ORIGINAL RESEARCH

SURGICAL MASKS FOR PROTECTION OF HEALTH CARE PERSONNEL AGAINST COVID-19: RESULTS FROM AN OBSERVATIONAL STUDY

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ABSTRACT

Purpose: The aim of the study was to describe the use of masks among health care personnel (HCP) exposed to index cases of coronavirus disease 2019 (COVID-19), and to evaluate any association with infection rate.

Methods: We did a retrospective, observational study of HCP at Zhongnan Hospital of Wuhan University for the management of COVID-19 (before person-to-person transmission was official confirmed, no additional protection was provided). A questionnaire was given to all staff listed on the roster in the clinical regions providing care for index patients with COVID-19. All participants were surveyed regarding hand-washing and use of surgical masks and gloves and were tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Data were analysed (Student's t test and Pearson χ^2 test) for an association between infection and use of personal protective equipment.

Results: Exposure of a total of 299 non-infected and 30 infected staff was confirmed. None of the 149 staff who reported use of all three preventative measures (hand-washing and use of gloves and masks) became infected. In contrast, all 30 of the staff who became infected had omitted at least one of the measures. Fewer staff who wore surgical masks ($P=0.000003$) became infected compared with those who did not. Infection rates were significantly lower in HCP from the internal medicine departments, as these personnel generally wore masks.

Conclusion: An association was found between SARS-CoV-2 infection of HCP and the non-use of masks when working with index cases in clinical settings. We recommend that all HCP follow the strict instructions for prevention and treatment of nosocomial infection during intimate contact with COVID-19, especially staff from surgical departments.

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INTRODUCTION

The ongoing epidemic of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can be traced back to a cluster of severe pneumonia cases identified in Wuhan, China in December 2019 [1]. The significant increases in the number of confirmed cases both in China and abroad led to the World Health Organization (WHO) announcement on January 30, 2020 that the event

now constituted a Public Health Emergency of International Concern [2]. The onset of coronavirus disease 2019 (COVID-19) is difficult to identify due to non-specific symptoms. The virus is highly contagious and may lead to death in some patients [3]. By June 23, 2020 3:58 pm CEST, there were 8,993,659 persons infected with the virus, 469,587 deaths and over 199 countries with confirmed cases [4]. The virus spread internationally within one month of the first reported cases and is now known

to be transmitted via close person-to-person contact [1].

Healthcare personnel (HCP) are at increased risk of COVID-19 because of contact with patients and colleagues. Transmission to HCP caring for patients was reported on January 20, 2020 [5]. Transmission may have occurred in situations where the use of personal protective equipment was inadequate, especially when the route of transmission is unclear [6, 7]. The National Health Commission of P.R. China, which oversees all hospitals in China, had stated that person-to-person transmission was occurring among different groups until January 19, 2020 [5]. Since then, droplets precautions and rigorous universal precautions or standard precautions have been recommended for the care of patients with COVID-19. The authors' institution (Zhongnan Hospital of Wuhan University) was in the first group of designated hospital for management of COVID-19 in Wuhan. From December 2019 to February 2, 2020, there were more than 40 infected staff, most of whom were from the surgical department. Many HCP from the surgical department were also exposed to aerosol-generating procedures. However, we observed that several internal medicine departments at the hospital had fewer cases of infected HCPs. This was despite the fact that the HCP in these departments came in contact with COVID-19 patients in the early days of the pandemic, when the new COVID-19 diagnosis had not yet been established and no special protective measures (except surgical masks, gloves and hand-washing) were in place. Previous research has shown that surgical masks provide protection against influenza, Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS) [8-10]. Whether they could provide effect protection against COVID-19 had not been established at the beginning of the pandemic [11]. The aim of the study was to describe the use of masks among HCP exposed to index cases, and to evaluate any association with infection rate in those HCPs.

METHODS

The procedures of this observational study were approved by the ethics committee of Zhongnan Hospital of Wuhan University. This study was conducted in diverse departments, including hepatopancreatobiliary surgery, urinary surgery, orthopedics department, infectious disease department, respiratory and critical care medicine department and the general medicine department. From December 2019 to January 29, 2020, when person-to-person transmission of COVID-19 had not been confirmed, patients were admitted to different departments without screening for COVID-19.

We recruited HCP from the Zhongnan Hospital as study participants. Person-to-person transmission of COVID-19 was announced in China on January 19, 2020, and the

study period extended from December 2019 to February 2, 2020 (two 14-day incubation periods after contact with patients) [12].

We defined COVID-19 as fever of 37.3° or higher, radiological infiltrates compatible with pneumonia, and positive SARS-CoV-2 nucleic acid test [13]. Exposure to the virus was defined as coming within two meters of a SARS-CoV-2 patient. Infected staff were defined as those who were diagnosed as SARS-CoV-2 nucleic acid test-positive 2-14 days following exposure, with no known exposure to cases outside the hospital. Epidemiological investigations showed that the family members and neighbors of these affected HCPs did not themselves become infected with SARS-CoV-2; therefore, these HCPs were considered as nosocomial infection instead of community infection. Participants were aged at least 18 years, were full-time employees and worked primarily at the study site. We excluded patients who had known pathogens, had radiological evidence of lobar consolidation, responded to antibiotics within 48 h, or had complications due to other chronic disease such as hypertension and diabetes. Contact tracing involved detailed interviews with confirmed COVID-19 patients on their activities from 24 hours before symptom onset to isolation. Contacts were offered chemoprophylaxis and were quarantined to prevent local transmission.

Nucleic acid tests and lung computed tomography scans were carried out for all HCPs. To investigate the possible association between infection and use of personal protective equipment and protocols (including mask, gloves and hand-washing), a questionnaire was given to all infected and non-infected staff listed on the current roster in the clinical regions that were providing care for index patients with COVID-19. The names of index patients were listed on the questionnaire and the staff were asked if they had been within one metre of the patient. Those HCP who replied affirmatively were asked to indicate whether they had used mask, gloves and hand-washing during patient care, selecting one of four responses: yes; most of the time; once in a while; or no. These responses were to ensure that "no" indicated a definite lapse in practice. The survey was distributed on February 15, 2020 and all responses were collected by March 26, 2020.

SARS-CoV-2 was detected by reverse-transcription polymerase chain reaction in an upper respiratory specimen collected within 2-14 days of symptom onset, with a typical chest computed tomographic image [13]. The Student's *t* test was used to compare the two means, and a Pearson χ^2 test was used to compare two proportions. Data analysis was performed using SPSS 17.0 (SPSS Inc., Chicago, IL) and *P* values of less than 0.05 were considered to be statistically significant.

RESULTS

The study subject flow is shown in Figure 1. Throughout the study period (January 20 to February 2, 2020), there were a total of 24 patients who were not admitted to isolation rooms. Initially, they were not screened but subsequently, they were confirmed as COVID-19 patients. Among them, two was admitted to hepatopancreatobiliary surgery department, one to urinary surgery, one to orthopedic, nine to the respiratory and critical care medicine department, four to the general medicine department and seven to the infectious disease department. None was nursed in negative-pressure rooms or isolation wards for the duration of their illness. No source control measures were provided since the patients were not (at this point) suspected of being infected with SARS-COV-2. Medical records were used to validate the contact with the infected patients. In addition to the questionnaire, we also conducted a telephone interview to the HCPs who had been exposed to the COVID-19 patients.

There was a suspected super spreader in the hepatobiliary surgery department. One doctor was infected initially. The department did not utilize any protective measures during the weekly Multiple Disciplinary Treatment (MDT) discussion and post-MDT dinner. After the MDT, several members of hepatobiliary surgery department became ill. One urology doctor (who did not wear a mask) was infected after implanting a urinary catheter into a COVID-19-positive patient. Two confirmed patients underwent bronchoscopy examination, and the doctors (who were wearing masks, gloves and white coats) were not infected. One patient underwent intubation in the

hepatobiliary surgery department. And most patients with COVID-19 underwent nebulized inhalation therapy in the respiratory department and infectious disease department.

Overall, 624 HCP were assessed for eligibility for this observational study: 596 completed and returned questionnaires, accounting for 97% of the staff on the roster during this period. Non-responders were mostly those on leave or on night shift (which was rotated among the staff). We excluded 266 staff who had no contact with index patients, considering that the main goal of this study was to determine the role of mask in protection against COVID-19, these medical personnel are not helpful in judging the effect of protection, so they are excluded. Twelve staff were excluded because of various medical complications. Finally, 330 HCP were included in the analysis, including 184 staff in the surgical department (hepatopancreatobiliary surgery, urinary surgery and orthopedics departments) and 146 in the internal medicine department (infectious disease, respiratory and critical care medicine and general medicine departments). One infected staff member from the General Medicine Department was exposed to an admitted patient with COVID-19 (which was initially mis-diagnosed as community-acquired pneumonia by the Infectious Disease Department). Baseline characteristics of the participants are shown in Table 1 and were similar, except for the variability in use of protective measures. Specifically, the HCP of the internal medicine were more accustomed to wearing surgical masks [75(40.7%) VS 132(91.0%), $P < 0.05$].

FIGURE 1.
STUDY SITE ENROLLMENT, FOLLOW-UP AND ANALYSIS.

Health care personnels (HCP) (n=624) were assessed for eligibility for this observational study: 329 HCPs were included in the analysis, and comprised 30 infected and 299 non-infected HCPs.

TABLE 1.
DEMOGRAPHIC PROFILES OF HEALTH CARE PERSONNEL ENROLLED IN STUDY (N=329).

Characteristic	Number of health care personnel (%)	
	Surgical departments (n=184)	Internal medicine departments (n=145)
Age, mean (SD), years	42 (10.6)	43 (10.8)
Sex		
Men	55 (29.9)	53 (36.6)
Women	129 (70.1)	92 (63.4)
Body weight index(SD)	24.6 (0.8)	23.9 (0.8)
Occupation		
Physician	30 (16.3)	25 (17.2)
Nurse	136 (73.9)	108 (74.5)
Administrative staff	3 (1.6)	2 (1.4)
Environmental services	15 (8.2)	10 (6.9)
Protective measures		
Medical masks*	75 (40.7)	132 (91.0)
Gloves	54 (29.3)	46 (31.7)
Hand-washing	160 (84.7)	125 (86.2)

* $P<0.05$

All surgeons and physicians have early shifts, ward rounds and consultations every day, so they have a lot of interactions with colleagues and patients. In the primary analysis, 30 staff were reported to have acquired COVID-19 after exposure to one or more index cases. The demographic profiles of the infected HCP are shown in Table 2. The incidence of laboratory confirmed COVID-19 infection events occurred in 26 of 184 staff (14.1%) in the surgical wards and four of 145 staff (2.8%) in the internal medicinal wards ($P=0.000593$). Staff who used masks and gowns and who washed their hands were found to have been less likely to develop COVID-19 than those who did not use them, but the association for gloves was not significant. None of the 149 staff reporting use of all three measures became infected. In contrast, all 30 infected staff had omitted at least one of these three measures. Logistic regression of the three measures with forward stepwise selection showed that only use of masks was significant in the final model (Table 3).

DISCUSSION

In this pragmatic, retrospective observational study, which involved multiple wards across a general hospital, there was a significant difference in the ability of surgical masks to prevent laboratory-confirmed COVID-19 among HCP routinely exposed to COVID-19 in the

TABLE 2.
DEMOGRAPHIC PROFILES OF THE INFECTED HEALTH CARE PERSONNEL (N=30).

Characteristic	Number of health care personnel (%)	
	Surgical departments (n=26)	Internal medicine departments (n=4)
Age (SD), years	46 (6.9)	47 (5.2)
Sex		
Men	14	0
Women	12	4
Unit		
Hepatopancreatobiliary surgery	14	
Urinary surgery	8	
Orthopedic surgery	4	
Department of respiratory and critical care medicine		1
Infectious disease department		0
General medicine department		3
Occupation		
Physician	15	1
Nurse	11	3
Protective measures		
Medical masks	4	1
Gloves	15	3
Hand-washing	21	3

TABLE 3.
PROTECTIVE MEASURES REPORTED BY INFECTED AND NON-INFECTED HEALTH CARE PERSONNEL.

	Infected HCP (n=30)	Non-infected HCP (n=299)	P
Protective measure			
Medical masks*	5 (16.7%)	188 (62.9%)	0.000003
Gloves	11 (36.7.0)	108 (36.1%)	0.88871791
Handwashing	24 (80.0%)	246 (82.3)	0.95220626
All 3 measures	0	149	

Abbreviation: HCP, health care personnel
 "yes" and "most of the time" were grouped together
 "no" and "once in a while" were grouped together
 * $P<0.05$

workplace. No staff who routinely used surgical masks and gloves and hand-washing became infected. Surgical masks, as a precaution against respiratory droplets, are adequate for prevention of nosocomial COVID-19 in the public wards.

Respiratory viruses, including SARS-CoV-2, are primarily transmitted by large droplets [14]. The WHO and the Centers for Disease Control and Prevention guidelines recommend the use of surgical masks during routine care for such patients, while N95 respirators are recommended during procedures in which aerosols may be generated and during other high-risk situations [15, 16]. However, the recommendation did not receive enough attention among HCP, especially in surgical departments. In this study, only 40% of the staff in the surgical departments wore surgical masks, in comparison with nearly 100% in the internal medical departments (where HCP routinely wear surgical masks). The current study was undertaken in response to the loose nosocomial infection control procedures, which made it challenging for infection control clinicians to effectively implement respiratory protection programs in health care settings [17]. This observational study provides a preliminary evaluation of the effectiveness of surgical masks against SARS-CoV-2.

The SARS-CoV-2 belongs to the β -coronavirus category. It has a diameter of approximately 60–140 nm; slightly larger than the influenza virus [18]. As with other respiratory pathogens, including influenza and the coronaviruses causing SARS and MERS, the transmission of SARS-CoV-2 is believed to occur through respiratory droplets from coughing and sneezing [19, 20]. Aerosol transmission is also possible in case of protracted exposure to elevated aerosol concentrations in closed spaces, as well as with close contact [1]. A recently reported randomized trial showed a significant benefit of both hand hygiene and face masks in preventing influenza transmission within households [21]. Surgical masks were also found to be effective in significantly reducing the risk of infection due to SARS [8, 22] and when staff used surgical masks, the incidence of influenza A (H1N1)-2009 remained low in exposed staff in Tan Tock Seng Hospital, Singapore [9]. Still, the situation is not straightforward: some HCP exposed to SARS with minimal precautions did not contract the disease, while there were anecdotal reports of those who used the N95 mask and contracted SARS [23]. The reality is that we may never be able to determine the best protective gear to wear for emerging infections, as it is practically impossible to conduct any randomized controlled trials. It is worth noting that surgical masks were required for all patients with lung infection disease as well as HCP of the respiratory and critical care medicine department and the infectious disease department, which may be resulted in an

extremely low infection rate. After the occurrence of “pneumonia of unknown cause”, all patients in the respiratory department and infectious disease department with the diagnosis of pneumonia were required to wear masks. Nurses conducted regular checks to confirm that everyone was wearing a mask.

There are many factors which may compromise the overall effectiveness of mask-wearing measures. Poor training, lack of guidance and consistency in the use of masks, and improper use may limit their usefulness [24]. Data from the SARS experience in Toronto, Canada illustrated the need for training and monitoring. Loeb and colleagues found that nine of 32 (28%) nurses entering a SARS patient’s room did not consistently wear appropriate respiratory protection [25]. In a logistics exercise undertaken during the peak of seasonal influenza activity in 2007 in Australia, compliance with N95 mask wearing by emergency department staff was found to be low, with only 36.1% of participants wearing the mask “occasionally” in week one and only 18.8% by week four [25].

The use of higher-level respiratory protection, such as N95 (or greater) respirators, for barrier protection in the healthcare settings has not been conclusively shown to reduce influenza transmission relative to surgical masks. Among HCP working outpatient clinics, N95 respirators resulted in no significant difference in the incidence of transmission of laboratory-confirmed influenza vs surgical masks [26]. A previous cost-effectiveness analysis demonstrated that only in the case of a highly pathogenic pandemic would N95 respirator use in HCP be a cost-effective intervention [27]. Given the large cost differential between surgical masks and N95 respirators, there is a need for more comprehensive economic evaluations to compare the relative costs and benefits of these interventions in situations and settings where alternative options are potentially applicable [28]. In this study, the HCP did not wear N95 respirators partly because of their exorbitant price.

Limitations

This study has some limitations. First, because this research is a retrospective, observational study, the findings would be limited by the reasonably low probability of getting tested for SARS-COV-2 when asymptomatic. Unrecognized infections may have increased the probability of finding no difference between interventions, even if a difference existed, but it may also cause the opposite. Second, due to the peculiar period, before person-to-person transmission of COVID-19 had been confirmed, we were able to recruit only a relatively small number of participants. Third, surgical masks may well have efficacy [29]; if so, the degree of efficacy was

too small to be detected in this study. Larger studies are needed, given the widespread use of these masks in health care. Fourth, for those infected HCP, we got a detail history about their exposures, including their family members, friends and neighbors, and none of them had COVID-19. But we still cannot guarantee the absence of exposure from SARS-CoV-2-positive people from outside the hospital. Finally, we categorized pathogens according to various transmission modes, while certain viruses are transmitted via multiple routes.

CONCLUSION

In conclusion, our data show a higher infection rate in those HCP who had used partial or no protection (masks, gloves and hand-washing). Surgical masks might be effective in protecting HCP against COVID-19 in public clinical settings. Further studies are needed to evaluate the efficacy of masks in the context of COVID-19. Considering the widespread and severe pandemic, we do recommend that all HCP follow the strict instructions for prevention and treatment of nosocomial infection during intimate contact with COVID-19, especially staff from surgical departments.

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