BRIEF REPORT

Risk of SARS-CoV-2 Transmission in Health Care Personnel Working in a Pediatric COVID-19 Unit

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ABSTRACT

OBJECTIVES: The paucity of symptoms and the difficulties in wearing personal protective equipment make children a potential source of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection for health care workers (HCWs). Previous experience in pediatric settings reported high rate of intrahospital SARS-CoV-2 transmission in HCWs caring for children. We aimed at investigating the rate and determinants of SARS-CoV-2 infection among HCWs working in a regional reference center in the Southern Italy.

METHODS: A prospective observational study was conducted to monitor the occurrence of SARS-CoV-2 infections among HCWs and investigate the relation between the infection rate and hours of exposure or number and characteristics of procedures, including nasopharyngeal swab, high-flow oxygen delivery, suctioning of airway secretions, sputum induction, and nebulizer administration.

RESULTS: After 5 months of monitoring, 425.6 hours of SARS-CoV-2 exposure (18.5 hours per person), and 920 hospital procedures, no case of nosocomial transmission was reported among the 23 HCWs enrolled in the study.

CONCLUSIONS: The application of stringent preventive measures, also outside the area dedicated to patients' care, can effectively control infection spreading also in pediatric settings.

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Dr Lo Vecchio conceived the study; Dr Pierri conceived the study and was involved in the study design and data collection; Drs Vassallo, Poeta, and Bruzzese were involved in the study design and data collection; Dr Varelli performed serological analysis; Drs Guarino and Montella reviewed the manuscript and provided substantial support to the project; and all authors read and approved the final manuscript as submitted.

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The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic challenged health systems worldwide and exposed health care workers (HCWs) to an increased risk of infection and death. The hospital setting had a major role in sustaining the pandemic, and authorities recommended adoption of adequate prevention and control measures for HCWs.[1]

The Italian National Institute of Health reported 30 835 diagnoses of coronavirus disease 2019 (COVID-19) and >200 deaths in HCWs, up to July 2020.[2]

Pediatric patients show a mild disease course in most cases and rarely require hospital care.

However, the paucity of symptoms and difficulties in wearing personal protective equipment (PPE) make children a source of transmission for families, health care personnel, and environments.[3,4]

A previous experience in Northern Italy, the area majorly struck by COVID-19, reported an intrahospital SARS-CoV-2 transmission rate of 24% among pediatricians and 31% among pediatric nurses in <1 month of activity.[5]

We aimed at investigating the risk of SARS-CoV-2 dissemination among HCWs caring for COVID-19–affected children in a tertiary-care hospital.

METHODS

A prospective observational study was conducted (March 23 to August 23, 2020) at the Referral Center for Pediatric COVID-19 in the Campania region, the most populous region in Southern Italy, accounting for ~5 million inhabitants. The unit consists of 5 inpatient beds and an area dedicated to triage of suspected children. The health care staff consists of 2 senior pediatric infectious disease specialists, 6 fellows (mainly involved in triage and support activities), 12 nurses, a head nurse, a pharmacist, and a cleaning man. All HCWs were exclusively dedicated to the care of children with suspected or confirmed SARS-CoV-2 infection during the study period.

Anonymized data were obtained from the hospital monitoring of HCWs working in COVID-19 units after approval of the institution's health department. All HCWs involved in the study signed a written informed consent.

Infection Control Measures

The ward is organized in 2 distinct sections: a contaminated area dedicated to patient's care and another clean area dedicated to HCWs activities. Health care personnel were specifically trained, and anyone wore PPE during their stay in the ward, according to the indication reported in Table 1.

Patients (if tolerated) and caregivers were asked to wear surgical masks during HCWs access in the room, and a single caregiver was allowed for each child. Contact with patients was limited as much as possible. Entrance in the contaminated area was scheduled to merge principal activities, including medical visits, blood withdrawal, chest radiographs, distribution of foods, and administration of treatments. All medical devices (ie, stethoscope, pulse oximeter, and otoscope) were dedicated to single patients.

HCWs used walkie-talkie to communicate between the contaminated and clean area, and mobile phones were used to communicate with patients when direct contact was not needed.

Social distancing between HCWs was promoted, also, in the clean area.

HCW Monitoring

A standardized registration form was used to collect the following data every time an HCW entered a single patient's room (a 13 m^2 room): the time of exposure (minutes recorded through a chronometer and, then, normalized to hours), the type and number of procedures (including medical visits), blood samples, nasopharyngeal or rectal swabs, airways aspiration, contact with stools or urine, and possible issues with PPE or during undressing procedures. The time spent in the contaminated area but outside the patient's room (ie, the time needed to move from a room to another, prepare drugs, and/or interact with other colleagues) was not included in the total amount.

In addition, the presence of a cough or crying, use of noninvasive ventilation, and use of PPE by patients and caregivers was recorded.

In accordance with local health management procedures, HCWs were continuously monitored for COVID-19–suggestive symptoms and screened every week by using a rapid lateral immunofluorescence (LIFA) test for SARS-CoV-2 immunoglobulin M (IgM) and immunoglobulin G (IgG), with 85% (IgM) to 100% (IgG) sensitivity and 96% (IgM) to 98% (IgG) specificity, according to manufacture label (Screen Test COVID; Screen Italia Srl, Torgiano, Italy; Table 2). In addition, before the opening of the COVID-19 unit (baseline) and after 3 and 5 months of observation, SARS-CoV-2 serology was performed by using chemiluminescent immunoassay (CLIA) reporting sensitivity of 79% to 100% and specificity of 97.5% to 99.6% for IgM (Snibe Diagnostic, Shenzhen, China) and IgG (Abbott, Abbott Park, IL), respectively (Table 2).[6]

SARS-CoV-2 was searched by real-time reverse-transcriptase polymerase chain reaction[7] of nasopharyngeal swabs in case of symptoms or positive results to an antibodies screening test and at the end of observation.

A diagnosis of SARS-CoV-2 infection (by real-time reverse-transcriptase polymerase chain reaction or IgM and/or IgG antibody testing) in HCWs was considered the primary outcome. The proportion of events were reported as percentages, mean, and SD, or median with interquartile ranges (IQRs) were used to describe continuous variables with normal or skewed distribution, accordingly.

RESULTS

Among the 1193 children seen by the COVID-19 pediatric team, most of them were managed in telemedicine, 164 accessed the triage and 27 needed hospital admission because of moderate-to-severe clinical presentation or presence of underlying at risk conditions (mean duration of hospitalization: 9.1 ± 7.1 days). During their stay, all caregivers were tested for SARS-CoV-2, and 9 resulted positive to nasopharyngeal swab.

TABLE 1 Pediatric COVID-19 Unit Structure, Organization, and Prevention Measures

	Contaminated Area	Clean Area
Health care facilities	5 single rooms with anteroom (no negative pressure)	Meeting room
	Triage area	Storage room
	Undressing area	Dressing room
	Nurse station	Nurse Station
PPE	Respirator: FFP2[a] respirator or FFP3[a] during invasive or aerosol-inducing procedures[b]	Surgical mask
	Goggles and face shield	Disposable gloves
	Hair net	
	Double disposable gloves	
	Waterproof gown	
	Leg cover boots (not waterproof)	
Additional precautionary measures	Remote communication (walkie-talkie or mobile phones)	Social distancing[c]
	Dedicated medical devices in each patient's room (ie, stethoscope, pulse oximeter, or otoscope)	
	Patients (if tolerated) and caregivers wearing mask	
	Single caregiver for each patient	

FFP2, filtering facepiece 2; FF3, filtering facepiece 3.

[a] FFP2 provides 94% to 95% filter capacity, comparable to a N95 respirator, and FF3 provides 99% capacity, comparable to N99.

[b] Nasopharyngeal swab, high-flow oxygen delivery, suctioning of airway secretions, sputum induction, and nebulizer administration.

[c] Social distancing was defined by maintenance of a 3- to 6-feet distance between HCWs in the ward, warning for assemblies of people, and the use of web platform for journal meeting and case discussion, limiting ward access only to HCWs on duty.

Among the 23 HCWs involved in the study (15; 68% female; median age of 29 years; IQR: 26–36), 22 had a direct contact with patients. The median of monthly working days and workhours were 18 (IQR: 15–18) and 186 (IQR: 170–187) for each HCW.

During the study period, 920 procedures, 302 aerosol-producing procedures (ie, nasopharyngeal swab, high-flow oxygen delivery, suctioning of airway secretions, sputum induction, or nebulizer administration), and a total of 425.6 hours of exposure to SARS-CoV-2 (18.5 hours per HCW, on average) were recorded.

A total of 20 HCWs reported at least 1 issue during undressing procedures, including difficulties during the removal of leg cover boots ($n = 20$) or mask ($n = 3$), and 15 HCWs testified at least 1 issue in wearing the PPE during patient assistance, including neck-cover repositioning ($n = 10$) or mask fitting ($n = 7$).

The number of issues was directly related to the hours of exposure (Spearman's correlation: $r = 0.872$; P value $<.05$) and number of procedures ($r = 0.975$; P value $<.05$).

At the baseline serological evaluation (March 26), 1 nurse resulted IgG-positive (1.48 sample per cutoff; the reference value was <1.4). He reported a single-day history of headache and low-grade fever after traveling in a high-prevalence area (Lombardy region in Northern Italy) at the end of February, before the opening of the COVID-19 unit and notification of other regional cases.

At the first screening test (April 3), the positive result of IgG testing was confirmed, and another nurse resulted IgM- and IgG-positive. Both were totally asymptomatic and resulted negative to SARS-CoV-2 nasopharyngeal swabs performed the same day of rapid test screening. Of note, the 2 nurses do not share work shift but became housemates since the beginning of pandemic to prevent spreading the infection to family. Both eventually resulted positive to follow-up screening tests and showed a complete seroconversion with positive IgG test results (4.86 and 1.44 sample per cutoff) at week 5.

Because of the timing, house sharing, and demonstration of early seroconversion against SARS-CoV-2, it is likely that the index colleague could have been the source of infection for the secondary case.

The agreement between LIFA rapid tests and CLIA serology was excellent either at baseline or after 5 months of observation.

DISCUSSION

Children represent a source of SARS-CoV-2 infection for families and hospital personnel. In our experience, no case of intrahospital SARS-CoV-2 infection was observed. A single new infection was reported in an HCW who likely contracted SARS-CoV-2 outside the work setting, sharing a home with a previously infected colleague.

These findings suggest that the application of stringent prevention measures is effective in preventing intrahospital transmission in pediatric health care settings and social distancing and PPE need to be maintained, also, outside the patients' area.

TABLE 2 Monitoring of Procedures and HCWs' SARS-CoV-2 Infections

	Baseline Evaluation, *n* (%)	First mo, *n* (%)	Second mo, *n* (%)	Third mo, *n* (%)	Fourth mo, *n* (%)	Fifth mo, *n* (%)	Total
HCWs' exposure							
Total children	—	14 (7.3)	20 (10.5)	22 (11.5)	67 (35.1)	68 (35.6)	191[a]
Hospitalized children	—	10 (37)	6 (22.2)	2 (7.4)	2 (7.4)	7 (26)	27[a]
Triaged children	—	4 (2.4)	14 (8.5)	20 (12.2)	65 (39.6)	61 (37.2)	164
Children wearing mask	—	6 (4.3)	15 (10.9)	15 (10.9)	55 (39.9)	47 (34.1)	138[b]
Caregivers of admitted patients with positive results	—	2 (22.2)	1 (11.1)	0 (0)	2 (22.2)	4 (44.5)	9[a]
Caregivers wearing a mask	—	14 (7.4)	20 (10.6)	20 (10.6)	67 (35.6)	67 (35.6)	188[a]
Cumulative hours of exposure	—	116.8 (27.4)	195.7 (46)	7.4 (1.7)	15.7 (3.7)	90 (21.1)	425.6
Cumulative No. procedures	—	259 (28.2)	241 (26.2)	59 (6.4)	129 (14.0)	232 (25.2)	920
Aerosol-producing procedures	—	47 (15.6)	55 (18.2)	44 (14.6)	72 (23.8)	84 (27.8)	302
Medical visits	—	90 (29.3)	83 (27)	5 (1.6)	47 (15.3)	82 (26.8)	307
Issues with PPE	—	8 (47.1)	5 (29.4)	0 (0)	0 (0)	4 (23.5)	17
Issues with undressing procedures	—	16 (69.5)	4 (17.5)	0 (0)	0 (0)	3 (13)	23
SARS-CoV-2 infection monitoring of 23 HCWs[c]							
HCW with SARS-CoV-2 symptoms	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
HCW with positive IgM rapid test result (LIFA)[d]	—	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
HCW with positive IgG rapid test result (LIFA)	—	2 (8.6)	2 (8.6)	2 (8.6)	2 (8.6)	2 (8.6)	2
HCW with positive IgM serology test result (CLIA)[e]	0 (0)	—	0 (0)	—	—	0 (0)	0
HCW with positive IgG serology test result (CLIA)	1 (4.3)	—	2 (8.6)	—	—	2 (8.6)	2
HCW with positive RT-PCR test result on nasopharyngeal swab	—	—	0 (0)	0 (0)	—	—	0
Health care–associated SARS-CoV-2 infection	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0

RT-PCR, reverse transcriptase-polymerase chain reaction; —, not applicable.

[a] The sum of single cells is higher or lower than the total because some patients and caregivers had hospitalization longer than 1 wk.

[b] Seven children aged <2 y did not tolerate masks.

[c] Percentages were calculated on the total of HCWs monitored during the study.

[d] LIFA manufacture label (Screen Test COVID; Screen Italia Srl, Torgiano, Italy) declared sensitivity of 85% (IgM) and 100% (IgG) and specificity of 96% (IgM) and 98% (IgG).

[e] CLIA IgM (Snibe Diagnostic) sensitivity of 79% and specificity of 97.5 and CLIA IgG (Abbott, Abbott Park, IL) at 14 d of infection sensitivity of 100% and specificity of 99.6%.

The high rate of nosocomial contagiousness reported in institutions caring for children[5] might be related to different factors.

In the first months of the pandemic and in low-prevalence settings, the paucity of symptoms and the presence of extrarespiratory manifestations (ie, diarrhea, vomiting, abdominal pain, or skin rash) in pediatric age hampered an early identification of cases and enhanced SARS-CoV-2 transmission in hospital settings.[8,9]

Secondly, infants and young children, who usually do not wear or tolerate masks, largely contaminate the environment through crying or drooling, even in absence of respiratory symptoms.[4] In addition, the concomitant presence of caregivers (often infected) increase the risk of SARS-CoV-2 exposure.

The identification of controlled pathways for COVID-19 children and caregivers and stringent application of infection precautions reduced the transmission rate.

In a previous report in Northern Italy, 22 HCWs were infected in a pediatric ward, but <20% contracted SARS-CoV-2 infection after application of distancing and prevention measures. In a similar experience in highly exposed HCWs caring for adults in Hong Kong and the United States, none or few infections were reported.[10,11] The present report confirmed the effectiveness of infection control measures and proper use of PPE in protecting HCW in a pediatric setting.[12,13] However, the application of prevention measures, even more stringent than that recommended by the Centers for Disease Control and Prevention (ie, filtering facepiece 3 masking during all procedures and recommended neck covering or use of protective coveralls) might have had an impact on the lack of intrahospital SARS-CoV-2 infection reported in our study population.

The current study was conducted in a low COVID-19–prevalence scenario (~80 cases per 100 000 inhabitants), in which the contact with SARS-CoV-2 was substantially limited to clinical activities. In this setting, 2 nurses contracted SARS-CoV-2 infection asymptomatically. The first resulted positive before the opening of the COVID-19 unit, and, after a recent history of traveling in a high-prevalent region, and the second nurse showed a positive rapid serological test result during the first week of clinical activity when he was protected by PPE and exposed for ~30 minutes to a single patient who had tested positive.

Both SARS-CoV-2 IgM and IgG antibodies rapidly increase after 6 to 7 days from the symptom onset and reach 88% and 100% sensitivity on day 12, respectively.[14] Hence, it is highly likely that the second nurse contracted SARS-CoV-2 outside the work setting, sharing a home with the index case. However, although both resulted negative to nasopharyngeal swab, a transitory exposure of the rest of the personnel to SARS-CoV-2 may be plausible during the first week of work. In this scenario, the application of social distancing and PPE also outside the contaminated area avoided the infection spreading to other HCWs. Although exposed to a negligible risk of reinfection, both HCWs who showed positive serology results during follow-up continued to be included in the active surveillance and respected the protocols of prevention measures.

Finally, although outside our goal and despite our small sample size, with our report, we provide useful information about the screening measures applied to HCWs engaged in COVID-19. Active surveillance of HCWs changed over time during the pandemic period, according to the availability of diagnostic tests, research input, and the epidemiological scenario. The low sensitivity of SARS-CoV-2 rapid serological tests hamper their use as screening tool. However, we found a complete correspondence between rapid screening test and serology. In our experience, a surveillance system based on COVID-19–symptoms monitoring, a weekly rapid test, and nasopharyngeal swabs for personnel who were symptomatic or had positive screen results appeared to be an effective and affordable algorithm for HCWs screening.

The application of stringent preventive measures, also outside the area dedicated to patients' care, and protocols of active surveillance can effectively control infection spreading also in pediatric settings.

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