



## SARS-CoV-2, surgeons and surgical masks

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### Abstract

The exact risk association of coronavirus disease 2019 (COVID-19) for surgeons is not quantified which may be affected by their risk of exposure and individual factors. The objective of this review is to quantify the risk of COVID-19 among surgeons, and explore whether facemask can minimise the risk of COVID-19 among surgeons. A systematised review was carried out by searching MEDLINE to locate items on severe acute respiratory syndrome coronavirus 2 or COVID-19 in relation to health care workers (HCWs) especially those work in surgical specialities including surgical nurses and intensivists. Additionally, systematic reviews that assessed the effectiveness of facemask against viral respiratory

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infections, including COVID-19, among HCWs were identified. Data from identified articles were abstracted, synthesised and summarised. Fourteen primary studies that provided data on severe acute respiratory syndrome coronavirus 2 infection or experience among surgeons and 11 systematic reviews that provided evidence of the effectiveness of facemask (and other personal protective equipment) were summarised. Although the risk of COVID-19 could not be quantified precisely among surgeons, about 14% of HCWs including surgeons had COVID-19, there could be variations depending on settings. Facemask was found to be somewhat protective against COVID-19, but the HCWs' compliance was highly variable ranging from zero to 100%. Echoing surgical societies' guidelines we continue to recommend facemask use among surgeons to prevent COVID-19.

**Key Words:** COVID-19; Health care worker; Personal protective equipment; SARS-CoV-2; Surgeon; Surgical mask

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**Core Tip:** The risk of coronavirus disease 2019 (COVID-19) among surgeons is unknown. By searching Medline we identified 14 primary studies that provided data on severe acute respiratory syndrome coronavirus infection among surgeons and identified 11 systematic reviews that provided evidence on the role of facemask against respiratory viral infection among health professionals. About 14% of health professionals including surgeons had COVID-19, and facemask was found to be somewhat protective against COVID-19, but the health professionals' compliance was highly variable ranging from zero to 100%. In line with other guidelines we continue to recommend facemask use among surgeons to prevent COVID-19.

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## INTRODUCTION

Beginning in late December 2019, coronavirus disease 2019 (COVID-19) spread across the globe leading to the largest pandemic of the century affecting (as of January 13, 2021) about 104 million cases with over 2.2 million fatalities<sup>[1]</sup>.

Human to human transmission is believed to primarily occur through respiratory droplets (particles > 5-10 µm in diameter) during coughing and sneezing. Droplet nuclei are also increasingly recognised as a possible mechanism of spread, especially during prolonged exposure to high aerosol concentrations in closed spaces, in procedures like intubation, nebulisation, bone drilling and bronchoscopy<sup>[2]</sup>. Close contact is necessary for transmission of the disease and pre-symptomatic and asymptomatic individuals can contribute to up to 80% of COVID-19 transmission<sup>[3]</sup>. The spread, in fact, is primarily limited to household and healthcare settings, and other close contact settings. Across the world, thousands of health care workers (HCWs) have succumbed to the pandemic<sup>[4]</sup>. In fact, compared with the general community, front-line HCWs have a twelvefold increase in risk of a positive COVID-19 test<sup>[5]</sup>. HCWs who work in surgical specialties are at special risk of COVID-19 due to their intimate exposure to patients during surgical procedures some of which are aerosol generating. Indeed many initial cases of COVID-19 were among surgeons<sup>[4]</sup>; the first doctor to notify the emergence of the SARS-CoV-2 and subsequently sadly die of COVID-19, Mr Li Wenliang, was an ophthalmologist at Wuhan Central Hospital<sup>[6]</sup>.

Personal protective equipment (PPE) including facemask, hand hygiene, physical distancing and reducing contact time (< 15 min) are standard measures of preventing COVID-19<sup>[2]</sup>. For HCWs performing aerosol-generating procedures, well fitted face-piece respirators, for example, N95 or N99 masks are recommended as part of PPE. Among front-line HCWs, reuse or inadequate use of PPE was each associated with a

subsequent increased risk of COVID-19<sup>[6]</sup>. Given the uncertainty regarding the relative contribution of different transmission mechanisms, precautions against airborne transmission are recommended, but SARS-CoV-2 has also been detected in non-respiratory specimens<sup>[7]</sup>.

The exact risk association of COVID-19 for surgeons is not quantified which may be affected by their risk of exposure and individual factors including age and underlying medical conditions.

The objective of this review is to quantify the risk of COVID-19 among surgeons, and explore whether facemasks and other PPE could minimise the risk of COVID-19 among surgeons.

## SEARCH STRATEGY

MEDLINE search was conducted to locate items on SARS-CoV-2 or COVID-19 in relation to HCWs especially those working in surgical specialities like general surgeons, ophthalmologists, dentists, surgical nurses, anaesthetists, scrub nurse, and other staff that support operation theatre and surgical wards. Search terms including “exp Coronavirus”, “exp Coronavirus Infections”, “coronavirus.tw.” were combined with terms on surgeon or clinician\* or practitioner.tw, health or hospital or clinical or medical, health care worker or HCW or doctor or nurse or allied health or dental or dentist.tw or intensivist or anaesthetist or anesthetist.tw.

All hits were then screened, initially by one reviewer (HR) but subsequently by a second reviewer (MIK), to identify relevant articles, both primary and systematic reviews, for final inclusion on the basis of relevance to our study aim.

The data were abstracted onto an Excel abstraction sheet with the following columns: author name, journal, manuscript title, study year, study type, setting, country, final sample size, HCW-yes/no, surgeon- yes/no, gender distribution (male: female), age of participants, presence of comorbidities, methods applied to establish diagnosis including sample type used, radiological/imaging studies, key results including number of surgeons affected, whether the participants used PPE especially facemask, any beneficial/harmful effect of PPE reported, any limitation of the study acknowledged by authors or identified by us.

This being a systematised review (not a systematic review), it was not deemed necessary to follow Preferred Reporting Items for Systematic Reviews and Meta-Analyses and hence quality assessment was not conducted.

We then identified and summarised systematic reviews that assessed the effectiveness or efficacy of facemask and/or PPE in the prevention of SARS-CoV-2 among HCWs.

## RESULTS

We identified 14 original studies (as of November 29, 2020) that potentially include surgical HCWs. The studies included a pooled sample of 116136 HCWs, a large part of those included 100570 HCWs in a Centers for Disease Control (CDC) database and demographic data of 4099 orthopaedic surgeons and 9578 ear, nose and throat surgeons in the United States. One study involving elderly neurosurgeons in the United States did not provide the number of surgeons in their cohort<sup>[8]</sup>. Studies were conducted in the United States ( $n = 5$ ), China ( $n = 3$ ), the United Kingdom ( $n = 1$ ), Italy ( $n = 1$ ), Norway ( $n = 1$ ), Singapore ( $n = 1$ ) and Switzerland ( $n = 1$ ), and one study was conducted in 37 countries across the world. Study settings varied widely from general hospital to tertiary care, and from phone interview to analysis of large national dataset (Table 1).

Age of participants ranged from 18 to 62 years, mean or median age was 36-43 years; three studies focused on surgeons aged  $\geq 60$  years<sup>[8-10]</sup>. Where data on gender distribution were available, except in one study in China involving orthopaedic surgeons where all but one were male<sup>[11]</sup>, two-thirds to three fourths (66.6% to 77%) of cases were female<sup>[12-15]</sup>. Attack rate (of those exposed, number of those who had disease) was 14%<sup>[16]</sup>. Where information were available, the diagnosis was based on reverse transcription-polymerase chain reaction on nasal/pharyngeal/nasopharyngeal samples; this was supplemented by computerised tomography (CT) scan in one study<sup>[13]</sup> and CT scan plus other laboratory markers along with clinical features for three reverse transcription-polymerase chain reaction negative cases in another study<sup>[11]</sup>.

Table 1 Primary studies that reported coronavirus disease 2019 among surgeons

Ref.	Study country	Setting	Sample size	Age in years	Male: female	Comorbidity n (%)	Diagnostic TEST	Sample type	Risk of disease	Comment
Hunter <i>et al</i> <sup>[16]</sup>	United Kingdom	Hospital	1654	Mean 41.7	NR	NR	RT-PCR	Combined nose and throat swabs	Of 1654 HCWs tested, SARS-CoV-2 was detected in 240 (14%)	
Jella <i>et al</i> <sup>[9]</sup>	United States	National data pool	4099	All were aged ≥ 60	NR	NR	NR	NR	For the top most states affected by COVID-19, elderly orthopaedic surgeons aged ≥ 60 years comprised up to 48%	
Chow <i>et al</i> <sup>[12]</sup>	United States, Washington	Phone interview of HCWs with COVID-19	48	Median 43 (range 22-79)	11:37	23 (49.7)	Not specified	NR	Among 48 HCWs with COVID-19 interviewed, 31 (64.6%) worked a median of 2 (range: 1-10) d while being symptomatic	Facemask use by HCWs might prevent transmission from asymptomatic cases
Liu <i>et al</i> <sup>[13]</sup>	China	University hospital	30	21-59	10:20	NR	RT-PCR	NR	Of all 30 COVID-19 cases, 8 did not wear masks and 6 others wore irregularly	
Hughes <i>et al</i> <sup>[46]</sup>	United States	CDC data pool	571,708 with occupational status known	41 (IQR: 30-53)	79:21	17,838 (44%) had at least one comorbidity	Not specified	NR	Of 571,708 100,570 (22%) were HCWs. Nursing and residential care facilities were the commonest job settings	
Jella <i>et al</i> <sup>[8]</sup>	United States	National data pool	Not mentioned	All were aged ≥ 60	NR	NR	NR	NR	In the 10 states with the highest number of COVID-19 cases older neurosurgical workforce (≥ 60) accounted for 20.6%-38.9%	
Ruthberg <i>et al</i> <sup>[10]</sup>	United States	National data pool	9578	All were aged >60	NR	NR	NR	NR	Of all, 3081 were (32.2%) ENT surgeons aged > 60 years; the proportion by state ranged from 25.9% to 58.8%	
Durante-Mangoni <i>et al</i> <sup>[14]</sup>	Italy	Regional hospital	4 (details were known for only 3)	25-61 (of 3 cases)	2:1 (no details about the 4 <sup>th</sup> case)	NR	RT-PCR	Nasal/or pharyngeal swab	Four nurses infected. No transmission between HCWs wearing surgical masks and inpatients	Masks were beneficial
Jørstad <i>et al</i> <sup>[47]</sup>	Norway	Regional hospital	6	NR	NR	NR	Not specified	NR	Five ophthalmic surgeons and a ward nurse had COVID-19	
Ducournau <i>et al</i> <sup>[17]</sup>	37 countries (34)	Questionnaire survey	47	NR	NR	NR	Not applicable	NR	42 of 47 (89.4%) wore surgical mask, 12 of 47 (25.5%) wore N95 mask, 32 of 47 (68.1%) wore goggles	This study is about the compliance of surgeons with PPE
Canova <i>et al</i> <sup>[15]</sup>	Switzerl	Contact racing	21	Median 40 (range 18-62) yr	7:14	NR	RT-PCR	Nasopharyngeal swab	None wore a face mask	None were positive for virus
Guo <i>et al</i> <sup>[11]</sup>	Wuhan, China	Hospital	24 cases (and 48 controls)	36.1 (25-48)	23:1	1 (4.2%) had a comorbidity	RT-PCR and antibody tests	NR	Only 7 (29.2%) wore a facemask or respirator. Wearing respirator or mask	Orthopaedic surgeons are at risk of COVID-19 and

									all the time was protective (OR: 0.15, 95%CI: 0.04-0.55)	masks are beneficial
Chan <i>et al</i> <sup>[48]</sup>	Honkong, China	University hospital	14 (10 nurses and 4 other staff)	NR	NR	NR	NR	NR	Fourteen neurosurgery staff contracted COVID-19 following exposure to a patient	Full PPE should be worn during high risk procedures
Ng <i>et al</i> <sup>[18]</sup>	Singapore	University hospital	41 HCWs exposed to an index patient	NR	NR	NR	RT-PCR	Nasopharyngeal swab	None of the exposed HCWs were RT-PCR positive; 85% wore a surgicalmask, and the rest wore N95 masks	Possibly masks and other standard measures are beneficial

CDC: Centers for Disease Control and Prevention (United States); 95%CI: 95% confidence interval; ENT: Ear, nose and throat (surgeons); HCW: Health care worker; IQR: Interquartile range; NR: Not recorded; OR: Odds ratio; PPE: Personal protective equipment; RT-PCR: Reverse transcriptase polymerase chain reaction.

Use of PPE varied across the studies, an international survey among hand surgeons found 89.4% (42/47) wore surgical mask, 25.5% (6/47) wore N95 mask, and 68.1% (32/47) wore protective glasses<sup>[17]</sup>, but in practice compliance varied from zero in Switzerland<sup>[15]</sup> to almost 100% in Singapore in the early phase of the pandemic<sup>[18]</sup>. Wearing respirators or masks all the time was protective [odds ratio (OR: 0.15), 95% confidence interval (95%CI): 0.04-0.55] among orthopaedic surgeons<sup>[11]</sup>, and no transmission between HCWs wearing surgical masks and inpatients was reported in one study<sup>[14]</sup>. However, despite using facemasks and respirators, COVID-19 transmission occurred among HCWs including surgeons<sup>[11,13]</sup>.

Altogether, 11 systematic reviews were identified that included data involving effectiveness of facemasks against respiratory viruses among HCWs (Table 2). Three systematic reviews<sup>[19-21]</sup> have found facemasks to be effective mostly with low certainty of evidence from observational studies, another also found facemasks to be effective only in implant surgeons but not in other HCWs<sup>[22]</sup> another systematic review ruled out the effectiveness of medical masks and cloth masks but affirmed the effectiveness of N95 masks<sup>[23]</sup>. A systematic review indicated evidence of some effectiveness of cloth masks but that was considerably lower than that of surgical masks and respirators<sup>[24]</sup>, which was buttressed by a focussed systematic review that revealed minimum efficacy of cloth masks compared to medical grade masks<sup>[25]</sup>. Of two systematic reviews that evaluated the effectiveness of medical masks against respirators, one ruled out any difference<sup>[26]</sup>, but the other affirmed the superiority of N95 masks<sup>[27]</sup>. Finally, a systematic review of PPE use among surgeons found that whereas protection offered by fluid-repellent surgical mask was short-lasting (about 30 min) the protection offered by FFP2/3 respirators might last up to eight hours<sup>[28]</sup>.

**Table 2 Summary of systematic reviews that provided data on the role of facemask use against respiratory viral infection among health care workers**

Ref.	Participants	Intervention(s)	Comparator	Outcome	Comment
Jessop <i>et al</i> <sup>[28]</sup>	Surgeons	PPE including FFP2/3 and simple surgical masks	Nil	Protection using FFP2/3 respirators is reported to last up to 8 h, whereas protection is to last about 30 min for fluid-repellent masks	Narrative synthesis
Samaranayake <i>et al</i> <sup>[19]</sup>	Dentists	PPE: masks and respirators	Nil	Wearing layered, face-fitting masks/respirators and protective-eyewear can limit the spread of infection among HCWs; combined interventions such as a face mask and a face shield are better than individual ones	Mostly on HCWs in general, not just dentists
Aggarwal <i>et al</i> <sup>[49]</sup>	Community dwellers	Facemask and hand washing	Nil	There was no significant reduction in ILI either with facemask alone (pooled effect size: -0.17; [CI <sub>95%</sub> -0.43-0.10]) or facemask with hand wash (pooled effect size -0.09; [CI <sub>95%</sub> -0.58 to 0.40])	
Liang <i>et al</i> <sup>[20]</sup>	Diverse participants including HCWs	Facemask	Nil	Use of masks by HCWs can reduce the risk of respiratory virus infection by 80% (OR: 0.20 (95% CI: -0.11-0.37))	
Marson <i>et al</i> <sup>[22]</sup>	Surgeons	Facemask	Nil	The pooled effect of not wearing facemasks was a risk factor for infection RR: 0.77 (95% CI: 0.62-0.97), a case-control study demonstrated an OR of 3.34 (95% CI: 1.94-5.74) if facemasks were not worn by implant surgeons	The use of facemasks by implant surgeons may be beneficial
Sharma <i>et al</i> <sup>[25]</sup>	All settings including health care settings	Cloth facemask	Medical grade masks	Cloth facemasks show minimum efficacy in source control than the medical grade mask. The efficacy of cloth face masks filtration varies and depends on material type, and other factors	
Santos <i>et al</i> <sup>[24]</sup>	All settings including health care settings	Cloth facemask	Surgical masks and respirators	Cloth masks presented a considerably lower protection factor [1.9 (95% CI: 1.5-2.3)]; surgical and cloth masks reduced the total number of microbes expelled when coughing wearing a mask, while another study found that neither cloth nor surgical masks effectively filtered the virus expelled through coughing	Cloth masks are not recommended for HCWs
MacIntyre and Chughtai <sup>[23]</sup>	Community, HCWs and sick patients	Face masks	Respirators	RCTs in HCWs showed that respirators, if worn continually during a shift, were effective but not if worn intermittently. Medical masks were not effective, and cloth masks even less effective	
Chu <i>et al</i> <sup>[21]</sup>	Health-care and non-health-care settings	Physical distancing, face masks, and eye protection	N95	Face mask use could result in reduction in risk of infection [aOR: 0.15 (95% CI: 0.07-0.34), RD: -14.3% (95% CI: -15.9 to -10.7)], with stronger association with N95 compared to surgical masks ( $P = 0.09$ )	Low certainty of evidence
Bartoszek <i>et al</i> <sup>[26]</sup>	HCWs	Medical masks	N95	Compared with N95 respirators, the use of medical masks did not increase laboratory-confirmed viral respiratory infection [OR: 1.06 (95% CI: 0.90-1.25)]. Only one trial evaluated coronaviruses separately and found no difference between the two groups ( $P = 0.49$ )	Low certainty of evidence but only RCTs are included
Chou <i>et al</i> <sup>[27]</sup>	Health-care and community settings	Surgical, N95, and cloth	N95 or no mask	In health care settings, observational studies found that risk for infection with SARS-CoV-1 probably decreased with mask use and possibly decreased more with N95 mask use. RCTs found, N95 and surgical masks were probably associated with similar risks for ILI and laboratory-confirmed viral infection	Evidence on effectiveness of facemask is stronger in health care than community settings

aOR: Adjusted odds ratio; 95% CI: 95% confidence interval; HCW: Health care worker; ILI: Influenza-like illness; OR: Odds ratio; PPE: Personal protective equipment; RCTs: Randomised controlled trial; RD: Risk difference.

## DISCUSSION

This narrative mini-review suggests that HCWs including surgeons are at greater risk of COVID-19. Surgeons including ophthalmic, orthopaedic, dental and neurosurgeons are affected by COVID-19 as well as are other staff of surgical team including anaesthetists and scrub nurses across the world.

Based on data from the United Kingdom, we note that roughly about 14% HCWs (that include surgeons) suffer from COVID-19, but this proportion can vary, for example 6.4% in the Netherlands, 3.8% to 5.7% in China<sup>[29,30]</sup>, 17.8% in United States, 9% in Italy<sup>[30]</sup>, and 12% HCWs in India had COVID-19<sup>[31]</sup>. Exceptionally high proportion (29%) of HCWs were affected in Wuhan in the early phase of the pandemic<sup>[32]</sup>. Variability is understood, and may stem from the HCWs' exposure risk, their individual risk factors *e.g.*, comorbidities and advanced age, and compliance with preventive measures. To what extent surgeons comprise this could not be ascertained but about 12.5% of COVID-19 transmission occurs in operation theatres<sup>[33]</sup>, however, seeing about 79% of infection occurring among HCWs in general ward, it is likely that many surgical staff contract COVID-19 there<sup>[34]</sup>.

A systematic review shows the incidence of COVID-19 among HCWs in China was much higher than that in general public; for instance in early phase of the pandemic, the pooled incidence in HCWs was 145 per 100000 compared to 42 per 100000 in general population<sup>[29]</sup>. Although the incidence of COVID-19 was higher among HCWs including surgeons, the incidence of severe or critical disease was lower than among general community. A meta-analysis of studies from China, United States and Italy showed the incidence of severe or critical COVID-19 disease in HCWs to be 9.9% (95% CI: 0.8–18.9) whereas the overall incidence in all COVID-19 patients was 29.4% (95% CI: 18.6–40.2). Similarly, mortality among HCWs was lower compared to the mortality in all patients [0.3% (95% CI: 0.2–0.4) *vs* 2.3% (95% CI: 2.2–2.4)]<sup>[29,30,33]</sup>. The rate of severe or critical disease was lower despite a higher incidence. This is not fully understood and is a subject of further review but could be due to a number of facts: (1) Relatively younger age of and lower incidence of pre-existing medical conditions among working HCWs<sup>[5,35]</sup>; (2) Their readier accessibility to health care<sup>[30]</sup>; and (3) Their awareness of the disease course and knowledge when to seek help<sup>[36]</sup>. A study in the United States showed only 6% of HCWs were aged  $\geq 65$  years but approximately 40% of the fatal cases occurred in this age group<sup>[37]</sup>.

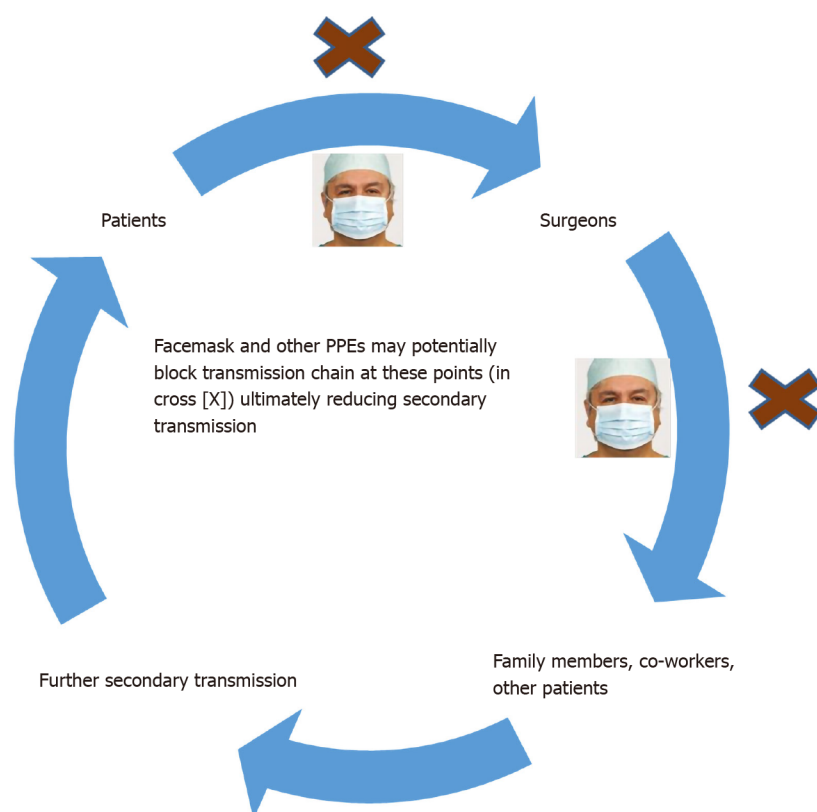
Risk factors of COVID-19 among HCWs including surgeons are unqualified hand washing [relative risk (RR): 2.6], suboptimal hand hygiene before contact with patients (RR: 3.1) and suboptimal hand hygiene after contact with patients (RR: 2.4) and improper PPE use (RR: 2.8)<sup>[38]</sup>.

This review shows wearing respirators or masks all of the time is protective [OR: 0.15 (95% CI: 0.04–0.55)]<sup>[11]</sup>, however the precise role of facemask and/or other PPE cannot be established because there are instances of no COVID-19 transmission when most (85%) HCWs used facemask as well when no (zero) HCW around an index case used facemask<sup>[15,18]</sup>. Data from systematic reviews show wearing facemask including by HCWs is effective against COVID-19, but the evidence is of low certainty, *i.e.* less convincing, primarily because the evidence comes from observational studies. A Cochrane systematic review reports with moderate certainty evidence that wearing a mask probably makes little or no difference to the outcome of laboratory-confirmed influenza compared to not wearing a mask [RR: 0.91 (95% CI: 0.66–1.26)]<sup>[39]</sup>. A large trial conducted in Hajj setting (not included in this minireview) also failed to provide evidence on facemask efficacy against viral respiratory infections<sup>[40]</sup>. Subsequently, another large trial conducted in Denmark shows COVID-19 infection rate in mask group to be 1.8% compared to 2.1% in control group with the between-group difference of -0.3 percentage point ( $P = 0.33$ )<sup>[41]</sup>.

Irrespective of the uncertainty of evidence or having no strong evidence of benefit, facemask and other PPE are recommended by public health bodies (CDC, World Health Organization) and medical societies; since apart from COVID-19 vaccine in the earliest phase of implementation in selected countries, there is, as yet, no other widely available preventive measures to combat COVID-19. In surgeons using a facemask and other shields during a procedure is a traditional practice and can help minimise further secondary transmission of COVID-19 in both healthcare and community settings (Figure 1). Currently, the compliance with PPE use among HCWs ranges from zero to 100%<sup>[15,18]</sup>. A cross-sectional survey in Asia-Pacific among 263 intensivists showed only 59% intensive care unit staff complied with airborne precautions irrespective of aerosol generation procedures even though 97% claimed to conform to the World Health Organization recommendations for PPE practice<sup>[42]</sup>.

A survey in Thailand involving 833 participants, both HCWs and non-HCWs, shows 454 participants (54.5%) developed adverse skin reactions most commonly acne (39.9%), rash (18.4%), and itching (15.6%)<sup>[43]</sup>. In many instances HCWs are not trained enough in PPE use and disposal, but the awareness of CDC guidelines on PPE use improves practice<sup>[44]</sup>.

Baldock *et al*<sup>[45]</sup> have some advice for orthopaedic staff that include using PPE such as N95 respirator, goggles, face shield, gown, double gloves, and surgical balaclava; be



**Figure 1** Schematic diagram showing how personal protective equipment use by health care workers may prevent secondary transmission of coronavirus disease 2019.

trained in the correct technique of donning and doffing PPE; minimise procedures that lead to aerosolisation, and avoid unnecessary patient-staff contact for example by using dissolvable sutures, clear dressings, split casts<sup>[45]</sup>.

## CONCLUSION

In conclusion, we note that surgeons are at risk of COVID-19, although the precise risk could not be estimated. There is low to moderate evidence from observational studies that facemask and PPE use by HCWs may be beneficial against COVID-19, although these are grossly underutilized<sup>[46-49]</sup>. Health education trainings can improve practice.

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