RESEARCH ARTICLE

The Frontline War: A Case-control study of risk factors for COVID-19 among health care workers [version 1; peer review: 1 approved, 1 not approved]

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Abstract

Purpose:
The global pandemic of COVID-19 has infected several people worldwide. World Health Organization(WHO) has reported that an alarming number of health care workers (HCWs) have been affected and have also succumbed to this disease. Though health infrastructure can be boosted in a short period, the number of HCWs cannot. Hence understanding the risk factors that the HCWs are exposed to and strategically protecting them is of paramount importance.
Methods:
A case-control retrospective study was carried out on 116 HCWs at a tertiary care hospital treating COVID-19 patients in South India. We attempted to investigate and stratify the specific risk factors for COVID-19 transmission among HCWs. Data was collected regarding their exposure to COVID-19 patients, infection control precautions used, possible breaches in the protocol, and details of Hydroxychloroquine (HCQ) prophylaxis.
Results:
The demographics were equally distributed among the cases and controls. Exposure to surgical procedures on suspected/positive COVID patients was also found to affect contracting the COVID-19 illness. HCWs who wore face shields instead of eye goggles along with the use of scrubs and hospital gowns were found to have a lesser incidence of COVID-19 illness.
Conclusion:
This study helped us understand the varied risk factors that health care workers are exposed to while treating COVID-19 patients. It helped us contextualize and strategize our infection control practices to prevent further morbidity and mortality due to COVID-19.

Open Peer Review

Approval Status ? ✓

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Any reports and responses or comments on the article can be found at the end of the article.

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COVID-19, SARS-CoV-2, Infection control, prevention, health care workers, coronavirus, risk factors

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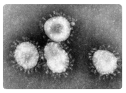

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Introduction

From a cluster of patients with viral pneumonia at a wet market of Wuhan, China, emerged one of the biggest pandemics of our era, the coronavirus disease 2019 (COVID-19) virus. From its origin in December 2019, this virus has rapidly encircled the globe, infecting over 110 million people and claiming up to 2.5 million lives worldwide to date. The most affected countries include the USA, Brazil, and India. India accounts for 2.5 crore total cases and 2.7 lakh deaths due to COVID-19.[1]

WHO reported that over 14% of the total COVID-19 cases account for HCWs and has reached even 35% in some countries.

In India, more than 15,000 HCWs have been affected and over 800 health care workers have succumbed to COVID-19 according to the Indian Medical Association (IMA) records.

India's health infrastructure has only 76 doctors for every 1 lakh population, which adds to the health care burden in the face of this pandemic.[2]

While health care systems and equipment can be boosted in a pandemic, the same cannot be done for health care personnel, which makes them a precious resource. Thus, protecting the health care personnel becomes paramount. However, with the increasing patient burden, the second wave of cases, shortage of staff, limited isolation facilities, and personal protective equipment we found more and more HCWs being ensnared by this disease. This posed a difficult problem for the health care community and society as a whole. The only protection that the HCWs have is infection control measures to prevent them from contracting this virus. A rapid review also confirmed that severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), like other coronavirus infections, is a burden on the HCW, and the use of personal protective equipment (PPE) and infection control training is associated with decreased risk.[3]

We conducted a case-control retrospective study, to assess the risk factors that HCWs were exposed to in a tertiary care hospital treating COVID-19 patients. We attempted to assess why some HCWs contracted COVID-19 while others did not. We intended to investigate specific risk factors for COVID-19 transmission among HCWs in a tertiary care university hospital. We also decided to stratify risk factors among Heath care workers based on their exposure, precautions taken, breach in infection control precautions, and prophylaxis used.

We found that despite using the conventional infection control precautions as per the Ministry of Health and Family Welfare (MoHFW), there were some interesting findings in the study that helped us review and contextualize the infection control policies based on available resources. These factors could also aid in shielding the HCWs from the next wave of the pandemic by refining and strengthening the infection control policies in individual health care facilities.

Methods

For this case-control study, a total of 116 HCWs working in Kasturba Hospital, Manipal (South India) were recruited from all clinical departments involved in the care of COVID-19 patients between July 2020 to September 2020 (3 months). Among these 50% were cases and 50% were controls in 1:1 ratio. Both cases and controls were between the age of 20 to 60 years.

Cases were defined as symptomatic HCWs working in our hospital who tested positive for COVID-19 by real time reverse transcription polymerase chain reaction (RT-PCR) using the TRU PCR kit by KILPEST's [Blackbio]. Controls were defined as HCWs who did not develop symptoms and did not test positive for COVID-19.

All 116 patients (57 cases and 59 controls) filled up a detailed questionnaire (after consenting) regarding demographics, details of their work profile, exposure details, details of precautions used, breach of infection control precautions, and Hydroxychloroquine (HCQs) prophylaxis.[5,6] Cases were asked for details of their COVID illness as well.

The details of work profile included the areas that the participants were exposed to in the hospital as frontline HCWs, the duration of exposure as number of days per week and number of hours per day and exposure to high-risk COVID areas such as the COVID intensive care units (ICU). The exposure details included details of COVID-19 exposure during collection of throat swab, intubation, handling and transport of respiratory secretions and exposure to high-risk activities such as surgical procedures on COVID-19 patients. Details of personal protective equipment used by HCWs such as face mask, gloves, face shield, hospital gown, scrubs, shoe covers and practise of hand hygiene were collected. Breach of these precautions in terms of omission of use or improper/intermittent use were also included. During data collection, the participants were asked to provide accurate information and assured of their anonymity. Hence potential bias such as improper reporting of breach in infection control precautions were also minimized.

The collected data was analysed using the SPSS for Windows version 22.0, RRID: SCR_002865 (SPSS, Inc., Chicago, IL). The variables were summarized using frequency and percentage. A Chi-square test was used to determine the association between the risk factors for COVID-19 transmission among healthcare workers (HCWs) and the dependant variable (case/control). The variables which were found to be significantly associated were subjected to multivariable logistic regression. Adjusted odds ratio with 95% confidence interval is reported. p-value <0.05 represents statistical significance.

Results

The recruited HCWs (n = 116) were equally distributed into cases and controls in a 1:1 ratio. All the 116 participants who were approached for the study were found to be eligible and consented to participate in the study. All the participants completed the entire questionnaire required for the study. Table 1 shows the baseline characteristic of all the recruits.

The maximum representation was between the age of 20–30 years (74%) followed by recruits between 31–40 years (26%). There were 64 males and 52 females among the study population. The HCWsincluded in the study were medical interns (46%), post-graduates (22%), medical staff (21%), and nurses (11%) who were involved in treating patients with COVID-19. Only 10% of the recruits had associated co-morbidities.

Table 1. Baseline characteristics of the participants including their demographics, co-morbidities, COVID exposure and duration of work.

Baseline characteristics	Cases (=57)	Controls (=59)	p value
Gender: Male	30 (52.6%)	34 (57.6%)	0.589
Gender: Female	27 (47.4%)	25 (42.4%)	0.589
Age: 20–30	43 (75.4%)	43 (72.9%)	0.829
Age: 31–40	12 (21.2%)	15 (25.4%)	0.829
Age: 41–50	1 (1.8%)	0 (0%)	0.829
Age: 51–60	1 (1.8%)	1 (1.7%)	0.829
Designation: Medical Intern	23 (40.4%)	30 (50.8%)	0.044
Designation: Medical post-graduate	18 (31.6%)	8 (13.6%)	0.044
Designation: Medical Staff Doctor	8 (14%)	16 (27.1%)	0.044
Designation: Staff Nurse	8 (14%)	5 (8.5%)	0.044
Comorbidities: None	51 (89.5%)	53 (89.8%)	0.99
Comorbidities: Type 2 Diabetes	1 (1.8%)	1 (1.7%)	0.99
Comorbidities: Chronic Lung disease (Asthma/COPD*)	4 (7%)	4 (6.8%)	0.99
Comorbidities: Obesity	1 (1.8%)	1 (1.7%)	0.99
Covid Exposure Area: COVID/COVID SUSPECT ICU#	17 (29.8%)	16 (27.1%)	0.914
Covid Exposure Area: COVID/COVID SUSPECT WARD	29 (50.9%)	30 (50.8%)	0.914
Covid Exposure Area: Emergency/Casualty	11 (19.3%)	13 (22%)	0.914
Duration of work: <3 hours	4 (7%)	2 (3.4%)	0.020
Duration of work: 3–6 hours	15 (26.3%)	30 (50.8%)	0.020
Duration of work: >6 hours	38 (66.7%)	27 (45.8%)	0.020
Days per week spent at the work place: <3 days	4 (7%)	2 (3.4%)	0.425
Days per week spent at the work place: 3–6 days	25 (43.9%)	22 (37.3%)	0.425
Days per week spent at the work place: 7 days	28 (49.1%)	35 (59.3%)	0.425
Whether the participant works in an ICU with COVID/COVID suspect patients: Yes	32 (56.1%)	26 (44.1%)	0.194
Whether the participant works in an ICU with COVID/COVID suspect patients: No	25 (43.9%)	33 (55.9%)	0.194

*COPD - chronic obstructive pulmonary disease.
#ICU - intensive care unit.

Table 2. Comparison between details of exposure among cases and controls in the study.

Details of exposure	Cases (=57)	Controls (=59)	p value
Whether the participant was involved in collection of throat swab:			0.196
Yes	32 (56.1%)	40 (67.8%)	
No	25 (43.9%)	19 (32.2%)	
Whether the participant has been involved in intubating a COVID/ COVID suspect patient:			0.719
Yes	7 (12.3%)	6 (10.2%)	
No	50 (87.7%)	53 (89.8%)	
Whether the participant has been involved in handling the respiratory secretions of a COVID patient:			n/a
Yes			
No	57 (100%)	59 (100%)	
Whether the participant has been involved in sample collection/ transport:			0.945
Yes	7 (12.3%)	7 (11.9%)	
No	50 (87.7%)	52 (88.1%)	
Whether the participant has entered the ICU room of a suspected/ confirmed COVID patient:			0.573
Yes	31 (54.4%)	29 (49.2%)	
No	26 (45.6%)	30 (50.8%)	
Whether the participant has been present in the operating room during a surgical procedure on a COVID/suspect patient:			0.054
Yes	16 (28.1%)	8 (13.6%)	
No	41 (71.9%)	51 (86.4%)	

The areas of work among both cases and controls were the emergency area (28%), COVID intensive care (51%), and COVID ward (21%). The duration of exposure was mostly more than 6 hours (66%) followed by 3-6 hours (39%). A majority of the recruits also reported working for 7 days of the week (49% cases and 59% controls) while 40% of all recruits clocked 3-6 days a week.

Exposure to patients in the COVID intensive care was equal (50%) among both cases and controls. Table 2 indicates the comparison between cases and controls based on their exposure to COVID-19 infection at work.

Involvement in taking a throat swab for the COVID test also was almost similar among the cases and the controls. Though they had a similar exposure of work in an intensive care setting, only around 10% of cases and controls were involved in intubating a COVID suspect or a COVID positive patient. None of the recruits were involved in endotracheal sample collection for a COVID suspect/COVID positive patient. Only 12% of cases and controls were involved in the collection/ transportation of blood/urine for a COVID suspect or COVID positive patient.

Surgical procedures including tracheostomy, emergency orthopedic and general surgery procedures, cesarean sections on a COVID suspect/positive patient saw a significant 28% cases in attendance compared to only 13% among controls (p=0.05). Table 3 compares the cases and controls based on the infection control precautions used. It was noted that an equal number of cases and controls wore a mask at all times during patient contact.

However, only 15% of the cases and controls were non-compliant with the use of gloves during patient contact. In addition to masks and gloves, HCWswere provided with face shields during patient contact. However, only 56% of the cases wore the face shield compared to 71% among the controls (p=0.09). Also, hospital gowns were provided toHCWs. Interestingly, only 47% of cases used this provision compared to 71% of the control population (p=0.009). Similarly, only 49% of cases wore scrubs compared to 67% controls (p=0.04). The use of shoe covers was similar among cases and controls with only half of the recruits regularly making use of them. All recruits performed hand hygiene following

Table 3. Comparison between details of precautions taken among cases and controls.

Details of precautions taken	Cases (=57)	Controls (=59)	p value
Whether the participant has worn a mask at all times while working in the hospital:			0.491
Yes	56 (98.2%)	59 (100%)	
No	1 (1.8%)	0 (0%)	
Whether the participant has worn gloves at all times during patient contact:			0.853
Yes	49 (86%)	50 (84.7%)	
No	8 (14%)	9 (15.3%)	
Whether the participant has worn a face shield during patient contact:			0.092
Yes	32 (56.1%)	42 (71.2%)	
No	25 (43.9%)	17 (28.8%)	
Whether the participant has worn hospital gown during patient contact:			0.009
Yes	27 (47.4%)	42 (71.2%)	
No	30 (52.6%)	17 (28.8%)	
Whether the participant has worn scrubs during patient contact:			0.041
Yes	28 (49.1%)	40 (67.8%)	
No	29 (50.9%)	19 (32.2%)	
Whether the participant has worn shoe covers during patient contact:			0.016
Yes	22 (38.6%)	36 (61%)	
No	35 (61.4%)	23 (39%)	
Whether the participant performed hand hygiene after patient contact:			0.99
Yes	56 (98.2%)	58 (98.3%)	
No	1 (1.8%)	1 (1.7%)	

doffing after patient contact. There was no significant difference in the breach of infection control precautions among cases and controls. Table 4 compares the breach in infection control precautions and prophylaxis used between cases and controls.

A majority of the recruits did not report improper use of PPE or making mistakes while implementing infection control precautions. Though some of the recruits (38% cases and 34% controls) stayed in the same duty room with another HCW

Table 4. Comparison between breach in infection control precautions and prophylaxis among cases and controls.

Details of breach in infection control precautions and prophylaxis	Cases (=57)	Controls (=59)	p value
Whether there was improper use of PPE while caring for a COVID/ COVID suspect patient:			0.924
Yes	12 (21.1%)	12 (20.3%)	
No	45 (78.9%)	47 (79.7%)	
Whether the participant made a mistake during implementation of infection control precautions:			0.183
Yes	8 (14%)	14 (23.7%)	
No	49 (86%)	45 (76.3%)	

Table 4. *Continued*

Details of breach in infection control precautions and prophylaxis	Cases (=57)	Controls (=59)	p value
Whether the participant has stayed in the same duty room as a HCW without wearing medical mask:			0.599
Yes	22 (38.6%)	20 (33.9%)	
No	35 (61.4%)	39 (66.1%)	
Whether the participant has consumed food within 1 metre of a HCW:			0.125
Yes	37 (64.9%)	30 (50.8%)	
No	20 (35.1%)	29 (49.2%)	
Whether the participant failed to keep safe social distance from a HCW:			0.862
Yes	27 (47.4%)	27 (45.8%)	
No	30 (52.6%)	32 (54.2%)	
Did you take HCQ prophylaxis			0.302
Yes	10 (17.5%)	15 (25.4%)	
No	47 (82.5%)	44 (74.6%)	

without masks, this data was similar among both cases and controls. Consumption of food within a meter of another health care worker also did not show a significant difference among cases (64%) and controls (50%). Half of the cases and controls reported failure to maintain safe social distance from another healthcare worker.

Hydroxychloroquine prophylaxis was taken by 17% cases and 25% controls. However, only 5 cases and 7 controls took the HCQ prophylaxis for the entire 8 weeks.

Among the cases, most of the recruits tested positive in July 2020 and had mild severity of COVID illness. Ten cases reported the spread of the COVID illness to their primary contacts.

Discussion

The COVID pandemic that broke out from the confines of China reached our district in South India by February 2020. However, the first HCW contracted COVID only in July 2020 with medical intern testing positive for COVID by RT-PCR. This five-month delay could be attributed to the stringent infection control precautions in place at our hospital. However, when the first case was detected among a HCW despite all the precautions, the initial question was whether it was a hospital-acquired or a community-acquired infection. Over the subsequent weeks, several other HCW contracted COVID thereby confirming the possibility of a hospital-acquired spread. This led us to revisit the infection control policies and re-evaluate the risk factors that the HCW are exposed to while treating COVID patients.

The volunteers in the study had a male: female ratio of 1.2:1 with 64 men and 52 women participants. This correlated with the findings in other Indian studies as well.[4] The age distribution among the cases and controls showed a predominant population between the age of 20–30 years (74%) followed by 30–40 years (23%). The age distribution did not follow a Gaussian pattern. This could be due to the hospital policy to protect older individuals with co-morbidities from COVID exposure by not allowing them on the front line. The age distribution is reflected in the type of health care worker included in the study as well. A majority of the recruits were interns and post-graduates followed by staff doctors and nurses. As the study population leaned towards the younger age group, 90% of them did not have associated co-morbidities. Table 1 shows the demographic profile of the cases and controls in the study.

In a large Indian study done on 18,000 HCW, it was noted that the median age was in the range of 18–40 years.[4] A case-control study done on HCW in North India, using a data portal to obtain exposure details among HCW fighting COVID-19, showed a mean age of 34 years with cases being slightly older than controls.[5] This younger age group resonates with the similar finding in our study and the trend of the younger HCWs manning the front lines was likely a strategy to deter increased morbidity and mortality among HCWs.

Evaluation of the details of their work profile showed a significant association between duration of exposure and contracting the COVID illness. The HCW who had >6 hours of work in the COVID area seemed more likely to contract

the disease as shown among the 67% cases vs the 46% controls (p=0.02). However, the number of days at work did not seem to have a significant bearing on contracting the COVID disease.

In a study done in Turkey on over 50 HCWs involved in COVID care, it was found that the positivity rates among the HCWs who worked in frontline positions were higher (RR=2.449, CI=1.06, p=0.027) than those who were not in frontline positions.[6] At this point, it is important to note that it is difficult to ascertain whether COVID infection in a HCW is hospital-acquired or community-acquired. However, owing to the cluster of cases following the index case among HCWs in our facility, the infection is more likely to be hospital-acquired rather than acquired from the community. A modeling study by Temime *et al.* found that R0 for Covid-19 (i.e. ability to transmit the infection to other people) was higher for HCWs compared to the general public as they have prolonged contact with infected individuals.[7] This further corroborates the assumption that the COVID-19 illness in the HCWscould be hospital-acquired rather than community-acquired.

The study showed similar exposure of both cases and controls to the COVID intensive care facility. Though only a few of the cases and controls were involved in high-risk procedures like the collection of throat swabs or intubation of a COVID suspect/positive patient, it did not predispose them to develop the disease. This could be because all precautions are taken stringently for high-risk procedures such as these and the risk of breach of infection control precautions is low. Though there is conflicting literature regarding the risk of transmission during high-risk procedures like intubation, most of the evidence suggested no or low rates of transmission during these procedures. A study by Van Doremalen also implicated aerosols generated during high-risk procedures as an important factor in the mode of virus transmission among HCWs.[8] An international registry study (INTUBATE COVID), included over 1700 clinicians who performed intubation on COVID patients, and only a mere 3% developed COVID.[6] Another study from Wuhan, China on 420 HCWs who were involved in intubation reported no transmission at all.[9]

Incidentally, exposure in the operating room to a COVID suspect/positive patient during surgical procedures indicated a significant risk for cases (28%) compared to controls (13%). SARS-CoV-2 shows high infectivity in the hospital setting as it has been isolated from sputum, nasopharynx, oropharynx, stool, blood, & conjunctiva.[10–12] This could be attributed to prolonged duration of exposure in closed spaces of an operation theatre, aerosol generation during intubation/airway suctioning during the administration of anesthesia, or even surgical smoke produced during laparoscopy.[13]

Usage of face shields was found to offer significant protection against COVID to HCWs. It was noted that only 56% of cases used face shields compared to 71% controls (p=0.09). WHO has included face shields as a part of standard PPE for COVID, to protect against aerosol generation.[14] However, some HCWs prefer using eye goggles over face shields. This has shown an increased risk of COVID transmission in our study. It is possible that using a face shield decreases accidental touching of the face compared to eye goggles.

Our study also noted a significant association between the use of gowns and protection against COVID. Gowns or coveralls are provided as a part of the standard PPE in keeping with the WHO guidelines.[14] However, our study noted less transmission risk among HCWs who used gowns compared to coveralls. Almost 71% of controls used gowns compared to 47% of cases who used coveralls instead. No study has compared the effectiveness of gowns and coveralls in reducing the transmission of the virus to HCWs. The only difference between the gown and the coverall is their design. Coveralls are designed to cover the entire body including the back and the legs. They also allow ease of movement. However, the zipper of the coverall may pose a risk if it is not covered by a flap as it can compromise barrier protection. They also generate more heat stress compared to gowns making it uncomfortable for HCWs to spend long hours in the PPE (especially during hot and humid months in South India). Also, coveralls are harder to don/doff and most HCWs are not familiar with its usage as gowns were more commonly used during the pre-COVID times. Gowns, on the other hand, offer complete protection to the front of the body which is more exposed to infection during patient care. Though it allows limited movement, it is comfortable during long duty hours and is also easy to doff carefully.[15]

It was also noted that the use of scrubs decreased the risk of transmission of COVID. Scrubs were used in only 49% of cases compared to 67% of the controls (p=0.04). Scrubs are beneficial compared to regular clothes as they allow for adequate microbial decontamination. Domestic laundering of regular clothes worn to the hospital is of concern due to lack of control and monitoring of decontamination thereby providing a route for pathogens to enter the clinical environment. This minor but significant association is of importance during this pandemic to prevent transmission via clothes as fomites.[16]

The Turkish study on HCWs reported an increased risk of transmission due to a breach of infection control precautions such as staying in a duty room without a mask with another HCW or eating meals together.[6] However, our study did not

show an increased risk of transmission due to these breaches in protocol. It should be noted that our study did not evaluate other possible avenues of infection among HCWs like commuting in a vehicle together or social interaction, etc.

The use of HCQs as prophylaxis was also evaluated in our study but it did not show any significant difference in the outcome. This could be because most of the recruits who took the HCQ prophylaxis were not compliant with it and less than 10% completed the entire course for 8 weeks. This is in conjunction with the results of a Cochrane database review[17] done on randomized control trials which showed no efficacy of HCQ in the prevention of COVID-19 infection. In another Indian study, it was noted that HCQ prophylaxis played no role in the prevention of COVID-19.[4] Multiple systematic reviews also concluded that there is no pertinent data to support the use of HCQ outside that of research.[18,19] Also, there is lack of clinical data to support its efficacy and adverse effects like prolongation of QTc. Further, the use of HCQ seems to be counter-productive as it tends to instil a false sense of protection.

Study limitations

A major limitation in our study was that it was a voluntary questionnaire-based study. Though the study was performed on health workers who included doctors, interns, nurses, and residents, there was a poor representation among the nurses as reflected in the limited number of nurses who participated in the study. This resulted in a skewed representation of theHCWs. Also, details of vaccination could not be collected from all the participants as many of them regarded sharing this detail as an invasion of their privacy. This detail could have helped us better understand the interplay between the risk factors that HCWsare exposed to and the benefit offered by vaccination.

Conclusion

We found that, in the face of this unprecedented pandemic, prevention is the goal to avert a health care crisis. In this regard, the frontline workers must be protected and equipped in every way to fight the battle ahead. With the recent increase in COVID cases, it becomes important to consolidate our resources and refine our infection control policies to shield us from the impending wave of pandemics. Small steps like shorter shifts and rotating HCWsthrough various areas of exposure with lesser risk may reduce the risk of contracting the infection. The provision of scrubs, which undergo industrial cleaning should be advocated for all HCWs. Use of gowns and face shields over the coveralls and eye goggles as a part of the PPE may also contribute to the mitigation of COVID-19 infection amongHCWs. Such changes as these will go a long way in strengthening our defenses at the frontline.

Consent

An informed written consent was obtained from all participants.

Author contributions

CAS and SV conceptualized the study. NB was involved in drafting the protocol and ethical clearance. AV and RN were involved with the initial planning data collection and data analysis. NB also contributed to the data processing and analysis. CAS, SV and NB were involved in preparing the draft and editing the final manuscript.

Data availability

Underlying Data

Figshare: *The Frontline War: A Case-control study of risk factors for COVID-19 among health care workers*

1. This project contains the Baseline characteristics of the participants including their demographics, co-morbidities, COVID exposure and duration of work. (raw)

   https://figshare.com/s/df9fc1ad42c71d0498cc

   https://doi.org/10.6084/m9.figshare.19249670

2. This project contains the comparison between details of exposure among cases and controls in the study (raw)

   https://figshare.com/s/4043be187ba173e733dd

   https://doi.org/10.6084/m9.figshare.19249694

3. *This project contains the* comparison between details of precautions taken among cases and controls (raw)

   https://figshare.com/s/6722f26025cd0acbc5f5

   https://doi.org/10.6084/m9.figshare.19249697

4. *This project contains the* comparison between breach in infection control precautions and prophylaxis among cases and controls

https://figshare.com/s/95e4d1cd29aa8c6f0ebd

https://doi.org/10.6084/m9.figshare.19249721

References

1. Dong E, Du H, Gardner L: **An interactive web-based dashboard to track COVID-19 in real-time.** *Lancet Infect. Dis.* 2020; **20**: 533–534.
PubMed Abstract | Publisher Full Text

2. Deo MG: **Doctor population ratio for India-The reality.** *Indian J. Med. Res.* 2013; **137**: 632–635.
PubMed Abstract

3. Chou R, Dana T, Buckley DI, *et al.*: **Epidemiology of and Risk Factors for Coronavirus Infection in Health Care Workers.** *Ann. Intern. Med.* 2020; **173**: 120–136.
PubMed Abstract | Publisher Full Text

4. Jha S, Soni A, Siddiqui S, *et al.*: **Prevalence of flu-like symptoms and COVID-19 in healthcare workers from India.** *J. Assoc. Physicians India.* 2020 Jul 1; **68**(7): 27–29.
PubMed Abstract

5. Chatterjee P, Anand T, Singh KJ, *et al.*: **Healthcare workers & SARS-CoV-2 infection in India: A case-control investigation in the time of COVID-19.** *Indian J. Med. Res.* 2020; **151**: 459.
Publisher Full Text

6. Çelebi G, Pişkin N, Bekleviç AÇ, *et al.*: **Specific risk factors for SARS-CoV-2 transmission among health care workers in a university hospital.** *Am. J. Infect. Control.* 2020; **48**: 1225–1230.
PubMed Abstract | Publisher Full Text

7. Temime L, Gustin MP, Duval A, *et al.*: **Estimating R0 of SARS-COV-2 in Health care settings.** *medRxiv.* 2020.
Publisher Full Text

8. Van Doremalen N, Bushmaker T, Morris DH, *et al.*: **Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1.** *N. Engl. J. Med.* 2020; **382**: 1564–1567.
PubMed Abstract | Publisher Full Text

9. El-Boghdadly K, Wong DJ, Owen R, *et al.*: **Risks to healthcare workers following tracheal intubation of patients with COVID-19: a prospective international multicentre cohort study.** *Anaesthesia.* 2020; **75**: 1437–1447.
PubMed Abstract | Publisher Full Text

10. Liu M, Cheng SZ, Xu KW, *et al.*: **Use of personal protective equipment against coronavirus disease 2019 by healthcare professionals in Wuhan, China: a cross-sectional study.** *Brit. Med. J.* 2020; **10**: 369.
Publisher Full Text

11. Zou L, Ruan F, Huang M, *et al.*: **SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients.** *N. Engl. J. Med.* 2020; **382**: 1177–1179.
PubMed Abstract | Publisher Full Text

12. Wang W, Xu Y, Gao R, *et al.*: **Detection of SARS-CoV-2 in different types of clinical specimens.** *J. Am. Med. Assoc.* 2020; **323**: 1843–1844.
PubMed Abstract | Publisher Full Text

13. Blouhos K, Boulas KA, Paraskeva A, *et al.*: **Understanding surgical risk during COVID-19 pandemic: the rationale behind the decisions.** *Front. Surg.* 2020; **7**: 33.
PubMed Abstract | Publisher Full Text

14. World Health Organization (WHO): **Infection prevention and control during health care when novel coronavirus (nCoV) infection is suspected: interim guidance.** 2020. Accessed 10 May 2021.
Reference Source

15. Park SH: **Personal protective equipment for healthcare workers during the COVID-19 pandemic.** *J. Infect. Chemother.* 2020; **52**: 165–182.
PubMed Abstract | Publisher Full Text

16. Owen L, Laird K: **The role of textiles as fomites in the healthcare environment: a review of the infection control risk.** *Peer J.* 2020; **8**: e9790.
PubMed Abstract | Publisher Full Text

17. Singh B, Ryan H, Kredo T, *et al.*: **Chloroquine or hydroxychloroquine for prevention and treatment of COVID-19.** *Cochrane Database Syst. Rev.* 2021.
Publisher Full Text

18. Kucharski AJ, Russell TW, Diamond C, *et al.*: **Early dynamics of transmission and control of COVID-19: a mathematical modelling study.** *Lancet Infect. Dis.* 2020; **20**: 553–558.
PubMed Abstract | Publisher Full Text

19. Gbinigie K, Frie K: **Should chloroquine and hydroxychloroquine be used to treat COVID-19? A rapid review.** *Br. J. Gen. Pract. open.* 2020; **4**: 20.
Publisher Full Text

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Version 1

Reviewer Report 19 December 2022

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✓ **Smitha Bhat**
Department of Medicine, Father Muller Medical College, Mangalore, Karnataka, India

Review of article on risk factors for COVID-19 among HCWs

The authors have written a well-researched article on a topic which may be relevant to future pandemics of air borne pathogens as well. Especially appreciable are certain valid points which may be used to inform policy - namely the fact that duration of exposure > 6 hours increases the risk of the disease, and that gowns (not coveralls) and face shields were protective.

Certain points may be looked in to:

1. Was the impact of asymptomatic episodes of COVID-19 and the immunity that they would confer considered – were COVID-19 antibodies measured to find out whether the control population did not have previous asymptomatic infection?

2. Did the lack of data from older individuals and those with comorbidities influence the results?

3. Authors may consider explaining the greater risk associated with intubation in the operation theatre compared to the intensive care unit, when in fact both are closed, air-conditioned environments.

4. In the discussion , the point on vaccination may be omitted. COVID-19 vaccination in India started from January 2021, after the conclusion of the study period.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Infectious diseases and diabetes

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 25 Jan 2023

Cynthia Sukumar

1. Was the impact of asymptomatic episodes of COVID-19 and the immunity that they would confer considered – were COVID-19 antibodies measured to find out whether the control population did not have previous asymptomatic infection?
The testing for COVID-19 antibodies was not done due to the cost constraint in this study. This has been included as a limitation of the study.

2. Did the lack of data from older individuals and those with comorbidities influence the results?
Yes. The lack of data from older individuals could have possibly influenced the results. HCWs above the age of 50 years were discouraged from frontline work in our institution.

3. Authors may consider explaining the greater risk associated with intubation in the operation theatre compared to the intensive care unit, when in fact both are closed, air-conditioned environments.
This could be attributed to the prolonged proximity to the intubated patients in the surgical setting compared to the intensive care units.

4. In the discussion, the point on vaccination may be omitted. COVID-19 vaccination in India started from January 2021, after the conclusion of the study period.
Vaccination details omitted from the discussion as advised.

Competing Interests: No competing interests.

Reviewer Report 24 November 2022

https://doi.org/10.5256/f1000research.120476.r155727

Biji Thomas
Department of Surgery, Ras al Khaimah College of Medical Sciences, Ras Al-Khaimah, United Arab Emirates

This is an interesting study and the premise is good. However, there are some important flaws in the methodology and conclusions.

1. How did you reach the sample size for the case and controls? No mention of sample size calculation based on the confidence level, the power of the study etc.

2. There is no mention or raw data provided about the time between exposure and the development of symptoms or positive testing in the case group. Instead, there is a vague statement that 'most' of the recruits tested positive in July 2020.

   This is important because you state that there was a "cluster of cases following the index case among HCWs" in your facility.

   This indicates that the mode of transmission was not probably patient-HCW, rather it was from HCW-HCW.
   The only way to exclude this is by meticulous contact tracing from the index case and then onwards through the cluster as cases appear.

   Whether some of the cases are community acquired or hospital acquired, can only be determined by citing the time interval between the exposure and the onset of symptoms or testing positive.

3. The duration of exposure is also very limited (between 3-6 hours over a week). There is no breakup of the time of exposure and whether the exposure occurred at the beginning of the study for both case and control groups or, instead, the exposure occurred throughout the study period.

   If it occurred throughout, the possibility that some of the control recruits may have developed symptoms or become positive after the study concluded cannot be excluded from the provided data.

4. "Surgical procedures including tracheostomy, emergency orthopedic and general surgery procedures, cesarean sections on a COVID suspect/positive patient saw a significant 28% cases in attendance compared to only 13% among controls".

   If the index patient of the cluster was working in the surgical setting, this would account for

increased number of cases in this subgroup, irrespective of the other factors. Unless, this factor is ruled out with data, this conclusion is unsupported.

5. "The HCW who had >6 hours of work in the COVID area seemed more likely to contract the disease as shown among the 67% cases vs the 46% controls (p=0.02)." How many of these recruits had contact with the positive cases among the recruits and for what duration?

   "However, the number of days at work did not seem to have a significant bearing on contracting the COVID disease." How is this compatible with the above conclusion?

6. "However, our study noted less transmission risk among HCWs who used gowns compared to coveralls. Almost 71% of controls used gowns compared to 47% of cases who used coveralls instead." Could the reason be that HCWs who wore gowns were most likely to be in a surgical setting where the patient has already been tested negative for COVID in the pre-operative assessment period?

My recommendation is that the data be retaken from the individuals with the missing parameters stated above and the article rewritten to remove the flaws.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
No

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: I am a clinical practitioner and am not qualified to comment on statistical analysis.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 25 Jan 2023

Cynthia Sukumar

1. Size for the case and controls? No mention of sample size calculation based on the confidence level, the power of the study etc.
The sample size of 116 (57 cases and 59 controls) was calculated for a confidence interval of 95% and power of 90%.

2. There is no mention or raw data provided about the time between exposure and the development of symptoms or positive testing in the case group. Instead, there is a vague statement that 'most' of the recruits tested positive in July 2020.

This is important because you state that there was a "cluster of cases following the index case among HCWs" in your facility.

This indicates that the mode of transmission was not probably patient-HCW, rather it was from HCW-HCW.
The only way to exclude this is by meticulous contact tracing from the index case and then onwards through the cluster as cases appear.

Whether some of the cases are community acquired or hospital acquired, can only be determined by citing the time interval between the exposure and the onset of symptoms or testing positive.

Time of exposure could not be ascertained as all the HCW were working in the COVID exposure area in the preceding weeks.
We surmised that the mode of transmission was not HCW-HCW as most of the HCWs who contracted the infection soon after the index case were from different areas of the hospital and did not have any contact with the index case. The index case underwent extensive line tracing and only 2 patients contracted the infection from exposure to the index case. Both were the intern's room-mates.

3. The duration of exposure is also very limited (between 3-6 hours over a week). There is no breakup of the time of exposure and whether the exposure occurred at the beginning of the study for both case and control groups or, instead, the exposure occurred throughout the study period.

If it occurred throughout, the possibility that some of the control recruits may have developed symptoms or become positive after the study concluded cannot be excluded from the provided data.

The duration of exposure has been considered as days per week and not hours per week. The exposure has occurred at the beginning of the study for both the cases and controls.

4. "Surgical procedures including tracheostomy, emergency orthopedic and general surgery procedures, cesarean sections on a COVID suspect/positive patient saw a significant 28% cases in attendance compared to only 13% among controls".

If the index patient of the cluster was working in the surgical setting, this would account for increased number of cases in this subgroup, irrespective of the other factors. Unless, this factor is ruled out with data, this conclusion is unsupported.
The index case was working in the medicine wards at the time of contracting the illness in July 2020.

5. "The HCW who had >6 hours of work in the COVID area seemed more likely to contract the disease as shown among the 67% cases vs the 46% controls (p=0.02)." How many of these recruits had contact with the positive cases among the recruits and for what duration?

"However, the number of days at work did not seem to have a significant bearing on contracting the COVID disease." How is this compatible with the above conclusion?

The HCW who had >6 hours of work continuously in the COVID area seemed more likely to contract the disease as shown among the 67% cases vs the 46% controls (p=0.02), when compared to the HCWs who worked in the COVID areas for 3-6 or <3 hours. However, the number of days at work did not seem to have a significant bearing on contracting the COVID disease, as most of the HCWs were rotated through different areas of work through the week.

6. "However, our study noted less transmission risk among HCWs who used gowns compared to coveralls. Almost 71% of controls used gowns compared to 47% of cases who used coveralls instead." Could the reason be that HCWs who wore gowns were most likely to be in a surgical setting where the patient has already been tested negative for COVID in the pre-operative assessment period?
Both coveralls and gowns were used in surgical and non-surgical settings.

Competing Interests: No competing interests.