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Sources of Infection and Risk of COVID-19 for Healthcare Workers at a Tertiary Hospital

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ABSTRACT

Objective: The aim of this study was to evaluate the exposure and risk of contracting coronavirus disease (COVID-19), the infectious disease caused by severe acute respiratory syndrome-related coronavirus 2 (SARS-CoV-2), among healthcare workers (HCWs) at a tertiary hospital early in the pandemic.

Materials and Methods: HCWs who presented at an occupational health outpatient clinic for COVID-19 contact tracing or assessment before returning to work between March 30, 2020 and May 31, 2020 were evaluated in this cross-sectional study. The dependent variable used was a COVID-19 diagnosis; the independent variables used were gender, marital status, age, occupation, smoking, presence of chronic disease, symptoms of COVID-19, source of contact, risk classification, and work in a COVID-19 unit. Logistic regression analysis was used to assess factors associated with the risk of COVID-19 and sources of infection.

Results: A total of 603 HCWs presented at the clinic during the study period. The most frequent sources of contact with SARS-CoV-2 were infected co-workers (50.7%) and patients at work (28.2%), followed by household contacts (9.9%). Those who worked in a COVID-19 unit had a 3.55 times greater risk of a COVID-19 diagnosis than other HCWs when adjusted for age, gender, and risk classification.

Conclusion: HCWs frequently face exposure to potential infection. Sufficient support for these workers to ensure adequate awareness of and compliance with protocols is of critical importance to protect public health. The results of this study also suggest consideration of the possibility of another source of contact for HCWs included in the no risk category. Regular screening for COVID-19 may be advisable.

Keywords: COVID-19, healthcare worker, occupational disease, risk classification

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INTRODUCTION

The outbreak of coronavirus 2019 (COVID-19), the infectious disease caused by severe acute respiratory syndrome-related coronavirus 2 (SARS-CoV-2), spread rapidly and was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 (1). The WHO reported 50 million confirmed cases of COVID-19 and 1 million deaths globally as soon as November 2020 (2).

Healthcare workers (HCWs) fight on the frontline, and as a result of their efforts to provide care and treatment services to COVID-19 patients both directly and indirectly, they are at high risk of exposure to the disease (3). In a cohort study of HCWs conducted early in the pandemic, the prevalence of COVID-19 was found to be 242 per 100,000 in the public community and 2747 per 100,000 among HCWs, and the incidence of the disease was found to be approximately 12 times higher in HCWs than the general population in the UK and the USA (4). According to the data from the Chinese National Health Commission, in March 2020, more than 3300 HCWs had been infected, and according to local media, more than had 22 died. It was reported early in the pandemic that 20% of HCWs in Italy were infected and that some had died (5). In Türkiye, it was reported in September 2020 that 29,865 HCWs (11.5% of all cases) had been diagnosed with COVID-19 and 72 had died (6).

HCWs have been classified in a very-high risk group of occupational risk categories (low, medium, high and very high). The greatest exposure is associated with aerosol-producing procedures, sample collection and processing, and autopsy procedures. Among those in the highest risk group are physicians, nurses, dentists, paramedics, emergency medical technicians, health and laboratory personnel who work with samples, and morgue workers (7). The WHO recommended contact tracing for HCWs who provide care to patients, developing a surveillance system for follow-up, rapid evaluation of signs of infection, and quarantining if necessary (8).

Table 1. Risk classification of healthcare worker contact with COVID-19 patients (12)

	Use of PPE in the following situations for healthcare workers	Risk category
Prolonged close contact with a COVID-19 patient while using PPE	Use of medical mask or N95 or used a medical mask when N95 indicated	Medium
	Use of eye protection	Low
	Use of gown or gloves	Low
	Proper use of all PPE	No risk
Prolonged close contact with a COVID-19 patient not using PPE	No medical mask or N95 used	High
	Use of a medical mask when N95 use indicated	Medium
	Not using eye protection	Medium
	Not using gown or gloves	Low
	Using all PPE properly	No risk

PPE: Personal protective equipment

Detailed risk assessment for HCWs who came into contact with COVID-19 cases to evaluate the type and severity of virus exposure included the nature of the contact and the use of personal protective equipment (PPE). Contact tracing, quarantine, and self-monitoring for 14 days after exposure were recommended by the WHO (9). The European Centre for Disease Prevention and Control proposed a similar approach for individuals classified as having high-risk exposure (10).

The early US Centers for Disease Control and Prevention (CDC) guidance also examined the level of exposure to determine the type of management and monitoring required. A close contact was defined someone who had been within 6 feet of someone with confirmed or suspected COVID-19 or a cumulative total of 15 minutes or more in a 24-hour period. Exposure to secretions or aerosolization was also considered potentially sufficient for quarantine measures (11).

The Scientific Advisory Board of The Ministry of Health in Türkiye official guidelines published to manage HCW contact with a COVID-19 patient used a similar system of categorization and evaluation that included contact distance and factors such as the use of PPE. If a healthcare professional did not use a medical or N95 mask when in close contact with a COVID-19 patient, it was defined as high risk (Table 1). Testing was recommended on the day any active symptoms were observed and 7 days after contact. Workers who were defined as having a low risk or medium risk could continue their work using a medical mask. High-risk situations included those with close (<6 feet) contact or >15 minutes duration, such as taking a sample from the respiratory tract, intubation, aspiration of respiratory secretions, noninvasive ventilation, high-flow oxygen therapy, cardiopulmonary resuscitation, use of a nebulizer, endoscopic procedures, bronchoscopy, dental practices, and mouth-nose-throat or ophthalmological examinations. Hydroxychloroquine was suggested as prophylaxis treatment for HCWs in the high-risk group (12).

This study was designed to evaluate the sources of infection and the risk of COVID-19 for HCWs at a tertiary institution.

MATERIALS and METHODS

Ethics committee approval was obtained from the Hacettepe University Non-Interventional Clinical Research Ethics Committee on August 25, 2020 (no: 2020/13-50).

A total of 603 HCWs who presented at an occupational health outpatient clinic for COVID-19 for contact tracing or back-to-work assessment between March 30, 2020 and May 31, 2020 were evaluated in this cross-sectional study. The COVID-19 Contact Tracing, Outbreak Management, Patient Monitoring, and Surveillance Guide prepared by the Scientific Advisory Board of the Turkish Ministry of Health was used to assess risk. Risk classifications defined as high, medium, low, and no risk guided contact tracing and return to work (Table 1) (12).

Sample selection was not used for the study; all outpatient clinic HCW presentations were included. The dependent variable was a COVID-19 diagnosis. Those with a positive polymerase chain reaction or enzyme-linked immunoassay test along with symptoms and thorax computer tomography findings were defined as a COVID-19 patient. Independent variables used were gender, marital status, age, occupation, smoking, presence of chronic disease, symptoms of COVID-19, source of close contact, risk classification, and work in a COVID-19 unit.

Statistical Analysis

Descriptive statistics were given as a percentage. Chi-squared and logistic regression analysis were performed using SPSS for Windows, Version 15.0 (SPSS Inc., Chicago, IL, USA). Logistic regression models were created to determine the relationship between independent variables and a COVID-19 diagnosis. A p value of <0.05 was considered significant.

RESULTS

Of the 603 HCWs enrolled in the study, 54.9% were women, 66.5% were married, 32.8% were nurses, 23.5% were assistant healthcare personnel, and 17.7% were doctors (Table 2). The greatest frequency of presentation during the study period was

Table 2. Sociodemographic characteristics of participants (n=603)

	n	%
Admission period		
March 2020	50	8.29
April 2020	488	80.93
May 2020	65	10.78
Gender		
Female	331	54.9
Male	272	45.1
Marital status		
Other	202	33.5
Married	401	66.5
Age (years)		
<30	166	27.5
30–40	236	39.1
40–50	147	24.4
50–60	46	7.6
60–70	8	1.3
Occupation		
Nurse	198	32.8
Assistant healthcare personnel (patient transport personnel, nursing staff, cleaning staff, support services, night management staff, administrative staff)	142	23.5
Doctor	107	17.7
Technician (health technician, anesthesia technician, radiology technician, medical technician, laboratory technician, ECG technician)	73	12.1
Hospital administration personnel (secretary, health administrator, hospital director, IT personnel)	46	7.6
Service provider -other than patient care services (waiter, cook, dietician, cashier, pharmacist, biologist)	37	6.1
Smoking		
History of regular smoking in the last 6 months	208	34.5
No regular smoking history for the last 6 months	395	65.5
Chronic disease		
At least 1 chronic disease	216	35.8
None	387	64.2

ECG: Electrocardiography

in April 2020 (Fig. 1). None of the HCWs with high-risk contact declined the use of prophylaxis medication.

The 4 most common symptoms of COVID-19 were cough (15.5%), fever (12.7%), muscle/joint pain or weakness (11.3%), and sore throat (8.5%) (Table 3). The most frequent contact sources were their co-workers (50.7%), patients (28.2%), and members of their household (9.9%). Another 11.3% did not know the exact source of close contact (Table 3).

Table 3. Symptoms and source of infection of healthcare workers with COVID-19

	n	%
Symptoms* (n=71)		
Cough	11	15.5
Fever	9	12.7
Muscle - joint pain/weakness	8	11.3
Sore throat	6	8.5
Shortness of breath	5	7.0
Diarrhea	4	5.6
Headache	1	1.4
Loss of taste or smell	1	1.4
Other (nausea, loss of appetite, postnasal drip, sneezing)	3	4.2
Contact source* (n=71)		
Co-worker	36	50.7
COVID-19 patient at work	20	28.2
Household	7	9.9
Community/unknown	8	11.3

*: Multiple selection may apply

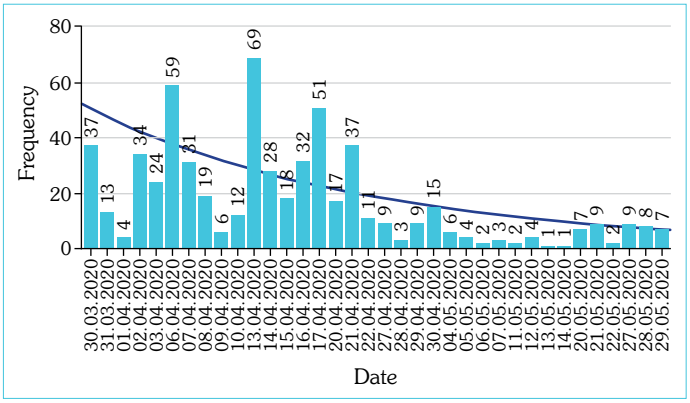

Figure 1. **Presentation rate at the outpatient clinic**
The clinic began to accept COVID-19 applications on March 30, 2020

Among the entire study group, no significant relationship was seen in the characteristics of HCWs based on risk classification and a COVID-19 diagnosis (p=0.95); however, when the no-risk group was excluded from the analysis, the risk of being diagnosed with COVID-19 was significantly higher in high-risk groups (p=0.008). HCWs who developed COVID-19 but were classified as no-risk likely had another source of exposure. The rate of diagnosis with COVID-19 was significantly higher among those who worked in a COVID-19 unit (p<0.001) (Table 4). Those who worked in a COVID-19 unit had a 3.55 times greater risk for a positive diagnosis than other employees when adjusted for age, gender, and risk classification (Table 5). HCWs classified as being at high risk had a 3.24 times greater risk of a COVID-19 diagnosis than other risk groups when adjusted for age, gender, and work in a COVID-19 unit (Table 5).

Table 4. Correlation between risk classification and COVID-19 diagnosis

	Diagnosed with COVID-19					
	Yes		No		Total	
	n	%	n	%	n	%
Risk classification (n=603)						
No risk	19 (26.8%)	17.4	90 (16.9%)	82.6	109 (18.1%)	100.0
Low risk	10 (14.1%)	8.2	112 (21.1%)	91.8	122 (20.0%)	100.0
Medium risk	17 (23.9%)	7.3	215 (40.4%)	92.7	232 (38.5%)	100.0
High risk	25 (35.2%)	17.9	115 (21.6%)	82.1	140 (23.2%)	100.0
Total	71 (100.0%)	11.8	532 (100.0%)	88.2	603 (100.0%)	100.0
Chi-squared on slope: p=0.946, χ^2 value=0.005						
Risk classification *(n=494)						
Low risk	10 (19.2%)	8.2	112 (25.3%)	91.8	122 (24.7%)	100.0
Medium risk	17 (32.7%)	7.3	215 (48.6%)	92.7	232 (47.0%)	100.0
High risk	25 (48.1%)	17.9	115 (26.0%)	88.1	140 (28.3%)	100.0
Total	52 (100.0%)	10.5	442 (100.0%)	89.5	494 (100.0%)	100.0
Chi-squared on slope, p=0.008. χ^2 value=6.963; *: No-risk group was excluded						
Work in a COVID-19 unit (n=603)						
Yes	36 (50.7%)	20.2	142 (26.7%)	79.8	178 (29.5%)	100.0
No	35 (49.3%)	8.2	390 (73.3%)	91.8	425 (70.5%)	100.0
Total	72 (100.0%)	11.9	531 (100.0%)	88.1	603 (100.0%)	100.0
Chi-squared, p<0.001, χ^2 value=17.360						

Table 5. The relationship between risk factors and COVID-19 diagnosis

	Diagnosed with COVID-19	
	Crude OR (%95 CI)	OR (95% CI)*
Work in a COVID-19 unit		
No	1.00	1.00
Yes	2.83 (1.71–4.67)	3.55 (1.91–6.59)
Risk classification		
Low risk	1.00	1.00
Medium risk	0.89 (0.39–1.99)	0.85 (0.37–1.97)
High risk	2.44 (1.12–5.30)	3.24 (1.42–7.36)

*: Adjusted for age and gender. Constant B=-0.667, Exp(B)=0.513, significance=0.407. No-risk healthcare workers were not included in logistic regression analysis (n=494). OR: Odd ratios; CI: Confidence interval

DISCUSSION

This study examined records of HCWs diagnosed with COVID-19 and their contact with COVID-19 patients and others during the first 3 months of the pandemic. The largest number of presentations at the clinic was seen in April 2020. The number of cases of COVID-19 was beginning to increase at this time, but it was still a largely unknown disease. Algorithms were used in assessment during this period of limited information and stressed resources; some HCW patients may not have presented at the clinic. Our results indicated that 38% of the HCWs in the study had medium-risk contact. The most common source of potentially infectious contact was their colleagues (50%) and patients at work (28%). The risk of developing COVID-19 was 3.2 times greater in those with a history of high-risk contact compared with those at low risk, and 3.5 times greater in those working in COVID-19 units than other units.

It appears that HCWs were often infected due to occupational risk factors, especially since the prevalence of COVID-19 in general society was still low in this early period of the pandemic. The rate of infection in the community and among healthcare workers are correlated, and those working in internal disease units were among the first to be exposed.

In a study conducted in Italy, it was observed that those who performed human health and social service activities were the occupational group at greatest risk and the group that filed the largest number of claims for compensation for occupational disease as a result of COVID-19 infection (13). The present study findings support the evidence seen in many other countries (Argentina, Australia, Belgium, Brazil, Peoples' Republic of China, France, Germany, Japan, Republic of Korea, Malaysia) that categorizes COVID-19 as an occupational disease for HCWs (14).

Strict measures were implemented by the government to curb the spread of COVID-19 in society, including limiting intercity travel, imposing curfews, halting the activities of restaurants and entertainment venues, and suspending elective patient care in hospitals. The results of this study indicate that approximately 80% of HCWs who were diagnosed with COVID-19 encountered the SARS-COV-2 virus at work via patients or colleagues.

During the early period of the pandemic, when there was only minimal information about the virus, it may be that risk was underestimated, particularly among colleagues who were asymptomatic. A case-control study conducted with HCWs in Zonguldak, Türkiye, revealed that the presence of COVID-19 in their family and inappropriate use of PPE, including spending more than 15 minutes with a COVID-19-infected HCW in the same room without a medical mask, significantly increased the risk of transmission (15). HCWs were encouraged to increase and improve their use of PPE and protective behaviors in personnel training programs (16). Occupational Health and Safety Law No. 6331 stated that employees were obliged not to endanger the health and safety of themselves or other employees who may be affected by their actions based on training and instructions provided by their employer (17). Healthcare professionals must always take the necessary measures to prevent the spread of COVID-19, in addition to other measures to protect and preserve public health. Equally important, however, are the employer's responsibilities to provide appropriate regular training and protection for their employees.

Periods of crisis, such as a pandemic or natural disaster regularly place HCWs in a position of intense need for their services with simultaneous personnel and other resource shortages, risk of infectious disease, long working hours, and physical and mental burnout. HCWs experience more work accidents and occupational anxiety and posttraumatic stress disorders in these periods. In order for healthcare professionals to cope with these crises and do the job they need to do, they must be adequately supported and their individual adaptation and resilience and skills must be developed through education and training (18).

The availability and proper use of PPE, as well as administrative and other measures to protect the health and safety of HCWs biological risk factors is critical. However, PPE alone is not sufficient. Both employees and employers have responsibilities (19). Both experimental and hospital studies have shown evidence of transmission of SARS-CoV-2 via aerosol-producing procedures. A laboratory study demonstrated that the live SARS-CoV-2 virus was found in the air 16 hours after being aerosolized (20). Proper use of PPE, physical distancing, and other measures reduce the risk of infection (21). Nonetheless, SARS-CoV-2 virus transmission by aerosolization is a significant source of risk and HCWs and their employers must take this into consideration (22). Viral shedding via a fecal-oral or a fecal respiratory transmission route is another concern (23).

In the COVID-19 guidelines prepared by the Scientific Advisory Board of the Turkish Ministry of Health, risk classifications were made according to physical distance and PPE practices observed by HCWs (12). We observed that the HCWs in the no-risk group had nearly the same prevalence of COVID-19 as the high-risk group. There may be some inconsistencies in risk classification and contact information due to patient histories and improper use of PPE. When the employees in the no-risk group were excluded from the evaluation, the risk of a COVID-19 diagnosis among all healthcare professionals in the study increased significantly based on contact conditions. This is important information for proper management of HCWs in high-risk groups. HCWs in the high-risk group who are exposed should be properly isolated at home, and necessary measures should be taken to prevent infection.

The most important obstacles to HCW compliance with the protection and prevention guidelines and the proper use of PPE were the lack of education and an inadequate safety culture. Fear of infecting their families has been reported to be the most important factor determining compliance with the rules. HCWs found the use of masks and other PPE difficult and uncomfortable, they felt isolated, and they did not want to use PPE due to associated stigma (24). Greater understanding of the use of protective measures and the means of transmission of this virus and others is a complicated but critical subject.

In this study, the risk of a COVID-19 diagnosis was significantly higher in units where COVID-19 patients were treated. There was no significant difference in the characteristics of employees in COVID-19 units and those working in other areas in terms of exposure to non-work COVID-19 cases. When adjusted for age, gender, and risk classification, employees working in COVID units were at 3.55 times greater risk than those in other units. This may be due to the fact that the study was conducted during the first months of the pandemic and the awareness and adaptation of physical distance and PPE usage were low, including among colleagues during break periods in social areas. At the time of the study, the prevalence of COVID-19 in general society was still low. Healthcare professionals were at a greater risk of encountering the SARS-COV-2 virus in hospitals. It was noted in an early study conducted in the UK that HCWs at risk of exposure to airborne spread should be protected. Those working in the clinical field received more laboratory-confirmed COVID-19 diagnoses than others. In particular, measures taken to protect emergency room workers proved successful (25). The increased risk of infection among HCWs suggests that exposure and infection with COVID-19 could be considered an occupational disease or occupational injury (26).

The best method of preventing the risk of infection in HCWs is the consistent use of appropriate PPE and adequate infection control training (27). Regular swab tests might also serve as a preventative tool to prevent infection among HCWs (28, 29). The lessons of this pandemic remind us that we must be vigilant and prepared.

CONCLUSION

The findings of this study indicated that working in a COVID-19 unit posed a risk in terms of COVID-19 transmission. It is appropriate to categorize and evaluate HCWs who come into contact with a COVID-19 patient according to the procedures they perform and the appropriate use of PPE. However, there were also HCWs diagnosed with COVID-19 who were in the no-risk category. Therefore, regular training and appropriate preventive measures, including regular screening of HCWs at regular intervals may be advisable, particularly given the fact that asymptomatic HCWs also tested positive for COVID-19 (30). In order to carry out adequate training and regular screening programs, hospitals need financial support to provide a sufficient number of sampling rooms with appropriate ventilation conditions, physical laboratory conditions, and sufficient workforce infrastructure.

The pandemic has reinforced the awareness of a need for better strategies to support HCWs and reduce their exposure to potentially mortal illness, as well as to protect public health. Appropriate management mechanisms to encourage and ensure compliance with appropriate protocols and the supply of needed resources will protect our HCWs and our general population.

Strengths and Limitations

As in any epidemic, determining the source of COVID-19 infection is important. A detailed occupational history of an HCW taken immediately after known contact or diagnosis could reduce bias related to the recollection of the contact event. Asymptomatic and undiagnosed individuals who did not present at the outpatient clinic may not have been accounted for in this study. The first patients were 2 internal medicine resident roommates who worked at our hospital, who were diagnosed on March 21, 2020. According to WHO guidelines, surgical masks were only recommended in case of contact with patients who suffered from symptoms of respiratory infections at that time.

The Internal Medicine Clinic served as a COVID-19 ward. The high rate of close contact in the clinic might be a confounding factor in the evaluation of the role of the work unit when considering the 14-day incubation period of SARS-CoV-2 infection. As this was a cross-sectional study, causal relationships could not be determined. This research was conducted among healthcare professionals of a tertiary hospital; the findings will not necessarily represent all healthcare professionals in the public and private sectors.

Ethics Committee Approval: The Hacettepe University Non-Interventional Clinical Research Ethics Committee granted approval for this study (date: 25.08.2020, number: 2020/13-50).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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Author Contributions: Concept – CŞ, DK, HEE,EÖ, DY, DÖ, TÇ, ŞAK, GTD, NÇB, GM; Design – CŞ, DK, HEE,EÖ, DY, DÖ, TÇ, ŞAK, GTD, NÇB, GM; Supervision – CŞ, DK, HEE,EÖ, DY, DÖ, TÇ, ŞAK, GTD, NÇB, GM; Resource – CŞ, NÇB, GM; Materials – CŞ, NÇB, GM; Data Collection and/or Processing – CŞ, DK, GTD; Analysis and/or Interpretation – CŞ, DY, NÇB, GM; Literature Search – CŞ, DY, HEE, ŞAK; Writing – CŞ, DK, HEE, ŞAK; Critical Reviews – CŞ, NÇB, GM.

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