SARS-CoV-2 infection in healthcare personnel with high-risk occupational exposure: evaluation of seven-day exclusion from work policy

Helena C. Maltezou[1], Xanthi Dedoukou[2], Maria Tseroni[1], Evi Tsonou[3], Vasileios Raftopoulos[4], Kalliopi Papadima[5], Elisavet Mouratidou[5], Sophia Poufta[1], George Panagiotakopoulos[2], Dimitrios Hatzigeorgiou[6], Nikolaos Sipsas[7]

[1]Directorate of Epidemiological Surveillance and Interventions for Infectious Diseases, [2]National Public Health Organization, Athens; [3]Department of Cardiovascular Diseases, Directorate of Non-Communicable Diseases, National Public Health Organization, Athens; [4]Department of HIV Surveillance, National Public Health Organization, Athens; [5]Department for Respiratory Infections, Directorate for Epidemiological Surveillance and Interventions for Infectious Diseases, Athens; [6]Medical Directorate, Hellenic Air Force General Staff, Athens; [7]Pathophysiology Department, Medical School, National and Kapodistrian University of Athens, Athens, Greece

Correspondance: Dr. Maltezou, Directorate for Epidemiological Surveillance and Interventions for Infectious Diseases, National Public Health Organization, 3-5 Agrafon Street, Athens, 15123 Greece; Tel: 30-210-5212-175; E-mail address: helen-maltezou@ath.forthnet.gr

Summary: HCP with occupational high-risk exposure to COVID-19 were at increased risk for serious morbidity, healthcare seeking, hospitalization and absenteeism. Our findings justify the seven-day exclusion from work policy for HCP with high-risk exposure.

ABSTRACT

Background. Starting in late February 2020, Greece is experiencing a coronavirus disease 2019 (COVID-19) epidemic. Healthcare personnel (HCP) were disproportionately affected, accounting for approximately 10% of notified cases. Exclusion from work for 7 days was recommended for HCP with high-risk occupational exposure. Our aim was to evaluate the 7-day exclusion from work policy for HCP with high-risk exposure.

Methods. HCP with a history of occupational exposure to COVID-19 were notified to the Hellenic National Public Health Organization, regardless of their exposure risk category. Exposed HCP were followed for 14 days after last exposure.

Results. We prospectively studied 3398 occupationally exposed HCP; nursing personnel accounted for most exposures (n=1705; 50.2%). Of the 3398 exposed HCP, 1599 (47.1%) were classified as low-risk, 765 (22.5%) as moderate-risk, and 1031 (30.4%) as high-risk exposures. Sixty-six (1.9%) HCP developed COVID-19 at a mean of 3.65 days (range: 0-17 days) post-exposure. Of the 66 HCP with COVID-19, 46, 7, and 13 had a history of high-, moderate- or low-risk exposure (4.5%, 0.9%, and 0.8% of all high-, moderate-, and low-risk exposures, respectively). Hospitalization and absenteeism were more prevalent among HCP with high-risk exposure. A logistic regression analysis showed that the following variables were significantly associated with an increased risk for the onset of COVID-19: male, administrative personnel, underlying disease and high-risk exposure.

Conclusion. HCP with high-risk occupational exposure to COVID-19 had increased probability of serious morbidity, healthcare seeking, hospitalization and absenteeism. Our findings justify the 7-day exclusion from work policy for HCP with high-risk exposure.

Keywords: SARS-CoV-2; COVID-19; healthcare personnel; exposure; occupational

INTRODUCTION

In December 2019 a novel coronavirus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerged in China and subsequently spread globally causing a pandemic of a respiratory disease named coronavirus disease 2019 (COVID-19) [1]. In Greece the first laboratory-confirmed case was detected on February 26, 2020, followed by a moderate epidemic with a toll of 2903 notified cases and 173 deaths as of May 27, 2020 [2]. In this context, healthcare personnel (HCP) were disproportionately affected, accounting for approximately 10% of notified cases (unpublished data). Hereby, we evaluate a 7-day exclusion from work policy for HCP with high-risk occupational exposure to a COVID-19 case.

METHODS

The healthcare system during the COVID-19 epidemic

In Greece there are 224 hospitals (public, private, and military) and 289 primary healthcare centers. Among them, 13 tertiary-care hospitals and one pediatric hospital have been designated as COVID-19 referral hospitals.

Infection control

Triage for prompt detection and isolation of COVID-19 cases was implemented in all healthcare facilities (HCFs). A surgical mask was offered to the patients with symptoms compatible with COVID-19 upon entering a HCF. The following personal protective equipment (PPE) was recommended for HCP caring for suspected or laboratory-confirmed COVID-19 cases: filtering face piece respirator (FFP)-2, non-sterilized single-use gloves, goggles or face shield, and gown resistant to fluid penetration. A FFP3 respiratory mask was recommended for HCP performing aerosol-generating procedures. In case of PPE shortages, HCP were advised to wear a surgical mask during the healthcare of a COVID-19 case, in order to preserve FFP2 respiratory masks for aerosol-generating procedures (intubation, extubation, tracheotomy, cardiopulmonary resuscitation, non-invasive mechanical ventilation, bronchoscopy, nebulization.). Handling of samples, management of apparel and waste, cleaning and disinfection were performed in accordance with the World Health Organization (WHO) and the European Centre for Disease Control and Prevention (ECDC) guidelines [1,3].

Study design

This was a prospective, observational study in a cohort of HCP with a history of occupational exposure to a COVID-19 case.

Contact tracing and risk assessment

Contact tracing and risk assessment of exposed HCP were performed by the Infection Control Committees of each HCF. In particular, the characteristics of contact (distance and duration), the performance of aerosolized-generating procedures (e.g. intubation) and the use of PPE by exposed HCP were considered. Exposed HCP were assessed using five scenarios of PPE use, considering also the use (or not) of a surgical mask by the COVID-19 case (ten scenarios in total) (Table 1). Exposures were categorized as high, moderate or low risk. HCP with occasional, no direct contact with a COVID-19 case or his secretions, were considered as not being at risk for infection.

Management of exposed HCP

The guidelines for the management of occupationally exposed HCP per risk category are shown in Table 2. In summary, HCP with high-risk exposure were excluded from work for seven days and self-isolated, while HCP with moderate-risk or low-risk exposure continued to work. HCP with high-risk or moderate-risk exposure were followed actively for the onset of symptoms on a weekly basis for 14 days after the last exposure to the COVID-19 case. HCP with low-risk exposure were recommended to report the onset of any symptom until 14 days after their last exposure. Exposed HCP, regardless of risk category, were offered testing for COVID-19 by reverse-transcriptase polymerase chain reaction (RT-PCR) in case of onset of fever and/or respiratory symptoms. Although testing of asymptomatic HCP was officially recommended only for those working in high-risk settings (transplantation units, hematology-oncology units, intensive care units), this was a common practice in many HCFs, regardless of exposure-risk category or working setting. HCP with laboratory-confirmed SARS-CoV-2 infection, regardless of onset of symptoms, were contacted through telephone call a week before the submission of the article, in order to verify their outcome. Besides

the issuance of the national guidelines, as depicted in Tables 1 and 2, and the follow-up of exposed HCP, the Hellenic National Public Health Organization had no involvement in the management of exposed HCP on-site.

Definitions

HCP were defined as all persons employed in HCFs, regardless of direct contact with patients or biological specimens. HCFs were defined as structures where healthcare services are provided. A COVID-19 case was defined as a person with compatible symptoms and a positive SARS-CoV-2 RT-PCR. Fever was defined as a temperature of $\geq$38.0^{o}C twice within 24 hours. Febrile episode was defined as fever only. Acute respiratory infection (ARI) was defined as the onset of at least one respiratory symptom (e.g. cough, sore throat, dyspnea). Pneumonia was defined as the onset of respiratory infection in a patient with radiographic or computer tomography (CT) findings compatible with pneumonia. Healthcare seeking was defined as any healthcare visit related to fever and/or respiratory symptom. Occupational exposure of HCP to COVID-19 was defined as the exposure to a COVID-19 case within the HCF. Healthcare-associated transmission of COVID-19 was defined as a case of COVID-19 in a HCP following occupational exposure. Close contact was defined as a contact of > 15 minutes within a distance of < 2 meters with a COVID-19 case or his respiratory secretions without wearing the complete set of appropriate PPE. Absenteeism was defined as absence of a HCP from work duties due to symptoms or due to isolation purposes (quarantine).

Data collection

The study period extended from March 13 (first day of protocol implementation) to May 3, 2020 (last day of lockdown in Greece). Data about contact tracing, risk assessment, and management of HCP exposed to COVID-19 cases in a HCF during the

study period were collected prospectively using one form per source of exposure. Data about the onset of symptoms, SARS-COV-2 testing and diagnosis, imaging tests (chest radiography and/or CT), hospitalization, absenteeism, and outcome of exposed HCP were also recorded. Only HCP exposed to a laboratory-confirmed case of COVID-19 were included. Cases of exposure in the community were excluded.

Statistical analysis

All study subjects were coded and scored, and the completed forms were included in the data analysis set. Statistical analysis was performed using IBM-SPSS 26 (IBM Corp. Released 2016). Descriptive statistics were used. Means and standard deviations were calculated for each continuous variable. The chi-squared test was applied to explore the existence of a statistically significant relationship between the categorical variables. The student's t-test was used to assess whether the means of the two groups were statistically different from each other, while ANOVA with post-hoc Bonferroni test (in case of equal variances) or Dunnett's test (in case of non-equal variances) were applied for the three groups (low-, moderate- and high-risk exposures). A $p<0.05$ was considered to indicate statistical significance in all analyses. Logistic regression analysis (stepwise approach) has been used twice to explore the factors that are associated with an increased probability for SARS-CoV-2 infection and for COVID-19. The equation included the following variables: gender, age, HCF category, profession, underlying disease, and exposure risk category (low-, moderate- or high-risk exposure). Odds ratio (OR) and confidence intervals (CIs) were estimated.

Ethical issues

The study was approved by the Board of Directors of the Hellenic National Public Health Organization (Athens, Greece). The study was considered as public health action to guide the management of exposed HCP. Written consent was not required, given that

the data were collected within the frame of epidemiological surveillance. Data were managed in accordance with the national and European Union laws.

RESULTS

During the study period, 88 HCFs (66 hospitals, 20 primary healthcare centers, and two private laboratories) notified a total of 3398 HCP with a history of occupational exposure to a COVID-19 case. The vast majority of the exposed HCP (2833 HCP; 83.4%) worked in hospitals and particularly in internal medicine departments (1368 HCP; 40.2%). In terms of HCP profession, nursing personnel accounted for most exposures followed by physicians [1705 (50.2%) and 1079 (31.7%), respectively]. The overwhelming majority of HCP were exposed either to a patient with COVID-19 (1725 exposures; 50.8%) or another HCP with COVID-19 (1660 exposures; 48.8%). Overall, there were 239 sources of exposure and a median number of 14 exposed HCP per source of exposure (range: 1-113 exposed HCP).

Of the 3398 occupationally exposed HCP, 1599 (47.1%) were classified as low-risk exposures, 765 (22.5%) as moderate-risk exposures, and 1031 (30.4%) as high-risk exposures. Table 3 shows the characteristics of exposed HCP per risk category. No prophylaxis has been administered.

Table 4 summarizes the findings of post-exposure follow-up among the 3398 HCP. A total of 755 (22.2%) HCP developed at least one symptom. HCP with high-risk exposure more frequently developed symptoms compared with HCP with moderate- or low-risk exposure (31,9%, 22.6%, and 15.8%, respectively; p-value <0.001). The most common symptoms were fever (24.8%), headache (21.1%) and cough (19.1%). Overall, 53 of the 755 symptomatic HCP sought healthcare. HCP with

high-risk exposure more frequently sought healthcare compared with HCP with moderate- or low-risk exposure (2,4%, 1.7%, and 0.9%, respectively; p-value = 0.01).

Of the 755 symptomatic HCP, 454 (60.1%) were tested by RT-PCR and 66 (8.7% of HCP with symptoms) tested positive. Of the 66 HCP with COVID-19, 46 (69.7%) had a history of high-risk exposure (4.5% of all high-risk exposures), 7 (10.6%) had a history of moderate-risk exposure (0.9% of all moderate-risk exposures), and 13 (19.7%) had a history of low-risk exposure (0.8% of all low-risk exposures) (p-value<0.001). In terms of timing, 60 (90.9%) of the 66 COVID-19 cases occurred by the end of the first week post-exposure. In particular, the mean onset date of symptoms was 3.65 $\pm$ 3.31 days (median: 3 days) following the last exposure (range: 0 to 17 days). Only one case occurred beyond 14 days. Of the 66 HCP with COVID-19, 16 (24.2%) had pneumonia. In total, 13 (0.4%) COVID-19 cases among 3398 HCP were hospitalized; none died. Hospitalization and absenteeism were more prevalent among HCP with high-risk exposure compared with HCP with moderate- or low-risk exposure (0.8%, 0.4%, and 0.1%, respectively; and 74.8%, 39.6%, and 21.3%, respectively; p-value<0.001 for both comparisons).

Overall, 1594 HCP (46.9%) were tested for SARS-CoV-2 infection regardless of symptoms and 76 (4.8%) were tested positive. HCP with a history of high-risk exposure more frequently were tested positive (5%, 1%, and 1%, respectively; p-value <0.001).

A logistic regression analysis showed that the following variables were significantly associated with an increased probability for COVID-19: male gender (OR=1.82, CIs=1.04-3.20; p-value=0.036), underlying disease (OR=9.29, CIs=4.13-20.91; p-value <0.001), administrative personnel (OR=3.06, CIs=1.43-6.55; p-value=0.004), and a history of high-risk exposure (OR=6.35, CIs=3.09-13.05; p-value

<0.001). The overall percent of COVID-19 cases that were correctly predicted by the logistic regression model was 91%. The explained variation in the dependent variable was 14.43% (Nagelkerke R^2). Similarly, the following variables were significantly associated with an increased probability for testing positive for SARS-CoV-2 infection: male (OR=1.79, 95% CIs= 1.03-3.13; p-value=0.039), underlying disease (OR=9.20, 95% CIs=3.92-21.61; p-value <0.001), administrative personnel (OR=3.34, 95% CIs=1.49-7.49; p-value=0.003), and a history of high-risk exposure (OR=3.58, 95% CIs=1.94-6.58; p-value <0.001). The overall percent of cases that were correctly predicted by the logistic regression model was 74.3% and the explained variation in the dependent variable was 12.7% (Nagelkerke R^2).

DISCUSSION

COVID-19 is easily transmitted through respiratory droplets and direct contact. Infection control is challenging because asymptomatic and presymptomatic persons can also contribute to transmission [4,5], while the highest viral load is estimated near the onset of symptoms [6]. In addition, SARS-CoV-2 remains viable in aerosols for up to three hours and on various surfaces for several days [7,8]. HCP have been recognized as a high-risk group for occupational infection [4,9-14], similarly to severe acute respiratory syndrome (SARS) virus and Middle East respiratory syndrome (MERS) virus [15-17]. Transmission of SARS-CoV-2 has been well documented in many healthcare settings [4,9,10].

This was a prospective, observational study of a cohort of 3398 HCP who had been potentially exposed to COVID-19 in their workplace. We evaluated the 7-day exclusion from work policy for HCP with high-risk exposure. The adoption of this policy was driven by the increasing pressure of the

epidemic on our healthcare system [18], but also by the shortages in HCP, following a decade of austerity policies in Greece [19]. The available published evidence of a mean incubation period of COVID-19 of approximately 5 days was considered [20,21].

Our study clearly showed that a history of high-risk occupational exposure to COVID-19 significantly increased the onset of various symptoms, ARI and serious morbidity within 14 days post-exposure, as indicated by the increase of healthcare seeking, hospitalization, and diagnosis of SARS-CoV-2 infection, compared with HCP with low- or moderate-risk exposure. Indeed, HCP with high-risk exposure were more than six-times more likely to develop COVID-19 compared with other risk groups. Similarly, in a United States hospital, of 121 exposed HCP, 43 (35.5%) developed symptoms during the 14-day follow-up and three were tested positive [9]. Two of the affected HCP did not wear a mask which underscores the increased transmission risk with prolonged, unprotected contact with a COVID-19 patient [9].

High-risk exposure also had a negative impact on the healthcare system per se, as indicated by the increased rates of absenteeism, including longer periods of absence from work, compared with low- and medium-risk exposure. Of note, a HCP was traced as the source of COVID-19 exposure in approximately half of the events.

In our cohort of exposed HCP, the overwhelming majority of HCP with COVID-19 became symptomatic by the first week post-exposure. Our findings strongly support the 7-day exclusion policy HCP with high-risk exposure and justify a 14-day monitoring of HCP, regardless of exposure-risk category. The WHO and the United States Centers for Disease Control and Prevention

recommend exclusion from work for a 14-day period [22,23]. The scientific rationale for the reduction by half of the length of work exclusion was based on the mean incubation period of COVID-19 of approximately 5 days [20,21]. In contrast, recommendations for HCP to continue working unless symptomatic have been issued in the United Kingdom and the Netherlands [24,25]. To the best of our knowledge, none of the abovementioned policies have been evaluated so far. Large quantities of viral RNA have been found in asymptomatic, pre-symptomatic and symptomatic residents, which suggest the potential for transmission regardless of symptoms [4]. In our setting, the 7-day exclusion from work policy enabled us to promptly recognize almost three out of four HCP with COVID-19 while at the same time all HCP with potentially high-risk exposure were isolated. The role of testing asymptomatic HCP with high-risk exposure upon returning to work should also be explored

In accordance with others [26], being a male and having an underlying disease were independent risk factors for the onset of COVID-19. In our cohort, administrative personnel were at increased risk for COVID-19. Following the first COVID-19 cases among HCP in Greece, the National Public Health Organization issued additional guidelines for wearing a surgical mask from the time of entering the facility until leaving. This, by definition, could render any COVID-19 exposure as a low- or moderate-risk. Several administrative employees avoided wearing surgical masks because of no direct patient contact; however accidental exposure to a COVID-19 case could not be ruled out. In our study the administrating personnel accounted for a higher proportion of high-risk exposures compared to other risk groups. HCP often found masks and other equipment uncomfortable to use [27]. A workplace culture supporting

training of all HCP categories, efficient communication of guidelines and delivery of good patient care could also influence their compliance with infection control guidelines [27].

The main advantage of our study is the active, prospective follow-up of a large number of exposed HCP and their management based on a standardized risk-assessment protocol. Potential limitations include the fact that mild illness might be not tested and thus not diagnosed. However, approximately half of all HCP in our cohort were tested for SARS-CoV-2 infection, regardless of onset of symptoms. Another limitation is the paucity of data about PPE doffing, given the importance of the latter in contaminations [28]. It is possible that incorrect doffing accounted for the few COVID-19 cases among HCP with low- or moderate-risk exposures.

In conclusion, the current study offers a good insight on healthcare-spread dynamics of COVID-19 and the protective role of PPE for HCP. Our findings justify the generalized use of surgical masks by all HCP upon entering a HCF. Furthermore, our findings strongly support the implementation of the 7-day exclusion from work policy for HCP with high-risk exposure and the 14-day post-exposure follow-up for all HCP, regardless of risk assessment. A similar exclusion policy might apply in other settings as well with a significant financial, societal and human-resources impact.

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DECLARATION OF INTEREST

Nothing to declare.

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Table 1. Risk assessment for HCP exposed to COVID-19

A. Close contact with a COVID-19 case wearing a surgical mask

Use of PPE by HCP	Exposure risk
• No use	moderate
• No surgical mask	moderate
• No goggles or face shield	low
• No gloves or gown[1]	low
• Use of PPE, but with surgical mask	low

B. Close contact with a COVID-19 case not wearing a surgical mask

Use of PPE by HCP	Exposure risk
• No use	high
• No surgical mask or FFP2	high
• No goggles or face shield[2]	moderate
• No gloves or gown[1,2]	low
• Use of PPE, but with surgical mask	low

HCP: healthcare personnel; PPE: personal protective equipment; COVID-19: coronavirus disease 2019

[1]Exposure risk increases in case of direct contact with a COVID-19 case

[2]Exposure risk increases in case of aerosol-generating procedures or uncontrolled splash of respiratory secretions.

Table 2. Management of HCP per category of risk exposure to a COVID-19 case

High-risk exposure

- 7-day exclusion from work, return to work wearing a surgical mask during the entire work shift
- 14-day active follow-up after the last exposure for onset of fever or symptoms
- In case of onset of fever or symptoms compatible with COVID-19
    - Isolation
    - Notification of the HCF by the National Public Health Organization
    - Clinical assessment and testing for SARS-CoV-2

Moderate or low-risk exposure

- Self-assessment and communication with the ICC for 14 days following the last exposure
- Asymptomatic HCP continue to work wearing surgical mask during the entire shift
- Daily temperature measurement, high suspicion for the onset of fever or symptoms compatible with COVID-19
- In case of onset of fever or symptoms compatible with COVID-19
    - Isolation
    - Notification of the National Public Health Organization
    - Clinical assessment and testing for SARS-CoV-2

HCP: healthcare personnel; COVID-19: coronavirus disease 2019; ICC: infection control committee

Table 3. Characteristics of 3398 HCP exposed to COVID-19 cases per risk category, Greece, March 13 to May 3, 2020

Characteristic	Low-risk N=1599 (%)	Moderate-risk N=765 (%)	High-risk N=1031 (%)	p-value
Male gender	474 (29.6)	236 (30.8)	281 (27.2)	0,212
Mean age ± sd (years)	44.64±10.34	44.28±10.12	45.37±19.53	0.232
Underlying disease*	24 (1.5)	31 (4.1)	26 (2.5)	0.001
Healthcare facility				
Hospital	1230 (77)	644 (84.2)	959 (93.1)	<0.001
primary healthcare center	115 (7.2)	44 (5.8)	49 (4.8)	
private laboratories	253 (15.8)	77 (10)	22 (2.1)	
Profession**				
Physician	451 (28.2)	257 (34.1)	371 (36.1)	<0.001
nursing personnel	868 (54.3)	392 (52)	445 (43.3)	
supportive personnel	77 (4.8)	21 (2.8)	14 (1.4)	
paramedical personnel	153 (9.6)	64 (8.5)	66 (6.4)	
administrative personnel	50 (3.1)	20 (0.6)	132 (12.8)	
Department				
internal medicine	627 (44.6)	363 (50.6)	378 (41.4)	<0.001
intensive care unit	119 (8.5)	64 (8.9)	41 (4.5)	
emergency department	170 (12.1)	79 (11)	51 (5.6)	
surgical	40 (2.8)	40 (5.6)	112 (12.3)	
maternity / gynecology	62 (4.4)	30 (4.29)	45 (4.9)	
anesthesiology / operation	156 (11.1)	59 (8.2)	48 (5.3)	
radiology department	67 (4.8)	40 (5.6)	99 (10.8)	
hemodialysis unit	89 (6.3)	20 (2.8)	28 (3.1)	
Other	75 (5.3)	22 (3.1)	112 (12.3)	
Source of COVID-19 exposure				
patient	937 (58.6)	457 (59.7)	331 (32.1)	<0.001

HCP	655 (41)	305 (39.9)	700 (67.9)
visitor	7 (0.4)	3 (0.1)	0 (0)

HCP: healthcare personnel; COVID-19: coronavirus disease 2019; sd: standard deviation
*Underlying diseases: diabetes mellitus (24), chronic respiratory disease (18), chronic cardiovascular disease (18), malignancy (11), immunosupression (9), chronic neurological disease (1)
**Nursing personnel includes nurses, midwifes, nurse assistants; supportive personnel includes cleaners, security personnel, waiters; paramedical personnel includes pharmacists, biologists, laboratory technicians, physiotherapists, ambulance drivers, social workers, health visitors

Table 4. Findings among 3398 HCP exposed to COVID-19 per risk category

Finding	Low-risk N=1599 (%)	Moderate-risk N=765 (%)	High-risk N=1031 (%)	p-value
Symptoms	253 (15.8)	173 (22.6)	329 (31.9)	<0.001
fever	45 (2.8)	47 (6.1)	95 (9.2)	<0.001
Cough	25 (1.5)	36 (4.7)	83 (2.4)	<0.001
headache	26 (1.6)	48 (6.3)	85 (8.2)	<0.001
Other	81 (5.1)	85 (11.1)	205 (19.9)	<0.001
Febrile episode	16 (1.0)	11 (1.4)	21 (2.0)	0.089
ARI	55 (3.4)	59 (7.7)	141 (13.7)	<0.001
Healthcare seeking	15 (0.9)	13 (1.7)	25 (2.4)	0.01
RT-PCR tested	636 (39.8)	370 (48.4)	588 (57.0)	<0.001
asymptomatic tested	497 (31.1)	273 (35.7)	370 (35.9)	
tested with symptoms	139 (8.7)	97 (12.7)	218 (21.1)	<0.001
SARS-CoV-2 infection	16 (1.0)	8 (1.0)	52 (5.0)	<0.001
no symptoms	3 (0.2)	1 (0.1)	6 (0.6)	
COVID-19	13 (0.8)	7 (0.9)	46 (4.4)	<0.001
Hospitalization	2 (0.1)	3 (0.4)	8 (0.8)	<0.001
Absenteeism	341 (21.3)	303 (39.6)	772 (74.8)	<0.001
mean duration (range)	1.51 (0-30)	2.82 (0-44)	6.92 (0-60)	<0.001

HCP: healthcare personnel; COVID-19: coronavirus disease 2019; RT-PCR: reverse transcriptase polymerase chain reaction; ARI: acute respiratory infection; SARS-CoV-2: severe acute respiratory syndrome virus 2