The epidemiology and dynamics of COVID-19 disease transmission among healthcare workers of a tertiary healthcare setting in India

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ABSTRACT

Context: The novel coronavirus disease 2019 (COVID-19) that has emerged as a pandemic now has put health care workers (HCWs) at great risk as they are the warriors in frontlines screening and treating the infected patients. When a COVID-19-positive HCW is identified, its contacts need to be traced to check the spread of the infection among patients and other HCWs. Aims: This study was aimed to study epidemiology and risk factors associated with severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) infection among HCWs and to quantify the risk of infection among HCWs in a tertiary level health care setting. Settings and Design: This cross-sectional study enrolled all the HCWs who were exposed to a patient with COVID-19 in a tertiary level health care center, Rishikesh, Uttarakhand from 1st May to 30th July, 2020. Methods and Material: All the exposed HCWs were followed up for 14 days after the last exposure to a patient with confirmed COVID-19 infection. Epidemiological data were obtained using structured interviews. Statistical Analysis Used: The data were analyzed using SPSS 23.0. Frequencies and proportions were calculated for descriptive variables, and risk ratios were calculated for risk factors affecting the transmission of disease. Results: We observed that 1,141 HCWs of the tertiary level health care hospital were exposed to COVID-19 patients during the study period. A total of 22 HCWs were tested COVID-19 positive among these exposed HCWs. Univariate analysis revealed a high risk of exposure to be significantly associated with a higher secondary attack rate of SARS CoV-2. Conclusions: The study demonstrates the risk of COVID-19 transmission through asymptomatic carriers. Therefore, periodic testing of all health care workers is necessary to ensure early mitigation of the shortage of health care providers.

Keywords: Asymptomatic carriers, COVID-19, healthcare workers, risk of exposure, SARS-CoV-2
either via airborne droplets or through contact with fomites.[1] As a part of a comprehensive strategy to break the chain of person-to-person transmission, case identification, isolation, testing, contact tracing, and quarantine are being done all over the world to control the pandemic.[4]

Health care workers (HCW) including the primary care physicians, nurses, community health workers serve on the frontline in the struggle against the pandemic. They have been among the key role players in containing the spread of the virus and treating individuals with the disease, thus, posing themselves at a higher risk of getting infected with the virus and its transmission, owing to their proximity to infected individuals while delivering health care services.[5] In an event of detection of a COVID-19-positive HCW, their contacts need to be traced to contain the spread of the disease among patients and other HCWs.[6]

Researchers in China identified 3,387 HCWs with SARS-CoV-2 infection (4.4 percent of all cases), with 23 deaths attributed to the virus.[7] According to the Italian National Institute of Health, 17,000 HCWs have been infected (representing 10% of all cases in Italy).[8] and the US Centers for Disease Control and Prevention (CDC) disclosed that over 9,200 HCWs were diagnosed with COVID-19 between February 12 and April 9, 2020.[9] Moreover, asymptomatic cases have been reported to be effective in the transmission of disease.[10] Only a few studies, however, have formally quantified the risk of infection among HCWs in a tertiary-level health care setting. Health care practitioners are among the most vulnerable groups to infection during the COVID-19 pandemic, thus assessing infection rates and related features is critical to improve and alter protective measures for this sensitive yet vital group. Herein, we report COVID-19 infection and secondary attack rates among HCWs who provided care for hospitalized patients with COVID-19 infection in a tertiary care hospital in India. This is an unprecedented study and so far, no such study has been conducted in any tertiary care center across India and Uttarakhand.

**Subjects and Methods**

This cross-sectional study enrolled all the HCWs who were exposed to patients with COVID-19 (confirmed by RT-PCR) in a tertiary level health care center, Rishikesh, Uttarakhand between 1st May and 30th July, 2020 after taking their consent. The study was ethically approved by the Institutional Ethics Committee of AIIMS Rishikesh (AIIMS/IEC/20/412 Date 25.6.2020). All the exposed HCWs were followed up for 14 days after the last exposure to a patient with confirmed COVID-19 infection. The last follow-up date was 30th July, 2020.

Because of the descriptive nature of the study including all the HCWs who were exposed to positive patients during the study period, sample size calculation was not done. Epidemiological data were obtained using structured interviews. The data were entered in MS Excel. All analyses were done using SPSS software version 23.0.

When an OPD and IPD patient in this tertiary level health care center was tested COVID-19 positive during a defined study period, a thorough epidemiological investigation, including contact tracing was implemented by the contact tracing team of the hospital. The period of investigation included details of HCWs contacts from 2 days before the date of symptom onset (or date of positive RT-PCR result for asymptomatic cases) to the date when RT-PCR result for COVID-19 was confirmatory.

All HCW contacts who had a history of exposure with a COVID-19 confirmed patient were traced and asked to report to COVID-19 screening OPD for further evaluation. All the exposed HCWs were further divided into high- and low-risk of exposure categories on the basis of their exposure history as per the criteria set by the Ministry of Health and Family Welfare, Government of India (GoI).[11]

An HCW was considered to be at high risk if he/she did not wear appropriate personal protective equipment (PPE) during face-to-face interaction with a confirmed case for more than 15 min during the investigation period. Whether the PPE was regarded as “appropriate” depended on the exposure setting and the procedures performed. For example, for physicians who performed aerosol-generating procedures, such as intubation, an N95 respirator, gown, gloves, and shoe cover were required. For such procedures, a surgical mask or partial PPE would not be appropriate. Accordingly, the medical staff would be listed as close contact.

All HCWs with a high-risk of exposure were quarantined for 14 days after their last exposure to the index case, and reverse transcription polymerase chain reaction (RT-PCR) test was done between days 5 and 10 of exposure. During the quarantine period, further testing was only performed if a close contact developed symptoms during the quarantine period, and the first test was negative.

In the low-risk category, were the HCWs who had brief interactions (less than 15 min) with HCWs with COVID-19 (beginning 48 h before the onset of symptoms) or prolonged (more than 15 min) close contact (beginning 48 h before the onset of symptoms while wearing a facemask for source control) while the HCW was wearing a facemask or respirator. Use of eye protection in addition to a facemask or respirator was further a factor for considering the HCW at a lower risk of exposure. All HCWs with low-risk exposure were also tested on the day 5th of exposure. They were allowed to resume duties after a negative RTPCR report.

**Results**

A total of 91 patients were diagnosed with the COVID-19 disease during the study period in the tertiary level health care hospital of Rishikesh town. A total of 1,141 HCWs of this tertiary level health care hospital were exposed to these COVID-19 patients.
during the same period. Among these exposed HCWs, 738 were male and 403 were female HCWs. The median age of the exposed HCWs was 39 years (range: 11–88 years).

Among these exposed HCWs, 360 and 781 HCWs were identified as high-risk and low-risk contact, respectively, as per the Ministry of Health and Family Welfare, GoI guideline. Out of these, 930 HCWs were asymptomatic, and 211 were symptomatic. All these exposed HCWs were tested for RT PCR for COVID-19. A total of 22 HCWs were tested COVID-19 positive among these exposed HCWs [Figure 1].

Exposed HCWs were classified on the basis of gender, age group, symptom status, risk of exposure, and their work profile [Table 1].

Of the 1141 primary contact HCWs, the majority were males and belonged to the younger age group, 23% of the HCW contact were symptomatic. High-risk exposure was present in 68.4% HCWs. Almost half of the exposed HCWs comprised of nurses (48.9%) followed by doctors (33.8%), and the remaining were paramedical staff (17.3%).

HCWs that tested positive after exposure to a patient with COVID-19 infection were classified on the basis of gender, age group, symptom status, risk of exposure, and their work profile [Table 2].

The majority of COVID-19 positive HCWs were males and belonged to the younger age group. Almost an equal number of HCWs were diagnosed with COVID-19 in both high and low risk of exposure. Maximum COVID-19 positive HCWs were asymptomatic. Nurses and doctors comprised the majority of the COVID-19 positive HCWs (86.4%) among those exposed.

Univariate analysis revealed a high risk of exposure was significantly associated with a higher secondary attack rate [Table 3]. Males, aged above 30 years, asymptomatic status, and doctors and nurses were found to have higher secondary attack rates. However, the difference was not significant.

**Discussion**

HCWs are believed to be having a very higher risk contracting an infection due to the nature of their job and the environment. Also, the transmission of infection among colleagues in hospitals raises great concern. During the initial phase of any infectious disease outbreak, such as that of COVID-19, HCWs being the first contact person for patients pose an increased risk of infection, especially before transmission dynamics are fully understood about the novel pandemic. We conducted this research to study epidemiology and risk factors associated with SARS CoV-2 infection among HCWs. Among the exposed HCWs in our study, we found SARS-CoV-2 infection was reported higher among males. However, other studies reported female predominance over males in COVID-19 seropositivity. One of the reasons for this observation in our study could be a higher proportion of male HCWs were recruited as compared to female HCWs in the tertiary care center where the study was conducted.

We found that nearly two-thirds of HCWs contacts had low-risk exposure, and one-third had a high risk of exposure. The results were different from those reported by Maskari Z, et al. where more HCWs were in the high-risk category (84.6%) than those in the low-risk category (15.4%). This study also sought a comparison of the SARS-CoV-2 secondary attack rate in HCWs with high and low occupational exposure to COVID-19 patients to determine whether a higher risk of exposure increases the risk of COVID-19 infection among HCWs. We observed a

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**Table 1: Characteristics of HCWs exposed with COVID-19 patients in All India Institute of Medical Science (AIIMS) Rishikesh from 1st May to 30th July 2020**

| Variables         | n (%)      |
|-------------------|------------|
| Gender            |            |
| Female            | 403 (35.50) |
| Male              | 738 (64.70) |
| Age group         |            |
| <30 years         | 912 (79.93) |
| >30 years         | 229 (20.07) |
| Symptom Status    |            |
| Asymptomatic      | 930 (77.31) |
| Symptomatic       | 211 (22.68) |
| Risk of Exposure  |            |
| Low Risk          | 781 (68.44) |
| High Risk         | 360 (31.55) |
| Profile           |            |
| Doctor            | 386 (33.82) |
| Nurses            | 558 (48.90) |
| Paramedical       | 197 (17.26) |

**Table 2: Characteristics of HCWs diagnosed with COVID-19 after exposure to a patient with COVID-19 infection in AIIMS Rishikesh from 1st May to 30th July 2020**

| Variables         | n (%)      |
|-------------------|------------|
| Gender            |            |
| Female            | 6 (27.3)   |
| Male              | 16 (72.7)  |
| Age group         |            |
| <30 years         | 16 (72.7)  |
| >30 years         | 6 (27.3)   |
| Symptom status    |            |
| Asymptomatic      | 20 (90.9)  |
| Symptomatic       | 2 (9.1)    |
| Risk of exposure  |            |
| Low risk          | 10 (45.5)  |
| High risk         | 12 (54.5)  |
| Profile           |            |
| Doctor            | 9 (40.9)   |
| Nurses            | 10 (45.5)  |
| Paramedical       | 3 (13.6)   |
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Significantly higher risk of COVID-19 infection among HCWs with high-risk exposure to COVID-19 positive patients as compared to HCWs with low-risk exposure. Similar results were seen in the studies conducted by Wang et al.[15] who reported that wearing the PPE correctly was associated with a lower risk of exposure and hence, lower infection rates among HCWs. In a cross-sectional study, Handal et al.[16] in Norwegian University Hospital reported no significantly increased risk of SARS-CoV-2 infection in health care workers with high exposure to COVID-19 patients. This finding is inconsistent with our results. Some other studies also found no significant differences on the infection rates of HCW that can be attributed to working in areas of high exposure risk.[17,18]

In the current study, among those with low risk of exposure, secondary attack rate was 1.4%, whereas for HCWs with a high risk of exposure, was 2.6%. Secondary attack rates also differed amongst varied profiles of HCWs. Based on the number of HCW contacts tested in each category, the secondary attack rate was found to be 2.3% among physicians, 1.74% among nurses, and 1.14% among paramedical HCWs. Results close to these findings were also reported by Sabetian et al.[14] where 3.2% of all physicians, 2.23% of all nurses, and 2.3% of all paramedical contacts tested positive for COVID-19.

It was noteworthy that the SARS-CoV-2 infection was higher in asymptomatic HCWs as compared to symptomatic HCWs in our study. This raises a great amount of concern for the health care sector as screening approaches focus mainly on symptomatic HCWs, and asymptomatic HCWs are often not tested.[19] Hence, all HCWs become a potential source for infection transmission in

| Variables          | Positive Exposure | Secondary attack rate | Risk ratio |
|--------------------|-------------------|-----------------------|------------|
| Gender             |                   |                       |            |
| Female             | 6                 | 1.48 (0.61-0.61)      | 1          |
| Male               | 16                | 2.16 (1.31-3.55)      | 1.465 (0.569-3.773) |
| Age group          |                   |                       |            |
| <30 years          | 16                | 1.75 (1.06-2.85)      | 0.664 (0.267-1.716) |
| >30 years          | 6                 | 2.62 (1.07-1.07)      | 1          |
| Risk of exposure   |                   |                       |            |
| High               | 12                | 3.33 (1.73-5.75)      | 2.659 (1.138-6.212) |
| Low                | 10                | 1.28 (0.62-2.34)      | 1          |
| Symptom status     |                   |                       |            |
| Asymptomatic       | 20                | 2.15 (1.32-3.30)      | 0.95 (0.11-0.33)  |
| Symptomatic        | 2                 | 2.297 (0.533-9.902)   | 1          |
| Profile            |                   |                       |            |
| Doctor             | 9                 | 2.33 (1.07-4.38)      | 1.52 (0.314-4.59)  |
| Nurses             | 10                | 1.79 (0.93-3.33)      | 1.180 (0.321-4.332) |
| Paramedical        | 3                 | 1.544 (0.413-5.768)   | 1          |
hospitals. Asymptomatic and presymptomatic infection has been well documented and identified as a source of transmission in some cases.\textsuperscript{[8–20]} Our study also reported a higher proportion as well as a secondary attack rate among asymptomatic HCWs. As a result, the current study was able to prove that asymptomatic close contacts can also serve as virus carriers, emphasizing the necessity for frontline employees to be tested on a regular basis and also be cautious with appropriate use of protective measures to reduce infection rates.

All HCW contacts irrespective of their symptom status and risk of exposure were tested for COVID-19 in our study. This was the major strength of the current study. This allowed us to isolate asymptomatic COVID-19 positive HCWs along with symptomatic ones and limit further infection transmission among the health workforce.

One of the limitations of the study is that the study was conducted during the time when COVID-19 cases were on the rise and hence, excluding a possible community-acquired infection from asymptomatic or symptomatic carriers is not possible. However, a strict inclusion criterion was used to ensure close contact with a COVID-19 positive patient (primary case). Another limitation is extensive social contacts of HCWs from various departments within the tertiary care hospital rendering it difficult to establish the primary source of infection in case an HCW had been in contact with multiple primary cases. To prevent duplication of contacts, one HCW contact was entered only for one case while conducting data analysis.

Conclusion

Frontline workers are at a high risk of contracting the coronavirus disease due to their interactions with other HCWs. Hence, it is important to understand the dynamics of transmission among HCWs through each other to prevent reduce the extent of burden, secondary transmission, and mortality among HCWs of an already burdened health care system. The transmission of COVID-19 cases need not necessarily be from symptomatic cases. The study shows the risk of transmission through asymptomatic carriers. Therefore, periodic testing of all health care workers is necessary to ensure early mitigation of the shortage of frontline workers. HCWs dealing with COVID-19 cases are at varied risk of acquiring COVID-19, indicating the need to be highly cautious of safety measures like appropriate use of PPE, hand hygiene, etc.

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Conflicts of interest

There are no conflicts of interest.

Key messages

a. The transmission of COVID-19 cases need not necessarily be from symptomatic cases. The study shows the risk of transmission through asymptomatic carriers. Therefore, periodic testing of all health care workers is necessary to ensure early mitigation of the shortage of frontline workers.

b. HCWs dealing with COVID-19 cases are at varied risk of acquiring COVID-19, indicating the need to be highly responsible.

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