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THE PHYSICAL AND PSYCHOLOGICAL EFFECTS OF PERSONAL PROTECTIVE EQUIPMENT ON HEALTH CARE WORKERS IN WUHAN, CHINA: A CROSS-SECTIONAL SURVEY STUDY

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CE Earn Up to 8.0 Hours. See page 941.

Contribution to Emergency Nursing Practice

- The current literature on health care workers wearing personal protective equipment (PPE) indicates that they experience a wide variety of discomfort, especially for nurses in the emergency department.
- This article contributes mainly that the discomfort caused by wearing PPE could be classified into 7 categories: (1) dizziness, (2) dyspnea, (3) nausea, (4) micturition desire, (5) retroauricular pain, (6) thirst, and (7) inconvenience at work. More complaints about uncomfortable symptoms and pressure sores were reported by female physicians and nurses and by those working at designated hospitals or in intensive care units and working in PPE for more than 4 hours.
- Key implications for emergency nursing practice are that shorter time per shift, adequate protective products, and proper psychological interventions may be beneficial to relieve discomfort.

Abstract

Introduction: The purpose of this study was to rapidly quantify the safety measures regarding donning and doffing personal protective equipment, complaints of discomfort caused by wearing personal protective equipment, and the psychological perceptions of health care workers in hospitals in Wuhan, China, responding to the outbreak.

Methods: A cross-sectional online questionnaire design was used. Data were collected from March 14, 2020, to March 16, 2020, in Wuhan, China. Descriptive statistics and χ^2 analyses testing were used.

Results: Standard nosocomial infection training could significantly decrease the occurrence of infection (3.6% vs 13.0%, $\chi^2 = 4.47$, $P < 0.05$). Discomfort can be classified into 7 categories. Female sex (66.0% vs 50.5%, $\chi^2 = 6.37$), occupation (62.7% vs 30.8%, $\chi^2 = 5.33$), working at designated hospitals (44.8% vs 26.7%, $\chi^2 = 5.17$) or in intensive care units (70.4% vs 57.9%, $\chi^2 = 3.88$), and working in personal protective equipment for > 4 hours (62.2% vs 39.2%, $\chi^2 = 9.17$) led to more

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complaints about physical discomfort or increased occurrence of pressure sores (all $P < 0.05$). Psychologically, health care workers at designated hospitals (60.0% vs 42.1%, $\chi^2 = 4.97$) or intensive care units (55.9% vs 41.5%, $\chi^2 = 4.40$) (all $P < 0.05$) expressed different rates of pride.

Discussion: Active training on infection and protective equipment could reduce the infection risk. Working for long hours increased the occurrence of discomfort and skin erosion.

Introduction

Coronavirus disease (COVID-19), which is now known to be caused by the severe acute respiratory syndrome coronavirus 2, has become a worldwide pandemic.¹⁻⁴ The virus has now spread to 6 continents, endangering more than 10 million people.⁵ The cumulative number of diagnosed patients had reached 85,204 in China as of June 29, 2020.⁶ Controlling the spread of the disease and providing medical care to the infected patients has been an unprecedented challenge. Despite wearing personal protective equipment (PPE), there is evidence of health care workers (HCWs) becoming infected.⁷⁻⁹ In addition, owing to the heavy workload at the forefront and discomfort from wearing PPE for long periods, HCWs, especially nurses in high-workload departments such as the emergency department, are suffering from considerable physical and mental burdens.¹⁰⁻¹³ Owing to its rapid spread and highly contagious nature, as of February 11, 2020, 1,716 HCWs in China had been infected by COVID-19 according to a report from the Chinese Center for Disease Control and Prevention.¹⁴ HCWs' main complaints include difficulty seeing owing to the misting of eye protection and difficulty breathing through protective masks. A proper method of donning and doffing PPE is highly important to protect HCWs from inadvertent exposure. The National Health Commission of the People's Republic of China has issued standard protocols for putting on and removing PPE according to different protective grades.¹⁵

There are 3 levels of protection in China depending on different departments and degrees of exposure risk. Equipment and N95 masks are required, and certain procedures must be followed in donning and doffing level II PPE and above. (Level III protection is for those who are performing operations such as tracheal intubation that may produce aerosols in patients suspected of having, or confirmed to have, COVID-19.) Level II protection is required for HCWs working in emergency departments with patients with fevers; those who enter observation rooms or isolation wards with suspected cases; those who transport patients suspected of having, or confirmed to have, COVID-19; and those who dispose of the corpses of patients who died

Reducing the working hours and having adequate protective products and proper psychological interventions may be beneficial to relieve discomfort.

Key words: Personal protective equipment; Health care worker; Safety; Discomfort; Psychological state

owing to COVID-19. Because level II PPE is used under most circumstances, with the exception of invasive operations, our research focused mainly on the use of level II PPE. Detailed donning and doffing procedures are described in the [Supplementary Figure](#), [Supplementary Table 1](#), and [Supplementary Videos 1 and 2](#) (the individual in the photo/videos is one of the authors).

The purpose of this study was to rapidly quantify the safety measures of donning and doffing PPE, complaints of discomfort caused by wearing PPE, and the psychological perceptions of HCWs in hospitals in Wuhan, China, responding to the COVID-19 outbreak. Furthermore, we aimed to explore group differences in safety measures by infection status; complaints of discomfort by sex, working time, occupation, department, age, and workplace; and psychological perceptions by demographic characteristics.

Methods

STUDY DESIGN AND PARTICIPANTS

We used a cross-sectional design. We conducted an anonymous questionnaire survey ([Supplementary Table 2](#)) of HCWs fighting COVID-19 in China (among HCWs working in Wuhan and those who came from all over the country to support them) from March 14, 2020, to March 16, 2020. To avoid cross-infection, this study was conducted online.

ETHICAL CONSIDERATIONS

This study was reviewed and approved by the Renmin Hospital of Wuhan University Medical Ethical Committee (approval number: WDRY2020-K134).

QUESTIONNAIRE

An original questionnaire was developed for the purposes of this study ([Supplementary Table 2](#)). The authors were actively involved in frontline clinical care in Wuhan, China,

and the survey was based on their expert experience with PPE in the early phases of the COVID-19 pandemic. There were 25 multiple-choice questions—6 had multiple-response options—with 5 questions per page, 5 pages in total.

DATA COLLECTION

We used the Questionnaire Star survey program (Wise Talent Information Technology Co, Ltd) to collect the information. A link to the questionnaire was published on the WeChat platform (Tencent), the most widely and frequently used social networking platform in China.¹⁶ It was open to all HCWs in Wuhan and those HCWs came to support them. The survey was voluntary, with no incentives offered, and completing the survey was considered implied informed consent.

We also attached a completeness check to the questionnaire, and responding to all 25 questions was mandatory; therefore, the participants had to choose at least 1 answer for each question listed. Participants were not permitted to review after submitting the questionnaire; therefore, the participants could not change their answers once they were submitted.

MEASURES

Demographic Information

Because our participants were all HCWs in Wuhan hospitals, we divided their demographic information as follows: the demographic variables included sex (male or female); age (20-30 years, 30-40 years, 40-50 years, and >50 years); occupation (physician, nurse, pharmacist, medical technician, or other); workplace (a designated hospital for patients critically ill with severe COVID-19; an undesignated hospital for patients uninfected with COVID-19; and Fangcang Hospital for patients with mild symptoms of COVID-19); and department (general isolation ward, intensive care unit [ICU], emergency department for patients with fevers, and other).

Safety Measures

The evaluation questionnaire included (1) whether or not the HCW had standard nosocomial infection training before treating patients in the wards, (2) whether or not the HCW was well acquainted with the standard operating procedure (SOP) of donning and doffing PPE, (3) the presence of a full-length dressing mirror, (4) measures that the HCW thought were necessary to standardize the donning procedure, and (5) the best length of the HCW's hair at work. The respondents were also asked if they had been infected by COVID-19 owing to exposure at work.

Complaints Owing to PPE

We asked questions on the specific time that the HCW spent in the ward wearing PPE, their discomfort owing to PPE, and possible solutions. The questions included:

Time. (1) The time it took for an HCW to put on PPE, (2) the maximum time an HCW had spent in PPE, and (3) the maximum tolerance time of an HCW in PPE.

Discomfort in PPE at Work. (1) Discomfort: dizziness or palpitation; chest distress or dyspnea; nausea or vomiting; micturition desire; retroauricular pain (mask pressure-related); thirst or dry throat; inconvenience at work; other symptoms of discomfort, for example, how an HCW felt in PPE, which was formatted as a multiple-response option.

Questions considering several vulnerable areas according to our clinical observation were also included: (2) Was there mist on the HCW's goggles? (3) What were the effective methods that the HCW used to prevent misting in practice? (This question allowed for multiple-response options.) (4) Did the HCW have pressure sores on their face? (5) In which areas did the HCW have pressure sores? (6) Did the HCW have skin injury owing to gloves? (7) What type of glove-related skin damage did the HCW have?

Feeling After Doffing PPE

(1) Discomfort that the HCW felt after doffing PPE, which was also a multiple-response option. (2) The first thing on an HCW's mind after doffing PPE.

Time off Between Shifts

We asked about the amount of time off that the HCW felt was necessary to recover from work between shifts.

Psychological States

The HCW's state of mind after donning PPE was also assessed. In a multiple-response-option format, the HCW was asked about experiencing 1 or more of 6 emotions: proud, excited, anxious, afraid, uncomfortable, or other.

STATISTICAL ANALYSIS

First, among the demographic information and safety measures, continuous variables were divided into categorical variables and were shown as numbers and percentages. Second, complaints owing to PPE were reported (also as numbers and percentages),

and the chi-square test or Fisher exact test was used for intergroup comparisons (sex, occupation, age, workplace, department, and time in PPE). Third, the psychological states of the HCW was described in a table categorized into different groups: occupation, age, sex, workplace, department, and time in PPE. A post hoc power analysis was performed to recommend the sample size for a replication study. All data were analyzed using SPSS version 26.0 (IBM Corp). *P* values less than 0.05 were considered statistically significant.

Results

A total of 299 individuals agreed to participate, with 297 valid and complete questionnaires for a completion rate of 99.33%.

DEMOGRAPHIC CHARACTERISTICS

The demographic characteristics are shown in [Supplementary Table 3](#). Of the 297 participants, 91 (30.6%) were men, and 206 (69.4%) were women. Most of the participants were in the age ranges of 20-30 years (54.9%) or 30-40 years (37.7%). In terms of their occupation, 37 were physicians (12.5%), 247 were nurses (83.2%), 6 were medical technicians (2.0%), and 7 had other occupations (2.4%). Overall, 248 participants worked at a designated hospital for patients critically ill with severe COVID-19 (83.5%), 45 worked at an undesignated hospital for patients uninfected with COVID-19 (15.2%), and 4 worked at Fangcang Hospital for patients with mild symptoms of COVID-19 (1.4%). With regard to their department, 136 worked in the general isolation ward (45.8%), 68 in the ICU (22.9%), 30 in the emergency department for patients with fevers (10.1%), and 63 in other departments (21.2%).

SAFETY MEASURES

Information regarding safety measures is shown in [Supplementary Table 4](#). Overall, 274 HCWs had received standard training on nosocomial infection before treating patients in the wards (92.3%). A total of 291 HCWs were well acquainted with the SOP (98.0%), 232 HCWs had access to a full-length dressing mirror for both donning and doffing PPE (78.1%), 36 only had a mirror for donning PPE (12.1%), 6 only had a mirror for doffing PPE (2.0%), whereas 23 had no mirror (7.8%). Regarding the measures that the HCWs believed were necessary for standardizing the donning procedure, 14 HCWs thought that only a full-length mirror was necessary (4.7%), 33 believed in having a

checking monitor (11.1%), 15 thought that checking with a partner was adequate (5.1%), and 234 HCWs attached importance to all of these measures to standardize the donning procedure (78.8%). For the best length of hair at work, 14 HCWs believed that “fully shaved” was the best (4.7%), 89 thought that their hair should be as short as possible (30.0%), 90 believed that just tying it up was adequate (30.3%), and 104 thought that the length did not matter as long as it was properly handled when donning PPE (35.0%). [Table 1](#) explores the relationship between standard nosocomial training, familiarity with the SOP, the availability of a dressing mirror, and the incidence of infection among the respondents. Standard training on nosocomial infection before treating patients in the wards could significantly decrease the infection rate compared with the no-training group (3.6% vs 13.0%, $\chi^2 = 4.47$, $P < 0.05$), whereas the unavailability of dressing mirrors could lead to a higher rate of infection (3.6% vs 13.0%, $P < 0.05$).

COMPLAINTS OWING TO PPE

Time

The time it took the HCWs to don PPE varied. A total of 52 HCWs claimed to be able to don PPE within 10 minutes (17.5%), 111 needed 10 minutes to 15 minutes (37.4%), 79 needed 15 minutes to 20 minutes (26.6%), and 55 spent more than 20 minutes donning PPE (18.5%). After donning PPE, most of the HCWs spent a maximum time of 4 hours to 6 hours (48.2%) or 6 hours to 8 hours (28.0%) working in it. For the maximum PPE tolerance time, 179 HCWs believed that 4 hours to 6 hours was their limit (60.3%), 66 thought that 2 hours to 4 hours should be the maximum (22.2%), whereas 46 HCWs believed that they could endure 6 hours to 8 hours in PPE at most (15.5%).

Discomfort in PPE

All the types of discomfort with multiple-response options demonstrated a comparatively high occurrence (more than 40%, [Figure](#)). Retroauricular pain (mask pressure-related) was the most reported complaint (81.8%), chest distress or dyspnea was the second (78.5%), inconvenience at work (for auscultatory tests, blood sample collection, and punctures) was the third (61.3%), followed by thirst or dry throat (60.3%), dizziness or palpitation (58.9%), micturition desire (55.6%), nausea or vomiting (42.1%), and other symptoms (14.8%). Overall, 240 HCWs reported misting on their goggles (81.8%). To prevent misting, most HCWs thought it was useful to apply cleaning agents (63.3%) or spray antimist agents on their goggles or glasses (47.1%). A total of 173

TABLE 1

Safety measures stratified by infection

Safety measures	Total (N = 297)	Infected (N = 13) No. of patients/total no. (%)	Uninfected (N = 284) No. of patients/total no. (%)	χ^2	P value
Standard training on nosocomial infection before treating patients in the wards				4.47	0.03
Yes	274 (92.3)	10 (76.9)	264 (93.0)		
No	23 (7.7)	3 (23.1)	20 (7.0)		
Acquaintance with SOP					0.24
Yes	291 (98.0)	12 (92.3)	279 (98.2)		
No	6 (2.0)	1 (7.7)	5 (1.8)		
Availability of the dressing mirrors					
Only donning	36 (12.1)	1 (7.7)	35 (12.3)	0.25	0.62
Only doffing	6 (2.0)	0 (0.0)	6 (2.1)		1.00
Both	232 (78.1)	9 (69.2)	223 (78.5)	0.63	0.43
None	23 (7.8)	3 (23.1)	20 (7.0)	4.47	0.03

SOP, standard operation procedure; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

HCWs reported having pressure sores on their faces (58.3%), mainly distributed on the nose (81.0%), cheek (66.5%), forehead (45.1%), and retroauricular areas (43.6%). Overall, 154 HCWs reported glove-related skin damage (51.9%): eczema (59.1%), dry skin (57.8%), and skin erosion (53.9%) were the main injuries.

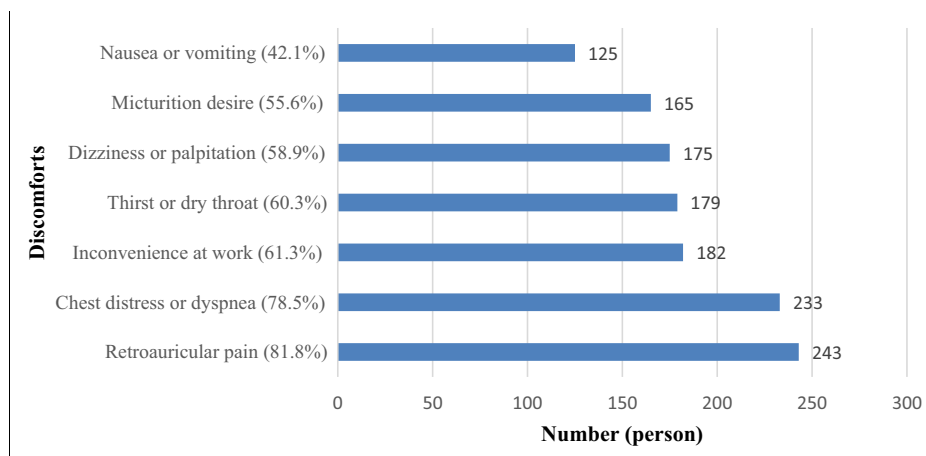
Feeling After Doffing PPE

The symptoms reported after doffing PPE included dizziness or palpitation (27.3%), chest distress or dyspnea (33.0%), nausea or vomiting (16.8%), and other symptoms (6.1%), whereas 160 HCWs reported none

of these symptom (55.2%). After doffing PPE, 130 HCWs reported that the first thing on their mind was to drink water (43.8%), whereas 104 wanted to clean themselves (35.0%), and 36 wanted to rest (12.1%).

Discomfort in PPE, Misting on Goggles, Pressure Sores, and Skin Injury Stratified by Sex, Occupation, Age, Workplace, Department, and Working Time

Discomfort in PPE, misting on goggles, pressure sores, and skin injury stratified by sex, occupation, department, age, workplace, and working time are shown, respectively, in



FIGURE

Bar chart of the discomfort caused by personal protective equipment in the study sample. The respondents reported a relatively high level of discomfort.

TABLE 2

Discomfort stratified by sex

Discomfort	Total (N = 297)	Male (N = 91)	Female (N = 206)	χ^2	P value
		No. of patients/ total no. (%)			
Discomfort in PPE					
Dizziness or palpitation	175	52 (57.1)	123 (59.7)	0.17	0.68
Chest distress or dyspnea	233	64 (70.3)	169 (82.0)	5.12	0.02
Nausea or vomiting	125	34 (37.4)	91 (44.2)	1.20	0.27
Micturition desire	165	48 (52.7)	117 (56.8)	0.42	0.52
Retroauricular pain (mask pressure related)	243	63 (69.2)	180 (87.4)	13.97	<.001
Thirst or dry throat	179	46 (50.5)	133 (64.6)	5.18	0.02
Inconvenience at work	182	46 (50.5)	136 (66.0)	6.37	0.01
Misting on goggles	243	72 (79.1)	171 (83.0)	0.64	0.43
Pressure sores	173	55 (60.4)	121 (58.7)	0.08	0.78
Skin injury because of gloves	154	48 (57.1)	106 (57.1)	0.04	0.84

PPE, personal protective equipment.

Table 2 and Supplementary Tables 5-8, and Table 3. Chest distress or dyspnea (82.0% vs 70.3%, $\chi^2 = 5.12$, $P = 0.02$), retroauricular pain (mask pressure-related) (87.4% vs 69.2%, $\chi^2 = 13.97$, $P < 0.001$), thirst or dry throat (64.6% vs 50.5%, $\chi^2 = 5.18$, $P = 0.02$), and inconvenience at work (for auscultatory tests, blood sample collection, and punctures) (66.0% vs 50.5%, $\chi^2 = 6.37$, $P = 0.01$) were more common in the female HCWs. Inconvenience at work (for auscultatory tests, blood sample collection, and punctures) was more frequently cited by physicians and nurses (62.7% vs 30.8%, $\chi^2 = 5.33$, $P = 0.02$) and by HCWs working in an ICU (70.4% vs 57.9%, $\chi^2 = 3.88$, $P = 0.049$) than by HCWs with other occupations and working in other departments (Supplementary Tables 5 and 6, both $P < 0.05$). There was no statistically significant difference stratified by age (Supplementary Table 7, $P < 0.05$). Compared with other workplace groups, the HCWs at a designated hospital for patients critically ill with severe COVID-19 reported a higher rate of discomfort symptoms such as nausea or vomiting (44.8% vs 26.7%, $\chi^2 = 5.17$, $P = 0.02$) and inconvenience at work (64.7% vs 42.2%, $\chi^2 = 8.12$, $P < .05$), as well as pressure sores (61.9% vs 37.8%, $\chi^2 = 9.14$, $P = 0.003$) (Supplementary Table 8, $P < 0.05$). The HCWs who worked in PPE for more than 4 hours were more likely to suffer from inconvenience at work (63.8% vs 49.0%, $\chi^2 = 3.90$, $P = 0.048$) and pressure sores (62.2% vs 39.2%, $\chi^2 = 9.17$, $P = 0.002$); those who worked for more than 6 hours reported a higher rate of micturition

desire (64.1% vs 45.1%, $\chi^2 = 5.04$, $P = 0.03$) and pressure sores (64.1% vs 39.2%, $\chi^2 = 8.55$, $P = 0.003$); and working more than 8 hours was related to a higher rate of pressure sores (65% vs 39.2%, $\chi^2 = 3.84$, $P = 0.05$) and skin injury (75% vs 43.1%, $\chi^2 = 5.84$, $P = 0.02$) owing to gloves (Table 3).

Time off Between Shifts

More than half the participants believed that an HCW needed 24 hours off between shifts (53.5%), and 27.61% felt that they needed 12 hours off between shifts.

PSYCHOLOGICAL STATES

Overall, 133 participants felt proud after donning PPE (44.8%), 74 felt excited (24.9%), 84 felt anxious (28.3%), 33 felt afraid (11.1%), 153 felt uncomfortable (51.5%), and 36 had other feelings (12.5%).

The different psychological states stratified by sex, age, occupation, workplace, and department are shown in Supplementary Table 9. There was no statistically significant difference in the psychological states stratified by sex and age. Physicians and nurses reported more psychological discomfort than staff in other positions (52.8% vs 23.1%, $\chi^2 = 4.40$, $P = 0.04$). The HCWs working at designated hospitals (60.0% vs 42.1%, $\chi^2 = 4.97$, $P = 0.03$) and in ICUs (55.9% vs 41.5%, $\chi^2 = 4.40$, $P = 0.04$) had different rates of feeling proud.

TABLE 3

Discomfort stratified by working time

Discomfort	Total (N = 297)	< 4 hr (N = 51) no. (%)	> 4 hr (N = 246) no. (%)	χ^2	P value	> 6 hr (N = 103) no. (%)	χ^2	P value	> 8 hr (N = 20) no. (%)	χ^2	P value
Discomfort in PPE											
Dizziness or palpitation	175	24 (47.1)	151 (61.4)	3.58	0.06	57 (55.3)	0.94	0.33	9 (45.0)	0.02	0.88
Chest distress or dyspnea	233	42 (82.4)	191 (77.6)	0.55	0.45	76 (73.8)	1.40	0.24	14 (70.0)	1.32	0.25
Nausea or vomiting	125	20 (39.2)	105 (42.7)	0.21	0.65	39 (37.9)	0.03	0.87	6 (30.0)	0.53	0.45
Micturition desire	165	23 (45.1)	142 (57.7)	2.73	0.09	66 (64.1)	5.04	0.02	13 (65.0)	2.28	0.13
Retroauricular pain (mask pressure related)	243	37 (72.5)	206 (83.7)	3.56	0.06	84 (81.6)	1.64	0.20	18 (90.0)	2.51	0.11
Thirst or dry throat	179	25 (49.0)	154 (62.6)	3.25	0.07	59 (57.3)	0.94	0.33	14 (70.0)	2.55	0.11
Inconvenience at work	182	25 (49.0)	157 (63.8)	3.90	0.05	58 (56.3)	0.73	0.34	12 (60.0)	0.69	0.41
Misting on goggles	243	43 (84.3)	200 (81.3)	0.26	0.61	83 (80.6)	0.32	0.57	18 (90.0)	0.38	0.54
Pressure sores	173	20 (39.2)	153 (62.2)	9.17	<.001	66 (64.1)	8.55	0.003	13 (65.0)	3.84	0.05
Skin injury because of gloves	154	22 (43.1)	132 (53.7)	1.87	0.17	60 (58.3)	3.13	0.07	15 (75.0)	5.84	0.02

PPE, personal protective equipment.

POWER ANALYSIS

A post hoc power analysis was conducted to recommend the sample size for a future replication study on the basis of our results. Here, we calculated the sample size using the rate-based sample size estimation formula in cross-sectional studies: $n = (Z\sigma/\delta)^2 \times p(1-p)$. Estimating the incidence of the survey population with 95% confidence level ($Z\sigma$ is taken as 1.96), the prevalence, p , of discomforts in PPE is approximately 80% (p takes a value of 80%), $q = 1-p$, and the tolerance, δ , takes a value of 5%. In this case, the required sample size is calculated to be 246. Considering the 5% invalid response, a sample size of 258 may meet the requirements.

Discussion

Here, we add uniquely to the published literature by rapidly quantifying the safety measures of donning and doffing PPE, complaints of discomfort owing to PPE, and the psychological perceptions of HCWs at hospitals in Wuhan, China, responding to the COVID-19 outbreak in March 2020. According to our online questionnaire survey, there was a high prevalence of uncomfortable symptoms suffered by the HCWs during their fight against the COVID-19

epidemic, although active and timely training was helpful for the effective prevention of infection. More complaints of discomfort were reported by women, physicians, nurses, and those working at a designated hospital or in an ICU. The HCWs working at a designated hospital or in an ICU were prouder than their comparable groups after doffing PPE.

SAFETY MEASURES

Training on nosocomial infection before treating patients in the wards is of considerable significance for preventing HCWs from contracting COVID-19, which was also demonstrated in previous studies.^{17,18} Adding a dressing mirror at all sites would support staff during donning and doffing PPE, and it is an easy improvement to implement.

We strongly recommend strictly adhering to the correct procedure for donning and doffing PPE.¹⁵ Timely, interactive training on the prevention of nosocomial infection and on the SOP for wearing PPE can considerably reduce the risk of HCWs' exposure to COVID-19. Studies have shown that adding computer stimulations or video-based learning methods could increase compliance and performance scores.¹⁹⁻²¹ Taking help from an assistant or partner, sometimes coupled with a mirror, was often resorted to

while donning PPE, and a hygienist supervised doffing.²² We recommend using a full-length dressing mirror, being checked by a partner before entering the wards, and assigning a “dofficer” (or donning/doffing officer) for both donning and doffing PPE. Hair length may not influence working or create extra risks of infection, but short hair is definitely easier to cover with a surgical cap, and saves time when putting on and removing PPE. According to a consensus by Chinese experts,²³ hair should be cleaned with running water once PPE is removed, hair should be cleaned before taking a shower, and the head should be lowered when cleaning hair to keep the contaminated water out of the eyes, nose, and mouth.

DISCOMFORT AND INCONVENIENCE OWING TO PPE

Female HCWs are more likely to suffer uncomfortable symptoms such as chest distress or dyspnea, retroauricular pain (mask pressure-related), thirst or dry throat, and inconvenience at work (for auscultatory tests, blood sample collection, and punctures), which suggests that there might be gender differences. These gender differences may be due to a difference in the types of work male and female HCWs are assigned, the design of PPE, the cultural and gendered norms of expressing and reporting discomfort, or in both physical strength and psychological reaction. Previous studies have shown that male HCWs are prone to a higher rate of skin erosion than female HCWs.²⁴ Physicians, nurses, or HCWs in an ICU were more likely to complain about the inconvenience of working while wearing PPE than those in other positions or departments. This may be due to the different tasks and work intensity because clinical practices such as auscultatory tests, blood sample collection, and venipuncture are usually performed by physicians or nurses, and HCWs in an ICU treat patients with the most severe or complicated conditions; therefore, their work intensity or duration of PPE wear is much higher than that of those working in other departments. Among the HCWs working at designated hospitals for patients critically ill with severe COVID-19, the prevalence of nausea or vomiting and inconvenience at work and pressure sores were significantly higher, further suggesting that the discomfort the HCWs felt was positively correlated with their workload. Complaints about inconvenience at work and pressure sores were more frequently reported by the HCWs who worked in PPE for more than 4 hours; the longer the duration of wearing PPE, the greater the rate of complaints about discomfort.

The following measures should be considered to alleviate discomfort owing to PPE: apply moisturizer before putting on and after taking off gloves; and refer to dermatologists if necessary.²⁵⁻²⁷ We recommend routinely supplying protective supplies such as hand moisturizer. As for mask-related discomfort, we recommend wearing a properly fitted mask and applying moisturizer or gel beforehand for lubrication.²⁸ We recommend nonirritating products for hand-washing, and applying adhesive bandages on the portions of the skin in contact with the mask to help reduce friction. Because of the possibility of conjunctival transmission of COVID-19—first reported by a Chinese expert²⁹ and later confirmed by scientific studies³⁰—we strongly recommend using face shields in conjunction with goggles.³¹ In addition, applying cleaning or antimicrobial agents on the goggles might also help prevent misting. According to the results of the intergroup comparison, the working time in PPE at designated hospitals and in an ICU should be reduced to approximately 4 hours, whereas in other workplaces and departments, 6 hours could be considered the maximum duration. A 24-hour break between shifts is recommended for HCWs to be refreshed from fatigue and work pressure, but a 12-hour break between shifts might be more feasible. Maintaining hydration before and after wearing PPE is recommended.

PSYCHOLOGICAL STATES

Timely psychological interventions that build confidence and relieve stress are important considerations.³² According to a survey on HCWs' emotional problems and coping strategies, positive attitudes in the workplace, clinical improvement of infected colleagues, and halting disease transmission among HCWs after adopting strict protective measures alleviated their fear and supported them through the pandemic.³³ Thus, a rational focus on facts and timely psychological assistance such as offering coping strategies and measures to provide adequate medical equipment to treat patients and prevent HCW infection are beneficial.

FOLLOW-UP AT STUDY SITE

We were motivated to conduct this research to share our useful experience and help reduce the discomforts of HCWs worldwide during the COVID-19 pandemic. Many of our recommendations here were adopted at our hospital site, which is designated as a special hospital for patients with COVID-19. These adoptions include every

HCW receiving training on nosocomial infection before treating patients, adding dressing mirrors to assist with both donning and doffing PPE, creating 4-hour shifts for nurses, and staffing the emergency and ICU departments with more nurses. Medical isolation pads were used to prevent pressure sores caused by wearing N95 masks, and hand creams were provided to every HCW. Informally, we found that most of the HCWs in our hospital thought that these recommendations were very helpful, and future study is needed to confirm the efficacy and effectiveness of these recommendations.

Limitations

This study has several limitations. First, we used a questionnaire designed for the purposes of this study; further work is needed to test the validity and reliability of the survey. Second, nurses working at a designated hospital made up most of the survey participants. Third, owing to the COVID-19 pandemic, this survey was administered online; therefore, the sampling was voluntary and Web-based, creating possible selection bias, and we could not confirm that the participants were who they reported they were. As a cross-sectional survey, no causation can be inferred. We conducted multiple group testing without applying a *P* value correction, which may have resulted in spuriously significant results.

Implications for Emergency Nurses

As our results demonstrated, discomfort owing to PPE is widespread among HCWs, especially among nurses fighting COVID-19 on the front lines. Female sex as well as working under relatively high pressure for long hours closely correlated with the occurrence of uncomfortable symptoms and skin erosion. Active training on the PPE donning and doffing procedure as well as education on nosocomial infection significantly reduced the risk of exposure. Most of our study participants were nurses at a designated hospital for patients critically ill with severe COVID-19, and these nurses are under tremendous pressure, which differs from ordinary times. We believe that working long hours in PPE as well as the heavy workload is quite comparable to work patterns in emergency departments, and thus our evidence and practical suggestions will be beneficial for daily emergency nursing practice.

Only 10% of our participants worked in the emergency department setting, and a replication study is warranted in this unique population alone.

Conclusions

HCWs in isolation wards should receive standard training on the PPE donning and doffing protocol, along with proper psychological encouragement and timely support. Fighting the COVID-19 pandemic is an unprecedented global challenge, and HCWs are shouldering considerable responsibility as well as pressure. In light of this highly infectious disease, PPE remains the first-line recommendation for effective prevention; however, PPE-related discomfort is widely experienced by HCWs. This study revealed the main types of discomfort, analyzed the relationship between demographic information and the occurrence of different physical complaints and mental states, and offered practical strategies for improvement.

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Author Disclosures

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Appendix

SUPPLEMENTARY TABLE 1

The procedure for donning and doffing the personal protective equipment

Donning procedure

In the clean zone for donning:

- (1) Clean your hands according to the hand hygiene rules for HCW;
- (2) Put on the medical protective mask (N95, and perform a seal-check; medical isolation pad could be used beforehand to prevent pressure sores);
- (3) Put on the surgical cap;
- (4) Put on the goggle;
- (5) Put on the first layer of shoe coverings;
- (6) Put on the protective clothing;
- (7) Put on the first pair of gloves (covering the sleeves of the protective clothing);
- (8) Put on the medical surgical mask;
- (9) Put on the surgical cap (covering the upper edge of the goggle) and face shield (if available);
- (10) Put on the gown;
- (11) Put on the second layer of gloves (covering the sleeves of the gown);
- (12) Put on the second layer of shoe coverings;
- (13) Put on the face shield.

Doffing procedure

1. In the contaminated area: Hand hygiene

2. In the first buffer room for doffing:

- (1) Hand hygiene, take off the face shield;
- (2) Hand hygiene, take off the shoe coverings(the outer layer);
- (3) Hand hygiene, take off the gown with the gloves (the outer layer) together (Attention: roll the gown inside-out without touching the contaminated outer surface, as shown in the [Supplementary video 1](#));
- (4) Hand hygiene, take off the surgical cap and medical surgical mask;
- (5) Hand hygiene, enter the second buffer room for doffing.

3. In the second buffer room for doffing:

- (1) Hand hygiene, take off the protective clothing and the gloves (the inner layer) together (Attention: roll the protective clothing inside-out without touching the contaminated outer surface, as shown in the [Supplementary video 2](#));
- (2) Hand hygiene, take off the goggle;
- (3) Hand hygiene, take off the surgical cap;
- (4) Hand hygiene, take off the shoe coverings (the inner layer);
- (5) Hand hygiene, take off the medical protective mask;
- (6) Nasal vestibule cleansing;
- (7) Put on the medical surgical mask.

4. In the clean zone:

- (1) Hand hygiene;
- (2) Take a shower.

HCW, health care worker.

SUPPLEMENTARY TABLE 2

A questionnaire on the health care workers comfort level of using personal protective equipment in light of the Coronavirus disease

01. Identity:

Physician Nurse Apothecary Medical technician Other

02. Age :

20-30 y.o. 30-40 y.o. 40-50 y.o. >50 y.o.

03. Gender :

Male Female

04. Workplace :

Designated hospital† Undesignated hospital‡ Fangcang hospital§

05. Department :

Emergency for patients with fever General isolation ward ICU Other

06. Standard training on nosocomial infection before treating patients in the wards :

Yes No

07. Well acquainted with the SOP :

Yes No

08. Equipped with a full-length dressing mirror :

Only when donning Only when doffing Both None

09. Steps you think are necessary for standardizing the donning procedure :

A full-length mirror A checking monitor Checking with a partner All of the above None of the above

10. Time it takes you for donning a suit of PPE :

< 10 min 10-15 min 15-20 min > 20 min

11. State of mind after donning PPE (multiple choice) :

Proud Excited Anxious Afraid Uncomfortable Other

12. The maximum time in the ward wearing PPE :

1-2 h 2-4 h 4-6 h 6-8 h > 8h

13. Your maximum tolerance time in PPE :

1-2h 2-4h 4-6h 6-8h >8 h

14. Discomforts you felt in PPE (multiple choice) :

Dizziness or palpitation Chest distress or suffocation Retroauricular pain (mask pressure related) Micturition desire
 Nausea or vomiting Thirst or dry throat Inconvenience at work (auscultatory, blood sample collecting, puncture)

15. Discomforts you felt after doffing PPE (multiple choice) :

Dizziness or palpitation Chest distress or suffocation Nausea or vomiting None Other

16. First thing in your mind after doffing PPE :

Drink water Clean yourself Have some rest Eat something Other

17. Misting on your goggle :

Yes No

18. The effective methods you 've used on preventing the mist (multiple choice) :
- Wearing contact lens Applying cleaning agent on the goggle Spray anti-mist agent on the goggle
- Applying povidone-iodine on the goggle Stick seal gum around the mask Other
19. Do you have any pressure sores on your face?
- Yes No
20. Places of your pressure sores (multiple choice) :
- Forehead Nose Cheek Behind the ear Other
21. Do you have any skin injury due to the gloves?
- Yes No
22. Type of your skin injury due to the gloves :
- Skin dryness Skin erosion Eczema Other
23. The best length of hair at work :
- Fully shaved As short as possible Just enough to tie up It doesn't bother as long as well-handled when donning
24. Time you need to restore after a shift :
- 12 h 24 h 36 h 48 h > 48 h
25. Were you infected by the SARS-CoV-2 at work?
- Yes No

HCW,health care worker; COVID-19, coronavirus disease 2019; ICU, intensive care unit; SOP, standard operation procedure; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

[†] The Designated Hospital, which is for severe and critical COVID-19 patients.

^{*} The Undesignated Hospital, which is for patients uninfected with COVID-19.

[§] Fangcang Hospitals which belong to field mobile medical system are a number of movable cabins with multiple medical functions and the ability of rushing to the scene during emergency, during the epidemic of COVID-19, they're mainly used for the treatment of mild patients.

SUPPLEMENTARY TABLE 3

Demographic characteristics for study sample

Characteristics	no. (%)
Total	297 (100.0)
Gender	
Male	91 (30.6)
Female	206 (69.4)
Age	
20-30 y	168 (54.9)
30-40 y	112 (37.7)
40-50 y	19 (6.4)
> 50 y	3 (1.0)
Identity	
Physician	37 (12.46)
Nurse	247 (83.16)
Apothecary	0 (0.00)
Medical technician	6 (2.02)
Other	7 (2.36)
Workplace	
The designated hospital for severe and critical COVID-19 patients	248 (83.5)
The undesignated hospital for patients uninfected with COVID-19	45 (15.2)
The Fangcang hospital for mild COVID-19 patients	4 (1.4)
Department	
The emergency for patients with fever	30 (10.1)
The general isolation ward	136 (45.8)
The ICU	68 (22.9)
Other	63 (21.2)

COVID-19, coronavirus disease 2019; ICU, intensive care unit.

SUPPLEMENTARY TABLE 4

Safety measures on donning and doffing personal protective equipment

Safety measures	no. (%)
Total	297 (100.00)
Standard training on nosocomial infection before treating patients in the wards	
Yes	274 (92.3)
No	23 (7.7)
Well acquainted with the SOP	
Yes	291 (98.0)
No	6 (2.0)
Equipped with a full-length dressing mirror	
Only when donning	36 (12.1)
Only when doffing	6 (2.0)
Both	232 (78.1)
None	23 (7.8)
Steps you think are necessary for standardizing the donning procedure	
A full-length mirror	14 (4.7)
Checking with a partner	15 (5.1)
A checking monitor	33 (11.1)
All of the above	234 (78.8)
None of the above	1 (0.3)
The best length of hair at work	
Fully shaved	14 (4.7)
As short as possible;	89 (30.0)
Just enough to tie up	90 (30.3)
It doesn't bother as long as well-handled when donning	104 (35.0)

SOP, standard operation procedure; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

SUPPLEMENTARY TABLE 5

Discomforts stratified by occupation

Discomforts	Total (N = 297)	Physicians or nurses	Other identities	χ^2	P value
		(N = 284)	(N = 13)		
		no. of patients/ total no. (%)			
Discomforts in PPE					
Dizziness or palpitation	175	168(59.2)	7(53.8)	0.145	0.704
Chest distress or suffocation	233	223(78.5)	10(76.9)	0.019	0.891
Nausea or vomiting	125	119(41.9)	6(46.2)	0.092	0.761
Micturition desire	165	157(55.3)	8(55.6)	0.197	0.657
Retroauricular pain (mask pressure–related)	243	235(82.7)	8(61.5)	3.759	0.053
Thirst or dry throat	179	172(60.6)	7(53.8)	0.234	0.628
Inconvenience at work	182	178(62.7)	4(30.8)	5.334	0.021
Misting on goggles	243	235(82.7)	8(61.5)	3.759	0.053
Pressure sores	173	165(58.1)	8(61.5)	0.060	0.806
Skin injury because of the gloves	154	149(52.5)	5(38.5)	0.976	0.323

PPE, personal protective equipment.

SUPPLEMENTARY TABLE 6

Discomforts stratified by department

Discomforts	Total (N = 297)	ICU (N = 81) (n%)	Other (N = 216) (n%)	χ^2	P value
Discomforts in PPE					
Dizziness or palpitation	175	50(61.7)	125(57.9)	0.362	0.547
Chest distress or suffocation	233	62(76.5)	171(79.2)	0.240	0.624
Nausea or vomiting	125	38(46.9)	87(40.3)	1.064	0.302
Micturition desire	165	38(46.9)	127(58.8)	3.369	0.066
Retroauricular pain (mask pressure–related)	243	71(87.7)	172(79.6)	2.550	0.110
Thirst or dry throat	179	52(64.2)	127(58.8)	0.718	0.397
Inconvenience at work	182	57(70.4)	125(57.9)	3.879	0.049
Misting on goggles	243	65(80.2)	178(82.4)	0.185	0.667
Pressure sores	173	46(56.8)	127(58.8)	0.097	0.755
Skin injury because of the gloves	154	38(46.9)	116(53.7)	1.088	0.297

PPE denotes personal protective equipment.

SUPPLEMENTARY TABLE 7

Discomforts stratified by age

Discomforts	Total (N = 297)	20-40 y (N = 275)	> 40 y (N=22)	χ^2	P value
		no. of patients/ total no. (%)			
Discomforts in PPE					
Dizziness or palpitation	175	161(58.5)	14(63.6)	0.218	0.640
Chest distress or suffocation	233	217(78.9)	16(72.7)	0.460	0.497
Nausea or vomiting	125	116(42.2)	9(40.9)	0.014	0.907
Micturition desire	165	150(54.5)	15(68.2)	1.534	0.215
Retroauricular pain (mask pressure–related)	243	224(81.5)	19(86.4)	0.330	0.566
Thirst or dry throat	179	164(59.6)	15(68.2)	0.621	0.431
Inconvenience at work	182	170(61.8)	12(54.5)	0.454	0.500
Misting on goggles	243	225(81.8)	18(81.8)	0.000	1.000
Pressure sores	173	164(59.6)	9(44.9)	2.938	0.087
Skin injury because of the gloves	154	145(52.7)	9(40.9)	1.140	0.286

PPE, personal protective equipment.

SUPPLEMENTARY TABLE 8

Discomforts stratified by workplace

Discomforts	Total (N = 297)	Designated Hospital	Other	χ^2	P value
		no. of patients/ total no. (%)			
		(N = 252) (n%)	(N = 45) (n%)		
Discomforts in PPE					
Dizziness or palpitation	175	155(61.5)	30(66.7)	0.433	0.511
Chest distress or suffocation	233	201(79.8)	32(71.1)	1.690	0.194
Nausea or vomiting	125	113(44.8)	12(26.7)	5.174	0.023
Micturition desire	165	140(55.6)	25(55.6)	0.000	1.000
Retroauricular pain (mask pressure–related)	243	209(82.9)	34(75.6)	1.398	0.237
Thirst or dry throat	179	156(61.9)	23(51.1)	1.858	0.173
Inconvenience at work	182	163(64.7)	19(42.2)	8.118	0.004
Misting on goggles	243	207(82.1)	36(80.0)	0.118	0.731
Pressure sores	173	156(61.9)	17(37.8)	9.139	0.003
Skin injury because of the gloves	154	133(52.8)	21(46.7)	0.571	0.450

PPE, personal protective equipment.

Bold formatting value indicates statistically significant.

SUPPLEMENTARY TABLE 9

Different psychological states stratified by demographic characteristics

Characteristics	Total (N = 297)	Proud (N = 133) no. (%)	χ^2	P Value	Excited (N = 74) no. (%)	χ^2	P Value	Anxious (N = 84) no. (%)	χ^2	P Value	Afraid (N = 33) no. (%)	χ^2	P Value	Uncomfortable (N = 153) no. (%)	χ^2	P Value	Other (N = 37) no. (%)	χ^2	P Value
Gender			3.849	0.050		0.937	0.333		0.042	0.837		0.715	0.398		0.954	0.329		1.030	0.310
Male	91	33 (36.3)			26 (28.6)			25 (27.5)			8 (8.8)			43 (47.3)			14 (15.4)		
Female	206	100 (48.5)			48 (23.3)			59 (28.6)			25 (12.1)			112 (53.4)			23 (11.2)		
Age			0.681	0.409		0.071	0.791		1.195	0.274		0.098	0.754		0.349	0.554		0.714	0.398
20-40 y	275	125 (45.5)			68 (24.7)			80 (29.1)			31 (11.3)			143 (52.0)			33 (12.0)		
> 40 y	22	8 (36.4)			6 (27.3)			4 (18.2)			2 (9.1)			10 (45.5)			4 (18.2)		
Identity			1.544	0.214		0.249	0.618		2.141	0.143		0.241	0.623		4.402	0.036		-	-
Physician or Nurse	284	125 (44.0)			70 (24.6)			78 (27.5)			31 (11.0)			150 (52.8)			37 (13.0)		
Other	13	8 (61.5)			4 (30.8)			6 (46.2)			2 (15.4)			3 (23.1)			0 (0.0)		
Workplace			4.968	0.026		0.006	0.937		0.960	0.327		0.265	0.607		0.499	0.480		3.123	0.077
Designated	252	106 (42.1)			63 (25.0)			74 (29.4)			27 (10.7)			132 (52.4)			35 (13.9)		
Other	45	27(60.0)			11 (24.4)			10 (22.2)			6 (13.3)			21 (24.7)			2 (4.4)		
Department			4.395	0.036		0.091	0.763		0.720	0.396		0.403	0.526		1.886	0.170		0.409	0.523
ICU	81	38 (55.9)			16 (23.5)			22 (32.5)			9 (13.2)			40 (58.8)			10 (14.7)		
Other	216	95 (41.5)			58 (25.3)			62 (27.1)			24 (10.5)			113 (49.3)			27 (11.8)		

ICU, intensive care unit.