Risk Factors of Healthcare Workers with Corona Virus Disease 2019: A Retrospective Cohort Study in a Designated Hospital of Wuhan in China

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Abstract:

Corona Virus Disease 2019 (COVID-19) originated in Wuhan, China has caused many healthcare workers (HCWs) infected. Seventy-two HCWs manifested with acute respiratory illness were retrospectively enrolled to analyze the risk factors. The high-risk department, longer duty hours, and suboptimal hand hygiene after contacting with patients were linked to COVID-19.

Keywords: risk factors, COVID-19, healthcare workers

1 Background

At present, the pneumonia epidemic caused by SARS-Cov-2 originating in Wuhan, China is still alarming, having drawn a high-level concern over the world. According to the experience during the 2002 severe acute respiratory syndrome (SARS) outbreak, more emphasis should be placed on healthcare workers (HCWs) protection, because an approximately 1725 of front-line HCWs were infected by SARS [1]. Given the current Corona Virus Disease 2019 (COVID-19) epidemic, the infection among medical and nursing personnel is a common occurrence, ever since the first 15 affected cases were reported in Wuhan [2]. It was estimated that a total of 1716 Chinese HCWs were infected by COVID-19 till February 11, 2020 [3]. To better understand how to protect staff, it is necessary to understand the predisposing factors for HCWs infection and nosocomial transmission. This retrospective cohort study of HCWs with acute respiratory illness in the designated hospital of Wuhan University sought to determine risk factors and behaviors associated with the development of COVID-19.

2 Methods

2.1 Participants

We conducted a retrospective cohort study among the HCWs (>18 years of age) with acute respiratory symptoms in a single-center setting, who worked at the forefront to fight against COVID-19 since it outbroke. To define the cohort, all participants were clinicians and nurses from a designated hospital. The designated Hospital is a 3300-bed grade-A tertiary hospital serving for the medical treatment in this outbreak. The case with acute respiratory symptoms was defined by any or multiple of the present symptoms like cough, fever, brachypnea, chest distress, headache, hemoptysis, others related to acute respiratory illness,

and diarrhea, testing with radiologic characters and laboratory evidence. All participants were given informed consent.

2.2 Procedure

HCWs in different departments were divided into two groups based on risk exposure. High-risk exposure was defined as the high-risk department (HRD) with interventional medical or surgical procedures that generate respiratory aerosols, including the respiratory department, infection department, ICU and surgical department. Other low-risk clinical departments were regarded as general groups (GD). Diagnosed cases of SARS-CoV-2 infection was identified as outcome variables. The follow-up was ended on Jan 28 because all HCWs were confirmed with COVID-19 infection or non-infection. HCWs were required to fulfill an online questionnaire giving detailed information on sociodemographic characteristics, time to symptomatic progression, contact history, medical practice, hand hygiene, and proper personal protective equipment (PPE) (Appendix 1). A total of 83 questionnaires were collected, of which 72 were valid, with an effective rate of 86.75%.

2.3 Case Definition

The outcome variable was regarded as diagnosed COVID-19, which is defined according to "The diagnosis of COVID-19 conformed to Diagnosis and treatment of novel coronavirus pneumonia (Trial Version 3)" issued by the National Health Commission of the People's Republic of China. All cases were diagnosed with the test by PCR nucleic acid. The novel coronavirus nucleic acid was detected by real-time fluorescence RT-PCR, and the virus gene was sequenced, which was highly homologous with the known new coronavirus.

2.4 Statistical Analysis

Continuous variables were described as mean (standard deviation) and median (interquartile range), while categoric variables were presented as counts (frequency or

percentages). Relative risk (RR) and its 95% confidence interval (95% CI) were calculated to compare outcomes between groups. Mentel-Haenszel tests and multivariate logistic regression were respectively used to identify the confounding factors and to assess the interaction effect between two variables. Kaplan-Meier survival curve was established, and the log-rank test was for subgroup differences. Statistical analyses were conducted using STATA software (version 14.0). *P*-value <0.05 was considered to be statistically significant.

3 Results

3.1 Baseline of sociodemographic characteristics

Of these 72 people, 39 were classified in GD and 33 in HRD. Ages ranged from 21 to 66 years with a median (interquartile range, IQR) of 31 (28-40,12). The median (IQR) of daily work was 8 (8-10, 2) hours (Table 1). Before the cohort started, subject baseline characteristics were compared. Gender (χ^2=2.243, *P* =0.134), types of HCWs (χ^2=0.076, *P* =0.782), and age (35.24 versus 37.98, *P* =0.579) were generally well-balanced between the exposed and non-exposed group.

3.2 Common symptoms

Common symptoms were fever (85.71%), cough (60.71%), brachypnea (7.14%), chest distress (7.14%), headache (7.14%), diarrhea (7.14%), and hemoptysis (7.14%) among the 28 HCWs diagnosed with COVID-19.

3.3 Contact history

Table 2 demonstrated that diagnosed family member (DFM), diagnosed patient (DP) and suspected patient (SP) were related to infections of HCWs, separately with the relative risk of 2.76 (95% CI = 2.02-3.77, *P*<0.01), 0.36 (95% CI = 0.22-0.59, *P*<0.01), and 0.49 (95% CI = 0.27-0.89, *P*<0.05).

3.4 Medical operation and protection

Illustrated in Table 2, the relative risks and their 95% confidence intervals of unqualified hand-washing, suboptimal hand hygiene before and after contact with patients, and improper PPE were 2.64 (95%CI = 1.04-6.71, $P<0.05$), 3.10 (95%CI = 1.43-6.73, $P<0.01$), 2.43 (95%CI = 1.34-4.39, $P<0.01$), and 2.82 (95%CI = 1.11-7.18, $P<0.05$), respectively.

3.5 HRD and GD

It was indicated that the HRD group had 2.13 times higher risk in developing COVID-19 compared with the GD group (crude RR =2.13, 95%CI: 1.45-3.95, $P<0.05$). After a stratified analysis with the Mantel-Haenszel method to adjust confounding factors, gender (RR_{HM}= 3.08, 95%CI: 1.09-8.71, $P_{\text{homogeneity}} = 0.70$), type of HCWs ($RR_{HM}$= 3.56, 95%CI: 1.29-9.84, $P_{\text{homogeneity}} = 0.27$), and gender * type of HCWs (RR_{HM}= 2.85, 95%CI: 1.03-7.90, $P_{\text{homogeneity}} = 0.25$) showed a homogeneity between layers.

3.6 Effect interaction

The interaction effect between exposure and other factors was conducted with logistic regression. It revealed that : 1) male + HRD (RR=2.45, 95%: 1.38-3.45, $P<0.01$) with control for HCW; 2) clinician + HRD (RR=2.00, 95%: 1.03-2.89, $P<0.05$) with control for gender; and 3) unclean hand after contact with patients (UHA) + HRD (RR=3.07, 95%: 1.14-5.15, $P<0.01$), UHA + GD (RR=2.45, 95%: 1.45-4.03, $P<0.05$) , and clean hand +HRD (RR=2.30, 95%: 1.30-3.77, $P<0.05$) with control for gender and HCW, were significant.

3.7 Time to event

Figure 1 is a Kaplan-Meier curve of the whole 72 participants in the cohort. It revealed that the cumulative proportion of infection-free would be decreased with daily workhour, which is

more obvious in HRD (P<0.05). To be specific, all of the staff in HRD would be infected if they worked 15 hours per day.

4 Discussion

Nosocomial infections of respiratory infectious diseases are common to see, and COVID-19 was found linked with the exposed department, duty hour, and hand hygiene in this study.

Similar to our finding, previous researches have proved the higher susceptibility of respiratory infectious disease for HRD workers [4]. This phenomenon has also been discovered in epidemics of SARS [5, 6]. For example, data from 7 hospitals in China showed an incidence of HCWs infected by SARS up to 13.53% in ICU [6]. We speculated that HRD experienced more exposures, such as a higher frequency of interventional medical operation and aerosol-generating procedure [7].

CHWs in China are generally working with long hours, with an average workweek exceeding 54 hours [8]. Moderate work hour benefits the health and safety of CHWs, while prolonged work (> 10 hours/day) would possibly increase the risk of respiratory infections [9, 10]. An obvious COVID-19 infection ascending with daily workhour was found in this study. Consideration of duty hour restrictions (less than 10 hours/day) should be considered, depending on the medical staff's specific role.

Contact transmission is one of the main routes of the SARS-CoV-2. Transmission from patients to HCWs usually follows contamination of the HCWs' hands after touching either patients or fomites, whereas hand hygiene is considered the most important prevention measure for healthcare-associated infections. Our results highlight the importance of hand hygiene after contacting or caring for COVID-19 patients, which is highly consistent with other researches [11, 12]. As we all know, washing hands can significantly reduce the residual viruses or bacteria on your hands.

Our research has some limitations. Recall bias on the part of HCWs is possible inherent in the survey study. To minimize the bias, investigators were required to verify the information using medical records in the hospital information system. Potential unmeasured confounding, especially with regards to gender differences was possibly another limitation. Hence, effect confounding was controlled as much as possible in the analysis. Limitations lie in small sample size, single-center aspect, and less representative research subjects, making the results difficult to be generalized. Nevertheless, the results support current recommendations for hand hygiene and duty hour reduction among HCWs.

5 Conclusion

HCWs worked in HRD and with suboptimal hand hygiene after contacting patients had a higher risk of COVID-19. Higher risk with longer duty hours was found, especially in HRD. A call to confirm these risk factors in other larger cohorts, as well as work to mitigate these, would be appropriate.

Authors' contributions

LR, designed the survey, analyzed data and wrote the manuscript; XyC, designed the survey, collected and analyzed data, and wrote the manuscript; YW, collected data, and wrote the manuscript; WwW, collected data, and wrote the manuscript; LZ, collected and analyzed data, and wrote the manuscript; XdT, edited the manuscript. All authors have read and approved the manuscript in its final form.

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Competing interests

The authors report no conflicts of interest.

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Table 1 Sociodemographic characteristics, contact histories and medical operation and protection of the participants

	Total cohort	**Infection**	**Non-infection**
	NO./median (IQR)	NO./median (IQR)	NO./median (IQR)
Gender (male/female)	22/50	14/14	8/36
Age (years)	31(28-40)	39(31.25-46.75)	30(26-34.50)
Occupation (clinician/ nurse)	38/34	19/9	19/25
HRD/ GD	33/39	18/10	15/29
Isolation/Non-isolation ward	6/66	1/27	5/39
Worktime (hours/day)	8(8-10)	8(8-10)	8(8-10)
Diagnosed family member (yes/no)	3/69	3/25	0/44
Suspected/Healthy family member (yes/no)	2/70	1/27	1/43
Diagnosed patient (yes/no)	55/17	15/13	40/4
Suspected patient (yes/no)	41/31	11/17	30/14
Huanan seafood market	1/71	0/28	1/43
Others (yes/no)	0/72	0/0	0/72
High-exposure operation (yes/no)	13/59	3/25	10/34
Tracheal intubation (yes/no)	0/72	0/28	0/44
Tracheotomy (yes/no)	0/72	0/28	0/44
Tracheal tube removal (yes/no)	1/71	0/28	1/43
CPR (yes/no)	1/71	0/28	1/43
Sputum suction (yes/no)	11/61	2/26	9/35
Fiber bronchoscopy (yes/no)	1/71	0/28	1/43
Laryngoscope (yes/no)	0/72	0/28	0/44
Unqualified hand-washing (yes/no)	50/22	24/4	26/18

Suboptimal hand hygiene before contact patients (yes/no)	39/33	22/6	17/27
Suboptimal hand hygiene after contact patients (yes/no)	28/44	17/11	11/33
Improper personal protective equipment (yes/no)	49/23	24/4	25/19

Note: IQR, interquartile range; HRD, high-risk department; GD, general department.

Table 2 The relative risk of infection in different contact history and medical operation and protection

Exposure factor	**Relative risk**	**95% CI**	***P* value**
Contact history			
Diagnosed family member	2.76	2.02-3.77	<0.01**
Suspected family member	1.30	0.31-5.35	>0.05
Diagnosed patient	0.36	0.22-0.59	<0.01**
Suspected patient	0.49	0.27-0.89	< 0.05*
Huanan seafood market	0.63	0.06-7.08	>0.05
Others	--	--	--
Medical operation and protection			
High exposure operation	0.54	0.19-1.53	>0.05
Tracheal intubation	--	--	--
Tracheotomy	--	--	--
Tracheal tube removal	0.63	0.06-7.08	>0.05
CPR	0.63	0.06-7.08	>0.05
Sputum suction	0.43	0.12-1.55	>0.05
Fiber bronchoscopy	0.63	0.06-7.08	>0.05
Laryngoscope	--	--	--
Unqualified hand-washing	2.64	1.04-6.71	< 0.05*
Suboptimal hand hygiene before contact patients	3.10	1.43-6.73	< 0.01**
Suboptimal hand hygiene after contact with patients	2.43	1.34-4.39	< 0.01**

Improper personal protective equipment	2.82	1.11-7.18	< 0.05*

Note: * $P<0.05$, ** $P<0.01$.

Figure legends

Figure 1 Kaplan-Meier survival estimates for COVID-19 between HRD and GD

Figure 1