

Responses of Italian public hospitals to COVID-19 pandemic: analysis of supply and demand of hospital ICU beds [†]

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Abstract: This study aims to analyze the pressure on the Italian public hospitals from the additional demand created by COVID-19. Starting from the analysis of regulatory interventions ordered by the Central Government in response to the emergency, this paper analyzes daily the trend of hospital beds and admissions in Intensive Care Units from March to November 2020. The results revealed a critical situation in the system for meeting demand, with numerous regions operating beyond their capacity, especially in the first wave of the pandemic. The study presents two relevant messages. First, it is necessary to slow the spread of COVID-19 in the Italian population, allowing more time for the reorganization of the supply and relieve the pressure on the health system: a third wave of the COVID-19 pandemic would cause the collapse of the National health system. Another suggestion regards the regionalized organization of health services: the design may be adequate in situations of routine demand but suffers important challenges during pandemics.

Keywords: COVID-19; Italian Health System; Hospital beds; ICU

1. Introduction

The new coronavirus (SARS-CoV-2 or COVID-19) outbreak appeared in Wuhan, China in December 2019 and rapidly was spread in Europe (EU) [1]. Italy was the first EU Country to suffer severe effects of this virus diffusion, with a spiral of infections that placed this Country at the top of the international rankings, overtaking China on March 19, 2020 [2, 3].

The outbreak of covid-19 in Italy officially started on 31 January 2020, after two Chinese visitors staying at a central hotel in Rome tested positive for the new coronavirus SARS-CoV-2 [4, 5].

On 21 February, after a few days of increasing concern, a 38-year-old man was admitted to the hospital in Codogno, Lombardy, and was confirmed as the first Italian citizen with covid-19 [4].

Since then, in less than one week, the number of cases in Italy increased beyond expectations, putting the Italian health service under considerable strain: cases were found initially in several bordering regions and autonomous provinces of northern Italy and then gradually spread across all Italian regions [4].

One of the major consequences of the rapid spread of the virus has been the overload of hospitals, particularly in intensive care units (ICUs): the 2019-nCoV infection caused clusters of severe respiratory illness similar to severe acute respiratory syndrome coronavirus and was associated with ICU admission, mechanical ventilation and high mortality in older patients and those with medical comorbidities [6].

In this context, the central government has promoted new policies to contain the spread of the virus. The new decrees were initially intended for the "red zone" regions, then spread whole country (Table 1).

Table 1. Measures adopted by the Central Government.

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<i>Measures for the containment and management of the COVID-19 emergency</i>						<i>Strengthening measures of the National Health Service</i>	
Decree-law of 23 February 2020	Prime Minister's Decree of 1° March 2020	Decree-law of 2 March 2020	Prime Minister's Decree of 4 March 2020	Prime Minister's Decree of 8 March 2020	Decree-law of 8 March 2020	Decree-law of 9 March 2020	Decree-law 17 March 2020
<i>Urgent measures for the containment and management of the epidemiological emergency from COVID-19.</i>	<i>Further implementing provisions of the decree-law of 23 February 2020, n. 6, containing urgent measures regarding the containment and management of the epidemiological emergency from COVID-19.</i>	<i>Urgent support measures for families, workers and businesses related to the epidemiological emergency caused by COVID-19.</i>	<i>Further implementing provisions of the decree-law of 23 February 2020, n. 6, containing urgent measures regarding the containment and management of the epidemiological emergency from COVID-19, applicable on the whole national territory.</i>	<i>Further implementing provisions of the decree-law of 23 February 2020, n. 6, containing urgent measures regarding the containment and management of the epidemiological emergency from COVID-19.</i>	<i>Extraordinary and urgent measures to counteract the epidemiological emergency from COVID-19 and contain the negative effects on the judicial activity.</i>	<i>Urgent provisions for the strengthening of the National Health Service in relation to the COVID-19 emergency.</i>	<i>Strengthening measures of the National Health Service and economic support for families, workers and businesses connected to the epidemiological emergency from COVID-19</i>

The measures introduced have not been enough to contain the further spread of the epidemic and the consequent overloading of hospital structures.

The need to face the epidemiological emergency from COVID-19, has forced the adoption of extraordinary and urgent measures aimed at strengthening the NHS, mainly introduced with the decree-laws of 9 March 2020 [7] and 17 March 2020 [8].

The decrees directly involve hospital structures. The main measures concerned:

- *the strengthening of human resources.* To address the urgent needs deriving from the diffusion of COVID-19, the entities of the National Health Service have been authorised to re-determine the plans of personnel needs and proceed with the consequent recruitment of health personnel. The increase in personnel concerned the hospital units most affected by the emergency (such as infectious and tropical diseases, emergency medicine, internal medicine, ICUs).
- *the establishment of temporary health areas:* hospitals have activated temporary health areas both inside and outside of the structures, for the management of the Covid-19 emergency.
- *the suspension of hospitalizations and non-urgent outpatient activities.* For priority management of the Coronavirus emergency, hospitals have been authorised to suspend or remodel non-urgent hospitalization and outpatient activities.
- *the increase in beds:* the emergency from COVID-19 required the immediate strengthening of the ICUs, especially in the most affected regions. Circular of 29 February 2020 n. 2619 of the Ministry of Health (whose recommendations were subsequently regulated by the decree law of 9 March 2020) underlined the urgent need for the regions to prepare an emergency plan to guarantee suitable levels of treatment through an adequate number of intensive care beds. Subsequently, the circular of the Ministry of Health of 1 March 2020 n. 2627 (whose recommendations were subsequently regulated by decree law n. 18 of 17 March 2020) required that, in the shortest possible time, an interregional cooperation model coordinated at national level was activated, with the involvement of public and private accredited structures. At the regional level, the model envisaged an increase of 50 per cent in the number of beds in ICUs and 100 per cent in the pulmonary and infectious disease units.

This study aims to analyze the pressure on the Italian public hospitals from the additional demand created by COVID-19. Specifically, the trend of hospital beds and admissions in ICUs from March to November 2020 was daily analysed, highlighting the daily bed occupancy rate and the regions whose public hospitals have been subjected to increased pressure [9].

The paper is organized as follows:

Section 2 describes data and method; section 3 reports the main results. Discussions and conclusions are reported in section 4.

2. Materials and Methods

This paper analyzes the daily trend of ICU beds and admissions for COVID-19 in Italian public hospitals between 2 March to 30 November 2020 [9].

Data were obtained from the official website of the Italian Health Ministry (<http://www.salute.gov.it/nuovocoronavirus>) that reports information of COVID-19 infection in Italy, and from the website of the National Agency for Regional Health Services (Agenas – *Agenzia Nazionale per i Servizi Sanitari Regionali*) (<https://www.agenas.gov.it/covid19/web/index.php>) that contains information of hospitals ICU beds trend in Italian regions.

3. Results

From March to November 2020, the number of beds in ICUs switched from 5213 to 7216 (Figure 1). The sudden emergency did not allow an immediate response from hospitals to the increase in cases. Until then, the organization of the Italian healthcare system was the result of a massive process of reform based on “managerialism” of healthcare. As a result, deep changes were made in the public healthcare offer, with a significant reduction of beds and health personnel. For this reason, the first months of the pandemic put public health facilities under great pressure. Starting from April, the national lockdown imposed in March allowed a reduction in cases, with a further decrease in the period between June and August. Starting from September 2020, the infections started to increase again. Public health structures, more prepared for a second wave of the epidemic, have increased the number of beds in ICUs: between September and October the number of beds has gone from 5889 to 7191. However, this has not prevented a new strong pressure on public health facilities.

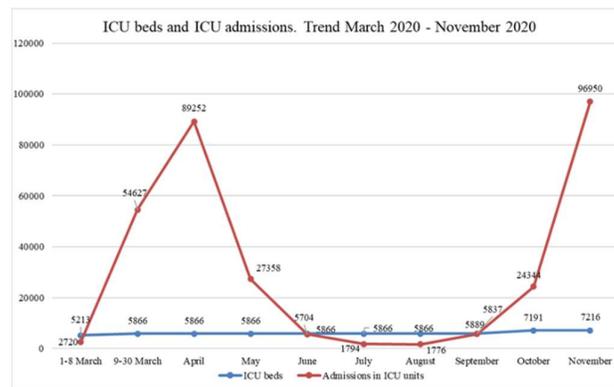


Figure 1. Overall trend of beds and admissions.

The following table (Table 2) shows the pressure on public hospitals in the Italian regions. The hospital bed-occupancy rates in ICUs were calculated daily; the table shows a summary of the results for each month (lowest bed-occupancy rate, highest bed-occupancy rate and average value for each period / month). The month of March was divided into two subperiods: the period from 2 to 8 March, as in those days most regions did not report Covid-19 cases, and the period from 9 to 30 March, in which the sudden increase in cases led to an increase in the bed-occupancy rate in all regions. In the analyzed period, the regions under the greatest pressure were Lombardy, the autonomous provinces of Trento and Bolzano, Marche, Piemonte and Valle d'Aosta, especially in the first wave of the pandemic.

Table 2. Hospital bed-occupancy rates in ICUs.

Regions		Periods									
		1-8 March	9-30 March	April	May	June	July	August	September	October	November
ABRUZZO	Min	0,00%	0,00%	14,68%	2,75%	0,00%	0,00%	0,92%	0,92%	4,59%	21,62%
	Max	0,00%	65,14%	69,72%	14,68%	5,50%	1,83%	1,83%	4,59%	19,59%	52,03%
	Mean	0,00%	37,28%	42,42%	6,87%	2,45%	0,41%	0,95%	3,24%	10,05%	39,39%
BASILICATA	Min	0,00%	0,00%	6,25%	0,00%	0,00%	0,00%	0,00%	1,56%	0,00%	15,07%
	Max	0,00%	29,69%	29,69%	6,25%	1,56%	0,00%	1,56%	3,13%	9,59%	41,10%
	Mean	0,00%	12,04%	17,76%	2,02%	0,42%	0,00%	0,15%	1,61%	3,48%	28,40%
BOLZANO	Min	0,00%	0,00%	18,57%	5,71%	0,00%	0,00%	0,00%	0,00%	0,00%	22,08%
	Max	0,00%	127,50%	92,86%	15,71%	5,71%	1,43%	2,86%	2,86%	23,38%	57,14%
	Mean	0,00%	55,28%	52,66%	9,86%	1,95%	0,18%	1,01%	1,43%	7,84%	48,44%
CALABRIA	Min	0,00%	0,00%	4,26%	0,71%	0,00%	0,00%	0,00%	0,00%	0,66%	7,24%
	Max	0,00%	16,31%	13,48%	2,84%	0,71%	0,71%	0,71%	2,63%	7,24%	34,87%
	Mean	0,00%	8,93%	7,57%	1,30%	0,17%	0,05%	0,59%	1,51%	3,03%	21,32%
CAMPANIA	Min	0,00%	1,87%	6,79%	1,17%	0,00%	0,00%	0,23%	0,94%	8,90%	33,66%
	Max	1,64%	42,39%	31,15%	7,03%	1,64%	1,41%	1,17%	9,13%	33,27%	44,95%
	Mean	0,23%	15,57%	17,74%	3,91%	0,58%	0,28%	0,49%	4,18%	18,85%	37,60%
EMILIA ROMAGNA	Min	3,56%	20,04%	45,88%	12,69%	0,00%	0,67%	0,67%	2,00%	2,45%	23,45%
	Max	16,70%	78,17%	83,52%	44,32%	12,03%	2,23%	2,45%	5,12%	22,20%	45,83%
	Mean	9,23%	51,13%	68,78%	27,44%	4,11%	1,65%	1,26%	3,71%	10,77%	39,04%
FRIULI VENEZIA GIULIA	Min	0,00%	0,79%	8,66%	0,79%	0,00%	0,00%	0,00%	1,57%	1,57%	21,14%
	Max	0,79%	47,24%	48,03%	4,72%	3,15%	1,57%	2,36%	4,72%	20,57%	32,57%
	Mean	0,22%	24,95%	23,49%	1,96%	0,66%	0,43%	1,80%	3,18%	8,45%	27,50%
LAZIO	Min	0,00%	1,44%	20,65%	10,23%	0,00%	1,62%	1,08%	1,44%	7,63%	21,84%
	Max	1,44%	27,65%	36,45%	18,85%	10,05%	2,33%	1,62%	8,44%	22,22%	42,03%
	Mean	0,87%	11,84%	32,68%	13,72%	5,52%	1,85%	1,34%	3,81%	13,75%	33,73%
LIGURIA	Min	0,54%	9,14%	37,10%	4,30%	0,00%	0,00%	0,00%	2,69%	11,29%	27,27%
	Max	5,91%	94,09%	96,24%	38,71%	3,76%	1,61%	1,61%	12,90%	27,27%	58,85%
	Mean	2,38%	55,87%	65,65%	18,26%	1,42%	0,33%	0,57%	7,35%	16,08%	48,69%
LOMBARDIA	Min	14,78%	51,22%	61,55%	17,29%	4,27%	0,71%	0,92%	2,14%	3,56%	40,35%
	Max	46,45%	135,30%	140,49%	57,27%	16,99%	4,17%	2,03%	3,87%	37,84%	91,60%
	Mean	30,17%	102,54%	104,18%	31,45%	8,42%	2,52%	1,30%	3,00%	12,99%	75,15%
MARCHE	Min	5,56%	43,52%	28,57%	5,36%	0,00%	0,00%	0,00%	0,60%	1,79%	21,76%
	Max	37,96%	100,00%	100,60%	27,38%	5,36%	0,60%	0,60%	2,38%	27,98%	48,70%
	Mean	19,84%	83,29%	61,25%	14,07%	0,85%	0,23%	0,27%	1,15%	9,01%	38,84%
MOLISE	Min	0,00%	10,53%	5,26%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	14,71%
	Max	10,53%	47,37%	42,11%	10,53%	10,53%	0,00%	0,00%	3,23%	17,65%	41,18%
	Mean	4,51%	30,14%	18,95%	7,13%	3,86%	0,00%	0,00%	1,83%	3,23%	24,51%
PIEMONTE	Min	0,63%	15,77%	39,88%	11,62%	0,00%	1,00%	0,40%	1,20%	2,40%	31,13%
	Max	14,20%	112,50%	90,78%	36,27%	10,82%	2,20%	1,20%	2,40%	30,26%	70,26%
	Mean	6,67%	69,11%	68,06%	22,23%	4,73%	1,46%	0,81%	1,66%	12,71%	59,23%
PUGLIA	Min	0,00%	0,65%	13,73%	3,59%	0,00%	0,00%	0,00%	1,96%	3,92%	23,58%
	Max	0,98%	34,64%	51,96%	13,07%	3,59%	0,00%	1,63%	4,90%	23,58%	57,45%
	Mean	0,33%	12,49%	24,81%	8,25%	0,92%	0,00%	0,69%	3,20%	10,40%	44,42%
SICILIA	Min	0,00%	0,00%	7,79%	1,70%	0,00%	0,00%	0,73%	2,43%	4,87%	22,45%
	Max	0,00%	19,46%	18,49%	7,30%	1,95%	0,97%	2,43%	4,62%	20,75%	43,03%
	Mean	0,00%	9,50%	12,37%	3,65%	0,95%	0,34%	1,59%	3,54%	11,71%	35,57%
SARDEGNA	Min	0,00%	0,00%	13,01%	1,63%	0,00%	0,00%	0,00%	4,07%	12,57%	23,89%
	Max	0,00%	19,51%	25,20%	10,57%	0,81%	0,00%	2,44%	17,07%	22,22%	42,22%
	Mean	0,00%	8,54%	18,62%	6,45%	0,30%	0,00%	0,26%	11,76%	17,56%	33,65%
TOSCANA	Min	0,00%	2,39%	28,19%	6,04%	0,00%	0,00%	0,00%	1,57%	4,92%	37,61%
	Max	1,86%	62,52%	66,00%	27,74%	5,59%	1,12%	1,57%	5,37%	35,43%	64,78%
	Mean	0,91%	40,15%	48,05%	14,64%	2,71%	0,32%	0,71%	3,80%	15,04%	55,56%
TRENTO	Min	0,00%	6,25%	23,33%	2,22%	0,00%	0,00%	0,00%	0,00%	0,00%	10,00%
	Max	6,25%	225,00%	90,00%	21,11%	3,33%	0,00%	1,11%	1,11%	10,00%	48,89%
	Mean	1,34%	96,79%	56,70%	9,53%	0,67%	0,00%	0,72%	0,11%	2,08%	34,30%
UMBRIA	Min	0,00%	2,86%	22,86%	1,43%	0,00%	0,00%	0,00%	2,86%	4,29%	47,42%
	Max	2,86%	67,14%	68,57%	18,57%	2,86%	1,43%	2,86%	8,57%	46,84%	80,41%
	Mean	1,84%	37,34%	45,57%	6,68%	1,67%	0,23%	0,78%	4,76%	21,88%	66,74%
VALLE D'AOSTA	Min	0,00%	0,00%	20,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	50,00%
	Max	0,00%	216,67%	130,00%	15,00%	0,00%	0,00%	0,00%	5,00%	35,00%	85,00%
	Mean	0,00%	91,36%	67,00%	5,97%	0,00%	0,00%	0,00%	0,17%	15,00%	69,00%
VENETO	Min	2,83%	10,32%	19,00%	1,00%	0,00%	0,00%	0,67%	1,33%	2,42%	16,00%
	Max	9,51%	69,64%	59,33%	18,33%	1,00%	0,50%	1,17%	3,50%	14,91%	38,79%
	Mean	5,64%	42,25%	36,75%	6,52%	0,17%	0,29%	0,90%	2,29%	6,04%	28,67%

In these regions, in the first months of the pandemic, the total daily number of ICU admissions exceeded the number of beds (Figure 2). However, in the same days there was also a high number of discharges, but also deaths (For example, on 23 March 2020, Lombardy recorded a total of 1183 hospitalizations in intensive care, 983 beds. On the same

day the region communicates 210 discharges and 320 deaths). In many cases, pressure on hospitals forced regions to take extraordinary measures. Regions responded to the lack of beds for patients with COVID-19 by sending patients who need intensive care but are not infected with COVID-19 to hospitals outside of the region to contain the virus [2].

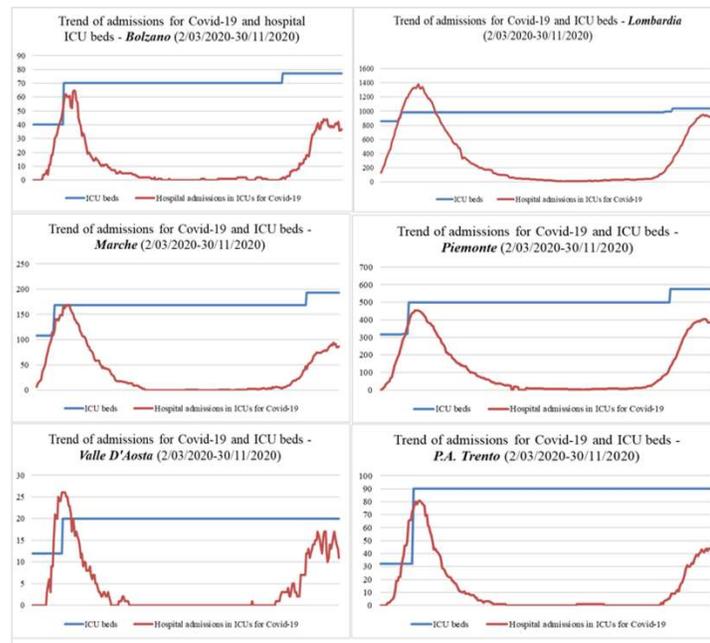


Figure 2. Regions under pressure.

4. Discussion and conclusion

This study analyzed the pressure on the Italian public hospitals from the additional demand created by COVID-19, with a particular focus on public hospitals ICUs. Starting from the analysis of regulatory interventions ordered by the Central Government in response to the emergency, this paper illustrated the daily trend of hospital beds and admissions in ICUs from 2 March to 30 November 2020. The results revealed a critical situation in the system for meeting demand, with numerous regions operating beyond their capacity. Especially in the first wave of the pandemic, results have showed a strong increase in cases in regions where the supply of health services was not sufficiently prepared.

The study presents two relevant messages. First, it is necessary to slow the spread of COVID-19 in the Italian population, allowing more time for the reorganization of the supply and relieve the pressure on the health system: a third wave of the COVID-19 pandemic would cause the collapse of the National health system. Another suggestion regards the regionalized organization of health services: Italy is used as a case study considering that, like in many other countries, a massive process of reform based on “managerialism” of healthcare is been faced [10].

As a result:

- deep changes have been made in the public healthcare offer, with a significant reduction of beds and health personnel (this is one of the reasons why hospitals found themselves unprepared to face such an important health emergency [11]);
- responsibilities for healthcare have been decentralized to regions, though the central government still retains a key role in ensuring all citizens uniform access to health services throughout the country [12]. During the covid-19 emergency, the Central

Government has directly intervened introducing specific measures with a direct impact on healthcare system and hospitals management.

The adopted measures have been aimed at increasing the production capacity of the INHS, showing that the regionalized organization of health services may be adequate in situations of routine demand but suffers important challenges during pandemics.

Supplementary Materials: Appendixes containing the data used for the analysis (daily admission in ICUs, public hospital ICU beds for each Italian region, discharges, deaths, hospital bed-occupancy rates in ICUs, etc.) will be made available on request at corresponding author to the following address: mgiancotti@unicz.it.

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