Factors that affect the duration of wearing disposable personal protective equipment by healthcare professionals in Wuhan during treatment of COVID-19 patients: An epidemiological study

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Abstract
The purpose of this study of healthcare workers who cared for COVID-19 patients was to identify factors that affected the duration of wearing personal protective equipment (PPE). The results of this study will provide initial guidance to practicing clinicians and a foundation for further research on this topic. This cross-sectional study examined 139 frontline healthcare professionals who worked at a single hospital in Wuhan, China, from March 16 to April 1, 2020. General and demographic data, physical and mental status, use of personal protective equipment, type of hospital work, and duration of wearing personal protective equipment were recorded. The mean duration of wearing personal protective equipment was 194.17 min (standard deviation: 3.71). Multiple linear regression analysis indicated that the duration of wearing personal protective equipment was significantly associated with the presence of a chronic disease, working hours when feeling discomfort, lack of patient cooperation and subsequent psychological pressure, prolonged continuous wearing of personal protective equipment, feeling anxious about physical strength, and the presence of fatigue when wearing personal protective equipment. These factors should be considered by practicing healthcare professionals and in future studies that examine the optimal duration of wearing personal protective equipment.

KEYWORDS
China, coronavirus disease 2019 (COVID-19), epidemiology, infection control, personal protective equipment (PPE)

1 INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a newly identified infectious disease caused by a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). COVID-19 is highly contagious and is mostly spread through respiratory tract droplets and by direct contact, but transmission via the gastrointestinal tract is also possible.
(Rathore, Galhotra, Pal, & Sahu, 2020). Thus, people in the general population are susceptible to COVID-19 (Li et al., 2020). The incubation period is longer than that of many other infectious respiratory diseases, and is generally 3 to 7 days but sometimes up to 14 days (Guo et al., 2020). Patients with severe disease can rapidly develop acute respiratory distress syndrome (ARDS) and septic shock, conditions associated with high mortality (Huang et al., 2020).

Since the beginning of March 2020, more than 3300 healthcare personnel in China had known SARS-CoV-2 infections (The Lancet, 2020). In Italy, 20% of medical and healthcare workers who were involved in responding to the COVID-19 epidemic were infected, and some of them died (Guardian, 2020; World Health Organization, 2020). Thus, in addition to being physically and mentally exhausted and suffering from the long hours of working with patients and colleagues, these individuals also faced an increased risk of infection (The Lancet, 2020). It is essential to protect all healthcare professionals from COVID-19. Thus, these individuals should wear a full set of disposable personal protective equipment (PPE) during their contact with patients (Huh, 2020). However, there are presently no uniform regulations regarding how long PPE should be worn by healthcare professionals when working in isolation wards.

To ensure the personal safety of healthcare staff, the PPE should provide “level 1 protection” and have a tight fit that prevents exposure (Ahmed et al., 2020). However, not all disposable PPE provides an appropriate balance of protection and comfort (Tabah et al., 2020). As the level of protection increases, overall breathability and wearing comfort decrease (Han, Ma, Hu, & Hao, 2020). Although wearing PPE probably provides healthcare professionals with a sense of security, those who wear PPE for a long time may experience blurred vision, shortness of breath, gasping, nausea, vomiting, diarrhea, skin damage (due to the high humidity), skin pressure damage, and even syncope (Tabah et al., 2020). In addition, long-term use of disposable PPE reduces its protectiveness, and could seriously endanger the health of healthcare professionals (Han et al., 2020; Kantor, 2020). On the other hand, the use of disposable PPE for very short durations will lead to waste of medical resources and increase the tension associated with human resource deployment during an epidemic. Thus, from the perspective of the safety and comfort of the healthcare professionals, it is necessary to examine how long they should wear PPE when working in isolation areas, and how to best prevent the occurrence of adverse events.

No previous research examined the optimal duration for wearing disposable PPE by healthcare professionals during treatment of COVID-19 patients. Thus, this study recorded the duration of wearing disposable PPE by healthcare professionals at a single hospital in Wuhan, China, and identified factors associated with the duration of wearing PPE. The long-term purpose was to identify the optimal duration for wearing disposable PPE, based on avoidance of controllable risk factors, and to provide evidence-based recommendations for optimizing the use of disposable PPE.

Many factors can affect the duration that a healthcare worker wears PPE, such as the individual’s physical and mental condition, the characteristics of the PPE, and the nature of the hospital work being performed. Therefore, this research analyzed the factors that affected the duration of wearing disposable PPE by examining the internal and external environment of healthcare professionals. The results will provide the first data on factors that affect the duration of wearing PPE by healthcare professionals, and will also provide constructive suggestions for future clinical work and research on this topic. We hypothesized that multiple factors affect the duration of wearing disposable PPE by healthcare professionals in Wuhan when caring for COVID-19 patients.

2 | METHODS

2.1 | Design

This cross-sectional study used purposive sampling to study all 176 members of the healthcare staff of the First Affiliated Hospital of Dalian Medical University who participated in the prevention and control of the COVID-19 epidemic from March 16, 2020 to April 1, 2020.

2.2 | Participants and procedures

All included participants were healthcare professionals (doctors and nurses) who worked in the clinical frontline; had education, physical, and mental status that allowed independent completion of the questionnaire; and volunteered to participate in this study. Individuals were excluded if they had a previous mental illness based on a written questionnaire. A total of 176 healthcare professionals in the hospital wards met these criteria, provided informed consent, and received questionnaires. After exclusion of questionnaires that were incomplete or had unusable responses (such as lacking the times of entering or exiting the quarantine ward), 139 valid questionnaires were analyzed.

This study was approved by the Research Ethics Committee of the First Affiliated Hospital of Dalian Medical University (PJ-KS-KY-2020-53). Permission was provided to perform this study within the premises of the First Affiliated Hospital of Dalian Medical University and Wuhan LeiShenShan Hospital. After obtaining informed consent, uniform instructions were used to administer the questionnaires, which were completed and collected on the same day. Part of the questionnaire was completed in the isolation ward, so photocopies were taken for uploading and the paper version (which remained in the isolation ward) was destroyed. Participants were reminded to record their times of entering and leaving the isolation ward and times of putting on and taking off PPE. These times were recorded to determine “working time”. We defined “the time of wearing PPE” as the time the worker was wearing PPE for the specified work shift. But, if the worker had unbearable discomfort, he or she could take off the PPE at any time when not in the isolation area.
2.3 Measures

2.3.1 General data

Age, gender, education, professional title, marital status, and previous experience in caring for patients with other infectious diseases (SARS, avian flu, and others) were recorded. The presence of a chronic disease (hypertension, diabetes, etc.) was also recorded.

2.3.2 Physical and mental variables

Before taking off PPE, oxygen saturation and pulse were recorded. The amount of drinking water (ml; within 1 h before entering the isolation ward); volume of first urination (ml; after entering the isolation ward); and sweating during the shift (clothes dry, slightly damp, wet, or soaked) were recorded. In addition, each participant provided “yes” or “no” responses to the following questions: Were you sick during the recent support period? Are you worried about getting infected? Did lack of patient cooperation lead to psychological pressure? Did high work intensity cause psychological stress? Did you have a headache while wearing PPE? Did you have a rash while wearing PPE? Did you vomit while wearing PPE? Did you have diarrhea while wearing PPE? Did you have shortness of breath when wearing PPE? Did you feel “dull” when wearing PPE? Did you have nausea while wearing PPE? Did you vomit while wearing PPE? Did you have fatigue when wearing PPE? Did you have discomfort when wearing PPE? Did you feel dizzy while wearing PPE? Did you have blurred vision when wearing PPE? Did you feel drowsy while wearing PPE? Did you have a headache while wearing PPE? Did you have a rash while wearing PPE? Did you feel irritable when your physical strength reached a limit? These questions were designed based on examination of the literature and consultation with experts.

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). This study used the Chinese version of this scale (Liu et al., 1996), which is free to use without permission. This scale has 19 self-assessment items that measure sleep quality in seven dimensions (sleep efficiency, sleep latency, subjective sleep quality, sleep duration, sleep disturbances, daytime dysfunction, use of sleeping medications). Each dimension was scored from 0 to 3, and the scores were added to calculate the total PSQI (range: 0 to 21). A higher total score corresponded to poorer sleep quality. Previous research indicated that this scale provided reliable assessments of sleep quality (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002; Liu et al., 1996).

The Self-Rating Anxiety Scale (SAS) (Zung, 1971) was used to measure anxiety. This study used the revised version from the Chinese Scale Cooperation Group (Wang et al., 1999), which is free to use without permission. This scale has 20 items, each item was scored from 1 to 4, and the total score was obtained by adding the scores of each item. The total score was then multiplied by 1.25 so that the total standard score ranged from 0 to 100. The standard cut-off value was 50, and a score above 50 points indicated the presence of anxiety symptoms. A standard score of 50 to 59 indicated mild anxiety, a score of 60 to 69 indicated moderate anxiety, and a score of 70 and above indicated severe anxiety.

The Self-Rating Depression Scale (SDS) (Zung, 1965) was used to measure depression. This study used the revised version from the Chinese Scale Cooperation Group (Wang et al., 1999), which is free to use without permission. This scale has 20 items, each item was graded from 1 to 4, and the scores of all items were added to calculate the total score. As above, the total score was then multiplied by 1.25 so that the total ranged from 0 to 100. The standard cut-off value was 53, and a score above 53 points indicated the presence of depressive symptoms. A score of 53 to 62 points indicated mild depression, a score of 63 to 72 indicated moderate depression, and a score above 72 indicated severe depression.

2.3.3 Types of PPE and related variables

The type of mask (N95 mask alone, N95 mask and a medical surgical mask, ordinary medical mask and a medical surgical mask, or others) and eye protection (goggles, face screen, goggles and face screen) used when working in the isolation ward, the duration of continuously wearing PPE, the maximum working hours when continuously wearing PPE, the hours working when feeling discomfort wearing PPE, the hours working when feeling tired after entering the isolation ward, and the hours working when at the limit of physical strength were recorded. For this last variable, this limit was defined by the time when a doctor or nurse wearing PPE felt that his or her physical strength did not allow further work. These variables were assessed based on examination of the literature and consultation with experts.

2.3.4 Types of hospital work

The timing of the work shift (day, before midnight, or after midnight), total number of patients cared for on a shift, number of patients 65 years-old or more, total number of beds in the isolation ward, total number of doctors and nurses, current number of doctors and nurses per day shift, current number of doctors and nurses per night shift, and environment of the isolation ward (negative pressure ward or general ward) were recorded. These variables were assessed based on examination of the literature and consultation with experts.

2.4 Statistical analysis

Two researchers entered all the data, and 10% of all entries were subjected to verification to ensure accuracy. SPSS 17.0 software was used for statistical analysis (SPSS Inc, Chicago, IL, USA). Descriptive methods were used for presentation of general information, physical and mental conditions, use of PPE, and type of hospital work. Count data were expressed as frequencies and percentages. Continuous data
that had normal distributions were presented as means ± standard deviations (SDs), and data with non-normal distributions as medians and inter-quartile ranges (IQRs). For single factor analysis of continuous variables, Pearson or Spearman correlation analysis was used to analyze the correlation of different variables with the duration of wearing PPE. For categorical variables, a t-test or a single factor analysis of variance was used. Stepwise multiple linear regression analysis was used to identify the independent effects of different variables on the duration of wearing PPE.

3 | RESULTS

3.1 | General characteristics of healthcare professionals

This study analyzed 139 healthcare professionals (nurses and doctors) who worked at LeiShenShan Hospital in Wuhan and cared for patients with COVID-19 during March 2020 (Table 1). The overall mean duration of wearing PPE was 194.17 min (SD = 3.71) and the mean age was 31.49 years-old (SD = 4.93; range: 22 to 43).

3.2 | Bivariate analysis of factors associated with duration of wearing PPE

Bivariate analysis (Table 2) indicated that the duration of wearing PPE had significant negative correlations with daytime dysfunction score on the PSQI (r = −0.167, P = 0.049) and the number of working doctors and nurses on the day shift (r = −0.193, P = 0.023). However, the duration of wearing PPE had significant positive correlations with maximum working hours while wearing PPE (r = 0.218, P = 0.010) and working hours when feeling discomfort (r = 0.218, P = 0.010).

3.3 | Univariate analysis of factors associated with duration of wearing PPE

Univariate analysis (Table 3) indicated that the duration of wearing PPE had significant positive associations with the presence of a chronic disease (t = 2.655, P = 0.009), lack of patient cooperation and subsequent psychological pressure (t = 2.271, P = 0.025), feeling “dull” when wearing PPE (t = 2.362, P = 0.020), feeling anxious because of limited physical strength (t = 2.226, P = 0.028), and work shift (t = 6.111, P = 0.003), but a significant negative association with the presence of fatigue when wearing PPE (t = −2.050, P = 0.042).

3.4 | Multivariate analysis of factors associated with duration of wearing PPE

All results in the univariate or bivariate analyses that had P-values below 0.05 were entered into a multivariate analysis (Table 4). The results indicated that the duration of wearing PPE had significant positive associations with the presence of a chronic disease (t = 2.707, P = 0.008), working hours when feeling discomfort wearing PPE (t = 3.326, P = 0.001), longest continuous working time while wearing PPE (t = 2.395, P = 0.018), and the presence of fatigue when wearing PPE (t = 2.280, P = 0.024), but had significant negative associations with lack of patient cooperation and subsequent psychological pressure.
TABLE 2  Bivariate analysis of the association of different variables with the duration of wearing PPE (n = 139)

| Label                                      | \( x \pm s \) (md, IQR) | The duration of wearing PPE | Label                                      | \( x \pm s \) (md, IQR) | The duration of wearing PPE |
|--------------------------------------------|--------------------------|-----------------------------|--------------------------------------------|--------------------------|-----------------------------|
| Age (years)                                | 31.49 ± 4.93             | 0.090 0.293                 | SAS                                       | 43.11 ± 11.48            | −0.043 0.615                |
| Oxygen saturation before wearing PPE(%)    | (98.00, 1)               | −0.260 0.758                | SDS                                       | 45.26 ± 12.02            | −0.047 0.587                |
| Pulse before wearing PPE (times / min)    | 88.02 ± 13.56            | 0.037 0.667                 | The maximum working hours when continuously wearing PPE(min) | 358.06 ± 108.48          | 0.218 0.010                 |
| Oxygen saturation before taking off PPE(%) | (98.00, 1)               | −0.043 0.611                | The hours working when feeling discomfort wearing PPE(min) | 127.71 ± 65.53           | 0.218 0.010                 |
| Pulse before taking off PPE(t times/min)   | 91.82 ± 12.06            | 0.044 0.604                 | The hours working when feeling tired after entering the isolation ward(min) | 193.24 ± 62.87           | 0.088 0.303                 |
| Water consumption (ml; within 1 h before entering the isolation ward) | (50, 100)               | 0.161 0.059                 | The hours working when at the limit of physical strength(min) | 305.48 ± 90.01           | 0.025 0.772                 |
| Volume of first urination (ml; after entering the isolation ward) | (200, 200)               | −0.084 0.328                | Total number of patients cared for on a shift | (8,10)                   | −0.056 0.529                |
| PSQI                                        | 9.94 ± 3.71              | −0.035 0.683                | Number of patients 65 years-old or more | (4,5)                    | −0.026 0.775                |
| -Sleep efficiency                           | 1.09 ± 1.07              | −0.002 0.978                | Total number of beds in isolation ward    | (48,10)                  | 0.070 0.411                 |
| -Sleep latency                              | 2.11 ± 0.91              | −0.024 0.782                | Total number of doctors and nurses         | (46,5)                   | 0.153 0.072                 |
| -Subjective sleep quality                   | 1.55 ± 0.77              | 0.003 0.971                 | Current number of doctors and nurses per day shift | (12,5)                  | −0.193 0.023                |
| -Sleep duration                             | 1.59 ± 0.88              | 0.035 0.683                 | Current number of doctors and nurses per night shift | (7,0)                   | 0.069 0.417                 |
| -Sleep disturbances                         | 1.29 ± 0.61              | −0.056 0.515                |                                        |                          |                            |
| -Daytime dysfunction                        | 1.90 ± 0.88              | −0.167 0.049                |                                        |                          |                            |
| -Use of sleeping medications               | 0.42 ± 0.82              | 0.051 0.548                 |                                        |                          |                            |

Abbreviations: \( x \pm s \), means ± standard deviations; Md, median; IQR, inter-quartile ranges.
| Label                                              | n (%) | The duration of wearing PPE (x ± s)min | t/F   | P     | Label                                              | n (%) | The duration of wearing PPE (x ± s)min | t/F   | P     |
|----------------------------------------------------|-------|----------------------------------------|-------|-------|----------------------------------------------------|-------|----------------------------------------|-------|-------|
| Gender                                             |       | -0.640                                | 0.523 |       | Did you have a headache while wearing PPE?            | -0.905 | 0.367                                 |
| -Male                                              | 9 (6.5) | 185.11 ± 42.43                        |       |       | -Yes                                               | 45 (32.4) | 199.02 ± 40.13                      |
| -Female                                            | 130 (93.5) | 194.79 ± 43.95                      |       |       | -No                                                | 94 (67.6) | 191.84 ± 45.43                      |
| Education                                          |       | 1.940                                 | 0.126 |       | Did you have fatigue when wearing PPE?              | -2.050 | 0.042                                 |
| -Master degree or above                            | 2 (1.4) | 223.00 ± 18.39                        |       |       | -Yes                                               | 40 (28.8) | 206.00 ± 39.73                      |
| -Bachelor degree                                   | 121 (87.1) | 196.67 ± 43.60                      |       |       | -No                                                | 99 (71.2) | 189.38 ± 44.60                      |
| -College degree                                    | 13    | 169.31 ± 44.12                        |       |       | Did you have shortness of breath when wearing PPE?  | 1.795  | 0.075                                 |
| -Technical secondary school education              | 3 (2.2) | 181.67 ± 28.43                        |       |       | -Yes                                               | 68 (48.9) | 187.41 ± 43.69                      |
| Professional title                                 |       | 0.069                                 | 0.977 |       | -No                                                | 71 (51.1) | 200.63 ± 43.16                      |
| -Director physician or director nurse              | 0     |                                        |       |       | Did you feel “dull” when wearing PPE?               | 2.362  | 0.020                                 |
| -Assistant director physician or assistant director nurse | 8 (5.8) | 199.38 ± 46.17                        |       |       | -Yes                                               | 95 (68.3) | 188.29 ± 40.74                      |
| -Doctor-in-charge or nurse-in-charge               | 45 (32.4) | 195.36 ± 45.82                      |       |       | -No                                                | 44 (31.7) | 206.84 ± 47.74                      |
| -Doctor or nurse practitioner                      | 68 (48.9) | 192.84 ± 43.01                        |       |       | Did you have nausea while wearing PPE?              | 0.254  | 0.800                                 |
| -Assistant doctor or nurse                         | 18 (12.9) | 193.89 ± 43.84                        |       |       | -Yes                                               | 32 (23.0) | 192.44 ± 44.91                      |
| Marital status                                     |       | 0.968                                 | 0.382 |       | -No                                                | 107 (77.0) | 194.68 ± 43.62                      |
| -Married                                           | 86 (61.9) | 197.88 ± 43.71                        |       |       | Did you vomit while wearing PPE?                    | -1.432 | 0.154                                 |
| -Unmarried                                         | 52 (37.4) | 188.60 ± 43.89                        |       |       | -Yes                                               | 2 (1.4)  | 238.00 ± 2.828                       |
| -Divorce                                           | 1 (0.7) | 164.00                                |       |       | -No                                                | 137 (98.6) | 193.53 ± 43.76                      |
| -Widowed                                           | 0      | 0                                     |       |       | Did you have diarrhea while wearing PPE?            | -0.565 | 0.573                                 |
| Previous participation in caring for patients with other infectious diseases (SARS, avian flu, and others) |       | 0.762                                 | 0.448 |       | -Yes                                               | 3 (2.2)  | 208.33 ± 35.47                      |
| -Yes                                              | 8 (5.8) | 205.03 ± 53.35                        |       |       | -No                                                | 136 (97.8) | 193.85 ± 43.99                      |
| Label                                      | n (%)          | The duration of wearing PPE  | t/F  | P         | Label                                      | n (%)          | The duration of wearing PPE  | t/F  | P         |
|-------------------------------------------|----------------|------------------------------|------|-----------|-------------------------------------------|----------------|------------------------------|------|-----------|
| -No                                       | 131 (94.2)     | 193.47 ± 43.26               |      |           | Did you have a rash while wearing PPE?    | 7 (7.7)        | 184.09 ± 31.85               | 0.795| 0.428     |
| -Yes                                      | 53 (38.1)      | 206.45 ± 43.56               | 2.655| 0.009     | -No                                       | 128 (92.1)     | 195.03 ± 44.63               |      |           |
| -No                                       | 86 (61.9)      | 186.59 ± 42.39               |      |           | Did you feel irritable when your physical strength reached a limit? | -0.379 | 0.705                      |
| Sweating during the shift                 |                | 0.355                        | 0.786|           | -Yes                                      | 110 (79.1)     | 194.89 ± 42.16               |      |           |
| -Clothes dry                              | 23 (16.5)      | 187.57 ± 60.25               |      |           | -No                                       | 29 (20.9)      | 191.41 ± 50.13               |      |           |
| -Slightly damp                            | 63 (45.3)      | 192.97 ± 41.75               |      |           | Did you feel anxious when your physical strength reached a limit? | 2.226 | 0.028                      |
| -Wet                                      | 45 (32.4)      | 198.53 ± 38.05               |      |           | -Yes                                      | 85 (61.2)      | 187.67 ± 42.92               |      |           |
| -Soaked                                   | 8 (5.8)        | 198.00 ± 38.96               |      |           | -No                                       | 54 (38.8)      | 204.39 ± 43.51               |      |           |
| Were you sick during the recent support period? |                | 1.175                        | 0.242|           | The type of mask used when working in isolation ward | 1.992 | 0.118                      |
| -Yes                                      | 12 (8.6)       | 208.33 ± 27.00               |      |           | -N95 mask alone                           | 14 (10.1)      | 203.57 ± 33.25               |      |           |
| -No                                       | 127 (91.4)     | 192.83 ± 44.87               |      |           | -N95 mask and a medical surgical mask     | 115 (82.7)     | 191.13 ± 44.73               |      |           |
| Are you worried about getting infected    |                | 1.885                        | 0.062|           | -ordinary medical mask and a medical surgical mask | 8 (5.8) | 226.13 ± 36.75               |      |           |
| -Yes                                      | 116 (83.5)     | 191.08 ± 43.06               |      |           | -Others                                   | 2 (1.4)        | 175.00 ± 35.36               |      |           |
| -No                                       | 23 (16.5)      | 209.74 ± 44.95               |      |           | The type of eye protection used when working in isolation ward | 1.044 | 0.355                      |
| Did lack of patient cooperation lead to psychological pressure? |                | 2.271                        | 0.025|           | -goggles                                  | 66 (47.5)      | 195.36 ± 40.87               |      |           |
| -Yes                                      | 51 (36.7)      | 183.25 ± 47.41               |      |           | -Face screen                              | 2 (1.4)        | 150.00 ± 42.43               |      |           |
| -No                                       | 88 (63.3)      | 200.49 ± 40.45               |      |           | -Goggles + face screen                    | 71 (51.1)      | 194.30 ± 46.29               |      |           |
pressure ($t = -3.050, P = 0.003$) and feeling anxious when physical strength reached a limit ($t = -2.469, P = 0.015$).

### 4 | DISCUSSION

This cross-sectional study examined healthcare professionals who cared for patients with COVID-19 at a single hospital in Wuhan, recorded the durations of wearing disposable PPE, and identified factors that influenced this duration. The results showed that the mean duration of wearing PPE was 194.17 min ($SD = 3.71$). No previous studies examined this topic, so a comparison with previous research is not possible. Moreover, these results are from a purposive sample of care givers who were frontline healthcare professionals in China. Previous studies showed that wearing disposable PPE for too long led to discomfort, reduced protection, and increased the probability of infection (Ambigapathy et al., 2020). During the study period (March 2020), none of the healthcare professionals examined here developed symptoms of COVID-19. Therefore, the durations of wearing PPE were apparently within the safe range. The data presented here thus provide a reference for subsequent studies of the effects of duration of wearing PPE by healthcare professionals, for subsequent research on the optimal duration for continuously wearing PPE, and for future development of relevant clinical standards or guidelines. In addition, the results presented here indicated that medical workers experienced discomfort when wearing disposable PPE after a mean duration of 127.71 min ($SD = 65.53$). This should be considered when formulating best practices for the duration of wearing PPE in clinical settings and in future studies.

This study showed that healthcare professionals with chronic diseases wore their PPE for longer periods than those without chronic diseases. The symptoms of chronic diseases are typically persistent, recurrent, and refractory (Han et al., 2020; Zhang et al., 2016). People with chronic diseases who continuously or intermittently experience symptoms of physical distress may have increased tolerance to wearing PPE because they have learned to adopt coping measures to manage physical discomfort. However, there is evidence that chronic diseases can reduce physical strength (Shen et al., 2019), and this would be expected to reduce the duration of wearing PPE. The present results are contrary to this expectation, possibly because this study examined subjects who were young ($M = 31.49, SD = 4.93$) and chronic diseases may not yet have led to significant negative effects, or because these healthcare professionals had certain personal characteristics that allowed them to overcome their limitations when responding to the COVID-19 pandemic. Subsequent research should examine the unique qualities of healthcare professionals who have chronic diseases, and seek to identify the specific positive psychological features that provide them with increased resilience during disease outbreaks.

The results presented here showed that healthcare professionals who experienced discomfort soon after changing into their PPE wore their PPE for shorter durations. Although this is as expected, there are currently no clear regulations on the duration for wearing PPE. Instead, a healthcare professional who experiences unbearable symptoms or whose work schedule is ending simply removes the PPE at

### TABLE 3 (Continued)

| Label | n (%) | $t/F$ | $P$ |
|-------|-------|-------|-----|
| Did high work intensity cause psychological stress? | Yes | 64 (46.0) | 192.70 ± 47.00 | 0.211 | 0.833 |
| No | 75 (54.0) | 194.41 ± 41.88 | 0.833 | 3.22 |
| Did you have blurred vision when wearing PPE? | Yes | 49 (35.3) | 193.10 ± 44.71 | 0.072 | 0.717 |
| No | 90 (64.7) | 194.74 ± 43.99 | 0.717 | 0.363 |

| Label | n (%) | $t/F$ | $P$ |
|-------|-------|-------|-----|
| Did you feel dizzy while wearing PPE? | Yes | 46 (33.1) | 193.78 ± 45.21 | 0.992 | 0.303 |
| No | 93 (66.9) | 194.35 ± 43.28 | 0.363 | 0.711 |

| Label | n (%) | $t/F$ | $P$ |
|-------|-------|-------|-----|
| Did you feel anxious when physical strength reached a limit? | Yes | 46 (33.1) | 193.78 ± 45.21 | 0.992 | 0.303 |
| No | 93 (66.9) | 194.35 ± 43.28 | 0.363 | 0.711 |

$\text{t} = 2.469, P = 0.015$ | $\text{t} = 3.050, P = 0.003$ | $\text{t} = -2.469, P = 0.015$ | $\text{t} = -3.050, P = 0.003$.
Note: Psychological state can directly affect physiological responses, reaching the limit of physical strength influenced the duration of wearing PPE. In other words, healthcare professionals who experienced anxiety and physical strength reached a limit wore their PPE for longer durations. That time. In addition, the results presented here also showed that those with longer working hours wore their PPE for longer durations.

The results presented here showed that feeling anxious about reaching the limit of physical strength influenced the duration of wearing PPE. In other words, healthcare professionals who experienced anxiety were likely to wear PPE for shorter durations. Previous studies showed that the psychological state can directly affect physiological responses, and that unhealthy psychology adversely affects physical health (Salovey, Rothman, Detweiler, & Steward, 2000; Vander Zee, Buunk, & Sanderman, 1995). In addition, psychological pressure can adversely affect a healthcare professional's physiological status and ability to work (Roberts & Grubb, 2014). This suggests that clinical managers and researchers should pay close attention to the mental status of their staff, promptly identify problems, and provide guidance to affected workers. In addition, frontline healthcare professionals who are experiencing obvious psychological pressure may want to reduce their working hours and duration of wearing PPE. These individuals should seek prompt help or support, and should try to relax and improve their mental state to improve engagement in their clinical work.

However, some similar factors had opposite effects on PPE wearing times, such as fatigue, feeling dull, and feeling anxious. In particular, healthcare professionals who developed symptoms of fatigue wore their PPE longer than those who did not and feeling dull had no effect on the duration of wearing PPE. However, feeling anxious about reaching the limit of physical strength was associated with a reduced duration of wearing PPE. This may be because the symptoms of fatigue and feeling dull were mild, and these individuals simply decided to continue working. This study had a small sample size and used an evaluation tool that was subjective. These results thus require further examination in follow-up research.

The results suggest that cooperation by patients affected the psychological status of healthcare professionals. More specifically, a lack of patient cooperation led to psychological pressure and reduced the duration of wearing PPE. These interventions will likely improve the coordination of treatment and nursing, and reduce the anxiety of healthcare professionals.

### TABLE 4

| Label | B     | SE    | β     | t     | p    |
|-------|-------|-------|-------|-------|------|
| Constant | 151.526 | 14.447 | —     | 10.488 | <0.001 |
| Do you have a chronic disease (hypertension, diabetes, etc.)? (yes or no) | 18.843 | 6.961 | 0.209 | 2.707 | 0.008 |
| The hours working when feeling discomfort wearing PPE | 0.170 | 0.051 | 0.254 | 3.326 | 0.001 |
| Did lack of patient cooperation lead to psychological pressure? (yes or no) | −21.196 | 6.950 | −0.233 | −3.050 | 0.003 |
| The maximum working hours when continuously wearing PPE | 0.075 | 0.031 | 0.186 | 2.395 | 0.018 |
| Did you feel anxious when your physical strength reached a limit? (yes or no) | −16.992 | 6.883 | −0.189 | −2.469 | 0.015 |
| Did you have fatigue when wearing PPE? (yes or no) | 16.802 | 7.368 | 0.174 | 2.280 | 0.024 |

Note: $R = 0.503, R^2 = 0.253, \text{adjusted } R^2 = 0.219, F = 7.346, P < 0.001$.  

The mean duration of wearing PPE was 194.17 min (SD = 3.71) and the duration of wearing PPE was significantly associated with the presence of a chronic disease, working hours when feeling discomfort, patient cooperation, a long continuous time of wearing PPE, feeling anxious about physical strength, and the presence of fatigue when wearing PPE. These factors should be considered by practicing clinicians and in future studies that examine the duration of wearing PPE. These results provide the first data on factors that affect the duration of wearing PPE by healthcare professionals, and a basis for future research on this topic.

This study also had several limitations. First, the study participants were a single purposive sample of healthcare professionals from a single hospital in China. Second, this study was performed during the late stage of the COVID-19 epidemic in Wuhan. During this period, there were fewer patients hospitalized with COVID-19 than earlier during the epidemic. Thus, the healthcare professionals had a reduced workload and increased availability of human resources. These factors may have led to decreased durations of wearing PPE. Third, participants may have reported inaccurate times of entering and leaving the isolation ward and of putting on and taking off PPE, and inaccurate information regarding water consumption and urination. Fourth, although the study used “total number of patients cared for on a shift, number of patients 65 years-old or more, and total number of beds in the isolation ward” to assess the workload, these factors may not accurately represent work quantity and quality, or even the ability to work. Finally, a major factor that determines the duration of wearing PPE is the manufacturer’s suggestion. Therefore, the use that time. In addition, the results presented here also showed that those with longer working hours were more anxious. In other words, healthcare professionals who experienced anxiety were likely to wear PPE for shorter durations. These interventions will likely improve the coordination of treatment and nursing, and reduce the anxiety of healthcare professionals.

### 5 CONCLUSIONS

The mean duration of wearing PPE was 194.17 min (SD = 3.71) and the duration of wearing PPE was significantly associated with the presence of a chronic disease, working hours when feeling discomfort, patient cooperation, a long continuous time of wearing PPE, feeling anxious about physical strength, and the presence of fatigue when wearing PPE. These factors should be considered by practicing clinicians and in future studies that examine the duration of wearing PPE. These results provide the first data on factors that affect the duration of wearing PPE by healthcare professionals, and a basis for future research on this topic.

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of PPE should follow the guidelines of the manufacturer and other protocols established by healthcare institutions. Although a healthcare professional should not make arbitrary decisions regarding the duration of wearing PPE, the factors identified here may cause deviations from proper and accepted use of PPE.

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CONFLICT OF INTEREST
There are no conflicts of interest.

AUTHOR CONTRIBUTIONS
F.L., T.J., T.S., and Y.L. designed the study; Y.L., X.L., G.X. collected data; F.L., T.J., Y.L., and Y.S. organize the data; F.L., T.J. conducted the statistical analyses, drafted the manuscript; F.L., T.J., T.S., Y.L., X.L., G.X., Y.L., and Y.S. contributed to the discussion. All authors had read and approved the manuscript.

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