Kong; All cases 2003 outbreak	1755 SARS-1 cases (405 HCWs) • 48% aged ≤39 y of age, 30% aged 40–59 y (all cases) • 55.7% female (all cases) • 15.8% physician, 51.9% nurse, 28.4% other, 4.0% medical students	23.1% (405/1755) of cases were in HCWs Mortality: 2.0% (8/405) • Physician: 6.2% (4/64) • Nurse: 0.5% (1/210) • Medical student: 0% (0/16) • Other HCW: 2.6% (3/115) Adjusted OR (95% CI) for mortality • HCW vs. non-HCW: ***0.30 (0.1–0.7)***	288 cases without laboratory confirmation; based on studies with laboratory confirmation, adjusted OR for mortality for HCW vs. non-HCW 0.6 (95% CI, 0.2–1.3)

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Appendix Table 3–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
MERS-CoV					
Al-Abdallat M et al, 2014 (18)	Retrospective cohort	Jordan; 3 hospitals; exposure 15 March–30 April 2012, study done May 2013	97 HCWs • Age, sex, HCW role/position not reported	Incidence of MERS-CoV seropositivity in HCWs overall: 6.2% (6/97) • Mortality: 16.7% (1/6) Outbreak hospital HCWs: 10% (6/57) Other HCWs (transfer hospital, outbreak investigators): 0% (0/40)	Small number of cases; clinical presentation of 5 nonfatal cases not described
Alraddadi et al, 2016 (19)	Retrospective cohort	Saudi Arabia; 1 hospital; May 2014–June 2014	283 HCWs • Mean age, 40 y (cases) • 64.4% female • 55% nurse, 16% physician, 12% respiratory therapist, 6.8% radiology technicians, 9.2% other (MICU and ED HCWs)	Incidence of MERS-Co seropositivity in HCWs: 7.1% (20/283); 8.0% (20/250) in units with direct contact • MICU: 11.7% (15/128) • ED: 4.1% (5/122) • Neurology unit (no direct contact): 0% (0/33) • Radiology technician (MICU and ED): 29.4% (5/17) • Nurses (MICU and ED): 9.4% (13/138) • Respiratory therapist (MICU and ED): 3.2% (1/31) • Physicians (MICU and ED): 2.4% (1/41) • Patient transport or clerical staff (MICU and ED): 0% (0/21) Mortality: 0% (0/20) Mechanical ventilation: 15% (3/20) Hospital admission without mechanical ventilation: 10% (2/20)	Potential recall bias
Amer et al, 2018 (21)	Retrospective cohort	Saudi Arabia; 1 hospital; June 2017	879 HCWs with unprotected exposure to MERS patient • Mean age, 32 y (15 cases) • 80.0% female (15 cases) • 80% nurse, 20% physician	Incidence of positivity for MERS-CoV PCR: 1.9% (17/879) • Mortality: 0% • Asymptomatic: 53% (8/15) • Mild symptoms: 47% (7/15)	Two patients with inadequate follow-up
Kim et al, 2016 (37)	Retrospective cohort	South Korea; 31 hospitals; dates not reported	737 HCWs with direct contact with MERS patient • Mean age, 33 y • 78% female • 19% physician; 69% nurse; 12% other	Incidence of MERS: 2.0% (15/737) Incidence of MERS-CoV seropositivity (ELISA and confirmatory IIFT) not meeting criteria for MERS: 0.27% (2/737)	No details on outcomes of MERS cases
Kim et al, 2016 (38)	Retrospective cohort	South Korea; 1 hospital ED; exposure May 26, 2015 with testing 3-6 weeks later	9 HCWs within 3–6 ft of MERS patient • 56% aged <30 y • 56% female • 33% doctor, 44% nurse, 11% nurse assistant, 11% security guard	Incidence of MERS in HCWS: 11% (1/9) • Case was a security guard with no PPE	Small cohort with single case
Ryu et al, 2019 (63)	Retrospective cohort	South Korea; public health center and EMS personnel; January 2016	34 HCWs with contact with MERS patient • Mean age, 44 y • 41.2% female • 32% general health care staff, 18% nurses; 12% doctors, 8.8% paramedics; 2.6% lab technician; 26.5% non–health-related workers	Incidence of MERS-CoV seropositivity: 0% (0/34)	No cases; small sample size

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Appendix Table 3—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Wiboonchutikul et al, 2016 (71)	Retrospective cohort	Thailand; 1 hospital; exposure 18 June–3 July 2015	38 HCWs with exposure to MERS patient • Mean age, 38.1 y • 79% female • 7.9% physician, 21% nurse, 7.9% nursing or patient assistant, 21% radiology technician, 39.4% laboratory personnel, 2.6% housekeeping	Incidence of MERS-CoV seropositivity: 0% (0/38)	No cases
Memish et al, 2014 (54)	Cross-sectional	Saudi Arabia; hospitals throughout country; September 2012 to September 2013	1695 HCWs (contacts of MERS patients) • Age, sex, HCW role/position not reported	Prevalence of MERS-CoV PCR positivity: 1.12% (19/1695) • Female: 1.30% (15/1155) • Male: 0.74% (4/540)	No detail on clinical presentation, no information on HCW role/position
Adegboye et al, 2019 (17)	Case series	Saudi Arabia; throughout Saudi Arabia; 2012–2016	787 cases of MERS (166 HCWs) • Mean age, 35 y (HCWs) • 37% female (HCWs) • HCW role/position not reported	Mortality in HCWs with MERS: 3.0% (5/166) Adjusted OR (95% CI) for mortality • HCW vs. non-HCW: ***0.08 (0.03 to 0.40)*** • Comorbidity vs. no comorbidity: ***2.43 (1.11–5.33)*** • Male vs. female: 1.41 (0.83–2.40) • Age (per year): ***1.03 (1.01–1.04)***	Potential residual confounding
Al-Tawfiq and Memish, 2019 (20)	Case series	Lebanon, Malaysia, Oman, Qatar, Saudi Arabia, and United Arab Emirates (cases report to WHO) from December 2016 to January 2019	403 MERS cases (105 HCWs) • Mean age, 47.7 y (HCWs) • 25.6% female (all cases) • HCW role/position not reported	26.1% (105/403) of cases were in HCWs • Mortality: 16% (17/105)	Mortality in HCWs includes primary cases; no analysis of risk factors for mortality in HCWs
Bernard-Stoecklin et al, 2019 (22)	Case series	South Korea; 11 health care–associated outbreaks; 2015–2017	2260 cases with MERS (105 HCWs) • Age, sex, role/position of HCWs not reported	Adjusted OR (95% CI) for mortality in persons with MERS • HCW vs. not HCW: ***0.07 (0.001–0.35)*** • Age ≥65 y vs. <65 y: ***4.79 (2.60–8.64)*** • ≥1 underlying comorbid condition vs. no comorbid conditions: ***0.07 (0.001–0.35)***	Potential residual confounding
Elkholy et al, 2020 (29)	Case series	Worldwide (all cases reported to WHO) from September 2012–2 June 2018	2223 MERS cases (415 HCWs) • Mean age, 39.3 y (HCWs) • Female: 54.9% (HCWs) • HCW role/position not reported	18.6% (415/2223) of cases were in HCWs • Mortality: 5.8% (24/415) • Secondary cases: 4.7% (16/338) • Diagnosis year: ○ 2013: 18.9% (7/30) ○ 2014: 8.0% (16/200) ○ 2015: 1.1% (1/95) ○ 2016: 0% (0/34) ○ 2017: 0% (0/45) ○ 2018: 0% (0/4) Adjusted OR (95% CI) for mortality in HCWs with secondary MERS (factors in backwards stepwise model) • Year of infection (2013–2018): ***0.17 (0.07–0.45)*** • Comorbidity (none vs. any): ***0.22 (0.05–0.92)*** • Factors not retained in model: sex, residency, symptomatic, age	No information on HCW role/position

BMI = body mass index; CoV = coronavirus; COVID-19 = coronavirus disease 2019; ED = emergency department; EMT = emergency medical technician; GAD = generalized anxiety disorder; GHQ = General Health Questionnaire; HAM-A = Hamilton Anxiety Scale; HAM-D = Hamilton Depression Scale; HCW = health care worker; IES-R = Impact of Event Scale–Revised; IL = interleukin; ISI = Insomnia Severity Index; MERS = Middle East respiratory syndrome; MICU = medical intensive care unit; NRS = numeric rating scale; PCR = polymerase chain reaction; PHQ = Patient Health Questionnaire; PPE = personal protective equipment; SARS = severe acute respiratory syndrome; WHO = World Health Organization.
* Values in boldface and italics indicate a statistically significant difference between groups.

Appendix Table 4. Cases of SARS-1 and MERS Reported to the World Health Organization, Overall and in HCWs

Country, Time Frame (Reference)	Overall Cases, *n*	HCW Cases, *n (%)*
SARS-1, 1 November 2002–31 July 2003 (81)		
Canada	251	109 (43)
China	5327	1002 (19)
China, Hong Kong	1755	386 (22)
China, Taiwan	346	68 (20)
Singapore	238	97 (41)
Vietnam	63	36 (57)
Total*	8096	1706 (21)
MERS (82)		
Saudi Arabia, 2012–2019	2106	402 (19)
Globally, July–December 2014	100	14 (14)
Globally, July–December 2015	257	46 (18)
Globally, July–December 2016	99	6 (6)
Globally, July–December 2017	94	9 (8)
Globally, July–December 2018	50	0 (0)
Globally, July–December 2019	51	2 (4)

HCW = health care worker; MRS = Middle East respiratory syndrome; SARS = severe acute respiratory syndrome.
* Includes countries with <50 cases not shown in table.

Appendix Table 5. Results of Individual Studies and Risk Factors for SARS-CoV-2, SARS-CoV-1, and MERS-CoV Infection in HCWs*

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
SARS-CoV-2					
Ran et al, 2020 (61)	Retrospective cohort	China (Wuhan); 1 hospital serving outbreak; follow-up through 28 January 2020	72 HCW with acute symptoms • Median age, 31 y • 69% female • 53% clinicians and 47% nurses • 38.9% (28/72) diagnosed with COVID-19	RR (95% CI) for COVID-19 (PCR) • High-risk vs. general department: ***2.13 (1.45–3.95)*** • High-exposure operation: 0.54 (0.19–1.53) • Tracheal tube removal: 0.63 (0.06–7.08) • CPR: 0.63 (0.06–7.08) • Fiberoptic bronchoscopy: 0.63 (0.06–7.08) • Sputum suction: 0.43 (0.12–1.55) • Unqualified handwashing: ***2.64 (1.04–6.71)*** • Suboptimal handwashing before patient contact: ***3.10 (1.43–6.73)*** • Suboptimal handwashing after patient contact: ***2.43 (1.34–4.39)*** • Improper PPE (proper PPE defined as use of hospital masks, round caps, gloves, protective clothing, boot covers, and goggles or face shields): ***2.82 (1.11–7.18)*** • Increase in work hours: ***log-rank P = 0.02*** with interaction with high-risk department Contact history: • Diagnosed family member: ***2.76 (2.02–3.77)*** • Suspected family member: 1.30 (0.31–5.35) Diagnosed patient: ***0.36 (0.22–0.59)*** Suspected patient: ***0.49 (0.27–0.89)*** Huanan seafood market: 0.63 (0.06–7.08)	Potential recall bias; unclear if most risk estimates adjusted; reference group unclear for some estimates; some estimates imprecise; 11 of 83 cases dropped for invalid surveys
Ng et al, 2020 (55)	Retrospective cohort	Singapore; February 2020	41 HCWs with exposure to COVID-19 patient and aerosol-generating procedures for ≥10 min at ≤2 m • Age, sex, and HCW role/position not reported • 0% (0/41) diagnosed with SARS-CoV-2 infection	Incidence of SARS-CoV-2 infection in exposed HCWs: 0% (0/41); no HCWs developed symptoms • Aerosol-generating procedures: endotracheal intubation (*n* = 10), extubation (*n* = 2), noninvasive ventilation (*n* = 25), other (*n* = 4) • Mask type during exposures: surgical mask, 85%; N95, 15%	No cases of COVID-19 occurred
Wang et al, 2020 (70)	Retrospective cohort	China (Wuhan); 1 hospital; January 2020	493 HCWs • Mean age, 32 y • 87% female • 27% doctor, 73% nurse • 2.0% (10/493) diagnosed with COVID-19	Incidence of COVID-19 • Respiratory department: 0% (0/70) • ICU: 0% (0/169) • Infectious disease department: 0% (0/39) • Hepatobiliary and pancreatic surgery department: 11% (8/74) • Trauma and microsurgery department: 2% (1/44) • Urology department: 1% (1/97) Unadjusted OR (95% CI) Nurse vs. doctor: ***0.04 (95% CI 0.005 to 0.31)†*** • In department with N95 mask use (no vs. yes): ***28.46 (1.65 to 488.48)†*** Adjusted OR (95% CI) for COVID-19 • In department with N95 mask use (no vs. yes): ***464.82 (97.73– ∞)***	Not peer reviewed; mask and other PPE use based on department practice, not individual participant use; estimate for mask very imprecise
SARS-CoV-1					
Caputo et al, 2006 (23)	Retrospective cohort	Canada (Toronto); 10 hospitals; February to 21 April 2003 and 22 April to July 2003	33 HCWs who performed 39 tracheal intubations in 35 SARS-1 patients • Age, sex not reported • 67% anesthesiologist; 15% respiratory therapist; 9% internal medicine; 9% other physicians • 9.1% (3/33) with SARS-1	Unadjusted OR (95% CI) for SARS-1† • N95 or N95 equivalent vs. surgical mask: 0.12 (0.01–1.92) • 2 glove layers vs. 1 layer: ***0.04 (0.002–0.78)*** • Goggles vs. no goggles: 0.10 (0.01–1.29) • Face shield vs. no face shield: 0.79 (0.06–9.50) • Powered air purifying respirator or Stryker suit vs. no personal protective system: 0.20 (0.01–4.12)	Potential recall bias; no control for confounders
Chang et al, 2004 (25)	Retrospective cohort	Taiwan; 1 hospital ED; 30 March–30 June 2003	193 HCWs • Mean age, 32.7 y • 72% female • 17% physician, 49% nurse, 8.8% radiology technician, 8.3% clerk, 6.7% sanitation worker, 6.7% administration personnel, 3.1% ambulance drivers • 4.7% (9/193) seropositive for SARS-CoV-1 (8 met criteria for SARS-1)	Prevalence of SARS-CoV-1 seropositivity • Physicians: 6.1% (2/33) • Nurses: 3.2% (3/95) • Ambulance drivers: 16.7% (1/6) • Sanitation workers: 15.4% (2/13) • Clerks: 6.3% (1/16) • Radiology technicians: 0% (0/17) • Administrative personnel: 0% (0/24)	No control for confounding; few cases

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Appendix Table 5–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Fowler et al, 2004 (30)	Retrospective cohort	Toronto; 1 hospital intensive care unit; 1–22 April 2003	122 intensive care unit HCWs • Mean age, 35.1 y (cases) • Sex not reported • 54% nurse, 15% nursing aid/patient assistant, 12% physician, 15% respiratory therapist, 2.5% physiotherapist, 1.6% other HCW • 8.2% (10/122) diagnosed with SARS-1	Incidence of SARS-1 • Physicians: 16.7% (3/18) • Nurses: 7.6% (5/66) • Respiratory therapist: 11.1% (2/18) Unadjusted RR (95% CI) for SARS-1 • Any involvement in intubation vs. no involvement, physician or nurse: *13.29 (2.99–59.04)* ○ Nurse: *21.38 (4.89–93.37)* ○ Physician: 3.82 (0.23–62.24) • Cared for patient treated with noninvasive positive pressure vs. conventional ventilation (restricted to nurses): 2.33 (0.25–21.76) • Cared for patient treated with high frequency oscillatory vs. conventional ventilation (restricted to nurses): 0.74 (0.11–4.92)	No control for confounding; some estimates imprecise
Ho et al, 2003 (32)	Retrospective cohort	Hong Kong; 1 hospital; 25 March–5 May 2003	1053 HCWs • Mean age, (cases) 36 y • 78% female (cases) • 13% physician, 47% nurse, 8.4% health care assistant, 10.5% cleaner, 12.4% clerical staff • 3.8% (40/1053) diagnosed with SARS-1	Incidence of SARS-1 • Physician: 5.1% (7/138) • Nurse: 3.8% (19/500) • Health care assistant: 7.9% (10/126) • Cleaner: 1.9% (3/158) • Clerical staff: 0.8% (1/131)	No control for confounding
Ho et al, 2004 (33)	Prospective cohort	Singapore; 1 hospital; 18 March–29 April 2003	372 HCWs • Mean age, 34.2 y • 77% female • 27.7% physician, 55.1% nurse, 17.2% allied health and clerical • 2.2% (8/372) seropositive for SARS-CoV-1; 6 met criteria for SARS-1	RR (95% CI) for SARS-CoV-1 seropositivity • Exposure only vs. direct contact: 2.40 (0.64–9.00) • Protected direct contact vs. unprotected direct contact: 0.16 (0.03–1.02) • Use of full PPE 100% of the time vs. <100% of the time: 0.19 (0.02–1.49)	No control for confounding; few cases with imprecise estimates
Ip et al, 2004 (34)	Retrospective cohort	Hong Kong; 1 hospital; blood samples obtained after 21 May 2003	742 HCWs • Mean age, 36.2 y (HCWs with serologic testing) • 79% female (HCWs with serologic testing) • 9.0% doctor, 3% nurse, 23% allied health, 14% health care/general service assistant, 13% ancillary, 3.7% other • 7.1% (53/742) diagnosed with SARS-1	Incidence of SARS-1 • Doctors: 2.4% (2/85) • Nurses: 11.6% (38/328) • Allied health: 0.9% (1/114) • Health care/general service assistants: 11.8% (12/102) • Ancillary: 0% (0/113) • Other: 0% (0/12)	No control for confounding
Jiang et al, 2003 (35)	Retrospective cohort	China (Guangzhou); 1 hospital; 30 January–30 March 2003	431 HCWs • Age, sex, role/type of HCW not reported • 17.9% (77/431) diagnosed with SARS-1	Incidence of SARS-1 • Ward A (no ventilation window, room volume 61.9 m2, 1 SARS-1 patient, total time of hospitalization 43 h): 73.2% (52/71) • Ward B (no ventilation window, room volume 85.1 m2, 1 SARS-1 patient, total time of hospitalization 168 h): 32.1% (9/28) • Ward C (ventilation window 1.1 m2, room volume 104.3 m2, 1 SARS-1 patient, total time of hospitalization 110 h): 27.5% (11/40) • Ward D (ventilation windows 1.9 m2, room volume 74.0 m2, 96 SARS-1 patients, total time of hospitalization 1272 h): 1.7% (5/292)	No control for confounding; too few wards to determine effects of ventilation and patient variables on risk for SARS-1 in HCWs
Lau et al, 2004 (43)	Retrospective cohort	Hong Kong; 16 hospitals; 4 March–31 May 2003	~28 000 HCWs Age, sex, and HCW role/position not reported 1.2% (339) diagnosed with SARS-1	Mean attack rate (SD) for SARS-1 across 16 hospitals: overall: 1.06% (SD 1.31) • Nurse: 1.07% (SD 1.38) • Nonmedical support staff: 2.34% (SD 3.43) • Other technical and medical staff: 0.32% (SD 0.49); *P = 0.035* for job category	No control for confounding; SARS-1 criteria not reported
Li et al, 2003 (45)	Retrospective cohort	China (Beijing); 1 hospital; 24 March–13 May 2003	770 HCWs • Age, sex and HCW role/position not reported • 2.43% (18/770) diagnosed with SARS-1	Incidence of SARS-1 • Doctor: 2.88% • Nurse: 4.78% • Nursing assistant: 6.67% • Other hospital staff: 0%	No control for confounding; few SARS-1 cases; number of HCWs in different roles/positions not reported

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Loeb et al, 2004 (50)	Retrospective cohort	Canada (Toronto); 1 hospital critical care units; 8–16 March 2003	43 nurses • Mean age, 41 y • 100% female • 18.6% (8/50) diagnosed with SARS-1	Unadjusted RR (95% CI) for SARS-1 • Gown vs. inconsistent gown: 0.36 (0.10–1.24) • Gloves vs. inconsistent gloves: 0.45 (0.14–1.46) • Consistent N95 or surgical mask vs. inconsistent mask: ***0.23 (0.07–0.78)*** • Consistent N95 vs. inconsistent mask: ***0.22 (0.05–0.93)*** • Surgical mask vs. no mask: 0.45 (0.07–2.71) • N95 vs. surgical mask: 0.50 (0.06–4.23) • Intubation (yes vs. no): ***4.20 (1.58–11.14)*** • Suctioning before intubation (yes vs. no): ***4.20 (1.58–11.14)*** • Suctioning after intubation (yes vs. no): 0.68 (0.21–2.26) • Nebulizer treatment (yes vs. no): ***3.24 (1.11–9.42)*** • Manipulation of oxygen mask (yes vs. no): 9.00 (1.00–64.89) • Manual ventilation (yes vs. no): 1.19 (0.30–4.65) • Manipulation of BiPAP mask (yes vs. no): 2.60 (0.8–7.99) • Performing an ECG (yes vs. no): 1.67 (0.51–5.46) • Endotracheal aspirate (yes vs. no): 1.00 (0.29–3.45) • Bronchoscopy (yes vs. no): 2.14 (0.46–9.90) • No significant associations: Mouth or dental care, insertion of nasogastric tube, insertion indwelling catheter, insertion of peripheral intravenous catheter, insertion of central venous catheter, bathing or patient transfer, administration of medication, venipuncture, manipulation of commodes or bedpans, feeding, chest physiotherapy, assessment of patient, insertion of peripheral intravenous line, radiology procedures, dressing change, urine specimen collected	Potential recall bias; no control for confounding
Nishiyama et al, 2008 (57)	Retrospective cohort	Vietnam (Hanoi); 2 hospitals; exposure 3–17 March 2003	85 HCWs • Age, sex, and HCW role/position not reported • Proportion diagnosed with SARS-1 unclear (29% of 146 HCWs potentially exposed diagnosed with SARS-1 and 40% seropositive for SARS-CoV-1, but analysis evaluated a subgroup of 85 HCWs)	Unadjusted estimates not reported Adjusted OR (95% CI) for SARS-1 (factors included in model) • Age: 0.97 (0.90–1.03) • Patient required oxygen vs. no oxygen: 2.65 (0.66–10.7) • Mask use: ○ Sometimes vs. always: ***2.90 (0.73–11.6)*** ○ No vs. always: ***12.6 (2.00–80.0)*** • Handwashing before patient contact: ○ Sometimes vs. always: 1.25 (0.25–6.10) ○ No vs. always: 3.69 (0.56–24.2) • Doctor vs. other staff: ***40.9 (2.65–630)*** • Nurse vs. other staff: ***57.3 (5.28–621)*** • Indirect contact with SARS patient vs. direct contact: 6.06 (0.63–58.7) • No attendance at lecture on nosocomial infection vs. attendance: 5.49 (0.90–33.4)	Potential recall bias; potential selection bias; some estimates very imprecise

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Raboud et al, 2010 (60)	Retrospective cohort	Canada (Toronto); 20 hospitals; 5 March–12 June 2003	624 HCWs who provided care to intubated SARS-1 patients • Mean age, 38.5 y (cases) • 75.2% female • 12.3% staff physician, 2.6% medical resident/intern, 45.4% registered nurse, 14.3% respiratory therapist, 10.7% radiology technologist, 6.1% housekeeper, 4.2% personal service assistant, 2.2% laboratory technician/technologist, 0.5% EMT; 1.8% other • 4.2% (26/624) with SARS-CoV-1 seropositivity	Prevalence of SARS-CoV-1 seropositivity • Physicians: 5.2% (4/77) • Medical resident/intern: 12.5% (2/16) • Registered nurse: 3.9% (11/283) • Respiratory therapist: 4.5% (4/89) • Radiology technologist: 1.5% (1/67) • Personal services assistant: 3.8% (1/25) • Paramedic/EMT: 100% (3/3) Unadjusted OR (95% CI) for SARS-1 seropositivity (unit of analysis HCWs)† • Chronic illness (yes vs. no): 0.62 (0.08–4.74) • Always wore goggles in patient room (yes vs. no): ***0.33 (0.15–0.72)*** • Always wore gloves in patient room (yes vs. no): 0.59 (0.17–2.06) • Always wore gown in patient room (yes vs. no): ***0.35 (0.14–0.91)*** • Surgical mask in patient room vs. no mask (reference): 3.27 (0.72–14.79) ○ N95 or equivalent: 0.59 (0.17–2.08) ○ Higher protection than N95: 0.25 (0.01–4.98) • N95 or N95 equivalent in patient room vs. surgical mask: ***0.18 (0.06–0.53)*** • Hand hygiene after removal of face protection vs. no hand hygiene (reference): 0.48 (0.19–1.22) ○ Hand hygiene before removing face protection, with or without hand hygiene after: 0.93 (0.29–3.01) • Infection control training (no vs. yes): ***3.93 (1.75–8.83)*** • Noninvasive ventilation (yes vs. no): ***3.15 (1.39–7.15)*** • High-flow oxygen (yes vs. no): 0.39 (0.09–1.66) • Mechanical ventilation (yes vs. no): 0.87 (0.38–1.97) • Present during intubation (yes vs. no): ***3.03 (1.37–6.70)*** • Present during suctioning before intubation (yes vs. no): 1.71 (0.70–4.17) • Present during suctioning after intubation (yes vs. no): 1.79 (0.79–4.02) • Present during manual ventilation before intubation (yes vs. no): ***2.84 (1.25–6.42)*** • Present during manual ventilation after intubation (yes vs. no): 1.27 (0.50–3.24) • Cardiac compressions (yes vs. no): 2.95 (0.36–24.50) • Sputum sample collection (yes vs. no): 2.68 (0.88–8.17) • Nebulizer treatment (yes vs. no): 1.17 (0.07–20.66) • Manipulation of oxygen mask (yes vs. no): 2.15 (0.94–4.89) • Insertion of nasogastric tube (yes vs. no): 1.02 (0.23–4.47) • Present during ECG (yes vs. no): ***3.74 (1.67–8.39)*** • HCW underlying chronic illness (yes vs. no): 0.94 (0.24–3.59) • Number of times entering patient's room, based on number of shifts with exposure (reference, >10 times): ○ 1–2 times: 0.67 (0.28–1.63) ○ 3–5 times: 0.69 (0.39–1.23) ○ 6–10 times: 0.41 (0.14–1.20) • Duration of face-to-face contact with patient, based on number of shifts with exposure (reference, >4 h) ○ <1 min: 0.83 (0.11–6.27) ○ 1–10 min: 0.98 (0.26–3.71) ○ 11–30 min: 1.33 (0.20–8.88) ○ 31–60 min: 2.73 (0.33–22.5) ○ 1–4 h: 2.37 (0.41–13.6) • Always wore recommended PPE, based on number of shifts with exposure (yes vs. no): 0.70 (0.19–2.58)	Potential recall bias; SARS-1 diagnosis did not require laboratory confirmation; collinearity in model not addressed

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
				• PPE removal, based on number of shifts with exposure (yes vs. no) ○ No hand hygiene described: 0.87 (0.16–6.45) ○ Hand hygiene performed once: 0.67 (0.11–3.99) ○ Adequate PPE removal: 1.18 (0.20–6.83) • Not statistically significant in univariate analyses: patient recognized as SARS case, Fio$_2$ on day 2 of hospital admission, bronchoscopy, chest physiotherapy , defibrillation, collection of stool sample, emptying urine bag or taking urine sample, emptying bed pan, insert central venous line, insert urinary catheter, insert peripheral intravenous access line, venipuncture/arterial blood gas, chest tube insertion, bathing, feeding, transporting, taking oral temperature, administering oral medication, or housekeeping activities Adjusted OR (95% CI) for SARS-1 (factors retained in model) • HCWs eye/mucous membranes exposed to body fluids: ***7.34 (2.19–24.52)*** • Patient APACHE II score ≥20: ***17.05 (3.20–90.75)*** • Present during ECG: ***3.52 (1.58–7.86)*** • Present during intubation: ***2.79 (1.40–5.58)*** • Patient Pao$_2$–Fio$_2$ ratio ≤59: ***8.65 (2.31–32.36)***	
Scales et al, 2003 (64)	Retrospective cohort	Canada (Toronto); 1 hospital intensive care unit; exposure occurred; 23 March 2003	69 HCWs with brief, unexpected exposure to SARS-1–infected patient • Age, sex, HCW role/position not reported • 10.1% (7/69) diagnosed with SARS-1	Incidence of SARS-1 • Entry into room: 19% (6/31) • Contact duration ≤10 min: 0% (0/11) ○ 11–30 min: 12.5% (1/8) ○ 31 min to 4 h: 25% (2/8) ○ ≥4 h: 75% (3/4) • Nature of contact: touched patient: 32% (6/19) • Contact with mucous membranes: 40% (4/10) • Procedure involving contact with mucous membranes or respiratory secretions: 40% (6/15) • Present during noninvasive positive-pressure ventilation: 18% (4/22) • Performed or assisted intubation: 60% (3/5) • Always wore: ○ Gloves: 20% (3/15) ○ Gown and gloves: 20% (3/15) ○ Any mask (N95 or surgical): 23% (3/13) ○ Gown, gloves, and N95 mask: 17% (1/6) ○ Gown, gloves, and surgical mask: 33% (2/6) ○ Gown, gloves, and any mask: 25% (3/12) ○ No precautions: 12.5% (1/8)	Potential recall bias; no control for confounding; few cases
Wang et al, 2007 (69)	Retrospective cohort	Taiwan; 4 hospitals; study began 1 July 2003	2512 HCWs • Mean age, 33.4 y • 88% female • 13% physician, 83% nurse • 0.36% (9/2512) seropositive for SARS-CoV-1; 1.0% (9/882) among those reporting contact with SARS-1 patients	Unadjusted RR (95% CI) for SARS-CoV-1 seropositivity • All HCWs (*n* = 2197) ○ Female vs. male: 1.10 (0.14–8.74) ○ Nurse vs. physician: 1.21 (0.15–9.61) ○ ED vs. ward: ***25.94 (7.07–95.14)*** • HCWs with contact with suspected or possible SARS cases (*n* = 882) ○ Female vs. male: 1.00 (0.13–7.91) ○ Nurse vs. physician: 0.92 (0.12–7.28) ○ ED vs. ward: ***9.45 (2.58–34.64)***	Potential recall bias; no control for confounding; imprecise estimates

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Appendix Table 5–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Wilder-Smith et al, 2005 (72)	Retrospective cohort	Singapore; 1 hospital; March 2003	98 HCWs (80 with serologic testing) • Median age, 28 y • 91% female • 10% doctor, 77.5%, 12.5% other • 45.9% (45/98) with SARS-CoV-1 infection (37 cases pneumonia, 2 cases subclinical, and 6 cases asymptomatic)	Unadjusted OR (95% CI) for SARS-CoV-1 infection† • Female vs. male: 0.47 (0.10–2.07) • Mask use vs. no mask use: *0.25 (0.09–0.69)* • Glove use vs. no glove use: *0.40 (0.17–0.96)* • Handwashing vs. no handwashing: 0.35 (0.11–1.12) • Close contact with SARS-1 patient (yes vs. no): 1.11 (0.23–5.26) Mean age: *29.2 y in cases vs. 33.7 in controls; P = 0.04*	Potential recall bias, no control for confounders; analyses appear to exclude 2 patients with subclinical SARS-1
Wong et al, 2004 (75)	Retrospective cohort	Hong Kong; 1 hospital; 4–10 March 2003	66 medical students • Mean age, 22.3 y (cases) • 50% female (cases) • 24% (16/66) diagnosed with SARS-1	Unadjusted RR (95% CI) for SARS-1 • Definitely visited patient's cubicle vs. did not: *7.4 (1.0–53.5)* • Association between distance from patient and likelihood of infection being present	Potential recall bias; no control for confounding
Yen et al, 2006 (77)	Retrospective cohort	Taiwan; 87 hospitals; 27 April 27–21 May 2003	87 hospitals • Study hospital: ○ Integrated infection control strategy involving triaging patients and use of physical barriers, separation of hospital space into zones of risk, and extensive installation of alcohol dispensers for glove-on hand rubbing 2 HCWs diagnosed with SARS-1 • Control hospitals: ○ No intervention ○ 93 HCWs diagnosed with SARS-1	Incidence of SARS-1 in HCWs • Study hospital vs. control hospitals: *0.03 case/bed vs. 0.13 case/bed, P = 0.03*	No control for confounding; no description of infection control measures in control hospitals; criteria for SARS-1 diagnosis in control hospitals unclear; only 2 cases in study hospital; analyzed as cases per hospital bed rather than per HCW
Chen et al, 2009 (26)	Case–control	China (Guangzhou); 2 hospitals; dates not reported	91 HCW cases with SARS-CoV-1 seropositivity (80 SARS-1) and 657 controls • 34.9% aged <26 y, 54.2% 26-40 y, 10.8% >50 y • 76.0% female • 31.5% doctor, 49.2% nurse, 7.3% health attendant, 5.0% laboratory technician, 7.0% other	Unadjusted OR (95% CI) for SARS-CoV-1 seropositivity • Single vs. double gowns: *2.12 (1.36–3.31)* • Single vs. double cotton masks: *2.53 (1.56–4.07)* • Single vs. double gloves: *5.20 (2.65–10.23)* • Shoe cover never vs. every time (reference): *3.80 (2.24–6.45)*; sometimes: *5.04 (2.04–12.48)*; often: 2.29 (0.96–5.67) • Cap never vs. every time (reference): *1.79 (1.03–3.10)*; sometimes: 0.48 (0.14–1.67); often: 0.59 (0.13–2.65) • Face shield in SARS ward never vs. every time (reference): 4.05 (0.54–30.34); sometimes: 0.22 (0.01–3.56) • Goggles while performing operation for SARS-1 patients never vs. every time (reference): *7.83 (1.07-57.63)*; sometimes: 0.84 (0.07–9.45) • Wash uncovered skin after caring for SARS-1 patients never vs. every time (reference): *3.29 (1.29–8.43)*; sometimes: 2.16 (0.77–6.05); often: 1.47 (0.45–4.79) • Wash hands after caring for SARS-1 patients never vs. every time (reference): 0.89 (0.52–1.51); sometimes: 1.03 (0.38–2.75); often: 1.14 (0.64–2.06) • Wash nasal cavity after caring for SARS-1 patients never vs. every time (reference): 3.21 (0.98–10.53); sometimes: 2.51 (0.72–8.77); often: 0.82 (0.13–5.13) • Wash oral cavity after caring for SARS-1 patients, never vs. every time (reference): *3.26 (1.15–9.21)*; sometimes: 2.05 (0.67–6.33); often: 0.28 (0.03–2.59) • Special training for SARS-1 (no vs. yes): *2.44 (1.41–4.23)* • Performing tracheostomy (yes vs. no): *4.15 (1.50–11.50)* • Performing endotracheal intubations (yes vs. no): *8.03 (3.90–16.56)* • Caring for "super spreading" patient (yes vs. no): *4.55 (2.75–7.54)* • Avoiding face to face while caring for patient, sometimes vs. never (reference): 0.64 (0.36–1.10); often: *0.53 (0.31–0.93)*; every time: *0.16 (0.06–0.46)*	Potential recall bias; methods for selecting controls unclear; collinearity in model not addressed

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Appendix Table 5–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
				• Air ventilation method in offices and SARS-1 wards, natural vs. artificial central ventilation (reference): ***0.28 (0.14–0.54)***; natural and additional electronic exhaust fan: ***0.17 (0.06–0.25)*** • Type of equipment for washing hands nonautomatic vs. automatic tap (reference): ***4.18 (1.66–10.51)***; others: 1.09 (0.12–9.74) **Adjusted OR (95% CI) for SARS-CoV-1 seropositivity (factors included in forward stepwise model)** • Single vs. double gloves worn: ***4.13 (1.99–8.55)*** • Caring for "super spreading" patient (yes vs. no): ***3.57 (1.94–6.57)*** • Avoiding face to face while caring for patient (reference never) ○ Sometimes: 0.67 (0.36–1.24) ○ Often: ***0.30 (0.10–0.90)*** ○ Every time: ***0.30 (0.15–0.60)*** • Air ventilation method in offices and SAR wards (reference artificial central ventilation) ○ Natural ventilation: ***0.40 (0.18–0.88)*** ○ Natural ventilation and additional electronic exhaust fan: ***0.27 (0.16–0.63)*** • Performing endotracheal intubation (yes vs. no): ***2.76 (1.16–6.53)***	
Lau, 2004 (41)	Case–control	Hong Kong; 5 hospitals; cases diagnosed 28 March–25 May 2003	72 HCW cases with SARS-1 and 143 matched controls • Mean age and sex not reported • 59.7% nurse, 23.6% health care assistant, 9.7% medical officer, 2.8% clerical staff, 4.2% workmen	Unadjusted matched OR (95% CI) for direct contact with SARS patient, direct patient contact in general, and no patient contact • Inconsistent N95 or surgical mask use vs. consistent: 2.00 (0.05–∞), 4.00 (0.21–235.99), 2.43 (0.41–16.77); for all HCWs, unadjusted unmatched OR, ***3.74 (1.06–13.24)†*** • Inconsistent N95 mask use vs. consistent: 2.86 (0.70–13.71), 1.28 (0.16–10.47), 1.83 (0.72–4.71); for all HCWs, unadjusted unmatched OR, ***2.08 (1.07–4.02)†*** • Inconsistent goggles use vs. consistent: ***6.41 (2.49–19.49), 6.93 (2.19–28.85), 3.50 (1.42–9.47)***; for all HCWs, unadjusted unmatched OR, ***13.82 (6.71–28.45)†*** • Inconsistent glove use vs. consistent: ***20.54 (2.96–887.72)***, 3.53 (0.77–21.85), ***2.42 (1.05–5.81)***; for all HCWs, unadjusted unmatched OR, ***4.54 (2.43–8.47)†*** • Inconsistent gown use vs. consistent: ***8.85 (2.46–48.28), 11.54 (2.56–106.36), 3.42 (1.38–9.30)***; for all HCWs, unadjusted unmatched OR, ***8.77 (4.58–16.82)†*** • Inconsistent cap use vs. consistent***: 7.30 (2.33–30.21), 12.81 (2.92–116.75), 4.05 (1.68–10.76)***; for all HCWs, unadjusted unmatched OR, ***11.79 (6.03–22.08)†*** • 1–2 PPE items inconsistently used vs. 0 items: ***5.35 (1.79–18.53), 4.85 (1.01–31.86),*** 1.56 (0.28–7.97); for all HCWs, unadjusted unmatched OR, ***3.40 (1.81–6.36)†*** • ≥3 PPE items inconsistently used vs. 0 items: ***7.84 (2.30–34.83), 10.83 (2.29–102.60), 3.40 (1.38–9.23)***; for all HCWs, ***unadjusted unmatched OR, 3.96 (2.40–6.52)†*** • Inconsistent hand hygiene vs. consistent: 4.83 (0.38–∞), 1.00 (0.02–19.21), ***6.38 (1.64–36.17)***	Potential recall bias; collinearity in model not addressed

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Appendix Table 5–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
				All HCWs, perceived inadequacy of supply (yes vs. no): • Surgical mask: ***28.00 (4.26–∞)*** • N95 mask: ***5.19 (1.95–16.13)*** • Gown: ***8.44 (2.77–34.37)*** • Gloves: ***29.34 (5.79–∞)*** • Goggles: ***19.81 (4.83–174.55)*** • Cap: ***52.41 (9.08–∞)*** • Any PPE item: ***6.78 (2.86–18.51)*** • 1–2 PPE items identified to be inadequate vs. 0 items (reference): ***3.25 (1.17–9.80)***; 3 items: ***52.24 (7.70–2280.07)*** All HCWs: • SARS infection control training <2 h vs. none (reference): 0.47 (0.18–1.14); ≥2 h: ***0.03 (0.001–0.20)*** • Understood infection controls measures (yes vs. no): ***3.14 (1.35–7.73)*** • Acquired updated information (yes vs. no): 0.27 (0.06–1.04) • High-risk procedures with SARS patients (yes vs. no): 1.22 (0.45–3.14) • Direct contact with SARS patients (yes vs. no): 0.57 (0.28–1.14) • Direct contact with patients in general (yes vs. no): 1.68 (0.07–117.74) • Seconded from another unit (yes vs. no): 0.60 (0.29–1.21) • Social contact with SARS patients (yes vs. no): 0.59 (0.28–1.19) • Frequency of touching N95 mask most of the time/always vs. never/occasional: 1.32 (0.63–2.74) • General problems with mask (yes vs. no): 0.66 (0.34–1.27) • Problems with mask fit (yes vs. no): 1.00 (0.51–1.95) • Problems with fogging of goggles (yes vs. no): 0.61 (0.31–1.17) • Overall problems in general compliance (yes vs. no): 0.58 (0.25–1.33) • Number of problems (inconsistent use of ≥1 PPE item with contact with SARS-1 patient, patients in general, or no patient contact; infection control training <2 h, not understanding infection control procedures, at least 1 PPE item perceived to be in inadequate supply, or inconsistent hand hygiene with no direct patient), 1 vs. 0 (reference): ***8.47 (1.37–∞);*** 2: ***17.78 (2.67–∞);*** ≥3: ***44.15 (7.02–∞)*** **Adjusted matched OR (95% CI) for SARS-1 (factors included in forward stepwise model)** • Perceived inadequacy of PPE vs. no perceived inadequacy: ***4.27 (1.66–12.54)*** • SARS infections control training <2 h or no training vs. ≥2 h: ***13.6 (1.24–27.50)*** • Inconsistent use of >1 type of PPE when having direct contact with SARS patients: ***5.06 (1.91–598.92)***	
Liu et al, 2009 (49)	Case–control	China (Beijing); single hospital; cases diagnosed between 5 March and 17 May 2003	51 HCW cases with SARS-1 and 426 controls • Mean age, 29.5 y (cases) • 68.6% female (cases) • 31.4% medical staff, 49.0% nursing staff, 19.6% other occupation	Unadjusted OR (95% CI) for SARS-1 (yes vs. no)† • 12-layer cotton surgical mask: 0.50 (0.23–1.10) • 16-layer cotton surgical mask: ***0.27 (0.14–0.51)*** • N95 mask: 0.52 (0.12–2.24) • Disposable mask: 1.12 (0.55–2.27) • Glasses: ***0.43 (0.23–0.81)*** • Multiple layers of protective clothes: ***0.44 (0.20–0.99)*** • Gloves: ***0.16 (0.05–0.57)*** • Goggles: 0.54 (0.29–1.00) • Performing nose wash: ***0.28 (0.13–0.60)*** • Taking training: ***0.24 (0.12–0.48)*** • N95 vs. 12- or 16-layer cotton surgical mask: 1.05 (0.24–4.66) • N95 vs. disposable mask: 0.49 (0.10–2.35) • Disposable vs. 12- or 16-layer cotton surgical mask: 2.13 (1.00–4.54)	Potential recall bias; controls not matched, other than meeting WHO criteria for close contact with SARS patient

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***Appendix Table 5*–Continued**

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
				Incidence of SARS-1 (yes vs. no) • Contact: ○ Nursing: 10.6% vs. 10.8%, *P* = 0.96 ○ Physical contact: 11.3% vs. 10.3%, *P* = 0.75 ○ Injection: 10.8% vs. 11.4%, *P* = 0.82 ○ Intubation: ***50.0% vs. 9.7%, P < 0.001*** ○ Chest compression: ***33.3% vs. 11.1%, P = 0.02*** ○ Respiratory secretion: ***18.3% vs. 9.0%, P = 0.004*** ○ Sputum: ***18.0% vs. 8.2%, P = 0.004*** ○ Feces: 12.7% vs. 10.1%, *P* = 0.45 ○ Urine: 11.8% vs. 10.4%, *P* = 0.66 ○ Pulmonary lavage: 0% vs. 11.9%, *P* = 1.0 ○ Equipment: 13.0% vs. 10.6%, *P* = 0.83 ○ Pathologic specimens: ***37.5% vs. 10.2%, P = 0.04*** ○ Deceased: ***27.8% vs. 10.0%, P = 0.04*** ○ Medical waste: 11.5% vs. 10.4%, *P* = 0.75 • Emergency care experience***: 21.1% vs. 8.4%, P = 0.001*** • 1 layer of masks: ***27.3% vs. 14.8%; P = 0.002*** for number of layers • Multiple layers of masks: 7.0% vs. 14.8% • Taking prophylactic medication: ***8.6% vs. 20.2%, P = 0.003*** • No change in sleeping hours per day: 11.3% vs. 11.4%, *P* = 0.12 for total numbers of sleeping hours • Increase in sleeping hours per day: 7.7% vs. 11.4% Adjusted OR (95% CI) for SARS-1 (factors included in forward stepwise model) • 16-layer cotton surgical mask (no vs. yes): ***6.04 (2.43–15.00)*** • 12-layer cotton surgical mask (no vs. yes): ***4.54 (1.62–12.74)*** • Emergency care experience (yes vs. no): ***2.97 (1.26–6.96)*** • Nose wash (no vs. yes): 2.41 (0.98–5.93) • Respiratory secretion contact (yes vs. no): ***3.27 (1.41–7.57)*** • Not taking prophylactic medicine vs. taking: ***2.77 (1.10–6.98))*** • Not taking training vs. taking: ***2.40 (1.08–5.31))*** • Multiple layers of masks (no vs. yes): ***2.44 (1.03–5.77))*** • Contact: chest compression (yes vs. no): ***4.52 (1.08–18.81))*** • Contact with sputum was excluded from the model owing to a high correlation with respiratory secretions; 12-layer and 16-layer surgical mask, intubation and chest compression, respiratory secretion and sputum, pathologic specimens and deceased, contact date and taking training, nose wash and taking training, and glasses and goggles highly correlated	
Ma et al, 2004 (52)	Case–control	China (Beijing); 5 hospitals; 2003 (exact dates not reported)	47 HCW cases and 426 controls • Mean age, 29 y (cases) • 70% female • Physicians, nurses, care givers and custodians and other medical personnel (numbers not provided)	Unadjusted OR (95% CI) for SARS-1 • HCW role: caregiver/custodian vs. other role (reference): 1.29 (0.27–5.86) ○ Nurse: 0.49 (0.19–1.29) ○ Physician: ***0.32 (0.11–0.95)*** • Time in current position <1 y vs. ≥1 y: ***3.08 (1.52–6.19)*** • Participation in emergency rescue vs. not: ***3.10 (1.56–6.16)*** • Eye goggles vs. no goggles: ***0.24 (0.10–0.55)*** • Exposure to secretions vs. not: ***3.98 (2.00–7.92)*** • Mask use vs. no mask: ***0.24 (0.09–0.64)*** • Mask type: disposable vs. ≤12-layer (reference): ***0.13 (0.05–0.34)*** ○ >16-layer: ***0.06 (0.03–0.15)*** ○ N95 and respirator: ***0.00 (0.00–0.33)***	Potential recall bias; controls were exposed to SARS-1 patients but otherwise not matched; collinearity in model not addressed

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Appendix Table 5–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
				• Gowns vs. no gowns: ***0.03 (0.01–0.08)*** • 1 gown layer vs. no gown (reference): ***0.03 (0.01–0.09)***; 2 layers: ***0.03 (0.01–0.12)***; 3 layers: ***0.02 (0.00–0.07)***; 4 layers: ***0.04 (0.01–0.19)*** • Gloves vs. no gloves: ***0.43 (0.22–0.85)*** • Eye cover vs. no eye cover: ***0.28 (0.14–0.57)*** • Prophylactic medicine (yes vs. no): ***0.31 (0.15–0.65)*** • Use of disinfectant for hands (yes vs. no): ***0.40 (0.19–0.81)*** • Handwashing (yes vs. no): 0.53 (0.26–1.06) • Nasal cleaning (yes vs. no): ***0.27 (0.11–0.62)*** • Training (yes vs. no): ***0.18 (0.09–0.36)*** • Accumulated contact days: ***0.83 (0.80–0.86)*** • Average number of patients contacted each day: ***0.73 (0.66–0.80)*** • Average hours working in the isolation room each day: ***0.73 (0.68–0.78)***; maximum hours: ***0.79 (0.75–0.83)*** • Average hours working in the contaminated area each day, ***0.67 (0.61–0.72)***; maximum hours, ***0.76 (0.71–0.80)*** • Average hours working in the semicontaminated area each day, ***0.63 (0.55–0.71)***; maximum hours, ***0.70 (0.63–0.77)*** • Number of supervised beds: ***0.84 (0.80–0.88)*** • Caring everyday life and contact with patients' secretions vs. medical exam, radiological exam, transferring infected patients, contact with dead body (reference): ***3.22 (1.29–8.24)*** ○ Transfusion: 1.06 (0.21–4.57) ○ Intubation, tracheotomy, airway management, chest compressions: ***6.22 (2.19–18.05)*** ○ ICU and special care: 2.59 (0.61–10.31) Adjusted OR (95% CI) for SARS-1 (factors in forward stepwise model) • Goggles vs. no goggles: ***0.27 (0.10 to 0.73)*** • Exposure to secretions vs not: ***4.70 (1.84–11.97)*** • Gowns vs. no gowns: ***0.02 (0.01–0.04)*** • Time in current position <1 y vs. ≥1 y: ***4.22 (1.67–10.66)*** • Daily care with and contact with patients' secretions: ***3.02 (1.23–7.46)*** • Type of mask (≤12 layers of cotton vs. others): ***76.68 (16.74–351.31)***	
Nishiura et al, 2005 (56)	Case–control	Vietnam (Hanoi); single hospital; 26 February–28 April 2003	29 HCW cases with SARS-1 and 98 controls • 57% aged 29–39 y; 33% 30–39 y; 43% 40–50 y • 60% female • 13% doctor, 26% nurse, 54% other HCW, 33% relative of patient	Unadjusted OR (95% CI) for SARS-1 • Female vs. male: ***3.3 (1.2–9.0)*** • Age: ○ 29 y: 0.9 (0.3–2.3) ○ 30–39 y: 0.4 (0.2–1.1) ○ 40–49 y: ***2.8 (1.2–6.6)*** ○ 50 y: 0.7 (0.1–3.2) • Occupation: ○ Doctor: 0.8 (0.2–2.9) ○ Nurse: ***3.2 (1.3–7.7)*** ○ Other HCW: 2.2 (0.9–5.2) • Relative of patient: ***<0.1 (0.0–0.4)*** *Period 1 (26 February–4 March) and period 2 (5–10 March)* • All precautionary measures (yes vs. no): ***0.2 (0.0–1.0)*** and ***<0.1 (0.0–0.3)*** • Handwashing before (yes vs. no): 1.0 (0.4–2.3) and not calculated (100% in cases) • Handwashing after (yes vs. no): 1.1 (0.5–2.8) and not calculated (100% in cases) • Mask vs. no mask: ***0.3 (0.1–0.7)*** and ***0.1 (0.0 to 0.3)*** • Gloves vs. no gloves: 0.7 (0.3–1.9) and not calculated (100% in cases) • Gowns vs. no gowns: ***0.2 (0.0–0.8)*** and not calculated (100% in controls)	Potential recall bias; controls not matched; 42% of controls were non-HCW relatives of patients

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Pei et al, 2006 (58)	Case–control	China; 3 hospitals; April–June 2004	147 HCW cases with SARS-1 and 296 controls • Mean age, 32 y (cases) • 81.6% female (cases) • 25.9% doctor, 51.7% nurse, 4.1% nursing staff, 3.4% worker, 11.6% technician, 1.4% administrator, 2.0% other (cases)	Unadjusted OR (95% CI) for SARS-1 • SARS-1 education before treating SARS-1 patients (yes vs. no): ***0.38 (0.17–0.80)*** • SARS-1 preventive training (yes vs. no): ***0.07 (0.03–0.13)*** • Isolated areas in SARS-1 wards (yes vs. no): ***0.25 (0.16–0.40)*** Working areas didn't overlap (yes vs. no): ***0.24 (0.15–0.40)*** • Endotracheal intubation (yes vs. no): ***9.06 (4.12–19.92)*** • Participating in care of critical care patients (yes vs. no): ***1.72 (1.11–2.65)*** • Avoiding face to face contact with patients (yes vs. no): ***0.29 (0.13–0.64)*** • Keeping a certain distance from SARS-1 patients (yes vs. no): ***0.45 (0.28–0.73)*** • 1-layer disposable suit vs. no suit (reference): ***0.23 (0.12–0.42)***; at least double layer: ***0.03 (0.01–0.10)*** • General cotton mask vs. no mask (reference): ***0.48 (0.25–0.95)***; double 12-layer cotton mask: ***0.13 (0.05–0.30)*** • 1-layer plastic gloves vs. no gloves (reference): ***0.11 (0.04–0.27)***; one layer latex medical gloves: ***0.08 (0.04–0.19)***; at least double layer latex medical gloves: ***0.07 (0.03–0.16)*** • Face screen or goggles (yes vs. no): ***0.50 (0.27–0.75)*** • Changing PPE <4 h (yes vs. no): ***0.50 (0.31–0.82)*** • Isolating medical staff's offices from SARS-1 wards (yes vs. no): ***0.57 (0.38–0.87)*** • Using ventilator in the office (yes vs. no): ***0.18 (0.11–0.31)*** • Well-ventilated office (yes vs. no): ***0.11 (0.06–0.22)*** • No-touch hand washing equipment (yes vs. no): ***0.11 (0.02–0.45)*** • Gargling (yes vs. no): 0.47 (0.22–1.01) • Interferon-alfa for prophylaxis (yes vs. no): ***0.19 (0.06–0.65)*** • History of diabetes (yes vs. no): ***3.04 (2.65–3.47)*** Adjusted OR (95% CI) for SARS-1 (factors included in multivariate model) • Endotracheal intubation vs. no intubation: ***30.79 (7.91–119.84)*** • At least double-layer disposable suit when caring for SARS patients vs. no suit: ***0.05 (0.007–0.39)*** • 1-layer plastic gloves vs. no gloves: ***0.10 (0.02–0.42)*** • 1-layer latex gloves vs. no gloves: ***0.10 (0.03–0.42)*** • Hand-sanitizing with iodine (yes vs. no): 0.23 (0.04–1.32) • Well-ventilated office (yes vs. no): 0.32 (0.09–1.15)	Potential recall bias; controls were exposed to SARS-1 patients but otherwise not matched; collinearity in model not addressed
Reynolds et al, 2006 (62)	Case–control	Vietnam (Hanoi); single hospital; contact with infected patient occurred between 26 February and 5 March 2003	36 HCW cases with SARS-1 and 157 controls (nested analysis based on 22 cases and 45 controls) • Mean age, and sex and not reported • 19.4% physician, 38.9% nurse, 11.1% midwife, 5.6% other clinical staff, 16.7% sanitation/kitchen, 5.6% other nonclinical staff	Unadjusted OR (95% CI) for SARS-1 • Touched index patient: 2.8 (0.9–8.5) • Talked to or touched index patient without mask: 1.9 (0.6–5.9) • Came within 1 m of index patient: ***9.3 (2.8–30.9)*** • Came within 1 m of index patient without mask: ***5.4 (1.8–16.3)*** • Spoke with index patient: ***3.5 (1.2–10.4)*** • Entered patient room: ***20.0 (4.1–97.1)*** • Spoke with index patient in his room: ***3.7 (1.1–12.6)*** • Saw (viewed) index patient: ***14.0 (3.6–55.3)*** Visited patient room when patient was not there: ***3.7 (1.3–10.9)*** • Touched visibly contaminated surface: ***7.8 (2.3–25.9)*** • Entered general ward: ***8.0 (1.7–38.4)*** • Upper respiratory infection within prior 6 months: ***0.2 (0.04–0.9)*** • "Other" clinical job: ***0.2 (0.03–0.7)*** • Direct patient care activities: 2.0 (0.7–5.6) • Sanitation/kitchen job: 2.2 (0.7–7.0)	Potential recall bias; controls were exposed to SARS-1 patients but otherwise not matched; potential selection bias for nested analysis

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Seto et al, 2003 (65)	Case–control	Hong Kong; 5 hospitals; dates not reported	13 HCW cases and 241 controls • Age not reported • 69% female (cases) • 15% doctor, 46% nurse, 31% health care assistant, 8% domestic staff (cases)	SARS-1 cases by mask type • Paper mask: 7.1% (2/28) • Surgical mask: 0% (0/51) • N95: 0% (0/92) Unadjusted OR (95% CI) for SARS-1; based on response of "yes" or "most of the time" • Mask use vs. nonuse: ***0.08 (0.02–0.33)*** ○ Paper mask use: 0.50 (0.10–2.42)† ○ Surgical mask use: 0.06 (0.004–1.06)† ○ N95 mask use: ***0.003 (0.002–0.59)†*** • Glove use vs. nonuse: 0.5 (0.14–1.7) • Gown use vs. nonuse: OR not calculated, ***use 0% in cases vs. 34% in controls, P = 0.006*** • Hand-washing vs. no handwashing: 0.2 (0.05–1) • All infection control measures vs. not all measures: OR not calculated, all measures ***0% in cases vs. 29% in controls, P = 0.02***	Potential recall bias; no control for confounding; controls not matched other than exposure to patients with SARS; laboratory confirmation of cases not reported
Teleman et al, 2004 (66)	Case–control	Singapore; 1 hospital; 1–22 March 2003	36 HCW cases with SARS-1 and 50 controls • 63.9% aged <30 y (cases) • 88.9% female (cases) • 72% doctor or nurse; 28% other HCW	Unadjusted OR (95% CI) for SARS-1 • Female vs. male: 6.1 (0.7–57.3) • Chinese vs. non-Chinese: 2.4 (1.0–5.9) • Age <30 vs. ≥30 y: 1.4 (0.3–1.7) • Comorbid condition (yes vs. no): 0.9 (0.3–3.2) • Vaccination in previous 5 y (yes vs. no): 1.03 (0.4–2.7) • Doctor or nurse vs. other HCWs: 0.7 (0.3–1.9) • Distance to source of infection < 1 meter vs. ≥1 meter: 0.9 (0.2–3.6) • Duration of exposure ≥60 min vs. <60 min: 0.7 (0.3–1.6) • Wearing N95 mask vs. not wearing: ***0.1 (0.03–0.4)*** • Wearing gloves vs. not wearing: 0.5 (0.2–1.2) • Wearing gowns vs. not wearing: 0.5 (0.1–1.4) • Touched patients (yes vs. no): 1.0 (0.4–3.0) • Touched patients' personal belongings (yes vs. no): 0.6 (0.2–1.7) • Contact with respiratory secretions (yes vs. no): ***6.9 (1.4–34.6)*** • Performed venipuncture (yes vs. no): 0.8 (0.3–2.4) • Performed/assisted in intubation (yes vs. no): 1.5 (0.4–5.4) • Performed suction of body fluids (yes vs. no): 1.01 (0.4–2.8) • Administered oxygen (yes vs. no): 1.0 (0.3–2.8) • Hand washing after each patient (yes vs. no): ***0.06 (0.007–0.5)*** Adjusted OR (95% CI) for SARS-1 (factors with *P* < 0.20 in univariate analysis included) • Male vs. female: 2.9 (0.2–34.0) • Chinese vs. non-Chinese: 2.0 (0.7–6.1) • Wearing N95 mask vs. not wearing: ***0.1 (0.02–0.9)*** • Wearing gloves vs. not wearing: 1.5 (0.3–7.2) • Wearing gowns vs. not wearing: 0.5 (0.4–6.9) • Hand washing after each patient (yes vs. no): ***0.07 (0.008–0.7)*** • Contact with respiratory secretions (yes vs. no): ***21.8 (1.7–274.8)***	Potential recall bias; controls not matched other than exposure to patients with probable SARS; collinearity in model not addressed

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Yen et al, 2011 (76)	Case–control	Taiwan; 50 hospitals; 25 February–5 July 2003	50 hospitals • Cases: 19 hospitals with at least 1 case of SARS-1 in HCWs • Controls: 31 hospitals with no cases	Unadjusted OR (95% CI for effectiveness (defined as the last nosocomial SARS-1 infection in the hospital occurred before the date of implementation of the measure† • Triage for patients with fever of unknown origin in ED: ***0.10 (0.02–0.43)*** • Set up fever ED station outside ED: ***0.04 (0.01–0.22)*** • Body temperature screening in main entrance: ***0.02 (0.00–0.40)*** • Body temperature screening for patients: ***0.05 (0.01–0.41)*** • Body temperature screening for HCWs: ***0.05 (0.01–0.41)*** • Separation of fever patients within physical barrier isolated region in ED: 0.26 (0.06–1.08) • Moving patient into a special designated centralized isolation ward or evaluate patients within a general ward: ***0.04 (0.01–0.18)*** • Separate elevators and routes for patients and HCWs: ***0.09 (0.02–0.33)*** • Installation of physical barriers between zones of risk for isolation ward: ***0.07 (0.01–0.38)*** • Installation of handwashing station in ED: 0.53 (0.14–2.00) • Disinfectant solution available at main entrance (of hospital): ***0.04 (0.004–0.33)*** • Set up handwashing facilities around whole hospital: ***0.20 (0.06–0.69)*** • Set up alcohol dispensers at checkpoints for glove-on hand rubbing between zones of risk: ***0.01 (0.001–0.11)*** • Set up standardized negative pressure isolation room in hospital: ***0.17 (0.05–0.63)*** • Set up simplified negative pressure isolation room within hospital: ***0.29 (0.09–0.93)*** • Wearing N95 mask in ED: 0.35 (0.11–1.13) • Wearing N95 mask within zones of risk: ***0.02 (0.001–0.39)*** • Mask worn when entering hospital: ***0.02 (0.001–0.40)*** • Wearing surgical mask in outpatient department: ***0.09 (0.01–0.88)*** • Wearing surgical mask in ward: ***0.09 (0.01–0.88)*** • Established crisis response team: ***0.02 (0.001–0.40)*** • Exclude visitors from hospital: ***0.11 (0.03–0.41)*** • Support from administration for infection control practitioner: ***0.11 (0.03–0.41)*** • Support from administration for infectious diseases specialist or physician: ***0.09 (0.02–0.52)*** • Support from superintendent/directors for infection control: ***0.08 (0.01–0.42)*** Adjusted OR (95% CI) for effectiveness (defined as the last nosocomial SARS-1 infection occurred before the date of implementation of the measure) (factors included in forward stepwise model) • Set up fever screen station outside of ED: ***0.05 (0.004–0.69)*** • Set up alcohol dispensers at checkpoint for glove-on hand rubbing between zones of risk: ***0.04 (0.003–0.63)***	No control for severity of outbreak across hospital; unit of analysis is hospitals rather than HCWs; highly correlated risk factors dropped from model but correlated risk factors not reported

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
Yin et al, 2004 (78)	Case–control	China (Guangdong); 10 hospitals; April to May 2003	77 HCW cases and 180 controls • 54% aged 18–29 y; 38% aged 30–39 y (cases) • 77% female (cases) • 38% physician, 62% nurse (cases)	Unadjusted OR (95% CI) for SARS-1 • Use of mask vs. no mask: ***0.08 (0.01–0.43)*** • ≥12-layer mask vs. no mask: ***0.07 (0.01–0.34)*** • Disposable mask vs. no mask: 0.22 (0.02–1.29) • Disposable mask vs. ≥12 layer mask: ***3.39 (1.72–6.67)†*** • Use of goggles vs. no goggles: ***0.10 (0.05–0.20)*** • Protection of nasal and eye mucosa: ***0.13 (0.02–0.97)*** • Use of shoe cover vs. no shoe cover: ***0.18 (0.10–0.35)*** • Use of gown vs. no gown: ***0.22 (0.12–0.39)*** • Use of gloves vs. no gloves: ***0.30 (0.17–0.53)*** • Mouth washing vs. no mouth washing: ***0.35 (0.13–0.93)*** • Showering and changing after work (before going home) vs. not: ***0.37 (0.19–0.72)*** • Check facial mask: ***0.42 (0.23–0.78)*** • Take oseltamivir phosphate vs. not: ***0.43 (0.24–0.78)*** • Food/drink/smoking in patient area (no vs. yes): ***0.43 (0.24–0.77)*** • Disinfection and wash hands (yes vs. no): ***0.49 (0.28–0.85)*** • Use of nose clip vs. no nose clip: ***0.70 (0.38–1.31)*** • Preventive measures recommended by Ministry of Health adopted 1 vs. 0 (reference): 0.62 (0.20–1.96); 2: 0.63 (0.19–1.99); 3: 0.33 (0.09–1.18); 4: ***0.23 (0.07–0.74)***; 5: ***0.07 (0.02–0.27)***; 6: ***0.02 (0.00–0.15)*** • WHO guide adopted (yes vs. no): ***0.00 (0.00–0.08)*** Adjusted OR (95% CI) for SARS-1 (factors in forward stepwise model) • Use of mask (12 layers or better) vs. no mask: ***0.78 (0.60–0.99)*** • Use of goggles: ***0.20 (0.10–0.41)*** • Use of shoe cover: ***0.58 (0.39–0.86)*** *Dose–response relationship present for mask, gown, gloves, goggles, shoe cover, gargle, use of eye and nose drops, and showering and changing after work. Attack rate in HCWs without any protection was 61.5% (16/26).*	Potential recall bias; controls were exposed to SARS-1 patients but otherwise not matched; collinearity in model not addressed
Chen et al, 2005 (27)	Cross-sectional	China (Guangzhou); 3 hospitals; May 2003	1856 HCWs (1135 worked with SARS patients) • Mean age, 30.8 y • 71.6% female • 30.7% doctor, 48.3% nurse, 5.5% health attendant, 4.0% laboratory technician, 11.5% other • 8.3% (95/1147) seropositive for SARS-CoV-1	Prevalence of SARS-CoV-1 seropositivity among HCWs who worked with SARS patients • Age ○ <26 y: 12.4% (44/355) ○ 26–30 y: 5.5% (17/310) ○ 31–35 y: 6.6% (14/211) ○ 36–40: y 7.6% (9/118) ○ >40 y: 7.8% (11/141) • Male: 4.7% (15/306) • Female: 9.7% (80/743) • Department SARS ward: 3.2% (13/409) • ED/fever clinic: 2.1% (4/188) • Infectious disease department: 15.2% (19/125) • Respiratory diseases department: 36.0% (36/100) • ICU: 12.7% (7/55) • Radiography: 3.5% (2/57) • Laboratory: 0% (0/66) • Others (internal medicine, surgery, logistic service): 9.5% (14/147) • Job title: ○ Doctor: 6.2% (24/388) ○ Nurse: 10.2% (52/510) ○ Health attendant: 13.2% (12/91) ○ Technician in laboratory: 0% (0/66) ○ Others: 7.6% (7/92)	No control for confounding; 16% of HCWs with SARS-CoV IgG did not have symptoms of SARS

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Appendix Table 5–Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
MERS-CoV					
Alraddadi et al, 2016 (19)	Retrospective cohort	Saudi Arabia; 1 hospital; May 2014 to June 2014	283 HCWs • Mean age, 40 y (cases) • 64.4% female • 55% nurse, 16% physician, 12% respiratory therapist, 6.8% radiology technicians, 9.2% other (MICU and EDU HCWs) • 7.0% (20/283) seropositive for MERS-CoV	Incidence of MERS-CoV seropositivity in HCWs • MICU: 11.7% (15/128) • ED: 4.1% (5/122) • Neurology unit: 0% (0/33) • Radiology technician (MICU and ED): 29.4% (5/17) • Nurses (MICU and ED): 9.4% (13/138) • Respiratory therapist (MICU and ED): 3.2% (1/31) • Physicians (MICU and ED): 2.4% (1/41) • Patient transport or clerical staff (MICU and ED): 0% (0/21) Mortality: 0% (0/20) Mechanical ventilation: 15% (3/20) Hospital admission without mechanical ventilation: 10% (2/20) RR (95% CI) for MERS-CoV seropositivity, present vs. absent • Comorbidity: 1.67 (0.70–3.96) ○ Diabetes mellitus: 1.89 0.60–5.95) • Exposure to MERS-CoV patient: 1.38 (0.20–9.72) • Taking vital signs: 0.92 (0.39–2.20); providing medication: 1.05 (0.44–2.49); placing urinary catheter: 0.67 (0.20–2.21); bathing: 1.14 (0.47–2.77); feeding: 1.02 (0.40–2.56); lifting, positioning: 1.99 (0.74–5.33); emptying bedpan: 1.57 (0.66–3.73); changing linen: 1.45 (0.61–3.47); providing injection: 1.54 (0.65–3.63); placing intravascular device: 2.30 (0.98–5.41); performing hemodialysis: 0.59 (0.14–2.46); taking medical history: 0.59 (0.23–1.50); performing physical exam: 0.54 (0.23–1.27); drawing blood: 1.21 (0.51–2.90); collecting respiratory laboratory specimens: 0.92 (0.39–2.17); performing radiograph: 1.99 (0.84–4.70); processing clinical specimen: 1.72 (0.54–5.45); visiting in the hospital: 0.79 (0.29–2.10) • Present for procedures listed below: 1.42 (0.43–4.66) ○ Manipulation of oxygen face mask or tubing: 0.92 (0.37–2.33) ○ Airway suction: 0.67 (0.29–1.60) ○ Noninvasive ventilation: 1.02 (0.43–2.41) ○ Manual ventilation: 0.53 (0.20–1.42) ○ Nebulizer treatments: 1.05 (0.45–2.50) ○ Intubation: 0.66 (0.27–1.63) ○ Cardiopulmonary resuscitation: 0.73 (0.29–1.84) ○ High-frequency oscillatory ventilation: 0.60 (0.08–4.25) ○ Chest tube insertion or removal: 0% vs. 9.3%, *P* = 0.23 ○ Insertion of nasogastric tube: 0.89 (0.34–2.38) ○ Insertion of peripheral line: 0.93 (0.39–2.21) ○ Insertion of central venous line: 0.62 (0.22–1.81) ○ Chest physiotherapy: 0.67 (0.20–2.21) ○ Tracheostomy care: 1.10 (0.41-2.91) ○ Bronchoscopy: 0% vs. 8.6%, *P* = 1 ○ Extubation: 3.06 (0.53–17.67) ○ Any aerosol-generating procedure: 1.13 (0.39–3.27) • Direct contact with blood, body fluid, or excretion of MERS-CoV patient: 0.66 (0.25–1.77) ○ Blood: 0.86 (0.30–2.48) ○ Sputum: 0.88 (0.31–2.54) ○ Urine: 1.37 (0.43–4.39) ○ Feces: 1.12 (0.35–3.64) ○ Other fluids: 1.50 (0.23–9.89)	Potential recall bias

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Appendix Table 5—Continued

Study, Year (Reference)	Study Design	Setting and Study Dates	Population Characteristics	Outcomes	Limitations
				• Smoking: 1.82 (0.77–4.29) • Currently smokes tobacco: 0.88 (0.31–2.54) • Smoked tobacco in the past: ***3.08 (1.12–7.99)*** • Respiratory pathogen infection control training: ***0.32 (0.12–0.85)*** • MERS-CoV infection control training: ***0.35 (0.14–0.85)*** • Same room or <2 m of any hospitalized patients with pneumonia or respiratory illness: 1.16 (0.28–4.80) RR (95% CI) for MERS-CoV seropositivity, always vs. sometimes/never • Gloves: 9.1% cases vs. 0% controls, RR not calculated • Gown: 0.89 (0.36–2.21) • Eye protection, direct contact: 0.21 (0.03–1.51) • Eye protection, aerosol-generating procedure: 0.44 (0.13–1.51) • Medical mask or N95 respirator, direct contact: 0.69 (0.28–1.69) ○ Medical mask: 2.06 (0.86–4.95) ○ N95: 0.44 (0.17–1.12) • Medical mask or N95 respirator, aerosol generating procedure: ***0.32 (0.12–0.86)*** ○ Medical mask: 0.59 (0.20–1.71) ○ N95: 0.45 (0.16–1.29) Adjusted RR (95% CI) for MERS-CoV seropositivity (factors included in backward stepwise model) • N95 use always vs. sometimes or never: 0.44 (0.15–1.24) (medical mask almost always worn in sometimes or never group) • Past or current smoking vs. none: 2.51 (0.92–6.87) • Participation in MERS-CoV training: ***0.33 (0.12–0.90)*** *Factors not included in model: Glove use, gown use, eye protection, time spent in MERS patient room, handling of MERS patient bedding, equipment, or fluids, or number of MERS patients cared for*	
Kim et al, 2016 (37)	Retrospective cohort	South Korea; 31 hospitals; dates not reported	737 HCWs with direct contact with MERS patient • Mean age, 33 y • 78% female • 19% physician; 69% nurse; 12% other • 0.27% (2/737) positive for MERS-CoV (ELISA and confirmatory IIFT); 2.0% (15/737) MERS cases excluded	Incidence of MERS-CoV seropositivity (ELISA and confirmatory IIFT); MERS cases excluded • Exposure without appropriate PPE vs. never: 0.7% (2/294) vs. 0% (0/443), P = 0.16 • Exposure without powered air-purifying respirator during aerosolizing procedure vs. never: 0.8% (1/122) vs. 0.2% (1/615), P = 0.30	Potential for recall bias; MERS cases excluded; only 2 cases

APACHE = Acute Physiology and Chronic Health Evaluation; CoV = coronavirus; COVID-19 = coronavirus disease 2019; CPR = cardiopulmonary resuscitation; ECG = electrocardiogram; ED = emergency department; ELISA = enzyme-linked immunosorbent assay; HCW = health care worker; IIFT = indirect immunofluorescence test; MERS = Middle East respiratory syndrome; MICU = medical intensive care unit; OR = odds ratio; RR = relative risk; PCR = polymerase chain reaction; PPE = personal protective equipment; SARS = severe acute respiratory syndrome; WHO = World Health Organization.
* Values in boldface and italics indicate a statistically significant difference between groups.
† Unadjusted OR calculated on the basis of available data.

Appendix Table 6. Demographic Characteristics and HCW Role or Position and Risk for Infection With SARS-CoV-2, SARS-CoV-1, or MERS-CoV in HCWs*

Study, Year (Reference)	Age	Sex	Physician	Nurse	Other HCW Role
SARS-CoV-2					
Wang et al, 2020 (70)	–	–	–	Nurse vs. doctor: *OR, 0.04 (95% CI, 0.005–0.31)†*	Respiratory department: 0% (0/70) ICU: 0% (0/169) Infectious disease department: 0% (0/39) Hepatobiliary and pancreatic surgery department: 11% (8/74) Trauma and microsurgery department: 2% (1/44) Urology department: 1% (1/97)
SARS-CoV-1					
Chang et al, 2004 (25)	Adjusted OR, 0.97 (95% CI, 0.90–1.03)	–	6.1% (2/33)	3.2% (3/95)	Ambulance drivers: 16.7% (1/6) Sanitation workers: 15.4% (2/13) Clerks: 6.3% (1/16) Administrative personnel: 0% (0/24) Radiology technician: 0% (0/17)
Chen et al, 2005 (27)	<26 y: 12.4% (44/355) 26–30 y: 5.5% (17/310) 31–35 y: 6.6% (14/211) 36–40 y: 7.6% (9/118) >40 y: 7.8% (11/141)	Male: 4.7% (15/306) Female: 9.7% (80/743)	6.2% (24/388)	10.2% (52/510)	Laboratory technician: 0% (0/66)
Fowler et al, 2004 (30)	–	–	16.7% (3/18)	7.6% (5/66)	Respiratory therapist: 11.1% (2/18)
Ho et al, 2003 (32)	–	–	5.1% (7/138)	3.8% (19/500)	Health care assistant: 7.9% (10/126) Cleaner: 1.9% (3/158) Clerical staff: 0.8% (1/131)
Ip et al, 2004 (34)	–	–	2.4% (2/85)	11.6% (38/328)	Allied health: 0.9% (1/114) Health care/general service assistants: 11.8% (12/102) Ancillary: 0% (0/113) Other: 0% (0/12)
Lau et al, 2004 (43)	–	–	–	1.07% (SD 1.38)	Nonmedical support staff: 2.34% (SD 3.43) Other technical and medical staff: 0.32% (SD 0.49);
Li et al, 2003 (45)	–	–	2.88%	4.78%	Nursing assistant: 6.67% Other hospital staff: 0%

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Appendix Table 6—Continued					
Study, Year (Reference)	**Age**	**Sex**	**Physician**	**Nurse**	**Other HCW Role**
Ma et al, 2004 (64)	–	–	Physician vs. other HCW (not physician, nurse or caregiver/custodian): ***OR, 0.32 (95% CI, 0.11–0.95)†***	Nurse vs. other HCW (not physician, nurse, or caregiver/ custodian): OR, 0.49 (95% CI, 0.19–1.29)†	–
Nishiura et al, 2005 (56)	29 y: OR, 0.9 (95% CI, 0.3–2.3) 30–39 y: OR, 0.4 (95% CI, 0.2–1.1) 40–49 y: ***OR, 2.8 (95% CI, 1.2–6.6)*** 50 y: OR, 0.7 (95% CI, 0.1–3.2)	Female vs. male: ***OR, 3.3 (95% CI, 1.2–9.0)***	OR, 0.8 (95% CI, 0.2–2.9)	***OR, 3.2 (95% CI, 1.3–7.7)***	–
Nishiyama et al, 2008 (57)	–	–	Physician vs. other staff: ***adjusted OR, 40.9 (95% CI, 2.65–630)***	Nurse vs. other staff: ***adjusted OR, 57.3 (95% CI, 5.28–621)***	–
Raboud et al, 2010 (60)	Not in model	Not in model	5.2% (4/77)	3.9% (11/283)	Medical resident/intern: 12.5% (2/16) Personal services assistant: 3.8% (1/25) Paramedic/EMT: 100% (3/3) Radiology technician 1.5% (1/67) Respiratory therapist: 4.5% (4/89)
Teleman et al, 2004 (66)	OR, 1.4 (95% CI, 0.3–1.7)†	Male vs. female: adjusted OR, 2.9 (95% CI, 0.2–34.0)	–	–	–
Wang et al, 2007 (69)	–	Female vs. male: RR, 1.10 (95% CI, 0.14–8.74)	–	Nurse vs. physician: RR, 1.21 (95% CI, 0.15–9.61)	–
Wilder-Smith et al, 2005 (72)	Mean age: 29.2 y in cases vs. 33.7 y in controls, ***P = 0.04***	Female vs. male: OR, 0.47 (95% CI, 0.10–2.07)	–	–	–
MERS-CoV					
Alraddadi et al, 2016 (19)	–	–	MICU and ED: 2.4% (1/41)	MICU and ED: 9.4% (13/138)	MICU: 11.7% (15/128) ED: 4.1% (5/122) Neurology unit: 0% (0/33) Radiology technician (MICU and ED): 29.4% (5/17) Respiratory therapist (MICU and ED): 3.2% (1/31) Patient transport or clerical staff (MICU and ED): 0% (0/21)

ED = emergency department; EMT = emergency medical technician; ICU = intensive care unit; HCW = health care worker; MICU = medical intensive care unit; OR = odds ratio; RR = relative risk.
* Values in boldface and italics indicate a statistically significant difference between groups.
† Variable not included in a multivariate model.

Appendix Table 7. Education or Training, Environmental and Physical Factors, and Infection Control Policies and Risk for Infection With SARS-CoV-2, SARS-CoV-1, or MERS-CoV in Health Care Workers*

Study, Year (Reference)	Education or Training on Infection Control	Ventilation or Negative Pressure Isolation Room	Environment and Physical Layout	Infection Control Policies
SARS-CoV-2				
No studies				
SARS-CoV-1				
Chen et al, 2009 (26)	Special training for SARS-1 (no vs. yes): *OR, 2.44 (95% CI, 1.41–4.23)†*	Air ventilation method in offices and SARS wards (reference, artificial central ventilation): Natural ventilation: *adjusted OR, 0.40 (95% CI, 0.18–0.88)* Natural ventilation and additional electronic exhaust fan: *adjusted OR, 0.27 (95% CI, 0.16–0.63)*	Type of equipment for washing hands: Nonautomatic vs. automatic tap (reference): *OR, 4.18 (95% CI, 1.66–10.51)†* Others: OR, 1.09 (95% CI, 0.12–9.74)†	–
Lau, 2004 (41)	SARS infection control training <2 h or no training vs. ≥2 h: *adjusted OR, 13.6 (95% CI, 1.24–27.50)*	–	–	–
Liu et al, 2009 (49)	Not taking training vs. taking training: *adjusted OR, 2.40 (95% CI, 1.08–5.31)*	–	–	–
Ma et al, 2004 (52)	Training (yes vs. no): *OR, 0.18 (95% CI, 0.09–0.36)†*	–	–	–
Nishiyama et al, 2008 (57)	No attendance at lecture on nosocomial infection vs. attendance: adjusted OR, 5.49 (95% CI, 0.90–33.4)	–	–	–
Pei et al, 2006 (58)	SARS-1 education before treating SARS-1 patients (yes vs. no): *OR, 0.38 (95% CI, 0.17–0.80)†* SARS-1 preventive training (yes vs. no): *OR, 0.07 (95% CI, 0.03–0.13)†*	Using ventilator in the office (yes vs. no): *OR, 0.18 (95% CI, 0.11–0.31)†* Well-ventilated office (yes vs. no): adjusted OR, 0.32 (95% CI, 0.09–1.15)	No touch hand washing equipment (yes vs. no): *OR, 0.11 (95% CI, 0.02–0.45)†* Isolating medical staff's offices from SARS-1 wards (yes vs. no): *OR, 0.57 (95% CI, 0.38–0.87)†* Isolated areas in SARS-1 wards (yes vs. no): *OR, 0.25 (95% CI, 0.16–0.40)†* Working areas didn't overlap (yes vs. no): *OR, 0.24 (95% CI, 0.15–0.40)†*	–
Yen et al, 2011 (76)		Set up standardized negative pressure isolation room in hospital: *OR, 0.17 (95% CI, 0.05-0.63)†* Set up simplified negative pressure isolation room within hospital: *OR, 0.29 (95% CI, 0.09–0.93)†*	Set up fever screen station outside of ED: *adjusted OR, 0.05 (95% CI, 0.004–0.69)* Set up alcohol dispensers at checkpoint for glove-on hand rubbing between zones of risk: *adjusted OR, 0.04 (0.003–0.63)* Body temperature screening in main entrance: *OR, 0.02 (95% CI, 0.00–0.40)†* Separation of fever patients within physical barrier isolated region in ED: OR, 0.26 (95% CI, 0.06–1.08)†	Wearing N95 mask in ED: OR, 0.35 (95% CI, 0.11–1.13) † Wearing N95 mask within zones of risk: *OR, 0.02 (95% CI, 0.001–0.39)†* Mask worn when entering hospital: *OR, 0.02 (95% CI, 0.001-0.40)†* Wearing surgical mask in outpatient department: *OR, 0.09 (95% CI, 0.01–0.88)†* Wearing surgical mask in ward: *OR, 0.09 (95% CI, 0.01–0.88)†*

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Appendix Table 7—Continued

Study, Year (Reference)	Education or Training on Infection Control	Ventilation or Negative Pressure Isolation Room	Environment and Physical Layout	Infection Control Policies
			Installation of handwashing station in ED: OR, 0.53 (95% CI, 0.14–2.00)† Disinfectant solution available at main entrance (of hospital): ***OR, 0.04 (95% CI, 0.004–0.33)†*** Set up handwashing facilities around whole hospital: ***OR, 0.20 (95% CI, 0.06–0.69)†***	Established crisis response team: ***OR, 0.02 (95% CI, 0.001–0.40)†*** Exclude visitors from hospital: ***OR, 0.11 (95% CI, 0.03–0.41)†*** Support from administration for infection control practitioner: ***OR, 0.11 (95% CI, 0.03–0.41)†*** Support from administration for infectious diseases specialist or physician: ***OR, 0.09 (95% CI, 0.02–0.52)†*** Support from superintendent or directors for infection control: ***OR, 0.08 (95% CI, 0.01–0.42)†***
MERS-CoV				
Alraddadi et al, 2016 (19)	Participation in MERS-CoV training: ***RR, 0.33 (95% CI, 0.12–0.90)***	–	–	–

AOR = adjusted odds ratio; CoV = coronavirus; ED = emergency department; MERS = Middle East respiratory syndrome; OR = odds ratio; RR = relative risk; SARS = severe acute respiratory syndrome.
* Values in boldface and italics indicate a statistically significant difference between groups.
† Variable not included in a multivariate model.