

# A COVID-19 nosocomial cluster in a university hospital in southern Italy: a social network analysis

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## Abstract

**Introduction.** Healthcare workers on duty at the hospital are at high risk of COVID-19 infection. However, despite the introduction of risk-lowering practices in the hospital setting, there have been many cases of SARS-COV-2 infection among Health Care Workers. Fast and efficient contact tracing and Sars-CoV-2 PCR-based testing of the close contacts of Health Care Workers with confirmed infections are essential steps to limit nosocomial outbreaks.

**Methods.** This cross-sectional study was conducted at Bari Policlinico General University-Hospital (Apulia, Italy) and describes the management of a cluster of SARS-COV-2 infections in three Operative Units. The contact tracing activities and the measures implemented to control the outbreak are described.

**Results.** Among the 186 Health Care Workers active in the cluster setting, there were 9 (4.8%) confirmed cases, including the index case. Due to the outbreak, three Operative Units were closed to limit virus circula-

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## Acronyms and Synonyms

Apulia = Puglia (in Italian)

HCWs: Healthcare workers

ECDC: European Centre for Disease Prevention and Control

CR: Control Room

SU1: Surgery Unit 1

SU2: Surgery Unit 2

SU3: Surgery Unit 3

ICU: Intensive Care Unit

OU: Operative Unit

tion. Health Care Workers with confirmed infections tested negative after a mean of  $28.0 \pm 6.6$  days (range: 13–37) and none required hospitalization.

**Conclusions.** Protection of the health of Health Care Workers during the COVID-19 pandemic should be a public health priority. However, despite recent recommendations and the implementation of protective measures, SARS-CoV-2 infections of Health Care Workers remain at a high rate, indicative of the continued high risk of cluster onset in the nosocomial setting.

## Introduction

COVID-19 is the infectious disease caused by the novel coronavirus SARS-CoV-2. Neither the virus nor the potentially fatal disease it causes were known before the outbreak began in Wuhan, China, in December 2019. COVID-19 is now a pandemic of global proportions (1).

The most common symptoms of COVID-19 are fever, dry cough, and fatigue. Other, less common symptoms include aches and pains, nasal congestion, headache, conjunctivitis, sore throat, diarrhea, loss of taste and/or smell, a skin rash, and discoloration of the fingers or toes. While the symptoms are usually mild (1) and most patients (about 80%) recover from the disease without needing hospital treatment, roughly 1 out of every 5 infected individuals develops serious illness, with severe breathing difficulties. The elderly and people with underlying medical problems, such as high blood pressure, heart and lung disease, diabetes, immunodepression, or cancer, are at higher risk of developing serious illness. However, anyone with COVID-19 can become seriously ill (1).

The SARS-CoV-2 virus is thought to spread from person to person mainly through respiratory droplets produced when an infected person coughs, sneezes, or talks. Droplets that land in the mouth or nose or that are inhaled and enter the lungs can initiate COVID-19 (2). At the time of this writing, almost 490,000,000 cases of COVID-19 and 6,000,000 infection-related

deaths have been reported worldwide (3), including almost 126,000,000 cases and 1,000,000 deaths in Europe (4). Italy, one of the hardest hit countries in Europe, has thus far recorded over 14,000,000 cases and almost 160,000 deaths (4).

In the absence of an appropriate and effective vaccine, the prevention of COVID-19 and its spread has depended on frequent handwashing with soap and water, avoiding close contact, covering the mouth and nose with a cloth face cover, covering coughs and sneezes, daily cleaning and disinfection of frequently touched surfaces, and daily health monitoring (5).

Healthcare workers (HCWs) on duty at the hospital are at high risk of SARS-CoV-2 infection (6). To reduce this professional risk, in addition to the measures described above, several practices specific for healthcare settings have been recommended, including telemedicine consultations, nurse-directed triage protocols, the screening and triaging of everyone entering a healthcare facility for signs and symptoms of COVID-19, periodically re-evaluating patients admitted for signs and symptoms of the disease (targeted SARS-CoV-2 testing), mandatory cloth face coverings or facemasks for both patients and HCWs, physical distancing between people (when possible), the postponement of elective procedures, including surgeries, and of non-urgent outpatient visits, and the appropriate use of Personal Protective Equipment (PPE) (6) by HCWs.

Despite these recommendations and an

acute awareness that HCWs may spread the infection to patients and colleagues (7), the rates of infection among HCWs remain high. Indeed, a Chinese study estimated that HCWs account for 3.8% of all cases (8). In the USA, by 6 June 2020, nearly 600 frontline HCWs had died due to COVID-19. In a study from the European Centre for Disease Prevention and Control (ECDC) conducted on 8 May 2020, case-based surveillance data from 124,796 reported cases with known HCW status from 15 countries in the EU/EAA and the UK were analyzed; HCWs accounted for 23.2% of the COVID-19 cases (9). In Italy, till April 2022, HCWs accounted for 1.8% of the 14,650,301 reported infections (10).

Nosocomial outbreaks of COVID-19 have been described in the literature. Bays et al. (11) described a cluster in a US community hospital, where 421 HCWs were exposed to two separate index patients. Case contact investigations identified 8 secondary infections in HCWs. Von Freyburg et al. (12) described a cluster in a teaching hospital, where, after contact tracing, 49 HCWs were identified as infected. These reports demonstrate the need for rapid and efficient contact tracing and SARS-CoV-2 PCR testing of all contacts after a confirmed case, especially in the nosocomial setting (2).

The aim of this study was to evaluate the effectiveness of a contact tracing procedure implemented to protect the HCWs of Bari Policlinico General University-Hospital (become “COVID hospital” from March to June 2020). Our study was carried out in Apulia (southern Italian region, ~4,000,000 inhabitants), where between February 2020 and July 2020, 4,541 confirmed cases of COVID-19 and 546 related deaths were recorded (13).

## Methods

This cross-sectional study was conducted at Bari Policlinico General University-

Hospital (Apulia, Italy), which consists of 50 operative units (OUs), around 1,000 beds and employs 3,397 HCWs (14).

In March 2020, in order to cope with the SARS-CoV-2 outbreak, the Bari Policlinico was designated by the Apulian regional authorities as a “COVID hospital,” which necessitated a full reorganization to create ad hoc units for COVID-19 patients as well as spaces designed to avoid the infection of HCWs and other patients (15). The hospital director instituted an Infection Control Team (Control Room (CR) charged with ensuring the health of patients and HCWs, maintaining contact tracing activities, and managing hospital outbreaks). The CR’s activities were coordinated by the Hygiene and the Occupational Medicine Departments of the Bari Policlinico Hospital.

Contact tracing activities for HCWs were set up by the CR in accordance with the Apulian Authorities’ recommendations (14). Following the ECDC guidelines (16), a “contact” of a COVID-19 patient was defined as: “any person who had contact with the patient in the 14 days before the onset of symptoms or, for an asymptomatic carrier of SARS-CoV-2, prior to his or her laboratory diagnosis (16). The associated risk of infection was classified considering the level of exposure, which, in turn, determined the managerial and monitoring strategies. Two level of exposure were defined (16):

- low-risk exposure, defined as a person
  - who had face-to-face contact (within 2 m) with a COVID-19 patient for < 15 min
  - who was in a closed environment with a COVID-19 patient for < 15 min
  - a HCW who, while wearing the recommended PPE, had contact with a COVID-19 patient (17)
- high-risk exposure, defined as a person
  - who had face-to-face contact (within 2 m) with a COVID-19 patient for > 15 min
  - who had physical contact with a COVID-19 patient

- who had unprotected direct contact with the infectious secretions of a COVID-19 patient (e.g., due to being coughed on)
- who was in a closed environment with a COVID-19 patient for > 15 min
- who, being a HCW, while not wearing the recommended PPE or whose PPE had a possible breach, had contact with a COVID-19 patient (17)

The Apulian regional recommendations (15) required that HCWs with a low-risk exposure perform daily self-monitoring of symptoms (fever and/or respiratory symptoms) for 14 days post-contact, while continuing work activities in his or her OU. If symptoms developed, a SARS-CoV-2 PCR test was scheduled. For HCWs with a high-risk exposure, suspension from work and home isolation were mandatory, the contact was communicated to the Health Prevention Department, and possible symptoms development was monitored daily. Seven days after the high-risk contact with the COVID-19 patient, even if the latter remained asymptomatic, SARS-CoV-2 PCR testing of the HCW was scheduled. For both levels of exposure, if the test was negative, the HCW returned to work wearing suitable PPE and doing active monitoring of respiratory signs and symptoms for 7 days thereafter. If the test was positive, the CR initiated contact tracing activities. COVID-19 patients were retested 14 days after the cessation of symptoms. If they remained positive, isolation measures were extended. Recovery was defined by two negative tests conducted 24 h apart, in which case the HCW returned to work and was provided with suitable PPE (15).

The nosocomial cluster described in this study developed in an entire floor of a hospital pavilion housing three surgical units (SU1, SU2, SU3) and in a connected area of operating rooms. Overall, 150 HCWs worked in the three units; in addition, several HCWs from other units visited the surgical units for routine activities and / or in the context of

surgical interventions. HCWs involved in the cluster - who were not assigned to SU1, SU2, or SU3 - worked in the intensive care unit (ICU). The activities described below cover the period between 21 March and 2 April 2020, which included the detection of the index case. Patients and community contacts were excluded from the analysis, as the focus of this study were the HCWs.

Molecular testing for the diagnosis of SARS-COV-2 was performed as recommended by the WHO (18).

For contact tracing procedures, an ad hoc format was established, in which socio-demographic and clinical data, aspects of the event-exposure (date, place, length and distance of exposure, use of PPE), and details of the contact were collected. For close contacts, the results of the SARS-COV-2 molecular tests were also recorded.

The data were entered on an Office Excel spreadsheet and analyzed using Stata MP16 software; the network diagram to describe the cluster was developed using Gephi software (19). Continuous variables are expressed as the mean±standard deviation

## Results

On 21 March 2020, the first case of COVID-19 (index case) was communicated to the CR of Bari Policlinico. The person was a HCW active in SU1, asymptomatic, and had been tested for SARS-CoV-2 as a family contact of an identified COVID-19 patient.

On the same day, the epidemiological investigation determined that the infection had taken place in SU1 2 days before the diagnosis (perhaps by sharing desks or meals), which complicated an assessment of the level of individual risk. Therefore, prudently, all 47 HCWs on SU1 were classified as high-risk contacts, which required their suspension from work and quarantine at home. A SARS-CoV-2 test was

scheduled for those HCWs 7 days after the last contact with the index patient.

Simultaneously, contact tracing activities were set up for all HCWs of SU2 and SU3 as well as for the HCWs of all other units identified by the epidemiological investigation as having had contact with the index patient. These efforts resulted in the identification of 72 contacts, 52 (72.2%) of whom reported that, at the time of contact, appropriate PPE had been used; however, in 4 of these 52 (7.7%) HCWs the use of PPE was assessed as insufficient. Consequently, 48/72 (66.7%) low-risk and 24/72 (33.3%) high-risk contacts were documented. HCWs at high-risk were scheduled for SARS-CoV-2 test 7 days after the last contact with the COVID-19-confirmed patient.

After 24 h, on 22 March 2020, one of the high-risk HCWs from SU2 tested positive (SU2-1-case2). Accordingly, as previously done for SU1, all HCWs from SU2 (56 HCWs) were classified as high-risk contacts (including the HCWs already isolated after contact with the index patient). They were thus suspended from work and PCR-tested for SARS-CoV-2 7 days after the last contact with SU2-1-case2. Contact tracing activities were set up for all HCWs on SU3 and for the HCWs from other units who, according to the epidemiological investigation, had been in contact with SU2-1-case2.

On 23 March 2020, the tests performed after contact tracing of the index case revealed two other cases of COVID-19. Both HCWs were from the ICU and had worked closely with the index patient (ICU-1-case3 and ICU-2-case4); the two HCWs were asymptomatic. On the same day, given the growing number of cases and assuming endemic circulation of the virus through the surgery ward, the CR decided to completely close the ward and suspend its activities (considering the suspension of scheduled surgical interventions due to the generalized lockdown in Italy and the presence of other SUs in the Policlinico, this

strategy had a minimal impact on the surgical activities). Hospitalized patients were tested for SARS-CoV-2; those who were negative were transferred to another department of the hospital, where they were kept in isolation. Moreover, all the HCWs from SU1, SU2, SU3, and the other OUs who had worked in the surgery block were placed in quarantine and suspended from work. These HCWs underwent a SARS-CoV-2 PCR test 7 days after their last access to the hospital (assessed by last shift as determined from the time card).

In the following days, screening of the HCWs from the surgery block revealed five other COVID-19 cases. Two of these patients were symptomatic (both with cough and fever) at the time of the test and both worked on SU2; one of them (SU2-p2-case5) was a close contact of the index patient, and the other (SU2-p3-case6) a close contact of both the patient and SU2-p1-case2. Among the three asymptomatic HCWs, two worked on SU1 (SU1-1-case7 and SU1-2-case8) and had been in close contact with the index patient, while the other (SU2-4-case9) worked on SU2 and had had close contact with SU2-p1-case2. All the other tested HCWs were negative and were re-admitted to work.

On average, the HCWs with confirmed SARS-CoV-2 infection became negative after  $28.0 \pm 6.6$  days (range: 13-37) and none required hospitalization.

Finally, considering the improved epidemiological conditions, on April 2 2020 the CR and the hospital director ordered the reopening of the closed OUs and the full resumption of their activities; the entire timeline is described in figure 1.

In summary, the above-described cluster involved 186 HCWs. In summary, there were 9 (4.8%) confirmed cases including the index case: 3 (6.4%) cases among the 47 HCWs of SU1, 4 (7.1%) cases among the 56 HCWs of SU2, 0 (0.0%) cases among the 47 HCWs of SU3, and 2 (5.6%) cases among

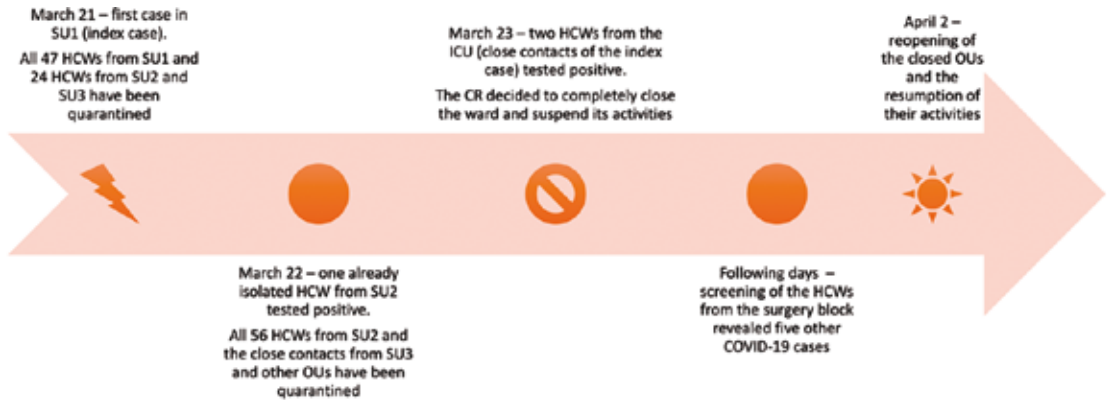


Figure 1. Timeline of contact-tracing procedures.

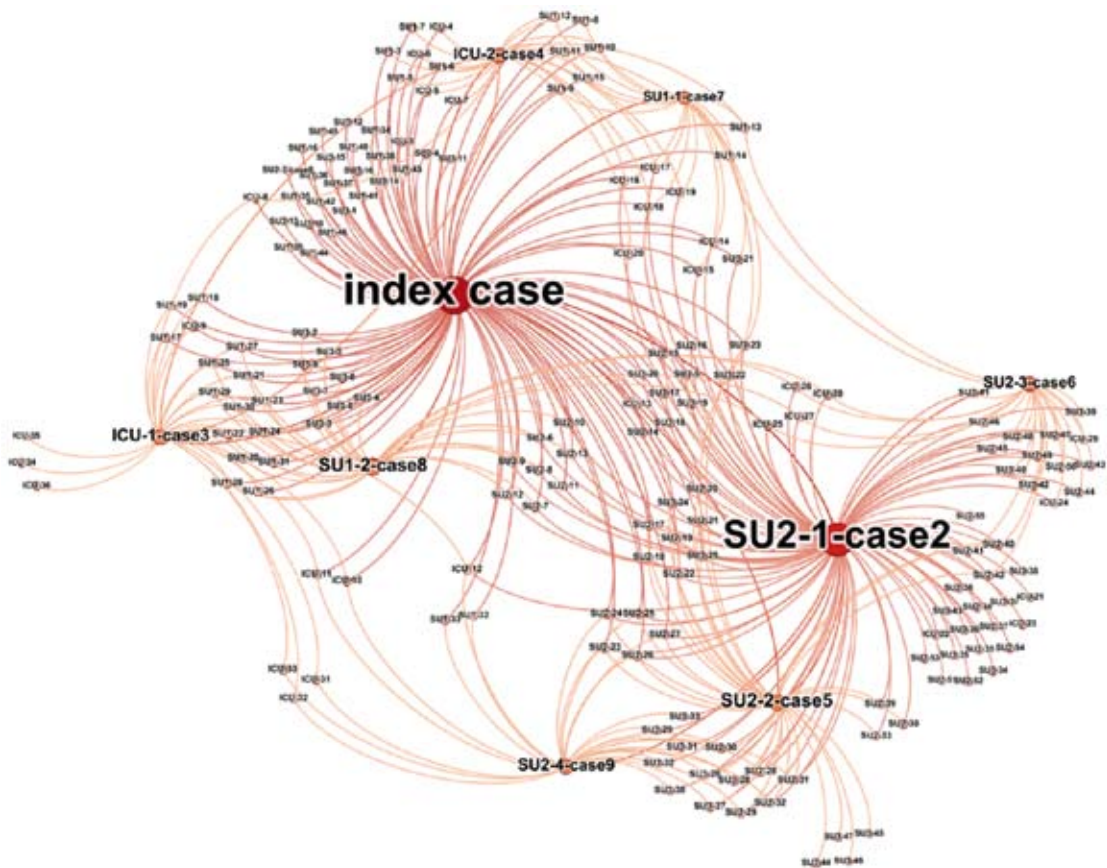


Figure 2. Network diagram. It characterizes networked structures in terms of nodes (healthcare workers) and the ties (at risk contacts) that connect them.

the 36 HCWs from the ICU. The cluster is described in Figure 2.

## Discussion and conclusions

Our study describes a nosocomial cluster in a large hospital in southern Italy. The index case was a community contact and the patient, despite having self-isolated as soon as he became aware of the SARS-CoV-2 positivity of a family member, spread the virus through close contact with colleagues during the days prior to receiving that information.

There are several take home messages that emerge from our hospital's experience with the described cluster. First, the *ad hoc* CR played a critical role in managing the emergency posed by the COVID-19 outbreak. The benefits of a synergy between the Hygiene and Occupational Medicine Departments of Bari Policlinico in implementing an immunization strategy at the hospital were described in previous reports (20, 21) and were once again demonstrated for the management of a nosocomial outbreak of COVID-19. Second, contact tracing activities and the related actions that were subsequently implemented were essential in containing the outbreak; in fact, only 8 secondary cases were identified after the beginning of virus containment procedures. The strong suspicion that the virus had become endemic within the ward guided the containment of the infection. The importance of the early isolation of the index patient and a meticulous investigation of his/her contacts through PCR tests were also pointed out by Jung et al. (22). These authors described an outbreak related to a paucisymptomatic 9-year-old girl with COVID-19 who had been admitted to a pediatric ward in a South Korean hospital. The ward was placed under cohort isolation and extensive contact-tracing was carried out. Of the patient's 1,206 close and casual

contacts, only one person tested PCR positive for the virus.

Another outcome of effective contact tracing and testing was that only 2 out of 9 patients were symptomatic at the time the Sars-CoV-2 PCR test was performed. If the 7 asymptomatic patients had not been considered as potentially infected, the outbreak would have been much more widespread. The network diagram (Figure 2) shows the complexity of reconstructing the contacts of the 9 patients in detail. The diagram also reveals that most of the HCWs were coworkers of the index patient and SU2-1-case2, the first two cases identified and thus the focus of subsequent contact tracing activities and decision-making.

The total absence of cases within SU3 indicates that transmission of the virus was neither airborne nor environmental (either of which would have resulted in many more cases), but occurred via close reciprocal contacts between HCWs. This observation coincides with others and has led to intense discussion among SARS-CoV-2 researchers. Indeed, on July 2020, Morawska et al (23), supported by an international group of 237 other scientists, published a commentary in the journal *Clinical Infectious Diseases*, that urged the medical community and public health authorities to acknowledge the potential for airborne transmission and call for preventive measures to reduce the related risk.

Thus far, there have been few reports of nosocomial clusters of COVID-19. In a 2020 study (11) from a US hospital, two separate index patients were admitted, in February and March 2020, without initial suspicion of COVID-19 and without contact or droplet precautions in place. Both patients underwent several aerosol-generating procedures. Ultimately, 421 HCWs were exposed and case contact investigations identified 8 secondary infections in HCWs. The authors of that study concluded that, despite the aerosol-generating procedures, there was

no evidence of airborne transmission, an experience consistent with our own. Based on their study at a university-hospital in northwest Italy, Garzaro et al. (24) described the hospital strategies that minimize exposure and diffusion, confer protection, and facilitate the early detection and isolation of infected personnel. They concluded that a proactive system that relies on the prompt detection of contagious HCWs and the identification of sources of exposure aid in reducing intra-hospital spread.

Protection of the health of HCWs, especially in the context of the COVID-19 pandemic, should be a public health priority. However, despite the many recommendations aimed at protecting HCWs, this group has been among those most affected by the virus, and hospitals continue to be high-risk environments. It is our hope that Public Health Authorities, having learned from the pandemic's first wave, are now ready to react effectively to a possible second wave, by ensuring the protection of both HCWs and patients.

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**Conflict of interest:** The authors have no competing interests to declare.

**Ethics.:** Only data collected for in-hospital epidemiological surveillance and administrative purpose were analyzed. Therefore, Ethical approval was not required. Data were treated according to Italian privacy law.

## Riassunto

*Un cluster nosocomiale COVID-19 in un ospedale universitario del sud Italia: un'analisi di social network*

**Introduzione.** Gli operatori sanitari in servizio presso i presidi ospedalieri sono ad alto rischio di infezione da COVID-19. Tuttavia, nonostante l'introduzione di misure di riduzione del rischio in ambito ospedaliero, sono stati riscontrati molti casi di infezione da SARS-COV-2 tra gli operatori sanitari. Un rapido ed efficiente tracciamento dei contatti e il PCR test per la ricerca di Sars-CoV-2 nei contatti stretti degli operatori sanitari con infezione

confermata sono misure essenziali per limitare i focolai nosocomiali.

**Metodi.** Il nostro studio trasversale è stato condotto presso L'Azienda Ospedaliero-Universitaria Policlinico Bari (Puglia, Italia) e descrive la gestione di un cluster di infezione da SARS-COV-2 in tre Unità Operative. Sono descritte le attività di tracciamento dei contatti e le misure attuate per controllare il focolaio epidemico.

**Risultati.** Tra i 186 operatori sanitari che hanno lavorato nel setting in analisi, sono stati riscontrati 9 (4,8%) casi confermati, incluso il caso indice. A causa del focolaio, tre Unità Operative sono state chiuse per limitare la circolazione del virus. Gli operatori sanitari con infezione confermata sono risultati negativi dopo una media di  $28,0 \pm 6,6$  giorni (range: 13–37) e per nessuno è stato necessario il ricovero ospedaliero.

**Conclusioni.** La protezione della salute degli operatori sanitari durante la pandemia di COVID-19 dovrebbe essere una priorità di salute pubblica. Tuttavia, nonostante le recenti raccomandazioni e l'attuazione di misure protettive, il tasso di incidenza di operatori sanitari con infezione da SARS-COV-2 rimane elevato, indicativo del continuo alto rischio di insorgenza di cluster in ambito nosocomiale.

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