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# Admissions to Emergency Department appropriateness during COVID-19 second wave in a large metropolitan hospital in Northern Italy

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**Abstract.** *Background:* In Europe, Italy and Lombardy, in autumn 2020, there was a steep increase in reported cases due to the second epidemic wave of SARS-Cov-2 infection. We aimed to evaluate the appropriateness of COVID-19 patients' admissions to the Emergency Department (ED) of the San Raffaele Hospital. *Methods:* We compared data between the inter-wave period (IWP, from 1st to 30th September) and the second wave period (WP, from 1st October to 15th November) focusing on the ED presentation, discharge priority colour code and outcomes. *Results:* Out of 977 admissions with a SARS-Cov-2 positive swab, 6% were in the IWP and 94% in the WP. Red, yellow and white code increased (these latter from 1.8% to 5.4%) as well as self-presented in yellow and white code. Discharges home increased from 1.8% to 5.4%, while hospitalizations decreased from 63% to 51%. *Discussion:* We found a rise in white codes (among self-presented patients), indicating inappropriateness of admissions. The increase in discharges suggests that several patients did not require hospitalization. *Conclusions:* The pandemic brought out the fundamental role of primary care to manage patients with low-intensity needs. The important increase in ED admissions of COVID-19 patients caused a reduction of NO-COVID-19 patients, with possible inadequate treatment. (www.actabiomedica.it)

**Key words:** SARS-Cov-2, COVID-19, Emergency Department, Emergency Room, Appropriateness

## Introduction

Starting from the first patient diagnosed with SARS-Cov-2 infection (1), Italy and Lombardy Region reported an epidemic outbreak with a rapid increase and two epidemic waves, which led them to be among the most affected areas in Europe (2-4).

During the first epidemic wave, from 21st February 2020 (diagnosis of the first patient) to 3rd June 2020 (end of the national lockdown), 233,836 cases with 33,601 deaths were registered in Italy. In the same period in Lombardy there were 89,442 cases and 16,172 deaths (5).

In Italy, mean age of patients dying for SARS-CoV-2 infection was 82 years (median 83, range 0-109, IQR 74-88). Women were 51,730 (43.6%). Median age of patients dying for SARS-CoV-2 infection was more than 30 years higher as compared with

the national sample diagnosed with SARS-CoV-2 infection (median age 47 years) (6). Overall, 3.0% of COVID-19 patients had no comorbidities, 11.6% a single comorbidity, 18.4% with 2, and 67.0% with 3 or more (6). Most common comorbidities observed in SARS-CoV-2 positive deceased patients were hypertension, type 2-diabetes, ischemic heart disease and atrial fibrillation) (6).

The 1st October 2020 can be considered as the beginning of the second epidemic wave, characterized by a rapid and progressive increase in reported cases, admissions to the Emergency Departments (ED) and hospitalizations (2). In this period, as of 31st December 2020, there were 1,789,757 national cases (8 times greater than the first wave) with 38,241 deaths, and 371,852 regional cases with 8,163 deaths (half of the first wave) (5) .

Since the beginning of the pandemic, many COVID-19 patients were treated in hospitals, both for the severity of the symptoms and for the initial difficult management of primary care, affecting the hospital admissions for other diseases, also including time-dependent acute illnesses (7).

San Raffaele Hospital (OSR) is one of the main private accredited hospital in Lombardy, with a leadership in the research and clinical assistance. It counts more than 750 physicians and 1,300 nurses, covering about 1,300 beds. Moreover, OSR has specific competences in the emergency management, with about 72,000 admissions/year to the ED, 25% of which in red code. During the pandemic, OSR had a notable change in its organization, with a major increase in intensive care beds. COVID-19-free beds were converted into beds for COVID-19 patients and two tensile structures with 24 additional intensive care beds have been built in the University sports field (8).

The aim of this paper is to compare an inter-epidemic time (from 1st September to 30th September) to a 6-weeks-epidemic period (from 1st October to 15th November), in terms of trend and appropriateness of COVID-19 patients' admissions to the OSR ED and, consequently, the efficiency of the primary care of the surrounding area. The assessment has been conducted using some "drivers" as the ED presentation (e.g self-presentation or ambulance transport), the priority discharge colour code and the outcome (e.g discharge or hospitalization).

## Materials and methods

We retrieved OSR ED admissions from PSNet Hi.Tech© software database, over the period from 1st September 2020 to 15th November 2020. The dataset included information on admission date, triage and discharge priority colour codes, (where white indicates a non-critical status, green low critical, yellow medium critical and red code a very critical status) (9-10) ED presentation, examination room, descriptive diagnosis, discharge date and outcome.

Considering 1st October as the beginning of the second COVID-19 wave, we compared examination room overall admissions distribution between 1st September to 30th September (Inter-Wave Period - IWP) and between 1st October to 15th November (Wave Period-WP), focusing on COVID-19 settings (COVID-19 medicine and COVID-19 Short-Stay Observation); the examination room represents a proxy of the clinical condition of the patients, therefore, the majority of the COVID-19 patients were cared for in the COVID-19 settings.

Since it was possible that some patients with SARS-Cov-2 asymptomatic subclinical infection accessed to the ED and that they were managed in an examination room other than the COVID-19 settings, in order to obtain a complete and well-selected sample of patients with SARS-Cov-2 infection, we crossed, through record-linkage technique, the ED database with the laboratory database (DNLab NOEMALIFE©) and we identify patients with at least a positive swab within 3 days from the ED acceptance date.

We analysed separately and compared data of the IWP to the WP, in order to assess the admissions' appropriateness. We analysed the following "drivers":

*ED presentation* grouped by self-presented, transported by ambulance, other (including sent by general practitioner or paediatrician, outpatients, inpatients, transferred from other ED);

*Discharge priority colour code*

*Outcomes,* grouped by discharge (including abandon, discharge in white code, visit refusal), hospitalization, transfers (including discharge in external structures); other (including death, currently visiting patients, cancelled patients).

The study was approved by the hospital ethics committee (protocol No. 34/int/2020) and was registered on ClinicalTrials.gov (NCT04318366).

*Statistical analysis*

We computed descriptive statistics, counts and percentages, for the categorical variables analysed. Differences between IWP and WP were tested using the chi-square test or Fisher's exact test, as needed. We considered significant a two-tailed p-values ≤0.05. All statistical analyses were performed using SAS 9.4 (SAS Institute, Inc., Cary, NC, USA).

## Results

*Overall admissions*

Starting from 1st September 2020 to 15th November 2020 a total of 9,707 ED admissions were registered, 4,315 (44.5%) in the IWP and 5,392 (55.5%) in the WP.

*Examination room distribution*

As regards the accesses distribution by examination room, COVID-19 admissions increased from the IWP to the WP, passing from 4.3% to 17.0% in COVID-19 medicine and from 0.0% to 5.8% in COVID-19-Short-Stay Observation. The accesses in the other rooms remained stable or declined. A reduction in admissions to Medicine (1,162/26.9% IWP to 1,012/18.8% WP), Surgery (1,218/28.2% IWP to 1,229/22.8% WP), Orthopaedics (658/15.3% IWP to 581/10.8% WP) and Ophthalmology (161/3.7% IWP to 128/2.4% WP) were registered (Table 1).

## SARS-Cov-2 infection admissions

Over the considered period, a total of 977 admissions with a SARS-Cov-2 positive swab were recorded (corresponding to 921 patients), 57 (5.8%) in the IWP and 920 (94.2%) in the WP.

**Table 1.** Overall admissions' distribution by examination room from 1st to 30th September 2020 (IWP) and from 1st October to 15th November 2020 (WP).

| Examination room | IWP | WP |
|---|---|---|
| | N (%) | N (%) |
| Cardiology | 185 (4.3) | 263 (4.9) |
| Surgery | 1218 (28.2) | 1229 (22.8) |
| External consultancy | 5 (0.1) | 7 (0.1) |
| Internal consultancy | 3 (0.1) | 9 (0.2) |
| Medicine | 1162 (26.9) | 1012 (18.8) |
| **COVID-Medicine*** | **186 (4.3)** | **919 (17.0)** |
| **COVID-Short-Stay Observation*** | **0 (0.0)** | **314 (5.8)** |
| Ophthalmology | 161 (3.7) | 128 (2.4) |
| Orthopaedics | 658 (15.3) | 581 (10.8) |
| Obstetrics/Gynecology | 398 (9.2) | 506 (9.4) |
| Paediatrics | 268 (6.2) | 323 (6.0) |
| Urgency | 71 (1.7) | 101 (1.9) |
| **NO-COVID admissions*** | **4,129 (95.7)** | **4,159 (77.1)** |
| **Total** | **4,315 (44.5**)** | **5,392 (55.5**)** |
| | *p-value<0.0001* | |

*Legend: IWP – Inter Wave Period, WP – Wave Period, COVID – Coronavirus Disease*

**in bold emphasis is placed on COVID admissions, divided by Medicine and Short-Stay-Observation, and non-COVID admissions.*

*** percentage of the total of 9707*

*Discharge priority colour code*

Table 2 and Figure 1 show admissions distribution by discharge priority colour codes over the IWP and WP. Red, Yellow and White codes increased from IWP to WP, from 3.5% to 7.5%, from 12.3% to 30.7% and from 1.8% to 5.4% respectively. Green codes decreased from 82.5% of the IWP to 56.4% of the WP.

*ED presentation*

No differences in admissions distributions by presentations over the IWP and WP were observed. Patients self-presented were 43.9% in IWP and 41.5% in WP, patients transported by ambulance were 54.4% in IWP and 56.0% in WP (see Table 3). In the analysis of the colour code in each presentation mode, we noted an increase in self-presented in yellow and white code from the IWP to the WP period (from 4.0% to 20.8% and from 4.0% to 8.9% respectively), while we observed a reduction in green code patients (from 92% to 68.5%). The increase in yellow codes was of greater importance in ambulance accesses (from 16.1% IWP to 38% WP), in which there were also an increase in red codes (from 6.5% IWP to 10.8% WP) and a decrease in green codes (from 77.4% IWP to 48.1% WP) (see Table 3).

**Table 2.** COVID-19 admissions' distribution by discharge priority colour code from 1st to 30thSeptember 2020 (IWP) and from 1st October to 15th November 2020 (WP).

| **Discharge priority colour codes code** | **IWP** | **WP** |
|---|---|---|
| | **N (%)** | **N (%)** |
| Red | 2 (3.5*) | 68 (7.5*) |
| Yellow | 7 (12.3*) | 278 (30.7*) |
| Green | 47 (82.5*) | 510 (56.4*) |
| White | 1 (1.8**) | 49 (5.4*) |
| **Total** | **57 (5.8**)** | **920*** (94.2**)** |
| | *p-value 0.0015* | |

*Legend: IWP – Inter Wave Period, WP – Wave Period. *The sum of the percentages is not 100% due to rounding up. ** percentage of the total of 977. ***The sum does not add to 920 because of 15 missing values*

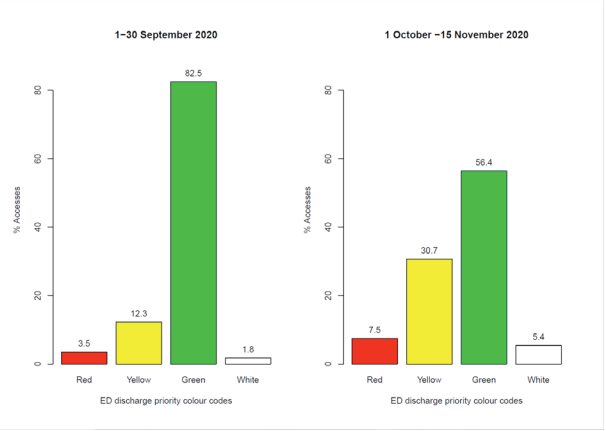


**Figure 1.** Barplot of discharge priority colour code's distribution from 1st to 30thSeptember 2020 (IWP) and from 1st October to 15th November 2020 (WP).
**Legend.** red code indicates a very critical, yellow medium critical, green low critical, white non-critical status

*Outcomes*

Table 4 and Figure 2 show admissions distribution by outcome over the IWP and WP. Discharge noticed an increase (from 31.6% of the IWP to 40.4% of the WP), while hospitalizations decreased from 63.2% of the IWP to 51.3% of the WP.

**Table 3.** COVID-19 admissions' distribution by ED presentation (stratified by colour code) from 1st to 30thSeptember 2020 (IWP) and from 1st October to 15th November 2020 (WP).

| **Presentation** | **IWP** | **WP** |
|---|---|---|
| | **N (%)** | **N (%)** |
| **Self-presented** | **25 (43.9)** | **382 (41.5)*** |
| Red | 0 (0.0) | 7 (1.9) |
| Yellow | 1 (4.0) | 77 (20.8) |
| Green | 23 (92.0) | 254 (68.5) |
| White | 1 (4.0) | 33 (8.9) |
| | *p-value* 0.104 | |
| **Ambulance** | **31 (54.4)** | **515 (56.0)**** |
| Red | 2 (6.5) | 55 (10.8) |
| Yellow | 5 (16.1) | 194 (38.0) |
| Green | 24 (77.4) | 246 (48.1) |
| White | 0 (0.0) | 16 (3.1) |
| | *p-value 0.020* | |

*Legend: IWP – Inter Wave Period, WP – Wave Period; *11 missing; **4 missing*

**Table 4.** COVID-19 admissions' distribution by outcomes from 1st to 30th September 2020 (IWP) and from 1st October to 15th November 2020 (WP).

| Outcome | IWP | WP |
|---|---|---|
| | N (%) | N (%) |
| Discharge | 18 (31.6) | 372 (40.4) |
| Hospitalization | 36 (63.2) | 472 (51.3) |
| Tranferred | 3 (5.3) | 43 (4.7) |
| Other | 0 (0.0) | 33 (3.6) |
| | *p-value 0.216* | |

*Legend: IWP – Inter Wave Period, WP – Wave Period*

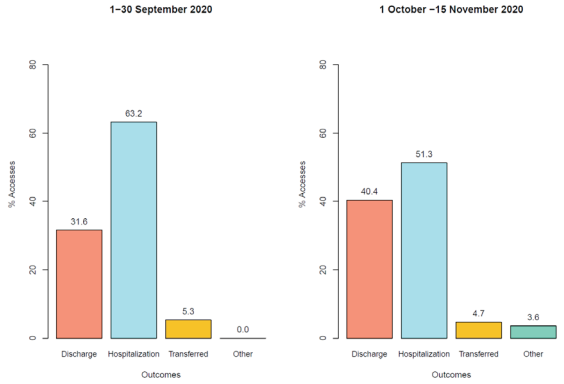


**Figure 2.** Barplot of outcomes' distribution from 1st to 30thSeptember 2020 (IWP) and from 1st October to 15th November 2020 (WP).

*Focus on distribution by age*

The analysis of the admissions in COVID-19 settings stratified by age showed a higher prevalence of patients <50 years in COVID-19 medicine and a number of patients> 50 years in COVID-19-Short-Stay-Observation (in this area there are no admissions in the IWP as it was closed). We observed an overall increase in admissions in COVID-19 medicine, as well as a reduction in NO-COVID-19 accesses, between IWP and WP for all age groups (Table 5).

Stratifying the discharge priority colour codes by age, there was an increase in yellow-coded patients in the 50-69 and over 70-year-old age groups (from 1.8% IWP to 11.5% WP and from 5.3% IWP to 15.1% WP respectively), while a reduction in green-coded patients was observed, especially in the under 50-year-old group (from 49.1% IWP to 21.5% WP respectively).

**Table 5.** COVID-19 admissions' distribution by age from 1st to 30th September 2020 (IWP) and from 1st October to 15th November 2020 (WP).

| Examination room Age | IWP | WP |
|---|---|---|
| | N (%) | N (%) |
| **COVID-Medicine** | **186 (4.3)** | **919 (17.0)** |
| <50 | 115 (2.7) | 391 (7.3) |
| 50-69 | 32 (0.7) | 298 (5.5) |
| ≥70 | 39 (0.9) | 230 (4.3) |
| | *p-value <.0001* | |
| **COVID-Short-Stay Observation** | **0 (0.0)** | **314 (5.8)** |
| <50 | | 73 (1.4) |
| 50-69 | | 121 (2.2) |
| ≥70 | | 120 (2.2) |
| | – | |
| **NO-COVID admissions** | **4,129 (95.7)** | **4,159 (77.1)** |
| <50 | 2131 (49.4) | 2279 (42.3) |
| 50-69 | 931 (21.6) | 925 (17.2) |
| ≥70 | 1067 (24.7) | 955 (17.7) |
| | *p-value 0.004* | |
| **Total** | **4,315** | **5,392** |

*Legend: IWP – Inter Wave Period, WP – Wave Period*

## Discussion

This report aims to provide a descriptive analysis of the admissions to the ED of a main metropolitan COVID-19 hub hospital in Milan. In order to validate the investigation and to evaluate the appropriateness of patients positive to SARS-Cov-2 admissions to the ED, we compared the inter wave period (IWP) and the wave period accesses (WP). As expected from the epidemiological evolution and the international literature (11-12) we observed an overall reduction of NO-COVID-19 accesses (from 95.7% of accesses in the IWP to 77.1% in WP) and an increase in patients treated in COVID-19 (Medicine and Short-Stay Observation) settings, with a clear prevalence of treatment in a low intensive

**Table 6.** COVID-19 admissions' distribution by discharge priority colour code (stratified by age) from 1st to 30th September 2020 (IWP) and from 1st October to 15th November 2020 (WP).

| **Discharge priority colour codes code** | **IWP** | **WP** |
|---|---|---|
| | **N (%)** | **N (%)** |
| **Red** | **2 (3.5)** | **68 (7.5)** |
| <50 | - | 3 (0.3) |
| 50-69 | 2 (3.5) | 29 (3.2) |
| ≥70 | - | 36 (4.0) |
| | *p-value 0.1925* | |
| **Yellow** | **7 (12.3)** | **278 (30.7)** |
| <50 | 3 (5.3) | 37 (4.1) |
| 50-69 | 1 (1.8) | 104 (11.5) |
| ≥70 | 3 (5.3) | 137 (15.1) |
| | *p-value 0.0165* | |
| **Green** | **47 (82.5)** | **510 (56.4)** |
| <50 | 28 (49.1) | 195 (21.5) |
| 50-69 | 13 (22.8) | 178 (19.7) |
| ≥70 | 6 (10.5) | 137 (15.1) |
| | *p-value 0.0003* | |
| **White** | **1 (1.8)** | **49 (5.4)** |
| <50 | 1 (1.8) | 42 (4.6) |
| 50-69 | - | 7 (0.8) |
| ≥70 | - | - |
| | - | |
| **Total** | **57** | **905*** |

care setting (Medicine). For some specialties, such as Paediatrics and Obstetrics / Gynecology, admissions were unaltered between the IWP and the WP (6.2% vs 6.0% and 9.2% vs 9.4% respectively), probably due to the non-postponement of the necessary treatments (e.g births, obstetric or paediatric emergencies not managed by the primary care paediatricians). On the contrary, the Surgery and Orthopedics admissions decreased (28.2% IWP vs 22.8% WP and 15.3% IWP vs 10.8% WP respectively), according to the other national literature (13); possible explanations include the patient's self-assessment of the non-urgency of care, related to the fear of contracting the coronavirus disease in the hospital (13). However, it is emphasized that the reduced admission to hospital for people with chronic diseases will lead to important consequences in both the near future and for the long-term consequences (14-16).

The red and yellow codes increased according to the increase in the number of cases of the second epidemic wave (WP), as did the white codes unexpectedly. The increase in white codes represents an index of inappropriateness of access and inefficient management of the primary care, as these patients do not present a seriousness of symptoms such as to require management in a hospital setting (17). This is confirmed by the increase in discharges and the consequent reduction in hospitalizations; therefore, a consistent part of the patients who accessed the ED were discharged, almost as many were hospitalized (40.4% versus 51.3%). This large number of discharges was possible because of a prompt take-over from primary care, with management of the patient at home (18).

In both the considered periods there was a clear prevalence of admissions by ambulance, and green code patients represented the majority of self-presented and by-ambulance admissions. In the IWP, however, there was a more homogeneous colour codes distribution.

Regarding the distribution by age, most of the overall accesses to the ED concerns patients aged <50 years, who are registered mainly in the green code; there is also an increase in patients > 70 years during the WP. Older COVID-19 patients have a more intensive care setting (COVID-19-Short-Stay Observation). There is no correlation between the reduction in NO-COVID-19 admissions and the age of the patients since a reduction is observed in all age groups.

It is emphasized that, although our work uses data from only one Hospital, there are some strengths including the use of original data, as well as the location of the Center in the COVID-19 most affected Region; moreover, it is a single but important Hospital in a large metropolitan area. The IRCCS San Raffaele Hospital is located in Municipality 3 of Milan (over 200,000 inhabitants) and has a user base that is concentrated in the eastern area of the metropolitan city of Milan, going north beyond the city of Monza and south to the city of Lodi.

The results are aligned with those of other studies, but our work compares the second wave of the pandemic (WP) with the inter-wave period (IWP), while

the international literature mainly compares the first wave of COVID-19 with data of 2019.

## Conclusion

A number of key messages emerge from our study. First, the COVID-19 pandemic has brought out the fundamental role of primary care in the management of patients with low-intensity needs, including COVID-19 patients. In the WP there was an increase in discharges and a reduction in hospitalizations, with a greater and prompt organization of primary care, able to manage the less severe patients. Second, the important increase in ED admissions of COVID-19 patients and the allocation of resources and spaces to them caused a reduction in the admissions of NO-COVID-19 patients, also for fear of possible infection. This involves an increase in the possibility of an inadequate treatment of NO-COVID-19 patients.

**Conflict of interest:** The authors declare that there is no conflict of interest and this research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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