

COVID-19 outbreaks in hospital workers during the first COVID-19 wave

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Background	Health care workers (HCWs) are on the frontline, playing a crucial role in the prevention of infection and treatment of patients.
Aims	This study was aimed to evaluate the prevalence of hospital-acquired coronavirus disease 2019 (COVID-19) infection at work and related factors at the University Hospital of Trieste workers exposed to COVID-19 patients.
Methods	From March 1 to May 31, of 4216 employees, 963 were in contact with COVID-19 patients or colleagues and were followed up. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in nasopharyngeal swabs was determined every 3 days, by RT-PCR.
Results	During the follow-up period, 193 workers were positive for COVID-19 (5%), and 165 of these (86%) were symptomatic. We identified five major cluster outbreaks of COVID-19 infection in Trieste Hospitals, four of which occurred before the implementation of universal masking for HCWs and patients (1–14 March 2020). COVID-19 infection was significantly higher in high-risk ward workers (Infectious Diseases, and Geriatric and Emergency Medicine, odds ratio [OR] 13.4; 95% confidence interval [CI] 5.8–31), in subjects with symptoms (OR 5.4; 95% CI 2.9–10) and in those with contacts with COVID-19 patients and colleagues (OR 2.23; 95% CI 1.01–4.9).
Conclusions	Hospital workers were commonly infected due to contact with COVID-19 patients and colleagues, mainly in the first 15 days of the pandemic, before the implementation of universal mask wearing of HCWs and patients. Repetitive testing and follow-up permitted the identification of COVID-19 cases before symptom onset, obtaining better infection prevention and control.
Key words	COVID-19; epidemiology; health care workers.

Introduction

The novel coronavirus (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]), which started in China in December 2019, caused the coronavirus disease 2019 (COVID-19) pandemic, which has severely affected health care workers (HCWs). HCWs are on the frontline and play a crucial role in the prevention of infection and treatment of patients. They are subject to psychological distress and fatigue in addition to the high risk of infection during their work tasks in hospitals [1–5]. To prevent infections among HCWs, hospitals periodically tested all HCWs and implemented infection control measures to detect early cases and to reduce the

spread of infection to patients and colleagues [2]. HCWs can acquire the infection not only from patients but also from colleagues, when protection measures are reduced during meetings or coffee breaks [6].

The prevalence of HCWs tested positive for SARS-CoV-2 is ranging from approximately 10% (95% CI 5.3–14.9), but with symptoms milder than the general population [7], due to younger age compared to patients. Very little data are available for Italy, and the deep analysis of COVID-19 clusters in HCWs is crucial to understand the diffusion of the infection to prevent it [8].

The objective of this study was to report the epidemiological, clinical and laboratory characteristics of COVID-19 infections in HCWs at the University

Key learning points

What is already known about this subject:

- Health care workers are at higher risk of developing COVID-19 due to contact with positive patients.
- They have an important role to prevent the spread of the infection.

What this study adds:

- Contact tracing of cases and periodical screening of health care workers for SARS-CoV-2 RNA detection in nasopharyngeal swabs with reverse transcription-polymerase chain reaction techniques permitted the identification of new cases mainly before the onset of symptoms.
- During the follow-up period, 85% of health care workers developed symptoms, mainly involving the upper respiratory tract, and 15% remained asymptomatic.
- We identified five major cluster outbreaks of COVID-19 at the University Hospital of Trieste, four of which occurred in the first 2 weeks of March.

What impact this may have on practice or policy:

- Contact tracing and periodical screening of workers are crucial for reducing the spread of the infection.
- Source control is crucial also in non-COVID-19 departments.

Hospital of Trieste during the first outbreak of COVID-19 from 1 March to 31 May 2020, and to investigate the related factors.

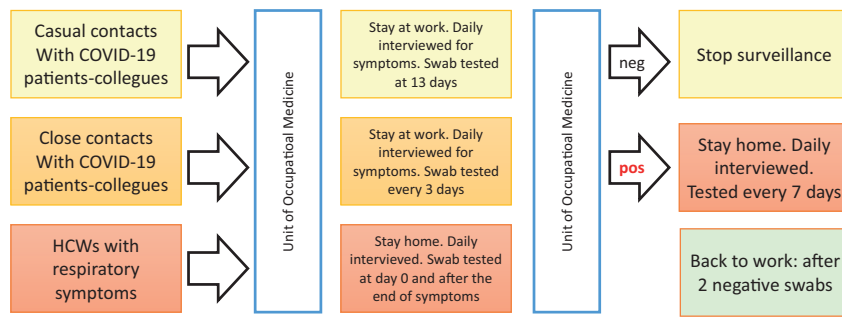
Methods

During the COVID-19 pandemic, the Unit of Occupational Medicine at the University Hospital of Trieste implemented infection prevention and control (IPC) measures involving specific surveillance for hospital workers and universal masking of all workers and patients. The use of personal protective equipment (PPE) was compulsory for the workforce according to the Istituto Superiore di Sanità Guidelines [9]. In case of exposure without suitable protection to a COVID-19 patient or colleague, the head nurse sent an e-mail describing the circumstances of the infection to the Unit of Occupational Medicine, which subsequently activated the surveillance protocol [9,10]. The workers received a phone interview to investigate primary and secondary contacts, and contacts were classified into close or casual contacts depending on exposure characteristics. Close contacts were defined according to the WHO guidelines: (i) face-to-face contact with a probable or confirmed case within 1 m and for at least 15 min, (ii) direct physical contact with a probable or confirmed case and (iii) direct care for patients with probable or confirmed COVID-19 without the use of recommended PPE. [9,11] Casual contacts were defined when an HCW had been exposed to a COVID-19 patient without matching the definition for close contact. According to Italian regulations, asymptomatic exposed staff were allowed to continue working and were advised to wear surgical masks at work as well as at home. If the patient was symptomatic or positive for SARS-CoV-2 detection in nasopharyngeal and oropharyngeal swabs by reverse transcriptase-polymerase chain reaction (RT-PCR), they were immediately restricted

from work. Close contacts had to monitor and report body temperature twice a day and were interviewed daily to verify their health status. They were swab tested every 3 days from contact time. Casual contacts were interviewed daily to verify their health status, and they had to monitor and report their body temperature twice a day and underwent a swab test 13 days after contact (Figure 1). In case of symptom onset, HCWs were immediately tested, stopped working and remained quarantined at home with daily monitoring by phone call. In case of worsening of existing symptoms, they had to contact their general practitioner or the emergency number to be admitted to the hospital where appropriate. Upper respiratory tract symptoms were defined as sore throat, anosmia, loss of taste and cough. Lower respiratory tract symptoms were defined as cases of dyspnoea, bronchitis or pneumonia. Nasopharyngeal and oropharyngeal specimens were collected using the swab technique by Occupational Medicine Unit staff, and RNA was extracted and determined by RT-PCR targeting the E, N and RdRp genes of SARS-CoV-2 according to the Centers for Disease Control and Prevention (CDC) and Charité laboratory protocols [12]. The cycle threshold values of RT-PCR were used as indicators of viral load of SARS-CoV-2 RNA, with lower cycle threshold values corresponding to higher viral copy numbers. A cycle threshold value of less than 30 was considered positive for SARS-CoV-2 RNA.

Data analysis was performed using STATA™ software (version 14.0; Stata Corp., LP, College Station, TX, USA).

Categorical data were cross-tabulated into $k \times k$ contingency tables and statistically tested using the chi-squared test. Continuous data were reported as mean and standard deviation and statistically tested using the Kruskal–Wallis test. COVID-19 as an outcome was analysed by univariate logistic regression analysis, with sex,



Definitions

Close contacts: face-to-face contact with a probable or confirmed case within 1 meter and for at least 15 minutes; direct physical contact with a probable or confirmed case; direct care for a patient with probable or confirmed COVID-19 disease without the use of recommended PPE

Casual contacts: a person that can't be considered close contact but had had a possible exposure to a COVID-19 patient

Respiratory symptoms: those with any respiratory symptoms or other symptoms that could be related to COVID-19 infection

Figure 1. Layout of the study and definitions used.

age (as a continuous variable), occupation (residence, nurse, nurse aid, others and physician as reference), wards (high risk, medium risk and low risk as reference), contacts (with HCWs, with patients and HCWs, contact of contact with patients as reference), use of PPE, comorbidity and symptoms as independent variables. Factors associated with COVID-19 infection in univariate logistic regression analysis were investigated using multivariate regression analysis. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated from the coefficients and standard errors of the logistic regression. Workers with missing data for relevant variables were excluded from the analysis. A P value of <0.05 was established as the limit of statistical significance.

The local Ethical committee approved the study (CEUR- 2020-Os-072) on 16 March 2020.

Results

Nine hundred and sixty-three of 4216 HCWs employed in Trieste University Hospitals reported exposure to patients and/or colleagues known to have COVID-19 between 1 March and 31 May 2020. Their main characteristics are presented in Table 1. One hundred and ninety-three (5%) were COVID-19 confirmed cases. Of the 193 positive HCWs, 165 (86%) were symptomatic, with a median (interquartile range [IQR]) time from contact to symptom onset of 4 (2–8) days. HCWs with SARS-CoV-2 had different job titles, mostly nurses and physicians, and the vast majority were employed in medical wards. Of the symptomatic positive cases, 114 (69%) were female, with a mean (SD) age of 43 (11.2) years. Instead, the percentage of females (n) and the mean (SD) age appeared slightly lower among asymptomatic infected subjects (61% [$n = 17$] and 39.5 [11.8] years). Most affected subjects had contact with an infected patient ($n = 103$; 53%), 32 reported exposures

only to colleagues (17%), 51 to both patients and colleagues (26%), and 7 to casual contact or contact with COVID-19 cases (4%). Most cases reported the use of PPE ($n = 172$; 89%): 101 (52%) wearing surgical masks and 71 (37%) wearing FFP2 or FFP3 masks, in accordance with safe routine procedures [9,13]. We identified five major cluster outbreaks of COVID-19 infection at the University hospital of Trieste, four of which occurred before implementation of universal masking of HCWs and patients (1–14 March 2020) (Figure 2). The first cluster of exposure occurred on 6 March 2020, in a Geriatric ward, at which time both HCWs and patients were without masks. The second and third clusters of contacts occurred in two internal medicine wards, where two other patients not suspected of having SARS-CoV-2 infection were admitted. At that time, the PPE was used, but HCWs did not wear masks during meetings and breaks. The fourth cluster was in Infectious Diseases ward, and the infection spread among co-workers during meetings. Finally, the fifth cluster of exposure occurred after implementation of universal masking and compliance with IPC measures in the Emergency Medicine ward (EMW). On 10 April 2020, a patient who underwent two consecutive negative RT-PCR tests over 24 h was admitted to the EMW, but a few days after he complained of fever $>37.5^{\circ}\text{C}$ and respiratory symptoms. Thus, the patient was tested again, and the test yielded positive results. The closure of the EMW was planned for 15 days, as the infection had largely spread among personnel. In that case, only the surgical mask was used during intubation of the patient. In total, 59% ($n = 114$) of the positive cases occurred within these five major cluster outbreaks at the University hospital of Trieste. The COVID-19 spread in the remaining hospital departments was much more prevalent, with some sporadic cases in other medical wards and very few cases in surgical wards (Figure 3).

Table 1. Main characteristics of 963 HCWs reporting contacts with COVID-19 patients and/or colleagues at the University Hospital of Trieste

	SARS-CoV-2 negative		SARS-CoV-2 positive		Total	P
	Asymptomatic	Symptomatic	Asymptomatic	Symptomatic		
<i>n</i> (%)	665 (69)	105 (11)	28 (3)	165 (17)	963	
Age (years), mean (SD)	44.3 (12)	45.7 (10)	39.5 (12) ^c	43 (11)	44 (12)	0.04
Women, <i>n</i> (%)	467 (70)	82 (78)	17 (61)	114 (69)	680 (71)	NS
Characteristics of contact, <i>n</i> (%)						
With patients	240 (36)	45 (43)	16 (57)	87 (53)	388 (40)	0.000
With colleagues	113 (17)	30 (27)	5 (18)	27 (16)	175 (18)	
With both	11 (2)	17 (16)	5 (18)	46 (28)	79 (8)	
Contact of contact or casual contact	301 (45)	13 (12)	2 (7)	5 (3)	321 (33)	
Occupation, <i>n</i> (%)						
Physician	174 (26)	18 (17)	14 (14)	40 (24)	236 (25)	NS
Resident ^a	38 (6)	7 (7)	1 (4)	13 (8)	59 (6)	
Nurse	283 (43)	46 (44)	13 (46)	72 (44)	414 (43)	
Nurse aid	81 (12)	16 (15)	4 (14)	26 (16)	127 (13)	
Other ^b	89 (13)	18 (17)	6 (21)	14 (8)	127 (13)	
Use of PPE, <i>n</i> (%)						
Surgical mask	642 (96)	78 (74)	27 (96)	145 (88)	892 (93)	0.000
FFP2/FFP3 mask	8 (1)	5 (6)	12 (44)	59 (41)	84 (9)	
Start of symptoms after contact (days), median (IQR)						
Asymptomatic	–	4 (2)	–	4 (3)	4 (3)	NS
Symptoms, <i>n</i> (%)						
Upper respiratory tract	–	82 (78)	–	128 (78)	210 (78)	NS
Cough	–	52 (49)	–	70 (43)	122 (45)	NS
Loss of smell and taste	–	7 (7)	–	67 (41)	74 (27)	0.000
Lower respiratory tract	–	1 (1)	–	14 (8)	15 (6)	0.008
Fever >37.5°C	–	36 (34)	–	85 (52)	121 (45)	0.006
Diarrhoea	–	19 (18)	–	13 (8)	32 (12)	0.001

NS, non-significant.

^aPhysician during postgraduate course.^bTechnicians and clerks.^cKruskal–wallis test.

Of the 193 positive cases, 128 (78%) had limited, mild upper respiratory tract symptoms, while 14 (9%) suffered from a more severe disease with lower respiratory tract symptoms, which were observed significantly more often in COVID-19 HCWs ($P < 0.05$), as well as loss of smell and taste ($P < 0.05$), and fever $>37.5^{\circ}\text{C}$ ($P < 0.05$), compared to symptomatic SARS-CoV-2-negative workers (Table 1). No one died. Factors associated with COVID-19 infection are reported in Table 2, using univariate and multivariate regression analyses. ORs were higher for workers employed in high-risk wards (Infectious Diseases, Geriatric and Emergency Medicine, OR 13.4; 95% CI 5.8–31), subjects with symptoms (OR 5.4; 95% CI 2.9–10), and those with contacts with COVID-19 patients and colleagues (OR 2.23; 95% CI 1.01–4.9). Compliance with the use of PPE was high in COVID-19 HCWs (OR 3.7; 95% CI 1.6–8.2).

Discussion

We investigated the COVID-19 first outbreak among HCWs that occurred at the University Hospital of Trieste

(northeastern Italy). Between 1 March and 31 May 2020, the Trieste Hospital surveillance system was notified of 963 workers who reported contact with COVID-19 patients and/or colleagues. Among such contacts, 193 cases were COVID-19 confirmed, representing 4.6% of all occupied workers in our hospital and 14% of total COVID-19 cases in the province of Trieste as of May 31 [14]. The incidence of the infection in the general population in Trieste was 59 cases/10 000 inhabitants from 1 March 2020 to 31 May 2020 [14].

Higher prevalence of infected HCWs was observed in the USA, with 19% of COVID-19 cases among HCWs registered by CDC [15], and 9.6% by Los Angeles County Department of Public Health [16]. In a recent meta-analysis, Sahu *et al.* [7] reported a prevalence of infection of 10.1% (CI 95% 5.3–14.9). In general, western countries reported higher values of COVID-19 infection in HCWs than in Chinese data [17], probably because in the first period of the pandemic, the diffusion of infection was underestimated between HCWs and risk perception was lower in western countries, probably due to less experience with the diffusive virus epidemic.

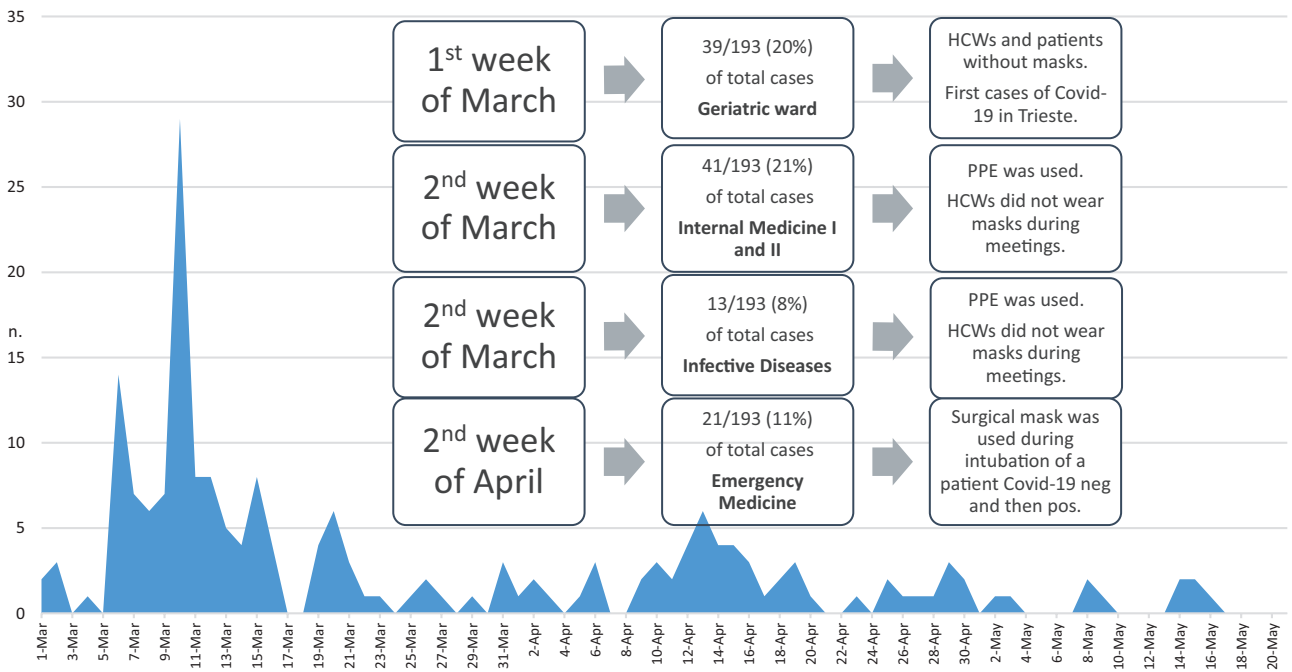


Figure 2. Time trends in hospital contacts among positive HCWs from March 1 to the end of May, 2020.

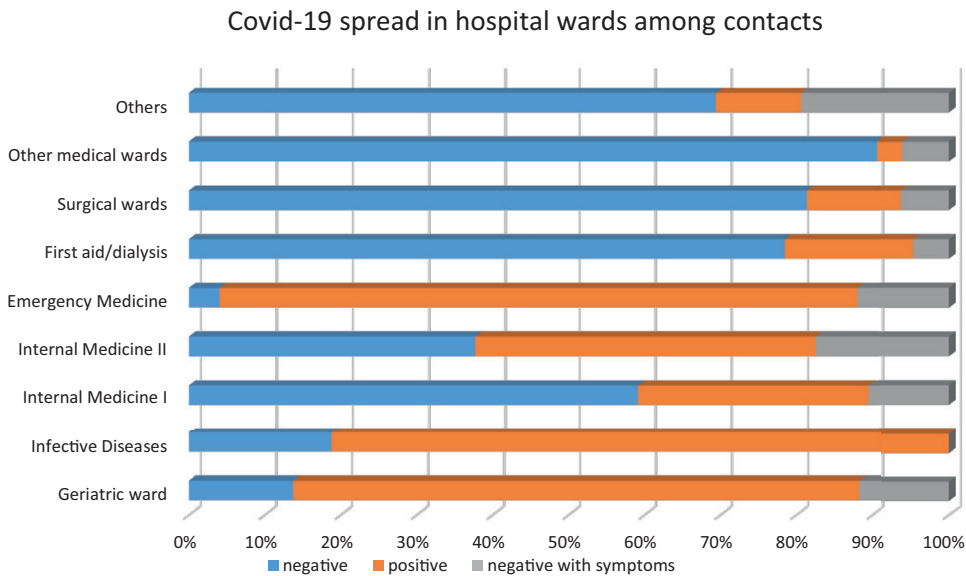


Figure 3. COVID-19 spread in different hospital wards among HCWs with exposure to positive patients and/or colleagues.

Our data on the prevalence of infection in HCWs are similar to those reported in Milan hospitals (4.2–5.3% in HCWs) in which all workers with close contacts were screened as in our study [8]. However, in a study conducted in a Madrid hospital [18], only symptomatic workers were screened, and the prevalence of infection was 11%. These data suggest that symptom-based screening does not permit a quick identification of infected people, resulting in the spread of infection [19].

The analysis of the clusters of COVID-19 infections that occurred during the lockdown in Italy revealed that more than 50% of cases were found in five

wards, mainly in the first 2 weeks of March. The spread of infection was due to the lack of protective measures with patients initially tested negative for SARS-CoV-2 or during meetings and coffee breaks with colleagues. Universal masking for HCWs and patients was implemented after half of March, but patients with respiratory symptoms were allowed not to wear a mask. This is what happened in the last cluster in EMW, in which patients that were COVID-19 positive did not wear a mask, while HCWs wear surgical masks, not enough to be protected against SARS-CoV-2 spread. During the first 14 days of March, awareness of the novel biological

Table 2. Univariate and multivariate logistic regression analysis of factors involved in COVID-19 positivity in HCWs

	Univariate analysis OR (95% CI)	Multivariate analysis OR (95% CI)
Age	0.98 (0.99–0.99)	0.98 (0.96–1.01)
Men versus women	1.14 (0.75–1.7)	1.69 (0.9–3.2)
Occupation		
Physician	1	
Resident ^a	1.36 (0.78–2.69)	
Nurse	1.12 (0.75–1.69)	
Nurse aid	1.39 (0.83–2.35)	
Other ^b	1.01 (0.6–2.00)	
Wards		
Low risk: surgical and medical wards	1	1
Medium risk: Internal Medicine I and II	4.6 (2.9–7.2)	1.88 (0.97–3.6)
High risk: Infectious Diseases, Geriatric and Emergency Medicine	30.8 (17.0–53.2)	13.4 (5.8–31.0)
Contacts		
With patients	1	1
With HCWs	0.62 (0.4–0.96)	1.39 (0.64–3.0)
With both	5.13 (3.1–8.6)	2.23 (1.01–4.9)
Contact with contact or causal contacts	0.61 (0.03–0.13)	1.40 (0.28–6.9)
Use of PPE	2.9 (1.63–5.1)	3.7 (1.6–8.2)
Use of N95 mask	7.8 (4.0–15.2)	
Comorbidity	0.88 (0.31–2.51)	
Symptoms	37.3 (23.8–58.5)	5.4 (2.9–10.0)
Lower respiratory symptoms	9.7 (1.26–74.9)	
Fever >37.5°C	2.03 (1.26–74.9)	
Cough	0.76 (0.46–1.2)	
Loss of smell and taste	9.7 (4.2–22.1)	
Diarrhoea	(0.18–0.83)	

Significant associations are highlighted in bold.

^aPhysician during postgraduate course.

^bTechnicians and clerks.

hazard and hospital masking policies were limited. Thus, improper use of PPE, especially during HCW meetings, was found to play a crucial role in the amplification of early outbreaks among co-workers. Moreover, the use of proper PPE and disinfection habits need to be associated with efficient ventilation to ensure good air quality in the workplace [20].

In addition, exposure to infected colleagues may be another reason for the infection of SARS-CoV-2 in HCWs. Sporadic spread was observed in other medical departments, and few infected HCWs were found in surgical wards. Interestingly, there were no cases that originated from the COVID-19 wards (excluding the accident in the Infectious Diseases ward) or intensive care units, showing better adherence to IPC measures and use of contact and droplet precautions by HCWs caring for patients with SARS-CoV-2.

Investigations among infected HCWs in China suggest that COVID-19 was predominantly acquired in the community within the household [21]. The proper preparedness of Oriental countries mindful of the previous SARS and Middle East respiratory syndrome coronavirus outbreaks seems to have significantly contributed

to better prevention and management of COVID-19 infection in health care settings [22,23].

In addition, the data recording process and the classification of occupational and non-occupational diseases may also explain some differences found in the proportion of HCWs infected by COVID-19 in Italy compared to Oriental countries [24].

Finally, it is very likely that the number of infected HCWs at the University Hospital of Trieste was due to the execution, based on an accurate contact tracing, of a large number of swab tests, resulting in the diagnosis of many pauci-symptomatic and asymptomatic subjects.

Sex-based differences in COVID-19 infection are known, and men are more likely to be affected and experience severe symptoms than women [25]. At the University Hospital of Trieste, male HCWs affected by SARS-CoV-2 were 32% ($n = 62$), higher than expected considering that they represent the 25% of the health care workforce.

The accurate surveillance activities put in place at the University Hospital of Trieste led to the identification of 128 (78% of symptomatic positive cases) who had limited, mild upper respiratory tract symptoms. A significant number of COVID-19 HCWs suffered from fever

>37.5°C (52%) and loss of smell and taste (41%), and few subjects had lower respiratory tract symptoms (9%) and diarrhoea (8%), in agreement with other investigations [26]. Our data strongly emphasize the importance of paying attention to symptoms such as fever and loss of smell and taste that are often the first or only ones present. However, 28 (15%) infected HCWs did not show any typical symptoms of SARS-CoV-2.

One of the first studies conducted on health workers in Italian hospitals observed that 44% of the infected workers had no fever or respiratory symptoms, and approximately one in three of the HCWs who tested positive never manifested any symptoms [27].

Pre-symptomatic and asymptomatic transmission contributes to the pandemic and symptom screening alone is not sufficient to identify individuals with COVID-19 [8].

The time between exposure to COVID-19 and the moment when symptoms start is commonly around 4–5 days but can range from 1 to 14 days [28], which is perfectly in line with our finding (median time of 4 days with an IQR of 2–8 days).

The time-trend analysis of contacts and cases onset showed a progressive improvement in the spread of nosocomial infections after the identification of the early four main clusters. Most transmission of COVID-19 occurred before the implementation of universal masking of HCWs and patients (1–14 March 2020), and largely among personnel employed in medical wards. Active surveillance also allowed 105 (38.9%) symptomatic HCWs to return to work as they tested negative for SARS-CoV-2, thus reducing workforce depletion.

Some limitations of our study need to be noted. First, it is possible that an initial unclear definition of contact, in addition to the fear of contagion, led to a large number of subjects reporting exposure; therefore, our results may be affected by selection bias. Second, the progressive reduction in HCW infections can be related to better adherence to protective measures, but also to a progressive decrease in COVID-19 infections in the general population.

Despite these potential limitations, our study aimed to provide the epidemiological, clinical and laboratory characteristics derived from the surveillance data of HCWs in Trieste Hospital during the COVID-19 outbreak in order to improve the IPC measures in health care settings. Accurate contact tracing and active surveillance allowed the isolation of a large number of HCWs who had initially acquired the infection because of an inadequate risk perception [29], and therefore to reduce the insidious spread from asymptomatic or mild cases. Finally, the incidence of COVID-19 infection in our HCWs decreased before the decline in the general population.

Universal mask wearing, when implemented together with strict employee surveillance and contact tracing, reduced nosocomial transmission of SARS-CoV-2 and strengthened the health care workforce. Disinfection

procedures, use of other PPE, and proper ventilation of workplaces can further contribute to reducing the onset of COVID-19 clusters in HCWs.

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Competing interests

None declared.

Data availability

The data underlying this article are available on request.

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