Original Article

Incidence and Source of COVID-19 Infection Among Health Care Workers in a Tertiary Hospital in South India—A Prospective Cohort Study

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Abstract

Background: Data for COVID-19 incidence and the source of infection among health care workers (HCWs) in Indian population are limited. The main objective of the study was to assess the incidence of COVID-19 infection and identify the source of infection among the HCWs in a tertiary teaching hospital. **Methods:** A prospective cohort study was conducted among the 2134 HCWs recruited by purposive sampling from a tertiary teaching hospital from May to August 2020 (4-month period—123 days). Over the 4-month period, all the HCWs who had symptoms or those were close contacts of COVID positive patients were traced and tested using validated COVID diagnostic test (reverse transcription–polymerase chain reaction [RT–PCR] test). A semi-structured questionnaire was used to interview each positive HCW to identify the source of exposure of the infection. **Results:** Incidence proportion was 9.3% among HCWs and was two times higher among males compared to females. Hazard ratio was found to be higher among males and HCWs working in the non-COVID areas. Test positivity rate was found to highest (around 57.8%) among those aged less than 30 years. The most common source of infection was infected HCW colleagues (40.9%) followed by exposure to patients in non-COVID areas (27.3%). Only 5.1% of total infection was found in HCWs who had worked in COVID zones. **Conclusions:** People working in non-COVID areas, those using shared workplace, dining halls, and staff hostels, must follow strict COVID protocols by using appropriate Personal Protective Equipment (PPE) and following social distancing measures.

Keywords: *Contact tracing, COVID-19, epidemiology, medical staff*

Introduction

COVID-19 has posed an unprecedented challenge for the health care systems across the globe. The routine health care services are disrupted, and large proportion of resources get diverted to COVID management.[1] A significant number of health care workers (HCWs) are getting the infection. Even a single mortality among HCWs can have a disastrous impact on the morale of the existing health staff and bring in fear.[2]

HCWs work with a constant fear of acquiring the infection as they are at a higher risk of acquiring COVID-19 infection[3-5] Surprisingly, there is a lack of evidence on the incidence of infection among HCWs in tertiary COVID hospital.[6] Although there are several media reports of infections among HCWs, there is a lack of scientific literature on the same. It is also observed that the existing studies have not focused on understanding the risk of infection in different types of health care settings.[5-7] This information is extremely crucial at this stage of the pandemic, since understanding the risk of infection can help in planning evidence-based targeted risk mitigation strategies.

This paper describes the incidence of infection among HCWs from May to August 2020 and the suspected sources of infection for each of these positive HCWs. This study is exceptionally important for health care decision makers, as it generates evidence of high-risk scenarios and provides specific tools to reduce the risk in a tertiary care setting.

Methods

A prospective cohort study was conducted from May to August 2020 among the COVID positive HCWs at Saveetha Medical College and Hospital (SMCH), a 1250 bedded Government-recognized COVID

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hospital, with 2134 health care staff. The hospital had earmarked 350 beds for the treatment for COVID-19 cases. The hospital continued to provide routine services to other non-COVID patients. Clear zoning of COVID and non-COVID areas was done. COVID areas which included COVID reception, COVID outpatient (OP), COVID sample collection kiosk, COVID admission desk, COVID wards, COVID intensive care unit (ICU), COVID labor ward, COVID emergency room, and COVID operating rooms. COVID OP, COVID sample collection kiosk, and COVID admission desk were located outside the hospital building. COVID wards were set up exclusively in separate floors in the hospital building with a separate entrance. All the new admissions in the hospital were admitted in a separate admission ward and were tested for COVID. Only the negative patients were transferred to the respective wards. Wearing of surgical masks was made compulsory for all staff, patients, and patient attenders inside the hospital.

The various hospital areas were defined as high, moderate, and low risk zones, and accordingly the type of Personal Protective Equipment (PPE) was recommended for the HCWs. All the PPE to the HCWs were provided free of cost. There had been no instance of shortage of PPE. All the HCWs working in COVID areas were provided with vitamin C and zinc prophylaxis. Provision of acrylic shields in all OP areas, reception, fever clinic, and admission clinic had been made to further reduce the transmission of infection.

Hospital started admitting COVID-19 cases from 1st May 2020 onwards. Doctors and other support paramedical staff were posted in COVID areas for 1 week posting and were given 1-week quarantine leave. The National Guidelines for COVID testing—reverse transcription polymerase chain reaction (RT–PCR) were followed. Only those staff who had symptoms or were in close contact with the positive patients or colleagues underwent RT–PCR testing. Testing was not routinely recommended for all the HCWs who had done COVID ward duty**.**

The first COVID-19 positive HCW was identified on May 23, 2020.

Study cohort description

By purposive sampling technique, all the 2134 HCWs working in the hospital were included in the study and were followed over a period of 4 months (123 days). HCWs turning RT–PCR positive were notified by infection control committee to the Department of Community Medicine for contact tracing.[8] Within 24 hours, all the health-care workers with RT–PCR confirmed COVID-19 infection were interviewed using a semi-structured questionnaire to obtain: Socio-demographic details like age, sex designation, place of stay, and department and clinical details like date of COVID testing, symptom profile, perceived source of exposure, close contacts, and usage of PPE. Close contacts of positive HCWs were categorized based on World Health Organization (WHO) risk categorization into high risk or low risk.[8]

High-risk contact as defined by WHO[8]:

1. Being within 1 meter of a COVID-19 case for >15 minutes.
2. Direct physical contact with a COVID-19 case.
3. Providing direct care for patients with COVID-19 disease without using proper PPE.

All the high-risk contacts were advised for testing for COVID and to isolate themselves after giving test. All the other low-risk contacts were advised to take precautions and to get tested if they develop any symptoms.

Statistical analysis

Epidemiological data obtained by semi-structured telephonic interviews were entered in MS Excel. Continuous variables were expressed as mean and categorical variables were summarized as numbers and percentages. Data were analyzed in SPSS version 25. *R*-naught (R_0) was calculated using individual-level contact tracing data. It was computed by taking average of number of secondary cases of diagnosed cases. In the present study, R_0 was calculated for each positive HCW and the average R_0 was taken.[9,10] Incidence rate per person time measures the number of new cases per person in the population over a defined period of time. In the present study, all the HCWs were followed for a 4-month period (123 days) and thus the incidence rate was calculated for 123 person days. Hazard ratio (HR) was calculated to find the individual hazard between groups to conclude how much is the hazard of becoming COVID positive in one group compared to the other group.[11] Incidence proportion was calculated to find out the proportion of disease-free persons developing the disease during the study period (123 days).[12] Results were reported following the STROBE guidelines for observational studies.[13]

Results

During the study period from May to August 2020, among the 2134 HCWs (HCWs), 707 (33.1%) were tested for COVID -19 infections with RT–PCR, which included 299 males (42.3%) and 408 females (57.7%). A total of 198 HCWs were tested positive (Incidence proportion—9.3%). Incidence proportion among male HCWs (14.6%) was more than two times compared to female HCWs (6.4%). The incidence rate per 123 person days was found to be higher among males and among those working in non-COVID areas. Males have twice the hazard and those working in non-COVID areas have 9 times the hazard to become COVID positive, respectively, with a HR of 2.28 among males/females and 9.5 among those working in the COVID/non-COVID areas [Table 1].

Among those who were tested for COVID, test positivity rate was 28% among the HCWs with male HCWs

having a significantly higher positivity rate of 36.8% compared to 21.6% among female HCWs (χ^2-value: 19.826, $P < 0.00001$). Maximum number of positive HCWs were in < 25 age group (60%) which also had the highest positivity rate (32.8%), followed by 26–30 years (21.7%) [Table 2].

Incidence proportion and incidence rate per 123 person days were found across all categories of HCWs. Incidence proportion was highest among pharmacists, (51.2%) followed by nurses (10.2%), Bachelor of Medicine and Bachelor of Surgery (MBBS) iInterns (11.3%), and Junior Residents (JR) (10.1%). Incidence proportion was found to be highest among pharmacists primarily because of a cluster outbreak in the pharmacy. Surprisingly, the incidence rate per 123 person days, among administrative staff and support staff (6.2%) who are not in direct contact with the patients, was found to be 7.15 and 4.35 per 123 person days, respectively [Table 3].

Symptoms at the time of diagnosis

Around 177 (89.4%) HCWs presented with some symptoms, while the remaining 21 (10.6%) were asymptomatic. Fever (62.1%) was the most common symptom, followed by fatigue (28.2%), sore throat (23%), myalgia (21%), cough (19.2%), headache (11.3%), cold (10.2%), loose stools (6.2%), loss of smell (5%), and chest discomfort (1%).

Disease severity: Most of the HCWs developed a mild illness (98%), only three HCWs developed moderate COVID illness with drop in oxygen saturation (SpO2) below 94%.

Source of Infection: The most common source of infection among HCWs was high-risk exposure to infected colleagues (40.9%), before they were diagnosed with the infection. The major place of exposure to infected colleagues was hostels (31.3%) compared to workplace exposure (9.6%).

Hostels were found to be a major source of infection among nurses (46.3%), MBBS interns (38.8%), pharmacists (42.9%), and support staff (60%). The main reasons for the high risk at hostels were found to be due to shared accommodation for nursing staff, exposure during dining at hostel mess, and a lack of universal usage of masks in the hostels.

Around 9.6% of exposures happened with positive colleagues in non-patient care settings in hospital like cafeteria, finance and medical records department, nursing stations, etc. Fifty percent of administrative staff got exposed from infected colleagues at workplace.

In the present study, 27.3% of HCWs reported acquiring the infection from the patients in non-COVID areas. The most common location of infection was in patient wards (13.6%) and operation theater (OT) (6.6%). The major reason for exposure was the lowering of guard by the health care staff while attending apparently non-COVID patients. Majority of the Junior Residents (JR) and Assistant Professors (AP)

Table 1: Infection rates and Incidence of COVID 19 among HCWs

Gender	Total HCW Working in Hospital	Total COVID Positive	Total COVID Negative	Incidence Proportion (%)	Incidence rate per 123 Person Days	HR
Male	756	110	646	!Zero Divide	14.16	2.28
Female	1378	88	1290	15	6.19	
Non COVID Area	1489	188	1301	12.6	13.12	9.5
COVID Area	645	10	635	1.6	1.38	
Total	2134	396	1936	9.3	9.6	-

*HR - Hazard ratio

Table 2: Age and sex wise distribution of COVID test positive health care workers

Sex	Male			Female			Total		
	Tested	Positive	Test positivity rate	Tested	Positive	Test positivity rate	Tested	Positive	Test positivity rate
Age									
<25	104 (34.8%)	51 (46.4%)	49%	259 (63.5%)	68 (77.3%)	26.3%	363 (51.3%)	119 (60.1%)	32.8%
26-30	83 (27.7%)	32 (29.1%)	38.6%	89 (21.8%)	11 (12.5%)	12.4%	172 (24.3%)	43 (21.7%)	25%
31-35	54 (18.1%)	15 (13.6%)	27.8%	24 (5.9%)	5 (5.7%)	20.8%	78 (11%)	20 (10.1%)	25.6%
36-40	22 (7.3%)	2 (1.8%)	9.1%	11 (2.7%)	1 (1.1%)	9.1%	33 (4.7%)	3 (1.5%)	9.1%
41-45	16 (5.4%)	5 (4.5%)	31.3%	6 (1.5%)	1 (1.1%)	16.7%	22 (3.1%)	6 (3%)	27.3%
46-50	9 (3%)	3 (2.7%)	33.3%	14 (3.4%)	2 (2.3%)	14.3%	23 (3.3%)	5 (2.52%)	21.7%
51-55	3 (1%)	0	0	2 (0.5%)	0	0	5 (0.71%)	0	0
56-60	5 (1.7%)	1 (0.9%)	20%	2 (0.5%)	0	0	7 (1%)	1 (0.5%)	14.3%
>60	3 (1%)	1 (0.9%)	33.3%	1 (0.2%)	0	0	4 (0.6%)	1 (0.5%)	25%
Total	299	110	36.8%*	408	88	21.6%*	707	198	28%

*Chi-square value 19.826, $P<0.00001$, Column percentages are given in italics and Percentage given within brackets are row percentages

Table 3: Healthcare Category wise Incidence of COVID-19 infection

Designation	Total working *n*=2134	COVID Positive *n*=198	COVID Negative *n*=1936	Incidence Proportion (%)	Incidence Per 123 Person Days
Junior Residents	257	26	231	9	7.53
MBBS Interns	160	18	142	10	7.4
Allied Health Sciences Interns	144	12	132	11	5.57
Senior Residents	58	0	58	8	-
Assistant Professors	112	9	103	0	3.84
Associate Professors	52	0	52	8	-
Professors	95	0	95	0	-
Nurses	657	67	590	0	9.33
Technicians (lab, OT)	177	12	165	10	4.32
Pharmacists	41	21	20	7	15.40
Administrative Staff	139	18	121	51	7.15
Support staff - Housekeeping, maintenance, security, drivers	242	15	227	13	4.35

who got positive in the hospital (46.2% and 44.4%, respectively) got infected due to exposure to patients in non-COVID areas.

Only 10 (5.1%) HCWs developed infection within a few days of working in the COVID areas. None of them reported any breach of PPE while working in that area. Around 10.6% of HCWs got exposed from sources outside the hospital. In 16.2% of HCWs, the source of infection could not be identified [Table 4].

Time distribution of COVID 19 cases: The peak in number of cases around June 21–June 27, 2020 was due to the cluster of HCWs turning COVID positive in the pharmacy department. Similarly, the rise in cases around July 26–August 1 was due to the COVID clusters among the house keeping staffs. The surge in number of cases from August 9 to August 15, 2020 was due to COVID cluster among staff nurses [Figure 1].

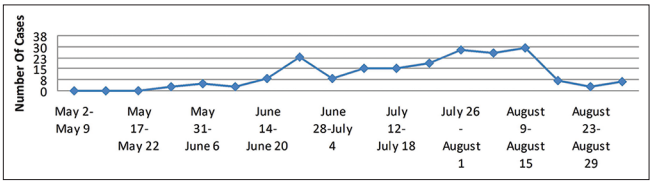

Figure 1: Time distribution of COVID -19 cases from May to August 2020

R naught (R_0)

In the present study, the median R_0 was 1.5. The R_0 value ranged from 1 to 8. Maximum R_0 have been observed in three individuals who infected around 5, 6, and 8 people, respectively, within one incubation period.

Discussion

The incidence rate per 123 person days of COVID infection among the HCW was found to be 9.6% during the 4-month period in SMCH. Similar study done in United States for a 3-month period from February to April found the incidence to be 19%.[14] Results were comparatively low (1.9%) in China but the study was done only for a 1-month period.[15] Also, it was noted that incidence is more among males when compared to the females. The test positivity rate was also found to be higher among younger age group. These findings may have been since risk perception is less among males and younger age groups, which in turn affect their attitude on the responsible use of PPE and social distancing measures.[16,17] Angiotensin converting enzyme inhibitor (ACE-2), which is major receptor for COVID-19, was found to be more expressed in lungs of COVID-affected men compared to women as evident from a study done by Wu C *et al*.[18] This high expression of receptors of coronavirus may also have been responsible for increased incidence of COVID 19 among males. It was observed that the COVID positivity rate among the HCW was higher in July and August which coincided with the increase in the number of outpatient and inpatient COVID patients in the hospital.

In this study, JRs and MBBS interns had higher incidence rates, compared to senior doctors. Most of the JRs and MBBS interns stay in hostels in single rooms. However, due to a lack of risk perception among colleagues in the hostels, many hostel inmates do not use masks regularly during social interactions. Dining in hostel mess is another area, where the doctors and nurses get exposed to colleagues without masks.

The major source of infection among COVID 19 positive HCWs was found to be exposed to other COVID-19–infected HCWs (40.9%), followed by exposure to patients in non-COVID areas (27.3%) and community exposure (10.6%). Importantly, only 5.1% of the COVID infection was reported among HCWs who had worked recently in the COVID-designated areas. Similar results were found in a study done by Trina F. Zabarsky in Cleveland VA Medical Center who reported only 18.75% HCWs got exposure from COVID-19 patients while others got infection from community and other infected HCWs, etc.[19] These findings reflect the low-risk perception in

Table 4: Source of infection for Health care workers

Source	Nurses (*n*=67)	Technicians (*n*=12)	JRs & PGs* (*n*=26)	MBBS** Interns (*n*=18)	AP's# (*n*=9)	Support Staff (*n*=15)	Admin (*n*=18)	Pharmacy (*n*=21)	Allied course (*n*=12)	Total (*n*=198)
Infected colleagues	32 (47.8%)	4 (33.3%)	3 (11.5%)	8 (44.4%)	1 (11.1%)	10 (66.7%)	9 (50%)	11 (52.4%)	3 (25%)	81 (40.9%)
Colleagues at workplace	1 (1.5%)	2 (16.6%)	2 (7.7%)	1 (5.6%)	1 (11.1%)	1 (6.7%)	9 (50%)	2 (9.5%)	0	19 (9.6%)
Colleagues at hostel	31 (46.3%)	2 (16.6%)	1 (3.8%)	7 (38.8%)	0	9 (60%)	0	9 (42.9%)	3 (25%)	62 (31.3%)
Outside Sources	5 (7.5%)	0	1 (3.8%)	2 (11.1%)	2 (22.2%)	3 (20%)	4 (22.2%)	3 (14.3%)	1 (8.3%)	21 (10.6%)
Family Members	1 (1.5%)	0	0	1 (5.6%)	2 (22.2%)	0	0	0	1 (8.3%)	5 (2.5%)
Market Place/community	4 (6%)	0	1 (3.8%)	1 (5.6%)	0	3 (20%)	4 (22.2%)	3 (14.3%)	0	16 (8.1%)
Patients in Hospital										
Non-COVID Area	17 (25.4%)	4 (33.3%)	12 (46.2%)	5 (27.8%)	4 (44.4%)	0	1 (5.6%)	5 (23.8%)	6 (50%)	54 (27.3%)
ER	2 (3%)	1 (8.3%)	1 (3.84%)	2 (11.1%)	0	0	0	0	0	6 (3%)
Wards	13 (19.4%)	0	2 (7.7%)	3 (16.6%)	3 (33.3%)	0	1 (5.6%)	0	5 (41.6%)	27 (13.6%)
OP	0	0	1 (3.8%)	0	0	0	0	0	0	1 (0.5%)
Pharmacy	0	0	0	0	0	0	0	5 (23.8%)	0	5 (2.5%)
Microbiology lab	0	0	0	0	0	0	0	0	1 (8.3%)	1 (0.5%)
OT	2 (3%)	2 (16.6%)	8 (30.8%)	0	1 (11.1%)	0	0	0	0	13 (6.6%)
Radiology Department	0	1 (8.3%)	0	0	0	0	0	0	0	1 (0.5%)
COVID Area	8 (12%)	0	1 (3.8%)	1 (5.6%)	0	0	0	0	0	10 (5.1%)
COVID ICU	3 (4.5%)	0	0	0	0	0	0	0	0	3 (1.5%)
COVID wards	5 (7.5%)	0	0	0	0	0	0	0	0	5 (2.52%)
Fever Clinic	0	0	1 (3.8%)	1 (5.6%)	0	0	0	0	0	2 (1%)
Admission desk	0	0	0	0	0	0	0	0	0	1 (0.5%)
Sample collection center	0	0	0	0	0	0	0	0	0	1 (0.5%)
Molecular Lab	0	0	0	0	0	0	0	0	0	1 (0.5%)
Source not identified	5 (7.5%)	4 (33.3%)	9 (34.6%)	2 (11.1%)	2 (22.2%)	2 (13.3%)	4 (22.2%)	2 (9.5%)	2 (16.7%)	16.2%)

*JRs - Junior residents; **MBBS - Bachelor of Medicine, Bachelor of Surgery; #APs - Assistant Professors; ER - Emergency department; OP - Outpatient; ICU - Intensive care unit

non-COVID zones among the HCWs and the lack of stringent adherence to PPE usage and infection control guidelines in non-COVID settings.

There was a false sense of security in dealing with COVID negative patients, especially in the OT and labor ward settings. Around two cases in the OT and two cases in the labor ward were initially negative when tested in outside lab. The HCWs were negligent in use of strict COVID protocols as the cases were negative for COVID. However, later they turned out to be positive on repeat testing. Due to the varying incubation period and the individual susceptibility of COVID-19 infection, the same patient can turn COVID positive the very next day as evident in a study done by Qin J *et al*.[20] After those instances, the hospital made use of complete PPE mandatory for every case in labor ward and OT, irrespective of the COVID status. Health ministry, Government of India (GOI), has put forth guidelines stating that all the hospitals must treat all patients as COVID-19 suspects.[21]

It was found that 40.9% of HCWs got infection from other infected HCWs and out of that majority (31.3%) got infected in the hostel environment. In hostel premises, the main problem identified was crowding of hostel mess and non-maintenance of social distancing. To overcome this problem in the mess, a meeting was organized with the mess committee of the SMCH and wardens were instructed to limit the number of people eating in the mess at one point in time. Only two chairs per table and that too in the opposite corners were arranged. HCWs were encouraged to take food in their rooms. Clusters among pharmacist, housekeeping staff, and staff nurses occurred due to HCWs living in sharing accommodation. Earlier six to seven nurses, technicians, and pharmacists used to share the dormitory accommodation. After identifying the clustering of cases, details were shared with the Medical and Nursing Superintendent of the hospital. In order to avoid clustering of cases in future, extra hostel accommodations were arranged. Facilities were arranged in Engineering College hostel and guest houses within the campus with only two to three HCWs per room following adequate social distancing measures.

In this study, only 5.1% of the HCWs got infection during their period of duty in the COVID zones. One reason is that extensive training on donning and doffing of PPE had been given to each staff working in the COVID zone, and another reason may be the high sense of risk perception in these zones; hence, the HCWs show complete compliance of usage of PPEs. There had been no instance of breech of PPE reported. Even in these HCWs, there is a strong

element of suspicion that some of these HCWs might have acquired the infection from the colleagues in the hostels.

So, with proper social distancing norms and usage of adequate PPE when dealing with patients in the hospital, the risk of transmission of COVID 19 infection among HCWs is less. Similar findings were found in a study done by Jha S *et al*.[22] and Jeremias A *et al*.,[23] which emphasized that HCWs with adequate PPE are at a reduced risk to COVID infection. In a study done by Dioscoridi L *et al*.,[24] it was found that due to the proper usage of PPE and following of social distancing norms, the HCWs have a controlled exposure to COVID-19 infection than their friends and relatives in their family and do not pose a transmission risk to their family members.

Conclusions

COVID-19 infection among HCWs is a real risk that needs to be addressed. The risk is higher among the younger staff, and those living in hostels as risk perception play an important role in health behaviors of the staff, especially regarding the usage of masks, and social distancing. We need to be aware of the source of infections and initiate appropriate measures to control the same. The hospital administrators and policy makers must conduct regular meetings among HCWs and staff members, especially the nonteaching and administrative staff to educate them about the use of PPE and social distancing measures and supervise their hostels and canteens to make sure proper COVID protocols are being followed. Low-risk perception among the colleagues is an important factor that leads to lowering of guard and mini outbreaks amidst the colleagues and friends. There is a minimal risk of getting infection while working in the COVID zones, provided the HCW uses appropriate PPE and follows proper donning and doffing protocols.

Limitations of the study

Exposures among HCWs were self-reported and are subjected to recall bias.

Ethical consideration

The study was approved by Institution Ethics Committee. Oral consent was taken from the HCWs.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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