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## Highlights

- In-hospital COVID-19 clusters onset were correlated to COVID-19 community incidence
- Preventive measures were not fully applicable due to several specific determinants
- These determinants were patient- (eg. dementia), and ward-associated factors (eg. shared rooms)
- Adapting hospital environment and care organization is needed to avoid cluster onset

Journal Pre-proof

**COVID-19 clusters in a teaching hospital during the second wave of the SARS-CoV-2 pandemic in France: a descriptive study and lessons learned for waves to come**

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**Abstract**

A total of 92 COVID-19 clusters involving 1,156 individuals (729 patients and 427 healthcare workers) occurred in Lyon University Hospital between 1<sup>st</sup> September 2020 and 31<sup>st</sup> March 2021, mostly on medical and geriatric wards. The number of clusters was closely correlated to the trend in COVID-19 community incidence over time; in-hospital clusters did not persist when community incidence decreased. Recommended preventive measures were not fully applicable due to specific ward-associated determinants and patient characteristics.

**Keywords:** SARS-CoV-2; COVID-19; healthcare-associated infection; cluster; community incidence

## Introduction

France faced a strong increase in COVID-19 incidence during fall 2020 with a peak at 501.5 cases/100,000 persons (1). During this second wave of the pandemic, the number of hospitalized COVID-19 patients reached high levels in our institution with concurrently an increase of healthcare-associated-COVID-19 (HA-COVID-19) cases and clusters. The objectives were to describe the characteristics of COVID-19 clusters involving patients at Lyon University Hospitals during the second wave of the pandemic and to discuss the lessons learned.

## Methods

Lyon University Hospitals (Hospices Civils de Lyon [HCL]) is a 5,362-bed university-affiliated hospital in France. It employs more than 22,000 people (including 13,100 healthcare workers (HCWs)). COVID-19 diagnosis was based on reverse transcription- polymerase chain reaction (RT-PCR) performed on nasopharyngeal sample (Panther System, Hologic, San Diego, CA) at the national reference center located at HCL. HA-COVID-19 among patients was categorized into three groups: definite, probable and of indeterminate origin according to the delay between hospital admission and time of COVID-19 diagnosis (2). A COVID-19 cluster was defined as  $\geq 3$  individuals (with  $\geq 2$  patients involved) with an epidemiological link (ie. a contact of at least 15 minutes in a confined space) in a same ward. Duration of the cluster was defined as the time between the first and the last nosocomial cases. COVID-19 clusters that occurred in HCL between 1<sup>st</sup> September 2020 and 31<sup>st</sup> March 2021 were prospectively documented by the Infection Control and the Occupational Health and Medicine Departments. The community incidence of COVID-19 was the total new COVID-19 cases per 100,000 population in the past 7 days in the Grand Lyon area (1).

The hospital control measures implemented at HCL are described in **Supplemental Material**. Data were collected on the number of clusters, number of COVID-19 cases, type of ward, date, duration of cluster and number of all-cause deaths in the month following the cluster. HCWs of the ward were systematically asked about the factors associated with the occurrence of cluster with prespecified questions. Continuous variables were reported as medians and interquartile range (IQR) and compared with Wilcoxon rank-sum tests. Qualitative variables were computed as number of individuals and frequency. Statistical analysis was performed using STATA 17<sup>®</sup> (College Station, TX, USA).

## Results

A total of 92 COVID-19 clusters involving 1,156 individuals (729 patients and 427 HCWs) were recorded (Table 1, Supplemental Figures).

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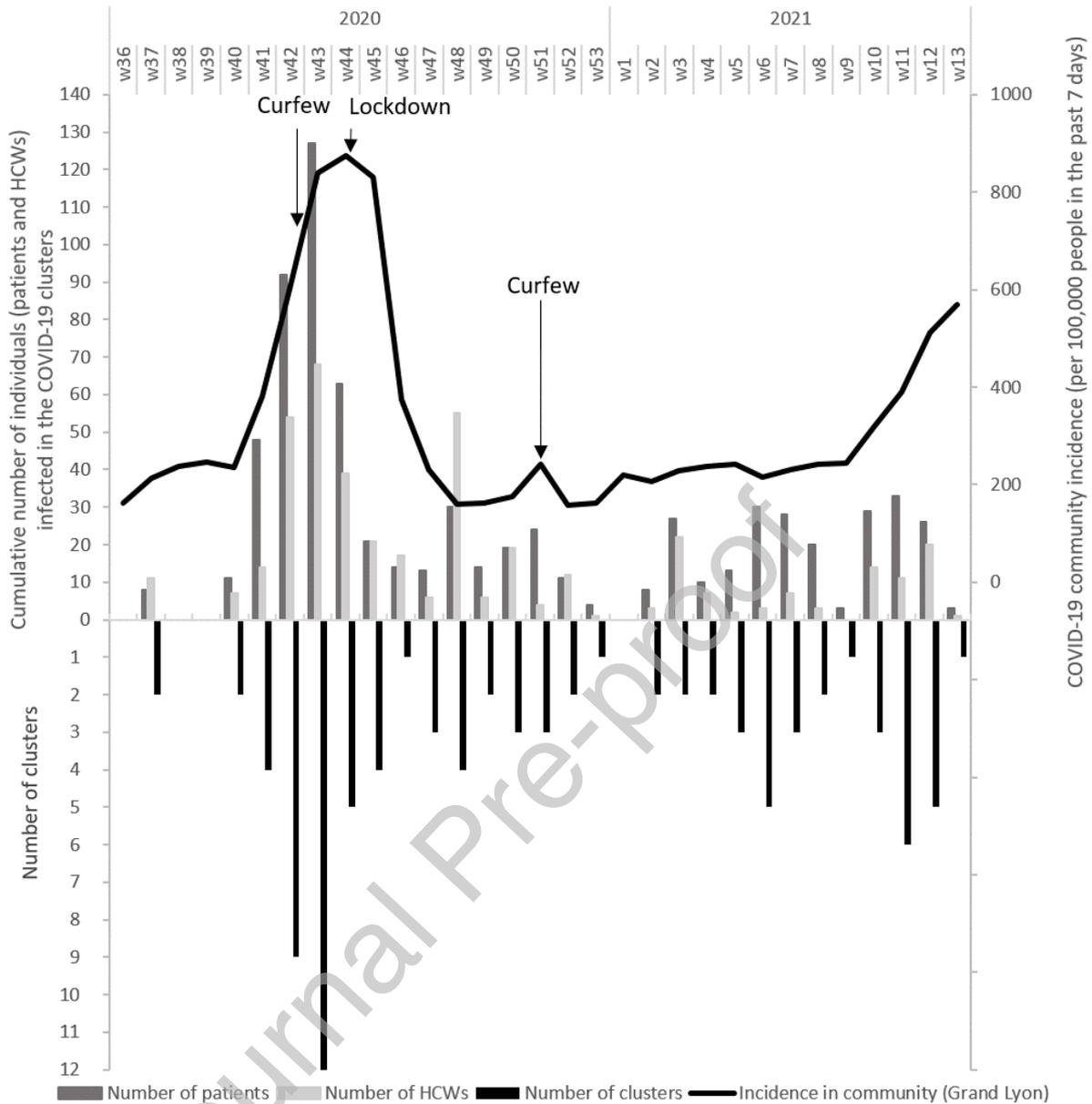
**Table 1. Description of healthcare-associated COVID-19 clusters occurring in Lyon University Hospitals between 1<sup>st</sup> September 2020 and 31<sup>st</sup> March 2021**

Ward type	Number of clusters, n (%)	Total number of infected patients, n (%)	Median number of infected patients by cluster, (IQR)	Total number of infected HCWs, n (%)	Median number of infected HCWs by cluster, (IQR)	Median ratio number of infected patients/number of infected HCWs, (IQR)	Median duration of the cluster (days), (IQR)	30-day all-cause mortality among infected patients in the month following clusters, n (%)
Medicine	33 (35.9)	232 (31.8)	6.0 (4.0-10.0)	186 (43.6)	4.0 (1.0-8.0)	1.7 (0.8-3.0)	10.0 (5.0-20.0)	69 (30.0)
Geriatric medicine recuperative care	17 (18.5)	183 (25.1)	9.0 (7.0-15.0)	69 (16.2)	2.0 (1.0-4.0)	3.8 (2.4-8.0)	12.0 (9.0-18.0)	39 (21.3)
Short-stay geriatric care	17 (18.5)	130 (17.8)	7.0 (4.0-10.0)	40 (9.4)	2.0 (0.0-3.0)	4.0 (2.7-5.0)	9.0 (8.0-14.0)	34 (26.2)
Long-term care	7 (7.6)	101 (13.9)	5.5 (4.0-18.0)	22 (5.2)	2.5 (0.0-6.0)	3.0 (2.5-3.8)	12.5 (8.0-26.0)	25 (24.8)
Surgery	14 (15.2)	67 (9.2)	4.0 (3.0-6.0)	71 (16.6)	3.0 (1.0-7.0)	1.4 (0.5-2.5)	6.0 (4.0-11.0)	5 (7.9)
General medicine recuperative care	2 (2.2)	8 (1.1)	4.0 (3.0-5.0)	11 (2.6)	5.5 (5.0-6.0)	0.7 (0.6-0.8)	7.0 (5.0-9.0)	0 (0.0)
Acute care units	1 (1.1)	5 (0.7)	5.0 (NA)	3 (0.7)	3.0 (NA)	1.7 (NA)	13 (NA)	0 (0.0)
Intensive care	1 (1.1)	3 (0.4)	3.0 (NA)	25 (5.9)	25.0 (NA)	0.1 (NA)	8 (NA)	0 (0.0)
<b>TOTAL</b>	<b>92 (100.0)</b>	<b>729 (100.0)</b>	<b>6.0 (4.0-10.0)</b>	<b>427 (100.0)</b>	<b>3.0 (1.0-6.0)</b>	<b>2.2 (1.3-4.2)</b>	<b>10.0 (6.0-16.0)</b>	<b>172 (23.6)</b>

Note: HCW: Healthcare worker, IQR: Interquartile range, NA: not applicable

Among patients, 372 cases (51.0%) were definite HA-COVID-19, 186 cases (25.5%) were probable and 171 cases (23.5%) were of indeterminate origin. In patients, the 30-day all-cause mortality was at 23.6% (172 patients). The median number of cases observed per cluster was 6 (IQR: 4-10) for patients, and 3 (IQR: 1-6) for HCWs ( $p<0.001$ ). The ratio of infected patients/infected HCWs was higher on geriatric wards compared to medical and surgical wards ( $p<0.001$ ). The median duration of clusters was lower on surgical wards compared to geriatric wards ( $p=0.02$ ). Distribution of the week of cluster occurrence is depicted in **Fig 1**.

**Fig 1. Description of healthcare-associated COVID-19 clusters occurring weekly in Lyon University Hospitals between 1<sup>st</sup> September 2020 and 31<sup>st</sup> March 2021.**



**Caption :** The black line represents the community incidence of COVID-19 in the Grand Lyon area (total new COVID-19 cases per 100,000 population in the past 7 days) (1). The dark grey columns represent the cumulative number of patients infected in the COVID-19 clusters by week; the light grey columns represent the cumulative number of HCWs infected in the COVID-19 clusters by week. The black columns on the lower side of the Figure represent the number of clusters by week.

The mean number of clusters per week was 3 during the whole reported study period, with a mean of 6 clusters per week between week #40 and #45 (48.1% of the individual cases during the study period), corresponding to the peak of the second COVID-19 wave.

The main reported factors associated with clusters were the presence of COVID-19 positive HCWs working on the ward at time of cluster onset (factor reported in 65.6% of clusters), shared rooms on the ward (34.8%), visitors on the ward (30.4%), and wandering dementia patients (8.7%). Other factors mentioned were communal showers, room doors constantly open with a risk of aerosol emission, inability for the patient to wear a mask and unsatisfactory social distancing compliance by HCWs in communal areas (i.e. during break-time).

## Discussion

Our results show that the number of clusters was closely correlated to the trend in COVID-19 community incidence over time without any substantial delay. The dynamic is similar to influenza for which similar trends have been described (3). A high community incidence increases the risk of occult SARS-CoV-2 infection for HCWs, visitors, and patients at admission. While HA-COVID-19 incidence is strongly driven by community incidence, measures might be anticipated to keep viruses out of the hospital, such as strengthening screening guidelines and wearing of personal protective equipment, implementing wards dedicated to COVID-19 patients and stopping visits (4).

Important lessons can be learned from this study. Clusters occurred even though infection control professionals (ICPs) and HCWs had already experienced the first wave. That underscored the complexity of controlling SARS-CoV-2 spread even with trained HCWs (5). A high number of clusters impacted the access to care with a potential loss of chance for patients. COVID-19 in HCWs was a cause of absenteeism; nurse shortage has been associated with increased rates of healthcare-associated infections, possibly due to, amongst others, a decrease in compliance to infection control measures or insufficient training of new nursing staff (6). Also, the literature has shown that HCW-to-HCW exposure gives rise to a higher risk of SARS-CoV-2 infection than exposure to a patient, and this might contribute to the triggering of clusters (7).

As mentioned elsewhere, an insufficient number of infection control professionals (ICPs) led to a work overload and non-optimal support of HCWs in clinical wards (8). In our institution, the number of ICPs remains below current French requirements. Moreover, some measures cannot be applied in practice according to specific ward-associated determinants: care organization (eg. difficulty to implement a cohorting of patients), hospital environment

(shared rooms, offices without possibility of ventilation which constrained HCWs to eat and drink in close proximity in rooms without aeration) or patient characteristics (e.g. wandering dementia patients, inability to wear a mask). These factors may have contributed to the spread of clusters (9,10).

Strengths of the study are the prospective collection of data and the substantial number of documented clusters. These results will allow us to evaluate further COVID-19 waves according to circulating strains and with nosocomial clusters related to other viral respiratory infections. A limit of the study was the difficulty to report in detail the determinants associated with cluster onset.

During COVID-19 waves, infection control and occupational health teams face a tricky challenge, namely taking into account for the applicability of the preventive measures in an ill-adapted hospital environment with human and care constraints. The inability to meet this challenge might increase the nosocomial risk for patients during future COVID-19 waves.

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