Igiene e Sanità Pubblica 2023; 85 (4): 110-117

Probable airborne transmission in a nosocomial Sars-CoV-2 outbreak with an high attack rate

Paola Anello[1], Riccardo Boscolo Cegion[2], Andrea Basso[2], Chiara Cabbia[1], Francesca Azzolini[1], Luciano Crimi[1], Myriam Ruggiero[1], Mara Carraro[1], Stefano Mazzon[3], Milvia Marchiori[1]

Affiliations

[1.] Direzione Medica di Ospedale, Presidio Ospedaliero di Camposampiero, Azienda ULSS 6 Euganea, Padova, Italy

[2.] Dipartimento di Scienze Cardio-Toraco-Vascolari e Sanità Pubblica, Università degli Studi di Padova, Padova, Italy

[3.] Unità Operativa di Recupero e Riabilitazione Funzionale, Presidio Ospedaliero di Camposampiero, Azienda ULSS 6 Euganea, Padova, Italy

Abstract

Throughout the current COVID-19 pandemic, preventing nosocomial COVID-19 outbreaks has been a significant challenge for hospitals.

It is essential to understand the ways in which SARS-CoV-2 spreads in healthcare settings to apply proper infection prevention and control (IPC) measures.

The objectives of this study are to report on the hospital's response to a COVID-19 cluster and the transmission dynamics in a hospital ward of Geriatrics, Rehabilitation and Long term care. The study will focus specifically on how insufficient air replacement and directional airflow in indoor settings may have contributed to the transmission of the virus.

Introduction

Throughout the current COVID-19 pandemic, preventing nosocomial COVID-19 outbreaks has been a significant challenge for hospitals [1]. It is essential to understand the ways in which SARS-CoV-2 spreads in healthcare settings to apply proper infection prevention and control (IPC) measures [2]. The objectives of this study are to report on the hospital's response to a COVID-19 cluster and the transmission dynamics in a hospital ward of Geriatrics, Rehabilitation and Long term care. The study will focus specifically on how insufficient air replacement and directional airflow in indoor settings may have contributed to the transmission of the virus.

Material and methods

Case Setting

The outbreak occurred in a 18-beds ward in a 340-beds hospital in northeastern Italy. Due to a temporary reorganization, the ward had split in two areas: Geriatrics (rooms 1 to 3) and Physical rehabilitation and Long-Term Care (LTC) (rooms 4 to 9) (Figure 1). The ward also includes gyms and rooms designated for rehabilitation exercises and the restoration of motor function. Air extraction occurs from the rooms' toilets through an extractor fan.

Igiene e Sanità Pubblica 2023; 85 (5):110-117

The entire staff comprised 35 healthcare workers (HCWs), including: 4 medical doctors, 4 physiotherapists, 2 speech therapists, 1 occupational therapist, 13 nurses and 11 assistant nurses.

Figure 1. Floor plan of the ward with numbering of the rooms and identification number of the patients involved in the cluster. V: room where the faulty ventilation system was present and with the 2 patients with tracheostomy.

Hospital COVID-19 prevention measures before the outbreak

At pre-admission, all patients were screened for SARS-CoV-2 using real-time polymerase chain reaction (RT-PCR). All SARS-CoV-2 infected patients were admitted to a dedicated ward. Once admitted, negative inpatients were tested using an antigenic test every 4 days. Additional tests were performed for patients with symptoms consistent with SARS-CoV-2 infection. Each inpatient was restricted to only one attending caregiver throughout the period of hospitalization; caregivers were only admitted following presentation of a negative SARS-CoV-2 antigenic test within 48 hours of the access. Visitors could schedule appointments twice a week and were required to have a negative antigenic swab test within the previous 24 hours. Family members and caregivers were not allowed to the gym.

Visitors to the hospital as well as outpatients were required by law to wear a face mask. Admitted patients were encouraged to use face masks if their condition permitted it. Wearing an FFP2 mask was mandatory for all HCWs.

Outbreak investigation and laboratory methods

Socio-demographic data, as well as administrative data related to the hospital stay, were extracted from the hospital information system.

The infection control staff investigated all COVID-19 cases and identified contacts.

According to the national bulletin, the Ba.5 Omicron variant was prevalent at the time of the outbreak [3].

A case of Omicron variant was defined as an individual (patient or staff) who has a positive PCR test result within 3-4 days from the admission or an exposure [4].

A contact was defined as patient who spent at least 15 min face to face at a distance <2 m

Igiene e Sanità Pubblica 2023; 85 (4):110-117

with a COVID-19 case (i.e., starting 48 h before symptoms onset or before a positive PCR if asymptomatic) without any mask or patients who shared a multi-bed room or a gym during physical rehabilitation. A Healthcare worker providing direct care for a COVID-19 case, without recommended personal protective equipment (PPE) or with a possible breach of PPE is also considered a contact [5].

An epidemic curve was constructed based on the dates of positivity detection. A timeline of infection-related events were visualized.

Results

Outbreak description

On October 11, two roommates (Patients 7 and 8, Fig.2) tested positive through a screening test. Immediately after the identification of these first cases, all patients and HCWs on the ward were tested for SARS-CoV-2, which was repeated every day until 10 days after the last exposure, and/or as soon as symptoms developed. On the same day, two more patients (patients 13 and 15) also tested positive for SARS-CoV-2. Epidemiological investigations revealed that the caregiver of Case 8 was diagnosed with COVID-19 on October 7, and their last visit was on October 5.

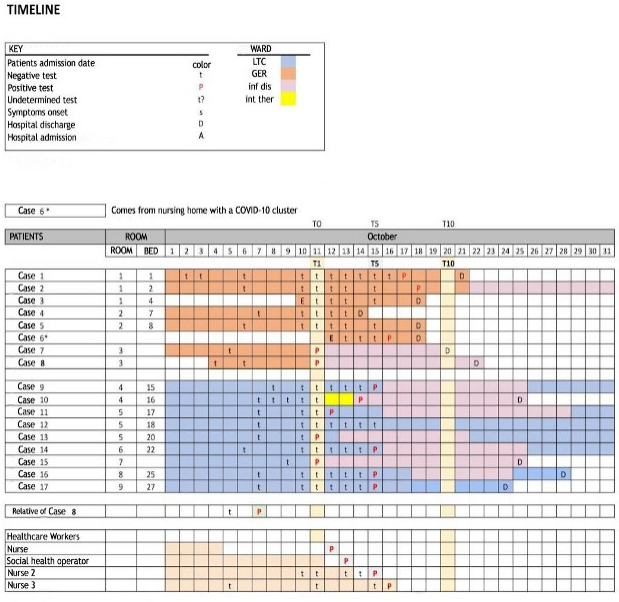

Figure 2. Timeline of the Geriatrics - RRF long-term care cluster.

During the outbreak period (October 11, 2022 to October 20, 2022), 13 out of 17 patients were diagnosed with COVID-19 (with an attack rate of 76.5%), and 4 HCWs had a positive RT-PCR (with an attack rate of 11.4%) (Fig.2). Figure 3 shows the epidemic curve of confirmed COVID-19 cases according to the date of testing and related to the respective room numbers.

Igiene e Sanità Pubblica 2023; 85 (5): 110-117

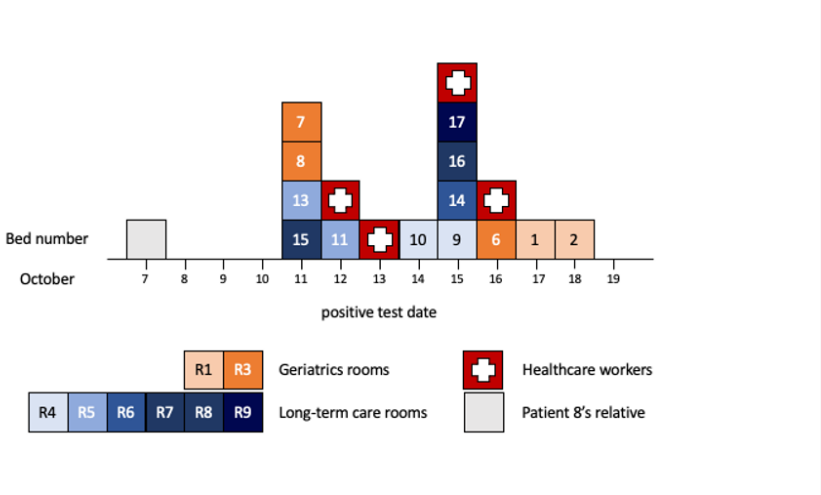

Figure 3. Epidemic curve of confirmed cases of SARS-CoV-2 infection by date of PCR confirmation and by room numbers.

Outbreak management

In the event of a cluster, all patients and healthcare workers (HCWs) on the ward were systematically tested every day using an antigen test for SARS-CoV-2. Testing was repeated five and ten days later using RT-PCR tests. COVID-19 testing was performed using nasopharyngeal and/or oropharyngeal swabs with PCR or antigen tests. Every positive antigen test was confirmed with PCR.

The ward was closed to admissions from October 12th to October 25th. Access to the ward gym was restricted, and alternative rehabilitation treatments were introduced at the patients' beds on October 12th. Daily rehabilitation treatments were suspended altogether from October 14th.

Positive patients were immediately placed in isolation and, upon bed availability, transferred to a COVID-19 ward. The ward staff and infection control team conducted hand hygiene and standard precaution and transmission-based precaution audits, including general cleaning, cleaning of equipment and the environment, hand hygiene, and PPE compliance. Given the escalation of positive cases, a ventilation system control was required. On October 17th, the air extractor located in the bathroom of room 5 (Fig. 1) was found to be broken down and was replaced.

Discussion

Here, we report a nosocomial cluster of SARS-CoV-2. According to the national bulletin, the Ba.5 Omicron variant was prevalent at the time of the outbreak [3]. The estimated incubation period of COVID-19 caused by the Omicron variant is 3.42 days (95% CI, 2.88 - 3.96 days) [4]. Transmission appeared to be facilitated by several factors, including delayed diagnosis of the index case, multi-bedded rooms, physical rehabilitation, and the use of gyms. Additionally, the breakdown of the air extractor in a room with patients with tracheostomy may have moved contaminated air to the corridor.

Igiene e Sanità Pubblica 2023; 85 (4):110-117

Since the start of the COVID-19 pandemic, several nosocomial outbreaks of SARS-CoV-2 have been described [6-12, 17, 18]. The main routes of transmission are respiratory droplets, direct contact (person-to-person), or more rarely, indirect contact (fomites), whereas aerosols in hospital settings are frequently due to aerosol-generating procedures (e.g., intubation, bronchoscopy, upper gastro-intestinal endoscopy, etc.) [12]. In nosocomial outbreaks, the spread of the infection is often driven by roommates, especially the unvaccinated [13, 14]. Moreover, encounters occurring in April to October have a higher odds ratio of transmission compared with those occurring in November to December [8]. Poor compliance with physical distancing and wearing masks can also increase the risk of infection [11]. Healthcare workers (HCWs) can also play a role in transmission, particularly if they are not adhering to infection prevention and control (IPC) protocols [15, 16]. Also, caregivers may play an important role as vectors for nosocomial infections, although they were often not considered as a subject of infection control implementation [1]. Long-distance airborne transmission of SARS-CoV-2 indoors has been investigated [17], but few studies reported its role in hospital outbreaks of SARS-COV-2 [12, 18].

Our report describes a COVID-19 outbreak in a Geriatrics-LTC ward with a high attack rate among patients. On day zero, four cases were identified in three different rooms. Patient 8 may have been in the incubation period at admission, rather than being infected by his caregiver. An antigenic test was performed at day two from the admission instead of four, which may have delayed case identification and allowed transmission to the roommate (Case 7). Perhaps the chain of transmission to Cases 13 and 15 remains unclear since all HCWs tested negative for COVID-19 at time 0. Cases 11, 13, 14, and 15 all attended the gym for rehabilitation. Cases 11 and 13, placed in the room with the broken-down air extractor, were tracheostomized and often underwent bronchoalveolar lavage, which is an aerosol-generating procedure. The attack rate was found to be high between inpatients and low between HCWs (76.5% vs. 11.4%), with a rapid rise of cases in a few days. Moreover, rehabilitation treatments and gyms may have enhanced the transmission, but they were suspended in the early phases of the outbreak. Therefore, it is likely that airborne transmission from room 5 may have played a role in the development of the outbreak.

This study has several limitations. First, no molecular typing of SARS-CoV-2 was performed to support epidemiological investigations. Another limit is that environmental sampling was not undertaken as the outbreak appeared to be under control after replacing the air extractor and implementing IPC measures.

Conclusions

In conclusion, this report is one of the few that addresses the potential role of long-range airborne transmission in a nosocomial outbreak of SARS-CoV-2. Transmission had occurred through a mixture of routes, but the faulty ventilation system in room 5 may have contributed to the spread of the cluster. This highlights the importance of ensuring proper ventilation and airflow in indoor settings, particularly in healthcare facilities, to control nosocomial outbreaks of SARS-CoV-2.

Funding: No funds were requested or obtained to carry out this study.

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

Igiene e Sanità Pubblica 2023; 85 (5): 110-117

Ethics: Only data collected for in-hospital epidemiological surveillance and administrative purpose were analyzed. The study was approved by an ethical committee.

Data were treated according to Italian privacy law.

References

1. Lee U, Kim SE, Lee SY, Wi HN, Choi O, Park JW, Kim D, Kim YJ, Shin HY, Kim M, Kim EJ, Kang SJ, Jung SI, Park KH. Source Analysis and Effective Control of a COVID-19 Outbreak in a University Teaching Hospital during a Period of Increasing Community Prevalence of COVID-19. J Korean Med Sci. 2021 Jun 21;36(24):e179. doi: 10.3346/jkms.2021.36.e179. PMID: 34155840; PMCID: PMC8216991.
2. Abbas M, Robalo Nunes T, Martischang R, Zingg W, Iten A, Pittet D, Harbarth S. Nosocomial transmission and outbreaks of coronavirus disease 2019: the need to protect both patients and healthcare workers. Antimicrob Resist Infect Control. 2021 Jan 6;10(1):7. doi: 10.1186/s13756-020-00875-7. PMID: 33407833; PMCID: PMC7787623.
3. ISS report "Prevalenza e distribuzione delle varianti di SARS CoV 2 di interesse per la sanità pubblica in Italia - Rapporto n. 24 del 29 settembre 2022 (dati aggiornati al 26 settembre 2022)"
4. Wu Y, Kang L, Guo Z, Liu J, Liu M, Liang W. Incubation Period of COVID-19 Caused by Unique SARS-CoV-2 Strains: A Systematic Review and Meta-analysis. JAMA Netw Open. 2022;5(8):e2228008. doi:10.1001/jamanetworkopen.2022.28008
5. World Health Organization. (2020). Rational use of personal protective equipment (PPE) for coronavirus disease (COVID-19): interim guidance, 19 March 2020. World Health Organization
6. Klompas M, Baker MA, Rhee C, Tucker R, Fiumara K, Griesbach D, Bennett-Rizzo C, Salmasian H, Wang R, Wheeler N, Gallagher GR, Lang AS, Fink T, Baez S, Smole S, Madoff L, Goralnick E, Resnick A, Pearson M, Britton K, Sinclair J, Morris CA. A SARS-CoV-2 Cluster in an Acute Care Hospital. Ann Intern Med. 2021 Jun;174(6):794-802. doi: 10.7326/M20-7567. Epub 2021 Feb 9. PMID: 33556277; PMCID: PMC7924623.
7. Aghdassi SJS, Schwab F, Peña Diaz LA, Brodzinski A, Fucini GB, Hansen S, Kohlmorgen B, Piening B, Schlosser B, Schneider S, Weikert B, Wiese-Posselt M, Wolff S, Behnke M, Gastmeier P, Geffers C. Risk factors for nosocomial SARS-CoV-2 infections in patients: results from a retrospective matched case-control study in a tertiary care university center. Antimicrob Resist Infect Control. 2022 Jan 17;11(1):9. doi: 10.1186/s13756-022-01056-4. PMID: 35039089; PMCID: PMC8762437.
8. Hawkins LPA, Pallett SJC, Mazzella A, Anton-Vazquez V, Rosas L, Jawad SM, Shakespeare D, Breathnach AS. Transmission dynamics and associated mortality of nosocomial COVID-19 throughout 2021: a retrospective study at a large teaching hospital in London. J Hosp Infect. 2023 Jan 9:S0195-6701(23)00002-6. doi: 10.1016/j.jhin.2022.12.014. Epub ahead of print. PMID: 36632897; PMCID: PMC9827730.
9. Bianchi FP, Stefanizzi P, Migliore G, Melpignano L, Daleno A, Vimercati L, Marra M, Working Group CR, Tafuri S. A COVID-19 nosocomial cluster in a university

hospital in southern Italy: a social network analysis. Ann Ig. 2023 Jan-Feb;35(1):39-48. doi: 10.7416/ai.2022.2519. Epub 2022 Apr 19. PMID: 35442385.

10. Karan A, Klompas M, Tucker R, Baker M, Vaidya V, Rhee C. The Risk of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Transmission from Patients With Undiagnosed Coronavirus Disease 2019 (COVID-19) to Roommates in a Large Academic Medical Center. Clin Infect Dis. 2022 Mar 23;74(6):1097-1100. doi: 10.1093/cid/ciab564. PMID: 34145449.
11. McCallum MK, Patriquin G, Davis IRC, MacDonald T, Gaston D, LeBlanc JJ, Shabi Y, Johnston BL. Factors contributing to a coronavirus disease 2019 (COVID-19) outbreak on a mixed medical-surgical unit in a Canadian acute-care hospital. Antimicrob Steward Healthc Epidemiol. 2022 Sep 8;2(1):e151. doi: 10.1017/ash.2022.288. PMID: 36483428; PMCID: PMC9726552.
12. Andrés M, García MC, Fajardo A, Grau L, Pagespetit L, Plasencia V, Martínez I, Abadía C, Sanahuja A, Bella F. Nosocomial outbreak of COVID-19 in an internal medicine ward: Probable airborne transmission. Rev Clin Esp (Barc). 2022 Dec;222(10):578-583. doi: 10.1016/j.rceng.2022.04.001. Epub 2022 Jun 29. PMID: 35798645; PMCID: PMC9239913.
13. Hall V, Foulkes S, Insalata F, Kirwan P, Saei A, Atti A, Wellington E, Khawam J, Munro K, Cole M, Tranquillini C, Taylor-Kerr A, Hettiarachchi N, Calbraith D, Sajedi N, Milligan I, Themistocleous Y, Corrigan D, Cromey L, Price L, Stewart S, de Lacy E, Norman C, Linley E, Otter AD, Semper A, Hewson J, D'Arcangelo S, Chand M, Brown CS, Brooks T, Islam J, Charlett A, Hopkins S; SIREN Study Group. Protection against SARS-CoV-2 after Covid-19 Vaccination and Previous Infection. N Engl J Med. 2022 Mar 31;386(13):1207-1220. doi: 10.1056/NEJMoa2118691. Epub 2022 Feb 16. PMID: 35172051; PMCID: PMC8908850.
14. Nasa P, Azoulay E, Chakrabarti A, Divatia JV, Jain R, Rodrigues C, Rosenthal VD, Alhazzani W, Arabi YM, Bakker J, Bassetti M, De Waele J, Dimopoulos G, Du B, Einav S, Evans L, Finfer S, Guérin C, Hammond NE, Jaber S, Kleinpell RM, Koh Y, Kollef M, Levy MM, Machado FR, Mancebo J, Martin-Loeches I, Mer M, Niederman MS, Pelosi P, Perner A, Peter JV, Phua J, Piquilloud L, Pletz MW, Rhodes A, Schultz MJ, Singer M, Timsit JF, Venkatesh B, Vincent JL, Welte T, Myatra SN. Infection control in the intensive care unit: expert consensus statements for SARS-CoV-2 using a Delphi method. Lancet Infect Dis. 2022 Mar;22(3):e74-e87. doi: 10.1016/S1473-3099(21)00626-5. Epub 2021 Nov 10. PMID: 34774188; PMCID: PMC8580499.
15. Pan Z, Zhang H, Yang J, Tang S, Cheng Z, Wu K, Liu B. Surgical Masks for Protection of healthcare Personnel Against Covid-19: Results from an Observational Study. Clin Invest Med. 2021 Jun 14;44(2):E48-54. doi: 10.25011/cim.v44i2.36355. PMID: 34152707.
16. McGrath J, McAloon CG, More SJ, Garrett S, Reidy C, Geary U, Noonan N, Bergin C. Risk factors for SARS-CoV-2 infection in healthcare workers following an identified nosocomial COVID-19 exposure during waves 1-3 of the pandemic in Ireland. Epidemiol Infect. 2022 Nov 13;150:e186. doi: 10.1017/S0950268822001595. PMID: 36372066; PMCID: PMC9744455.
17. Duval D, Palmer JC, Tudge I, Pearce-Smith N, O'Connell E, Bennett A, Clark R. Long distance airborne transmission of SARS-CoV-2: rapid systematic review. BMJ.

2022 Jun 29;377:e068743. doi: 10.1136/bmj-2021-068743. PMID: 35768139; PMCID: PMC9240778.

18. Stern RA, Charness ME, Gupta K, Koutrakis P, Linsenmeyer K, Madjarov R, Martins MAG, Lemos B, Dowd SE, Garshick E. Concordance of SARS-CoV-2 RNA in Aerosols From a Nurses Station and in Nurses and Patients During a Hospital Ward Outbreak. JAMA Netw Open. 2022 Jun 1;5(6):e2216176. doi: 10.1001/jamanetworkopen.2022.16176. Erratum in: JAMA Netw Open. 2022 Jun 1;5(6):e2221256. PMID: 35675074; PMCID: PMC9178433.

Corresponding Author

Paola Anello MD,

Via Pietro Cosma 1, 35012 Camposampiero (PD), Italy

paola.ring@gmail.com

+39 3471099029