

COVID-19 Transmission and Clinical Features in Pediatric Intensive Care Health Care Workers

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What is already known on this topic?

- Transmission of SARS-CoV-2 to HCWs occurs mainly during procedures such as intubation, ventilation, and aerosol therapies.

What this study adds on this topic?

- All PICU staff need to advise caution particularly during airway management and aerosol procedures on COVID-19 patients.
- Improper PPE use by PICU staff, omission of masks, and lack of social distancing measures at work increase the rate of SARS-CoV-2 transmission to HCWs.

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ABSTRACT

Objective: This study aims to investigate modes of transmission and clinical features of coronavirus disease 2019 in healthcare workers in pediatric intensive care units.

Materials and Methods: This multicenter descriptive study was conducted between March and November 2020. Patient demographics, clinical characteristics, origin of coronavirus disease 2019, treatment modalities, and loss of workdays were recorded.

Results: Seven hundred and sixty-eight healthcare workers from 16 pediatric intensive care units were enrolled and 114 (14.8%) healthcare workers with a mean age of 29.7 ± 6.7 years became coronavirus disease 2019 patients. Seventy-six (66.7%) patients were female. Approximately half (54.3%) of the patients were physicians, 34.2% were nurses, and 11.4% were ancillary staff. Transmission was deemed to occur through patient contact in 54.3% of the patients. Comorbid illness was present 10.5% of the patients. Transmission occurred during endotracheal intubation in 21%, cardiopulmonary resuscitation in 9.6%, and non-invasive ventilation in 12.2% of patients, while transmission was a result of multiple possible procedures in 43.8%. Intensive care admission was needed for 13.1% of the patients. Five patients needed oxygen by cannula, 7 needed oxygen with a non-rebreathing mask, 5 needed high-flow nasal cannula support, 5 needed non-invasive ventilation, and 3 needed invasive mechanical ventilation. Fortunately, no infected healthcare workers died.

Conclusion: Coronavirus disease 2019 in healthcare workers is a significant problem in pediatric intensive care units. Transmission seems to occur particularly frequently during patient care procedures such as intubation, ventilation and aerosol therapy, which highlights the importance of proper use of full sets of personal protective equipment during all procedures during care of coronavirus disease 2019 patients.

Keywords: Children, COVID-19, health care worker, pediatric intensive care unit, SARS-CoV-2

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic brought life all over the world to a standstill and posed serious problems in provision of health care. Many healthcare workers (HCWs) got infected at work and lost their lives, and healthcare facilities had difficulty in providing ample service during local surges.^{1,2}

Healthcare workers have to treat COVID-19 patients, which puts them at the frontline in this global war. Use of personal protective equipment (PPE) reduces transmission of COVID-19 even in critical care. Recommendations on the use of PPE by HCWs have been published by the World Health Organization (WHO) and the Center for Disease Control (CDC).³ During the severe acute respiratory syndrome (SARS) epidemic in 2003, 21% (1706 / 8096) cases were HCWs.⁴ In a single-center case series of 138 COVID-19 patients hospitalized in Wuhan, China, in January 2020, 29% (40/138) were HCWs.⁵ One report states that about 10 000 HCWs were infected and 74 died in Italy.⁶

In this study, we aimed to investigate COVID-19 in PICU staff with respect to role at work, mode of transmission, symptoms, treatment modalities, lost workdays, and outcome. To our best knowledge, this is the first multicenter study of COVID-19 in PICU.

MATERIALS AND METHODS

Design and Setting

This was a descriptive multicenter study conducted between March and November 2020 in 16 PICUs. Legal approval was obtained from the Scientific Research Platform under the Ministry of Health taken in accordance with the recent law on studies on COVID-19 (Approval code: 2020-09-16T16-41-23). Ethical approval was obtained from the Human Research Ethics Committee (Decision number: İ1-70-21). The study was conducted in accordance with the Declaration of Helsinki. Written approval was obtained from all participating PICUs and written consent was obtained from all participants.

Study Population

Pediatric intensive care unit staff between the ages of 18–65 who had contact with COVID-19 were enrolled.

Exclusion Criteria

1. Insufficient response to the questionnaire
2. Lack of COVID-19 contact

Data Collection

An online questionnaire was sent to all participating centers. All medical personnel had contact with COVID-19. All those who filled out the questionnaire were included in the study. Demographic data, role in the PICU, comorbidity, pregnancy, type of contact with SARS-CoV2, symptoms, extent of PPE use, diagnostic methods, and laboratory results were recorded.

COVID-19 Transmission Route

The history of contact with COVID-19 (+) based on the statements of the participants was taken into account.

Study Group

Staff who underwent testing for contracting COVID-19 were included, regardless of whether or not they were symptomatic.

Treatment modalities were recorded as home quarantine only, medication at home, ward admission, or ICU admission. Need for respiratory support and the type of respiratory support needed (oxygen by nasal cannula, nonrebreathing oxygen mask, high-flow nasal cannula (HFNC), non-invasive ventilation (NIV), invasive mechanical ventilation (IMV) were recorded. Days off from PICU, time to symptom resolution, sequelae, and deaths were recorded.

Statistical Analysis

The Statistical Package for Social Sciences, version 16.0 software (SPSS Inc.; Chicago, IL, USA) was used to interpret data. Shapiro-Wilk test was used to check for normality. Normally distributed data were expressed as mean \pm standard deviation (SD), while data without normal distribution were expressed as median (minimum to maximum). A *P* value less than .05 was considered significant.

RESULTS

Ample data were available for 768 PICU staff from 16 PICUs and 114 (14.8%) HCWs who were positive on polymerase chain reaction (PCR) testing. The mean age was 29.7 ± 6.7 years, and 76 (66.7%) patients were female. Three institutions with both the highest number and highest ratio of COVID-19 positive HCWs were center 1 [15.8% (n = 18)], center 2 [13.2% (n = 15)], and center 3 [13.2% (n = 15)]. Sixty-two (54.3%) patients were physicians, 39 (34.2%) were nurses, and 13 (11.4%) were ancillary staff such as janitors and patient care personnel. Comorbid illness was present in 10.5% of infected PICU staff. Seven percent of infected HCWs were on medication chronically and 24.6% of infected staff were smokers. Demographic data of infected HCWs with COVID-19 are shown on Table 1.

Most of the infected HCWs (62/114, 54.4%) were exposed to SARS-CoV-2 during patient contact. Twenty-one percent of transmissions occurred during endotracheal intubation, 9.6% occurred during cardiopulmonary resuscitation (CPR), 12.2% occurred during NIV, and there were multiple possible procedures for 43.8% of episodes of transmission (Figure 1). Transmission occurred due to factors other than patient contact in 45.6% of the patients. Twenty (38.1%) HCWs contracted the disease from colleagues outside the patient care area, 15 (28.8%) contracted the disease at home, and 17 (32.7%) staff contracted the disease at mall or public transport situations. Clinical features of the patients and data on personal protective equipment (PPE) usage are summarized on Table 2.

Among the PICU personnel infected by SARS-CoV-2, PCR tests in 108 (92.3%), thorax computerized tomography (CT) findings in 28 (23.9%), and anti-SARS-Cov-2 immunoglobulin M (IgM) in 15 (12.8%) were positive. Also, CRP in 85.7%, white blood cell in 83.3%, hemoglobin in 78.6%, activated partial thromboplastin time in 47.6%, international normalized ratio in 50%, brain natriuretic peptide in 9.5%, prothrombin time in 45.2%, procalcitonin in 45.2%, troponin T in 33.3%, and ferritin in 50% were checked during the disease period in infected HCWs.

Table 1. Demographic Data of Health Care Workers with COVID-19 in Pediatric Intensive Care Units

Gender	
Female, n (%)	76 (66.7)
Male, n (%)	38 (33.3)
Age (years)	29.7 ± 6.7 (20-49)
Comorbidity	
No, n (%)	101 (88.5)
Yes, n (%)	13 (11.5)
Chronic bronchitis, n (%)	2 (1.8)
Heart disease+DM, n (%)	1 (0.9)
Hypertension+DM, n (%)	1 (0.9)
Ulcerative colitis, n (%)	1 (0.9)
Immunodeficiency, n (%)	1 (0.9)
Tumor, n (%)	1 (0.9)
Renal diseases, n (%)	1 (0.9)
Familial Mediterranean fever, n (%)	1 (0.9)
Morbid obesity, n (%)	1 (0.9)
Hypertension, n (%)	1 (0.9)
Profession	
Attending/ professor, n (%)	3 (2.6)
PICU fellow, n (%)	12 (10.5)
Resident, n (%)	24 (21.1)
Nurse, n (%)	62 (54.3)
Patient care staff, n (%)	3 (2.6)
Janitor, n (%)	10 (8.8)

PICU, pediatric intensive care unit; DM, diabetes mellitus.

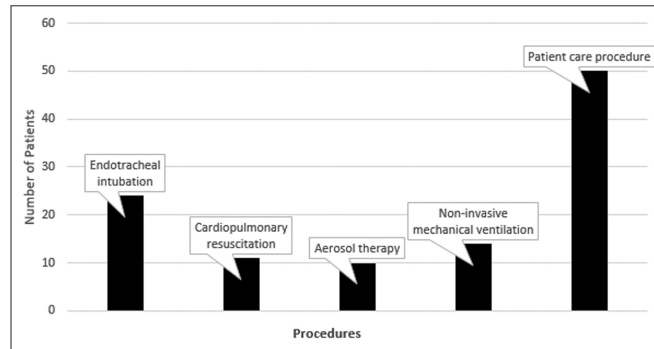


Figure 1. Possible SARS-CoV-2 exposure forms in infected PICU healthcare workers. SARS-CoV-2, severe acute respiratory syndrome coronavirus-2; PICU, pediatric intensive care unit.

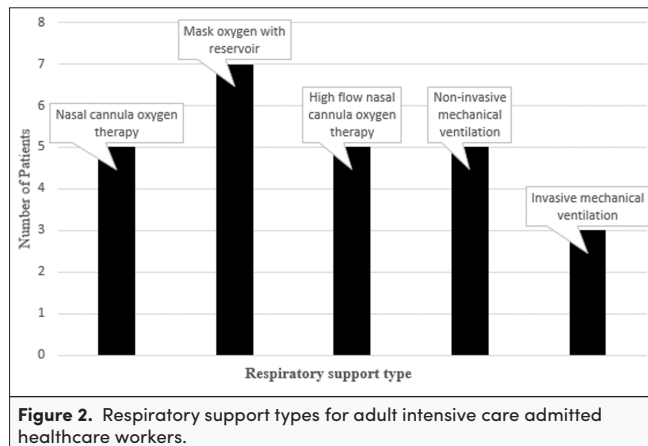
Twenty-six (22%) patients were isolated at home, 81 patients (56.1%) were treated with hydroxychloroquine and/or favipiravir at home, 10 patients (8.5%) were admitted to a hospital ward, and 15 patients (13.1%) needed ICU admission. All patients received oxygen by simple mask unless otherwise indicated. Five patients needed oxygen by nasal cannula, 7 needed oxygen by non-rebreathing mask, 5 patients needed NIV, and 3 needed IMV. Data on treatment are summarized on Figure 2.

Mean quarantine and/or hospitalization period was 16.2 ± 14.5 days. Time to PCR negativity was 10 ± 5.3 days. Time to symptom resolution was 11.7 ± 11.3 days. Fortunately, there were no deaths.

Table 2. Clinical Features and Personal Protective Equipment Use in Healthcare Workers with COVID-19

COVID-19 Symptoms	
Yes, n (%)	89 (78.8)
No, n (%)	25 (21.2)
Symptoms	
Muscle pain, n (%)	73 (74.5)
Headache, n (%)	59 (60.2)
Loss of taste and sense, n (%)	50 (51)
Cough, n (%)	49 (50)
Fever, n (%)	42 (42.9)
Diarrhea, n (%)	31 (31.6)
Cold, n (%)	29 (29.6)
Shortness of breath, n (%)	24 (24.6)
Nausea and vomiting, n (%)	23 (22.6)
Weight loss, n (%)	13 (13.3)
Other, n (%)	11 (12)
Use of PPE in contact with COVID-19 (+) patients with surgical masks	
Properly use of full PPE, n (%)	49 (59.8)
Eye protection omitted, n (%)	21 (25.6)
Mask omitted or surgical mask used where N95 should be used, n (%)	20 (24.4)
Gloves and gown omitted, n (%)	5 (6.1)
Use of PPE in contact with COVID-19 (+) patients without a surgical mask	
Properly used all PPE, n (%)	41 (49.4)
Eye protection omitted, n (%)	18 (21.7)
Mask omitted or N95 or surgical mask used where N95 should be used, n (%)	21 (24.4)
Gloves and gown omitted, n (%)	6 (7.2)

PPE, personal protective equipment; COVID-19, coronavirus disease 2019.



DISCUSSION

Healthcare workers are at high risk of exposure to infectious diseases, including COVID-19, which spreads through respiratory secretions, body fluids, and contaminated surfaces.⁷ The rapid rise in the number of patients with COVID-19 resulted in many HCWs contracting the disease.⁸ Prompt diagnosis of COVID-19 in HCWs is crucial in prevention of the spread of COVID-19 throughout the hospital.⁹ In our multicenter study of 768 healthcare staff, 114 (14.8%) had COVID-19. One single-center study reports that 16.3% of 432 healthcare personnel were found to be symptomatic for COVID-19 and were positive on testing.¹ In another study of 1353 HCWs, 6% were found to be symptomatic and positive for COVID-19.² On April 8, 2020, the incidence of COVID-19 among HCWs was reported to be 11% in Italy,¹⁰ 13.6% in Spain,¹¹ and 3.8% in China.¹⁰ Sahu et al³ published a meta-analysis of 11 studies in which the rate of SARS-CoV-2 infection was reported to be 10.1%. The rate of COVID-19 positivity among PICU staff was found to be similar in our study. Publications on COVID-19 situation among PICU staff are scarce. To our best knowledge, this is the first multicenter study of COVID-19 in PICU staff in Turkey.

Contracting SARS-CoV 2 during the pandemic is intrinsic to the nature of the job for HCWs. Fortunately, PPE use was proven to be very effective in preventing infection of HCWs, particularly when used during airway management procedures and aerosol therapies.

All types of HCWs are at risk. Reports on COVID-19 transmission to various types of HCWs are scarce. Gong et al⁴ reported that in their study conducted in England between March 20 and May 13, 2020, 42.9% of COVID-19 positive staff were nurses, 19.1% were physicians and 38.1% were miscellaneous personnel. In keeping with previous reports, our study shows that among HCWs, physicians and nurses are at a particularly high risk of contact with COVID-19 patients.

Studies suggest that spread of COVID-19 among health care staff was mostly due to patient contact and contact with colleagues with insufficient PPE.¹ Meng et al⁵ have published a report of an estimated 2500 tracheal intubations of critically ill patients. They emphasized the importance of an airway management protocol and the use of complete sets of PPE in reducing the transmitted viral load.⁵ A study that retrospectively

analyzed 202 urgent intubations of COVID-19 patients reported that all personnel were using PPE and rapid sequence intubation was accomplished with an 89.1% rate of successful first attempt. No staff members were infected.⁶ In our study, 62 (54.3%) staffs were infected through COVID-19 patient contact, and 80.6% of them may have got infected during patient care, 38.7% may have got infected during intubations, and 17.7% may have got infected during CPR. The remaining 52 (45.6%) were infected due to unprotected (without a mask) contact among colleagues at the workplace or unprotected household contact. The number of infections was high because there was unprotected contact among staff and proper use of PPE was insufficient early in the pandemic.

Studies suggest that in order to control an outbreak of COVID-19 in the hospital, patients need to be isolated in negative pressure room or units. Should that be unavailable, naturally ventilated rooms with continuous air flow need to be used. If possible, there should be 1 patient per room, all patients should wear masks, and healthcare staff should wear complete sets of PPE at all times.¹² Medical and surgical masks should cover the mouth and nose, and this option is safe during standard patient care and outside of patient care area. Healthcare workers should use N95 filtering facepiece respirator (N95), Filtering facepiece2 (FFP2), and Filtering facepiece3 (FFP3) masks during invasive procedures such as intubation, endotracheal aspiration, CPR, and aerosol therapies (HFNC, inhaler therapies, NIV). These masks protect from 95% of particles with a radius larger than $>0.3 \mu\text{m}$.¹³ FFP3 masks, the European counterpart to the US N95 masks, are recommended for protection against SARS-CoV-2 laden aerosols.¹⁴ An FFP3 mask, goggles or face shield, waterproof gown, and gloves were recommended for healthcare staff in another study. If waterproof gowns are not widely available, single-use plastic gowns are recommended.¹⁵ In our study, when contact with patients who wore surgical masks in accordance with guidelines published by the Turkish Ministry of Health, a full set of PPE was used appropriately in 59.8% of encounters. Centers with a low number and ratio of COVID-19 positive personnel despite high numbers of staff, the low incidence of COVID-19 in HCWs may be due to proper use of PPE.

Severe acute respiratory syndrome coronavirus-2 is known to spread through respiratory droplets, but the virus has also been demonstrated in blood and other bodily fluids.¹⁴⁻¹⁷ Ran et al¹⁶ have reported that working in COVID-19 wards, insufficient hand hygiene, and long shifts increase the risk of contracting the disease. The working hours of the HCWs in our units are between 8 and 16 hour shifts. Chu et al¹⁷ have emphasized that atypical symptoms, spread during the incubation period, lack of PPE, and contact between visitors and healthcare staff contribute to the risk of infection. Comparison of our data with previous reports revealed that social distancing was neglected at work and there was a low rate of appropriate use of PPE.

The PCR test, different radiologic methods, and serologic testing are simple diagnostic tools for HCWs with a history of COVID-19 exposure and/or symptoms that can be consistent with COVID-19. In our study, the diagnosis of COVID-19 was made with PCR testing in 92.3%, thorax CT scans in 23.9%, and serology in 12.8% of HCWs that were infected. Knoll RL et al¹ reported that 91 of 432 healthcare workers underwent PCR testing, and

19.5% were found positive in one study,¹ while among 14 staff on a neurosurgical ward, 85.7% were found to be PCR-positive and 86% were found to be positive on CT.⁸ Chu et al¹⁷ published that out of 54 staff from the emergency room, other wards, and technology department reveal, 52 (96.2%) were found to have COVID-19 on the CT scan. Publications on the diagnosis of COVID-19 in healthcare staff are scarce. Our results are similar to some reports^{8,17} and different than others.¹

Obviously, infected persons need isolation, drug treatment, hospitalization, and/or ICU admission. These conditions mean loss of human power in healthcare facilities like PICUs. In our study, 15 (13.1%) of the HCWs needed ICU admission and 3 of these patients needed IMV. Fortunately, they all survived. Takeda et al¹⁸ have reported that 2 of 6 staff members with COVID-19 were admitted to the ICU and needed NIV. Gong et al⁴ reported a 58.4% admission rate (97 of 166 patients) among their staffs. Literature on the condition of adult and pediatric ICU staffs that were COVID-19 positive is limited. There was a higher ICU admission rate in our study when compared to previous published papers.

Significant developments occurred in the field of COVID-19 vaccination globally. All healthcare staff were vaccinated in January and February 2021 in our country with the Chinese coronavirus vaccine (Sinovac Biotech®, CHINESE). However, there was no vaccine during our study, therefore our participants were not vaccinated at the time. We have observed a significant decrease in infected HCWs after widespread vaccination of HCWs in Turkey.

Our study is the first multi-center study of COVID-19 in PICU staff in Turkey, but it is limited in that it is a retrospective study conducted as an online questionnaire, which may have missed some cases.

In conclusion, COVID-19 is a significant problem among PICU staff. Infection tends to occur particularly frequently during invasive procedures such as intubation, ventilation, and aerosol therapy. Caution should be exercised throughout the workday, particularly during these aforementioned procedures. Insufficient use of PPE by PICU staff, working and interacting with colleagues without masks, and lack of social distancing increase the rate of SARS-CoV-2 infection.

Ethics Committee Approval: This study was approved by Ethics committee of Ankara University, (Approval No: İ1-70-21).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept – T.K.; Design – E.B.; Supervision –M.Y., N.Ş.; Resources – E.U., Z.Ö., E.Ş., Y.S., O.D., Ş.S., M.D.; Materials – E.B.; Data Collection and/or Processing – E.U., Z.Ö., E.Ş., Y.S., O.D., Ş.S., M.D., E.B.,T.K., Analysis and/or Interpretation – E.B., A.O., M.C., G.Ö., M.H., M.N.Ö., H.A., N.Y., A.Y., E.G., H.Ö., D.Y.; Literature Search – T.K., E.B.; Writing Manuscript – T.K.; Critical Review – T.K., D.Y.

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