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LETTER TO THE EDITOR Open Access

The potential role of ICU capacity strain in COVID-19 mortality: comparison between first and second waves in Pavia, Italy

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To the Editor,

In novel coronavirus disease (COVID-19) pandemic, a high mortality rate was reported during wave 1, particularly when COVID-19 load exceeded 100% ICU capacity [1]. With better knowledge of the disease [2, 3], a lower mortality was expected in wave 2; however, similar mortalities were reported for hospital/ICU populations [4]. Within the same wave, in-hospital mortality was lower once past the peak of hospital affluence [1, 5], suggesting a role of ICU facilities' availability. However, their actual role remains unclear since mortality was high also in non-overwhelmed healthcare systems [6].

To test if disproportion between ICU facilities and hospitalized patients impact COVID-19 mortality, we compared the first 8 weeks of waves 1 vs. 2 in Pavia (Lombardy, Italy). ICU-timing (time from hospital to ICU admission), percentage of COVID-19 hospitalized patients admitted to ICU, and percentage of intubated patients in ICU were considered ICU capacity strain's markers. All patients during wave 2 received steroids as appropriate [3]. Local ethic committee approved the study.

Patients' characteristics are in Table 1. In wave 1, a steep increase of ICU COVID-19 patients reached a peak of 64 on day 34 (Fig. 1A); a plateau phase lasted 14/56 days (25.0%); thereafter, a reduction was observed. In wave 2 (Fig. 1B), a slower increase achieved a lower peak (54 patients) on day 40 and lasted 4/56 days (7.1%; p=0.010).

At day 56 of wave 1, patients admitted to ICU were 139, ICU mortality was 54/84 (64.3%), patients still in ICU were 55 (39.6%), and their follow-up ICU mortality was 14/55 (25.5%), lower than in the beginning of the same wave (p<0.0001).

At day 56 of wave 2, patients admitted to ICU were 119, ICU mortality was 18/74 (24.3%; p<0.0001 vs. wave 1), patients still in ICU were 45 (37.8%), and their follow-up ICU mortality was 16/45 (35.6%), similar to the first 8 weeks (p=0.2133). Findings in ward patients are displayed in Fig. 1C, D.

In waves 1 and 2, hospital mortality was in overall ICU patients 48.9% and 30.3% (p=0.0033), in intubated patients 50.7 and 36.7% (p=0.0410), in ward patients 33.3% and 19.6% (p<0.0001), respectively.

Wave 2 determined a lower ICU strain: patients that could be treated in ICU were 17.7 vs. 13.1% (relative increase 35.1%; p=0.0104); ICU-timing was shorter (57±92 vs. 90±91 h; p=0.0047), with patients admitted to ICU within 48 h 58.0 vs. 40.3% (p=0.0059); and intubation was less frequent (75.6 vs. 96.4%; p<0.0001).

ICU-timing was resulted in an independent risk factor for hospital mortality when adjusted for age, gender, and need of invasive ventilation (p<0.0001).

The improvement of ICU and ward patients' outcome exceeded what expected from steroids' introduction [3], supporting that other factor may have a role [5]. ICU strain was significantly higher during wave 1. Moreover, patients were admitted to ICU later, when intubation

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Table 1 Features of the patients admitted to general ward and to ICU during the first and the second COVID-19 waves in Pavia

		1st + 2nd waves (*N* = 1736)	1st wave (*N* = 1062)	2nd wave (*N* = 674)	*P* value
Ward patients	*n* (%)	1478 (85.1)	923 (86.9)	555 (82.3)	**0.0104**
Male	*n* (%)	914 (61.8)	555 (60.1)	359 (64.7)	0.0866
Age	Years	69.6 ± 15.2	69.8 ± 15.4	69.3 ± 15.0	0.5154
Hospital stay	Days	11.9 ± 10.8	11.3 ± 10.6	13.0 ± 11.1	**0.0027**
Hospital deaths	*n* (%)	416 (28.1)	307 (33.3)	109 (19.6)	**<0.0001**
ICU patients	*n* (%)	258 (14.9)	139 (13.1)	119 (17.7)	**0.0104**
Male	*n* (%)	215 (83.3)	117 (84.2)	98 (82.4)	0.7392
Age	Years	61.9 ± 11.2	61.4 ± 11.1	62.5 ± 11.5	0.4323
Invasive mechanical ventilation	*n* (%)	224 (86.8)	134 (96.4)	90 (75.6)	**<0.0001**
ICU timing	Hours	74.8 ± 92.5	89.8 ± 90.6	57.3 ± 92.0	**0.0047**
ICU stay	Days	26.8 ± 23.2	26.6 ± 23.9	27.1 ± 22.4	0.8685
ICU deaths	*n* (%)	102 (39.5)	68 (48.9)	34 (28.6)	**0.0009**
Hospital stay	Days	37.3 ± 26.3	36.3 ± 28.4	38.5 ± 23.5	0.5089
Hospital deaths	*n* (%)	104 (40.3)	68 (48.9)	36 (30.3)	**0.0033**

ICU intensive care unit. Data are expressed as *n* (%) or mean ± standard deviation. In bold: significant *p* values <0.05

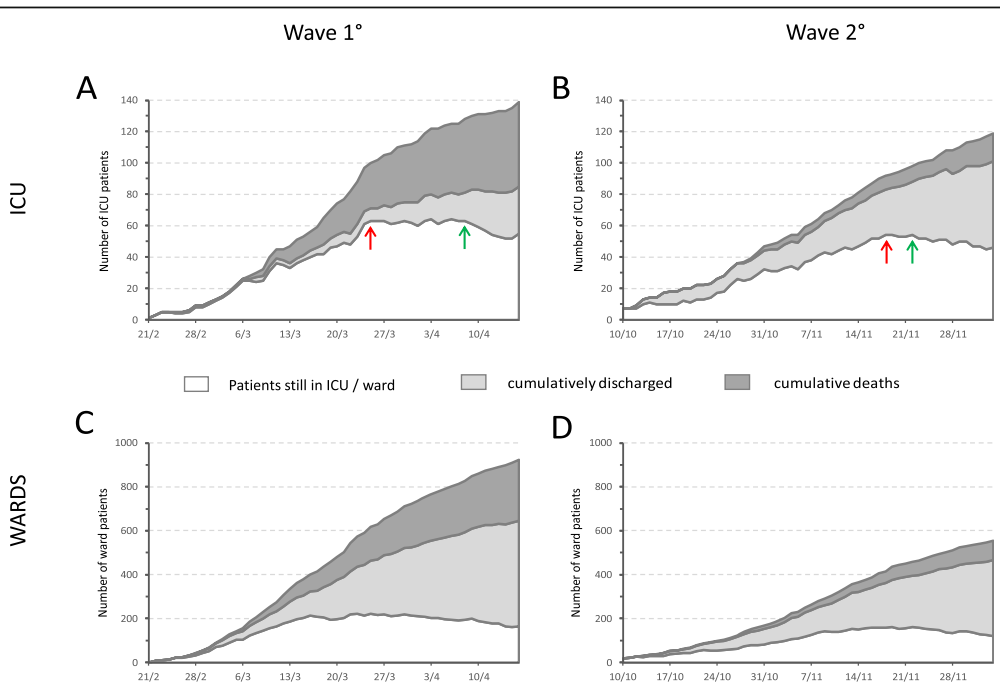

Fig. 1 The first 8 weeks of the two pandemic waves in ICU and in the wards: this timeframe was representative of the critical phase for our healthcare system, including rapid increase of ICU patients up to a peak (red arrows), plateau phase, and initial decline (green arrows). **A** Wave 1 in ICU. A steep increase of ICU COVID-19 patients was observed until a peak of 64; pre-pandemic capacity was 32 beds. The peak was reached on day 34; a plateau phase persisted until day 48; thereafter, a reduction was observed. After 8 weeks, 139 patients had been admitted to ICU (13.1% of hospital admissions) with 55 (39.6%) patients still in ICU, 30 (21.6%) discharged and 54 (38.8%) deceased. At this time, mortality was 54/84 (64.3%) in ICU patients. **B** Wave 2 in ICU. The initial increase was slower, and a lower peak (54 ICU patients) was achieved on day 40; a plateau phase lasted until day 44, when the decline started. After 8 weeks, 119 patients had been admitted to ICU (17.7% of hospital admissions, p= 0.0104 vs. wave 1) with 45 (37.8%) patients still in ICU, 56 (47.1%) discharged, and 18 (15.1%) cumulative deaths (p<0.0001 vs. wave 1). At this time, mortality was 18/74 (24.3%) in ICU patients (p<0.0001 vs. wave 1). **C** Wave 1 in the wards. After 8 weeks, 923 patients had been admitted (86.9% of hospital admissions) with 175 (19.0%) patients still in the ward, 475 (51.5%) discharged, and 273 (29.6%) deceased. At this time, mortality was 273/748 (36.5%) in ward patients. **D** Wave 2 in the wards. After 8 weeks, 555 patients had been admitted (82.3% of hospital admissions, p= 0.0104 vs. wave 1) with 134 (24.1%) patients still in the ward, 334 (60.2%) discharged and 87 (15.7%) deceased (p<0.0001 vs. wave 1). At this time, mortality was 87/421 (20.7%) in ward patients (p<0.0001 vs. wave 1)

was almost unavoidable, which may increase mortality [5]. ICU-timing was an independent predictor of mortality, suggesting intensive care should be considered a time-dependent treatment for COVID-19 patients.

In conclusion, COVID-19 mortality notably decreased in wave 2 at our institution; beyond the benefits of a deeper knowledge of the disease, lower ICU capacity strain and timelier ICU admission may have played a role.

Abbreviations

COVID-19: Novel coronavirus disease; ICU: Intensive care unit

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Authors' contributions

FM conceived the research protocol, collected and analysed the data, wrote the draft, and revised it critically before submission. SC collected and analysed the data and revised the draft critically before submission. SM collected and analysed the data, wrote the draft, and revised it critically before submission. RB collected the data and revised the draft critically before submission. AGC collected the data and revised the draft critically before submission. All authors read and approved the final manuscript.

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Availability of data and materials

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Declarations

Ethics approval and consent to participate

The study was approved by local ethic committee.

Consent for publication

All the patients signed an informed consent for data publication.

Competing interests

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