Title page

Positive Rate of Serology and RT-PCR for COVID-19 between Community Residents and Healthcare Workers in Wuhan, China

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Summary

This study aimed to evaluate infection rates of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) among different populations in Wuhan, China. This cross-sectional, survey-based study examined the results of SARS-CoV-2-specific serological tests and RT-PCR testing from 4454 community residents and 4614 healthcare workers from May 15 to May 29, 2020. Healthcare workers were classified as either administrative and logistical staff (n=1378), non-first-line healthcare workers (n=2630), or first-line healthcare workers (n=606) according to their frequency of contact with coronavirus disease 19 (COVID-19) patients. The positive rates of SARS-CoV-2-specific IgG, IgM, and RNA were 2.9%, 0.4%, and 0.1% in community residents, and 3.3%, 0.6%, and 0.2% in healthcare workers, respectively. There were no statistically significant differences between the two groups. Spearman's correlation analyses showed that the frequency of contact with COVID-19 patients negatively correlated with the positive rates of RT-PCR ($r_s=-0.036$, P=0.016), but did not significantly correlate with the positive rates of IgM ($r_s=-0.006$, p=0.698) or IgG ($r_s=0.017$, p=0.239). There was no statistically significant difference of SARS-CoV-2-specific IgG, IgM, or RNA positive rates between community residents and healthcare workers. The positive rate of SARS-CoV-2 RNA was lower in first-line healthcare workers than that in non-first-line healthcare workers and administrative
and logistical staff.

1. Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread rapidly and caused a global pandemic of coronavirus disease 19 (COVID-19). China was one of the first and most affected countries during the worldwide outbreak. As of August 4, 2020, there had been 84491 confirmed cases and 4634 deaths from COVID-19 reported in China (1). Among these, a total of 50343 confirmed cases and 3869 deaths occurred in Wuhan alone (2). Although the overall situation of the current COVID-19 outbreak is effectively controlled in China, there may have been some individuals, especially those who were asymptomatic or experienced milder symptoms, did not present to clinics or emergency rooms and thus failed to receive a diagnosis, which would have greatly undermined national prevention and control work (3).

Real-time reverse transcriptase polymerase chain reaction (real-time RT-PCR) is a relatively simple, effective, and sensitive method to detect virus RNA (4, 5). Serological testing can also be used to detect IgM and IgG antibodies against SARS-CoV-2 (6). The IgG antibody can remain in convalescent COVID-19 patients for up to six months following symptom onset (7). A recent study used host serologic responses to estimate the cumulative infection prevalence of SARS-CoV-2 in China from March 9 to April 10, 2020. Their results revealed that the seropositive prevalence
rate was 3.8% in 714 healthcare workers, 3.8% in 346 hotel workers, and 3.2% in 219 family members of healthcare workers in Wuhan (8). Mass screening through viral RNA testing and the serological testing can accurately evaluate infection with SARS-CoV-2 across the population, and help us understand the epidemiology on SARS-CoV-2 infection, infectivity of and immunity to SARS-CoV-2. The current study collected and analyzed the results of SARS-CoV-2-specific serological test and RT-PCR test for 4454 community residents and 4614 healthcare workers in Wuhan from May 15 to May 29, 2020. The findings provide an understanding of the differences, or lack thereof, in infections with SARS-CoV-2 between community residents and healthcare workers from Wuhan.

2. Materials and methods

2.1 Data collection

From May 15 to May 29, 2020, we enrolled a total of 4454 community residents in Wuhan and 4614 healthcare workers from a tertiary hospital located in Wuhan into this study. Demographic data including age, gender, and job title were collected for each participant. According to their frequency of contact with COVID-19 patients, healthcare workers were classified into: (i) administrative and logistical staff who were not in daily contact with patients; (ii) non-first-line healthcare workers who were in daily contact with non-COVID-19 patients; or (iii) first-line healthcare workers who were in daily contact with known COVID-19 patients or
suspected patients in the fever clinic, designated wards, or intensive care units. The local protocols for infection prevention and control were developed and approved by experts from the infection control unit, following the World Health Organization (WHO) Guidelines (Table 1). This study was approved by the Ethics Committee of Renmin Hospital of Wuhan University (No.WDRY2020-K073) and was exempt from informed consent.

2.2 Laboratory measurements

From each participant, we collected blood samples for SARS-CoV-2-specific serological test and nasopharyngeal swabs for viral genome detection, respectively. Anti-SARS-CoV-2 IgG and IgM antibodies were detected using a Diagnostic Kit for IgM/IgG Antibody to Coronavirus according to the manufacturer’s instructions (Colloidal Gold Method; Livzon Diagnostics Inc. Zhuhai, China). The presence of SARS-CoV-2 RNA in nasopharyngeal swab samples was evaluated by real-time RT-PCR assay using the Chinese Control and Prevention (China CDC) recommended kit (DAAN Gene Co., Ltd. of Sun Yat-sen University, Guangzhou, China).

2.3 Statistical analysis

Statistical software package IBM SPSS Statistics 20.0 (IBM, Chicago, IL) was applied for statistical analysis. Continuous variables were expressed as the mean ± standard deviation (SD); categorical variables
were expressed as the count (%). The statistical differences of serology and RT-PCR results between community residents and healthcare workers were evaluated using chi-square test. The statistical differences of serology and RT-PCR results among different groups of healthcare workers were assessed using Spearman's correlation analysis. Statistical significance was defined as $P<0.05$.

3. Results

A total of 4454 community residents and 4614 healthcare workers were enrolled in this study. Demographic characteristics are shown in Table 2. There was a statistically significant difference in gender between the two groups ($\chi^2=383.904, P<0.0001$), but no significant difference in age ($t=-0.119, P=0.905$). The positive rates for SARS-CoV-2-IgG antibodies, IgM antibodies, and RNA were 2.9%, 0.4%, and 0.1% in community residents, and 3.3%, 0.6%, and 0.2% in healthcare workers, respectively. There was no significant difference observed between the community residents and healthcare workers. The comparison of positive rates of SARS-CoV-2-IgG, IgM, and RNA between different groups of healthcare workers is shown in Table 3. The positive rates of SARS-CoV-2-IgG antibodies, IgM antibodies, and RNA were 3.1%, 0.6%, and 0.4% in administrative and logistical staff, 3.2%, 0.6%, and 0.1% in non-first-line healthcare workers, and 4.5%, 0.3%, and 0% in first-line healthcare workers, respectively. Spearman's correlation analyses revealed that the apparent frequency of contact with
COVID-19 patients was negatively correlated with the positive rates of SARS-CoV-2 RNA \((r_s=-0.036, P=0.016)\), but not significantly correlated with IgM \((r_s=-0.006, P=0.698)\) or IgG \((r_s=0.017, P=0.239)\).

In this study, there were 12 participants (3 community residents and 9 healthcare workers) with positive results for SARS-CoV-2 RNA. Among them, only 1 participant was also positive for both IgM and IgG, while 6 participants were IgM negative and IgG positive, and 5 participants were negative for both IgM and IgG. A total of 259 participants were negative for RNA but positive for antibody (IgG or IgM) detection, and 27 of them were positive for both IgM and IgG.

4. Discussion

SARS-CoV-2 has been demonstrated to have higher transmissibility than both SARS-CoV and MERS-CoV (9). The surge in new cases of COVID-19 placed healthcare workers under tremendous pressure in the early stages of the pandemic—especially in the epicenter, Wuhan (10). The healthcare workers were at high risk of nosocomial infection. In a Wuhan-specific retrospective study, 59.1% of 110 healthcare workers with COVID-19 were thought to have been infected through contact with COVID-19 patients, and 10.9% through contact with colleagues (11). Data from the municipal Notifiable Disease Report System suggest that a total of 32583 laboratory-confirmed COVID-19 cases, including 1496 healthcare workers, were identified in Wuhan from December 8, 2019, to
March 8, 2020 (12). As of April 3, 23 healthcare workers had died from COVID-19 in China, 18 of whom were from Wuhan (13).

The Chinese government has been improving the prevention and control program to curb outbreaks and save lives. With the increased awareness around personal protection, intensive training in infection control procedures, and rapid provision of medical assistance, the situation of SARS-CoV-2 infections among healthcare workers in Wuhan has gradually improved. Our results showed that while the positive rates of IgG, IgM, and RNA were slightly higher in healthcare workers than in community residents, those differences were not statistically significant (Table 2). The observed positive rates of IgG, IgM, and RNA among healthcare workers from a tertiary hospital in Wuhan from May 15 to May 29, 2020 were 3.3%, 0.6%, and 0.2%, respectively. Similarly, Xu et al. reported findings that the positive rates of IgG, IgM, and RNA in 714 healthcare workers were 3.8%, 0.8%, and 0.7%, respectively (8).

Our study also found that the positive rate of SARS-CoV-2 RNA was higher in non-first-line healthcare workers and non-clinical staff than in first-line healthcare workers (Table 3), in concordance with previous studies. Hou et al. showed that the seropositivity for SARS-CoV-2 antibodies (IgG, IgM, or both IgG/IgM positive) of healthcare workers in non-isolation medical areas (5.4%) and non-medical area (4.4%) in Wuhan was higher than in isolation areas (3.4%) (14). Lai et al. also found a higher
infection rate in non-first-line healthcare workers than in first-line healthcare workers from Tongji Hospital in Wuhan (1.4% [93 of 6574] vs 0.5% [17 of 3110]) (11). One possible reason for this is that the first-line healthcare workers were provided more extensive personal protective equipments and more intensive training on infection control procedures than the non-first-line healthcare workers and non-clinical staff. Therefore, it is vitally important that proper training on infection control and the use of personal protective equipment be strengthened for healthcare workers in both non-COVID-19 wards and non-clinical departments.

Mass screening of both symptomatic and asymptomatic healthcare workers can reduce and prevent nosocomial transmission (15). The mass screening reported here was a proactive approach for ensuring a safer medical environment and keeping the hospital running normally through this pandemic (16). In addition, it can also help guide infection prevention and control.

RT-PCR was recommended by the World Health Organization as the primary method for SARS-CoV-2 detection (17). In our study, there were 12 participants found positive for SARS-CoV-2 RNA. Among these participants, only 1 was positive for both IgM and IgG. Interestingly, we found 6 of them were IgM negative while IgG positive. We suspected that due to the long intervals from infection to detection, the IgM antibody decreased to undetectable levels. Five participants were detected as both
IgM and IgG negative, which may be because that the time is not long enough for the generation of IgM and IgG antibodies (18, 19). In this study, 259 cases were negative for PCR but positive for antibody (IgG or IgM) detection, 27 of which were positive for both IgM and IgG. One possible reason for this is that the viral load gradually decreased over time. Indeed, a previous study showed that the detectability of RNA decreased from 66.7% (58/87) within the first week of onset to 45.5% (25/55) within the 15th-39th days of sample collection (20). Therefore, the combination of RT-PCR testing and serological testing may be a more reliable method for the diagnosis of SARS-CoV-2 infection (21-23).

Our study has several limitations. First, no precise estimates were made for the exposure levels of healthcare workers. Second, the sensitivity of the serological tests may be affected by the wide range of time intervals from the onset of disease to sample collection. Third, because of the cross-sectional design, the dynamics of antibody levels in infected individuals cannot be evaluated. Future long-term follow-ups will be important for estimating the role of serology markers in epidemiological investigations of COVID-19.

5. Conclusion

There were no statistically significant differences in SARS-CoV-2-specific IgG, IgM, or RNA between healthcare workers and community residents in Wuhan from May 19 to May 25, 2020. The positive rate of
SARS-CoV-2 RNA was lower in first-line healthcare workers than in non-first-line healthcare workers and non-clinical staff. It is thus essential to establish and maintain vigilance against nosocomial transmission and infection even in non–COVID-19 wards and non-clinical departments.

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Conflict of interest

None of the authors has any potential conflict of interest to disclose.

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### Table 1 Protection measures according to frequency of contact with COVID-19 patients.

| Healthcare Group                  | Personal Protective Equipment                                                                 |
|-----------------------------------|------------------------------------------------------------------------------------------------|
| Administrative and logistical staff | Surgical mask and work clothes                                                                 |
| Non-first-line healthcare workers  | Work clothes, disposable hat, N95 respirators, single use gloves, and isolation gown if necessary |
| First-line healthcare workers      | Work clothes, disposable hat, N95 respirators, single use gloves, single use waterproof protective clothing, and a face shield or protective goggles |
Table 2. Demographic characteristics and positive rates of serology and real-time RT-PCR tests in different populations.

|                          | Community residents | Healthcare workers | $\chi^2$ | $P$ value | Odds Ratio (95%CI) |
|--------------------------|---------------------|--------------------|---------|-----------|-------------------|
| Male                     | 2220 (49.8%)        | 1371 (29.7%)       | 383.904 | <0.0001   | -                 |
| Median age (years, ±SD)  | 36.89 (±10.811)     | 36.86 (±10.644)    | -0.119  | 0.905a    | -                 |
| IgG+                     | 127 (2.9%)          | 154 (3.3%)         | 1.785   | 0.182     | 0.850 (0.670, 1.079) |
| IgM+                     | 19 (0.4%)           | 27 (0.6%)          | 1.129   | 0.288     | 0.728 (0.404, 1.311) |
| RNA+                     | 3 (0.1%)            | 9 (0.2%)           | 2.797   | 0.094     | 0.345 (0.093, 1.275) |

SD, standard deviation; a, t-test
Table 3 The results of serology and RT-PCR in different exposure groups of healthcare workers.

| Healthcare workers | Administrative and logistical staff | Non-first-line healthcare workers | First-line healthcare workers | rs | P value |
|--------------------|--------------------------------------|----------------------------------|--------------------------------|----|---------|
|                    | n=1378 (%)                           | n=2630 (%)                       | n=606 (%)                      |    |         |
| IgG+ (%)           | 43(3.1)                              | 84(3.2)                          | 27(4.5)                        | 0.017 | 0.239   |
| IgM+ (%)           | 8(0.6)                               | 17(0.6)                          | 2(0.3)                         | -0.006 | 0.698   |
| RNA+ (%)           | 6(0.4)                               | 3(0.1)                           | 0 (0.0)                        | -0.036 | 0.016   |