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Short Report

# Hospital factors associated with SARS-CoV-2 infection among healthcare personnel in Greece

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## SUMMARY

Healthcare workers (HCWs) have been recognized as a high-risk group for infection with severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). This study estimated their risk of infection based on hospital characteristics. Factors significantly associated with increased risk for SARS-CoV-2 infection were: working in a non-referral hospital compared with a coronavirus disease 2019 (COVID-19) referral hospital, working in a hospital with a high number of employees, and working in a hospital with an increased number of patients with COVID-19. This study revealed gaps in infection control in the non-referral hospitals. There is an urgent need for continuous training in infection control practices. Compliance of HCWs with the use of personal protective equipment should also be addressed.

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## Introduction

Since late 2019, the world has been faced with the coronavirus disease 2019 (COVID-19) pandemic – a respiratory disease caused by a novel beta-coronavirus, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) [1]. Healthcare workers (HCWs) have been recognized as a high-risk group for SARS-CoV-2 infection [2–4], as also shown during the epidemics of severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome [5,6]. During the first wave of the SARS-CoV-2 epidemic in Greece, HCWs accounted for approximately 10% of notified cases [2]. This study estimated the risk of infection among HCWs based on hospital characteristics.

## Methods

### *The healthcare system during the COVID-19 epidemic*

There are 224 hospitals (public, private and military) in Greece, including 126 public hospitals. The median number of HCWs employed in the 126 public hospitals is 491 (range 39–2679) per hospital, while the mean number of HCWs is 650.3 [standard deviation (SD) 537.5] per hospital. In accordance with the initial plan of the Ministry of Health, 13 tertiary care hospitals and one paediatric hospital were designated as COVID-19 referral hospitals, considering geographic and population catchment areas. As the epidemic progressed, three more hospitals were added, resulting in a total of 17 COVID-19 referral hospitals (all in the public sector). Upon laboratory confirmation of COVID-19 at any healthcare facility, patients requiring hospitalization were transferred to a COVID-19 referral hospital, including those already hospitalized for any reason. Symptomatic patients could attend the emergency rooms of the COVID-19 referral hospitals in order to seek health care.

### *Infection prevention and control*

Triage for prompt detection of patients with COVID-19 was implemented in all hospitals. A surgical mask was administered to symptomatic patients upon entering any hospital. The following personal protective equipment (PPE) was recommended for HCWs caring for suspected or laboratory-confirmed cases of COVID-19: a filtering face piece respirator (FFP)-2, non-sterilized single-use gloves, goggles or face shield, and a gown resistant to fluid penetration. An FFP3 respirator was recommended for HCWs performing aerosol-generating procedures [2]. In the case of shortages, surgical masks were recommended for HCWs caring for patients in order to preserve respirators for aerosol-generating procedures.

### *Contact tracing, risk assessment and management of exposed HCWs*

Contact tracing and risk assessment of exposed HCWs were performed by the infection control committee at each hospital. Exposures were categorized as high risk, moderate risk or low risk and managed accordingly [2]. HCWs with high-risk exposure were excluded from work for isolation purposes for 7 days. Exposed HCWs were tested for SARS-CoV-2 infection by reverse-transcriptase polymerase chain reaction (RT-PCR) if they developed symptoms. Although testing of asymptomatic HCWs was officially recommended only for HCWs working in high-risk settings (e.g. transplantation units, haematology-oncology units, intensive care units), this was common practice in many hospitals, regardless of exposure risk category or work setting [2].

### *Data collection*

The study period extended from 26<sup>th</sup> February (first case of COVID-19 detected in Greece) to 3<sup>rd</sup> May 2020 (last day of lockdown in Greece). Data on hospitalized patients with COVID-19 and HCWs with SARS-CoV-2 infection were retrieved from the national surveillance database (National Public Health Organization, Athens). Only HCWs with healthcare-acquired SARS-CoV-2 infection were included in this study.

### *Definitions*

HCWs were defined as all persons employed in hospitals, regardless of direct contact with patients or biological specimens. SARS-CoV-2 infection was defined as laboratory-confirmed infection with SARS-CoV-2 regardless of symptoms. A COVID-19 case was defined as a person with signs and symptoms compatible with COVID-19 who tested positive for SARS-CoV-2 infection on real-time RT-PCR. Healthcare-associated SARS-CoV-2 infection was defined as a case of SARS-CoV-2 infection in a HCW following occupational exposure.

### *Ethical issues*

Written consent was not required as the data were collected within the frame of epidemiological surveillance. Data were managed in accordance with national and European Union laws.

### *Statistical analysis*

All items were coded and scored, and included in the data analysis set. SPSS 26 (IBM Corp., Armonk, NY, USA) was used for data analysis. Student's *t*-test was used to assess whether the

**Table 1**

Multiple regression analysis to identify the factors associated with the number of healthcare workers (HCWs) with healthcare-associated coronavirus disease 2019 (COVID-19) in Greece

Factor	exp(B)	P-value
Number of hospitalized patients with COVID-19	0.042	<0.001
Number of HCWs working in the hospital	0.002	<0.001
COVID-19 referral hospital	−2.141	0.004

means of two groups were statistically different.  $P < 0.05$  was considered to indicate significance.

In order to estimate the ratio of HCWs with SARS-CoV-2 infection to hospitalized patients with COVID-19 per hospital, a variable (expressed as a percentage) was developed in which the nominator was the absolute number of HCWs with SARS-CoV-2 infection and the denominator was the total number of hospitalized patients with COVID-19.

A multiple stepwise regression analysis was conducted to assess the factors associated with the number of HCWs infected with SARS-CoV-2. The independent variables were: COVID-19 referral hospital vs non-referral hospital, total number of hospitalized patients with COVID-19 at each hospital, and total number of HCWs working at each hospital.

## Results

During the study period, a total of 1287 patients with COVID-19 were hospitalized in the 126 public hospitals. The median number of hospitalized patients with COVID-19 was 1 (range 0–254 patients) per hospital and the mean number of hospitalized patients was 10.21 (SD 29.88). Concomitantly, 158 HCWs working in the 126 public hospitals developed SARS-CoV-2 infection. The median number of HCWs with SARS-CoV-2 infection was 0 (range 0–15) per hospital and the mean number of infected HCWs was 1.25 (SD 2.77).

During the study period, a total of 860 patients with COVID-19 were hospitalized and 40 HCWs were infected with SARS-CoV-2 in the 17 COVID-19 referral hospitals. Therefore, the ratio of SARS-CoV-2-infected HCWs to hospitalized patients with COVID-19 was 4.65% [95% confidence interval (CI) 3.33–6.33%] in the COVID-19 referral hospitals. In the 109 non-referral hospitals, a total of 427 patients with COVID-19 were hospitalized and 118 HCWs developed SARS-CoV-2 infection. Therefore, the ratio of SARS-CoV-2-infected HCWs to hospitalized patients with COVID-19 was 27.63% (95% CI 22.87–33.09%) in the non-referral hospitals. The difference in this ratio between the COVID-19 referral hospitals and the non-referral hospitals was significant ( $P < 0.001$ ). The proportion of infected HCWs in the COVID-19 referral hospitals was 0.17% (40/22,374) compared with 0.19% (118/59,569) in the non-referral hospitals ( $P = 0.789$ ). Furthermore, no patients with COVID-19 were hospitalized in 60 of the 126 public hospitals, yet 29 HCWs developed healthcare-associated SARS-CoV-2 infection in these hospitals (either because of exposure to a contagious HCW or because of exposure to a non-hospitalized patient with COVID-19 in the emergency room).

Comparison of the 17 COVID-19 referral hospitals with the 109 non-referral hospitals revealed a significant difference in the mean number of hospitalized patients with COVID-19 [50.59 (SD 66.63) patients in the COVID-19 referral hospitals vs 3.92 (SD 8.91) patients in the non-referral hospitals;  $P = 0.011$ ]. In addition, the COVID-19 referral hospitals had significantly higher staffing [693.68 (SD 168.24) HCWs vs 427.17 (SD 40.91) HCWs;  $P < 0.001$ ]. The stepwise multiple regression analysis revealed that working in a non-referral hospital, working in a hospital with a high number of HCWs, and working in a hospital with an increased number of hospitalized patients with COVID-19 were significantly associated with an increased number of HCWs with healthcare-associated SARS-CoV-2 infection (Table 1).

## Discussion

COVID-19 is highly contagious, and outbreaks have been well documented in healthcare settings [2,3]. A gap in infection control practices will result in the amplification of healthcare-associated SARS-CoV-2 infections [7]. The strict implementation of triage and infection control guidelines, along with the appropriate use of PPE, is imperative for the prevention and control of transmission of infection in healthcare facilities. In order to raise infection control capacity and provide the highest standards of clinical care to patients with COVID-19, the Ministry of Health in Greece designated specific tertiary care hospitals as COVID-19 referral hospitals.

As expected, the number of hospitalized patients with COVID-19 was significantly higher in the COVID-19 referral hospitals compared with the non-referral hospitals. Nevertheless, this study showed that the ratio of SARS-CoV-2-infected HCWs to hospitalized patients with COVID-19 was approximately six times higher in the non-referral hospitals compared with the COVID-19 referral hospitals. In addition, this study found that working in a non-referral hospital was a risk factor for the onset of SARS-CoV-2 infection among HCWs, despite the fact that the latter cared for fewer, if any, patients with COVID-19, and that aerosol-generating procedures in patients with COVID-19 were performed almost exclusively in COVID-19 referral hospitals [8]. Furthermore, the fact that approximately one out of six HCWs with healthcare-associated SARS-CoV-2 infection in this study were employed in a hospital without any patients with COVID-19 indicates significant gaps in infection control. Similarly, a recent study in one of the French regions most affected by COVID-19 found that the rate of SARS-CoV-2 infection was at least two times higher in HCWs working in units not dedicated to patients with COVID-19 compared with HCWs working in COVID-19 units [7.8% (37/476) vs 3.5% (11/315);  $P = 0.005$ ] [9]. In another study, the present authors found that approximately half of 3398 HCWs with a history of occupational exposure to COVID-19 had been exposed to another HCW with COVID-19; and that administrative employees were more likely to get infected in hospital than other profession categories, suggesting that the former either did not comply with infection control guidelines or were less trained in the use of PPE [2]. These findings underscore the need for continuous education of HCWs in order to achieve high compliance with infection control guidelines, regardless of direct care of patients with COVID-19. The introduction of an integrated infection control strategy in a SARS-designated hospital

in Taiwan with no negative pressure isolation rooms during the SARS epidemic was associated with a significant reduction in the incidence of SARS among HCWs, compared with 86 hospitals that did not use the infection control strategy (0.03 cases/bed compared with 0.13 cases/bed;  $P=0.03$ ) [5]. Beyond triage of patients and extensive installation of alcohol dispensers, the strategy included reinforcement for HCWs to comply with infection control procedures, especially handwashing [5]. In addition, in the current study, HCWs working in hospitals with a large number of employees were more likely to acquire SARS-CoV-2 infection, which highlights the challenges associated with training HCWs in large hospitals efficiently. Another possible explanation is the difficulty to respect social distancing in large hospitals, especially during coffee breaks and meals at the self-service restaurant.

HCWs often consider masks and other PPE uncomfortable to use [10]. However, studies indicate that a workplace culture supporting training of all HCW categories, communication of guidelines, and good patient care practices could improve their compliance with guidelines [10]. In response to the increasing number of HCWs with healthcare-associated SARS-CoV-2 infection in several non-referral hospitals in Greece, the National Public Health Organization issued strict recommendations in March 2020 for the use of surgical masks during the entire work shift. The use of surgical masks by HCWs became obligatory by law in May 2020, and a fine was implemented for non-compliant HCWs.

A limitation of this study is the fact that public hospitals alone were studied. However, the overwhelming majority of patients with COVID-19 in Greece were cared for in public hospitals. A clear advantage of this study is the large number of consecutively diagnosed patients and HCWs with SARS-CoV-2 infection retrieved from the national surveillance database.

In conclusion, this study confirmed that HCWs represent a high-risk group for SARS-CoV-2 infection. It also shows that there are gaps in infection control in non-referral hospitals. Given the ongoing epidemic in Greece and globally, and the increasing potential for infected cases to seek health care in any healthcare facility, there is a need to raise infection control capacity and to address issues of HCW compliance with the use of PPE in all healthcare facilities.

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## Conflict of interest statement

None declared.

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None.

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