COVID-19 - Health care management

Reorganization of Intensive Care Units for the COVID-19 pandemic: effects on nursing sensitive outcomes

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Keywords

COVID-19 • Hospital reorganization • Intensive care • Pandemic • Nursing outcomes • Healthcare-associated Infections

Summary

Background. *Since the first months of 2020 COVID-19 patients who were seriously ill due to the development of ARDS, required admission to the intensive care unit to ensure potentially life-saving mechanical ventilation and support for vital functions. To cope with this emergency, an extremely rapid reorganization of premises, services and staff, to dedicate an entire intensive care unit exclusively to SARS-CoV-2 patients and increasing the number of beds was essential. The aim of the study was to evaluate the effects of reorganization of the COVID-19 intensive care unit in terms of nursing sensitive outcomes.*
Methods. *a retrospective observational study was conducted to compare nursing sensitive outcomes between pre-COVID period and COVID period.*
Results. *Falls (0.0 and 0.4%, respectively), physical restraint (1.8 and 1.1%, respectively), and pressure ulcers (8.0 and 3.0%, respectively) were similar in the COVID and in the pre-COVID group. After adjusting for gender, age, BMI, and number of comorbidities, the incidence of bloodstream infections was significantly higher in the COVID group than in the pre-COVID group. There were no statistically significant differences in the incidence between the two groups regarding other evaluated outcomes.*
Conclusion. *The selected nursing sensitive outcomes maintained similar values in the pre-COVID and COVID patient groups. Healthcare-related infections rate must be considered an important alarm signal of quality of nursing care especially in conditions of excessive workload, stress and the presence of less experienced staff increase.*

Background

Coronaviruses, widely distributed among mammals and birds, constitute a heterogeneous group of large single-stranded RNA viruses. In some rare cases, the subspecies Coronavirinae, consisting of alpha and beta coronaviruses, can evolve and be transmitted from animals to humans [1]. At the end of 2019, the world witnessed the spread of a new coronavirus, named SARS-CoV-2, and taxonomically classified among the severe acute respiratory syndrome-related coronavirus (SARS-CoV) species, subgenus Sarbecovirus, genus betacoronavirus [2]. The novel coronavirus was initially referred to as novel coronavirus 2019 (2019-nCoV) and later officially renamed by the International Committee on Taxonomy of Viruses as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). With the term COVID-19, the disease caused by the virus has been called. Although the first outbreaks were identified in China in the Hubei region near the city of Wuhan [3], the rapidity with which it spread and its severe symptoms soon became a serious global public health threat. There were significant outbreaks in many regions of China, followed by a global spread in Asia, Australia and Oceania, Africa, Europe, North America, South America [4]. Uncertainty dominated the first months of 2020. Information regarding its actual transmission modes and speed was lacking [5]. Only during the following months, after the first experiences lived by the population and health personnel from all over the world, more information was available to describe the spectrum of clinical diseases associated with SARS-CoV-2, and the effectiveness of therapeutic and pharmacological treatments [6, 7].
The first cases of COVID-19 in Italy were detected in the third decade of February 2020, in the Lombardy region. Compared to the situation experienced in other countries in that period, the regions of Northern Italy were hit hard by the pandemic. At the end of March 2020, over 40% (42,161) of the total Italian cases (101,000) were in the Lombardy region. These numbers continued to rise, and by the end of June 2020 in Italy there were 237,000 positive cases and 34,400 deaths, classifying Italy as one of the most affected areas during the initial phases of the pandemic [8]. The first available studies from China described the main initial symptoms, which included fever, cough, headache, muscle pain, and fatigue. They also reported a high incidence of severe cases with acute respiratory distress syndrome (ARDS) (17-29%) and critical conditions, septic shock, metabolic acidosis, coagulopathy, and multi-organ failure (23-32%) in hospitalized patients [9, 10]. Similar incidence rates for critical conditions (16%) were also observed in Lombardy and Northern Italy [6, 11].

Following the initial scientific evidence and available guidelines, the critical clinical cases required immediate admission to intensive care units to receive life-saving treatments, such as mechanical ventilation and support for other vital functions [12].

The beds in hospitals and especially in the intensive care units (ICUs) were all occupied in a very short time. As in the rest of the world, also in Italy hospitals were equipped specifically for COVID-19 patients and the number of ICU beds was increased. The University Hospital of Pisa (in Central Italy) reorganized its spaces, services, staff and dedicated an entire intensive care unit exclusively to COVID-19 patients, and increased the number its beds to cope with the emergency caused by the pandemic. This type of reorganization, carried out in very little time, in the first week of February 2020, with new additional health personnel, was implemented to improve the quality of care for patients and the well-being of health personnel in the workplace. Higher numbers of beds in the COVID-19 intensive care unit, entailed the presence of more staff. This was possible through three main actions: (i) reduction of general ICU beds and transfer of specialized nurses to the COVID-19 ICU; (ii) selection of nurses with previous experience in critical and intensive care currently working in departments of other medical specialties to be transferred to the COVID-19 intensive care unit; (iii) the hiring of over 120 new nurses. Different nursing teams were set up by balancing the different skills of individual nurses within groups. The one-to-one ratio of experienced nurses to novice nurses was maintained [13]. To guide the members of each group and promptly identify clinical, organizational or health problems, nurse who were experts of intensive care and educational and organizational processes were selected and assigned to each group. This reorganization made it possible to admit all the COVID-19 patients who presented to the hospital. At the end of the emergency caused by the first wave of the pandemic, the authors decided to investigate – under the umbrella of a broader research project [14] that included also this study – how this rapid and thorough reorganization, together with the hiring of new staff, could affect the quality of the care provided. Even if numerically speaking, the hospital managed to admit all patients presenting with SARS-CoV-2 thanks to its reorganization, once the healthcare emergency phase was over, the researchers decided to investigate the effects produced by this reorganization in terms of nursing sensitive outcomes.

In the literature there are many studies that report outcomes sensitive to nursing, and how to measure and interpret them [15-19].

The aim of this study was to evaluate the effects of staff and environment reorganization of the COVID-19 intensive care unit in the context of the pandemic and of the global health emergency in terms of nursing sensitive outcomes.

Methods

Study design and data sources

A cohort retrospective observational study was conducted to evaluate the effects of the reorganization of an intensive care unit (ICU) exclusively for COVID-19 patients in terms of nursing sensitive outcomes compared to ICU patients before the pandemic outbreak. This study followed the STROBE guidelines for observational studies [20]. This study was conducted in the ICU of a Teaching Hospital in Central Italy, between September 2019 and April 2020. The patients' data were collected in May 2020 through the hospital's database that includes data from the electronic medical records (EMRs). This database includes all the treatments provided by physicians, nurses, and various other health professionals, including patients' medical history, diagnoses, treatments, and medications.

Study population

The study population included all patients admitted to the study setting ICU in the period between September 2019 - February 2020 (pre-COVID period) and March 2020 - May 2020 (COVID period).

The index date was defined as the patient's date of admission to the ICU.

The follow-up period for each patient was defined as the time between the index date and the earliest of the following dates: date of transfer to a non-intensive ward, date of patient's death, or date of last data collected for this study.

Patients who stayed in the ICU for less than one day were excluded from the study.

Measures

The following patient characteristics were considered for our data analysis: age, sex, ethnic group, (comorbidities diagnosed before SARS-CoV-2 infection), and body mass index (BMI). In relation to the type of ventilatory therapy the patient was receiving, we considered: spontaneous breathing with oxygen, non-invasive ventilation (NIV), intubated/tracheostomized with mechanical ventilation.

In agreement with the major studies that have developed sets of indicators on the quality of nursing care in the ICU [21-24], the following were measured during this study: pressure ulcer incidence (patients who developed a pressure ulcer during stay in the ICU), incidence of falls (patients who fell with and without an injury during stay in the ICU), incidence of physical restraint (patients with physical restraint during stay in the ICU), mortality (deaths of to those in the ICU), incidence healthcare associated infections (HAIs) – cases presenting with HAIs during stay in the ICU: including urinary tract infections, bloodstream infections, local central venous catheter (CVC) associated infections, local peripheral venous catheter associated infections, and gastrointestinal tract infections.

Data analysis

Categorical variables were summarized by frequencies and percentages, and continuous variables by medians and interquartile ranges. Differences in the characteristics between the patients of the pre-COVID and COVID period were evaluated with Fisher's exact test and the Kruskal-Wallis test, for categorical and continuous variables, respectively.
Associations between the outcomes and length of stay were assessed using Poisson regression models. To obtain finite estimates for those outcomes that presented no occurrences either in the pre-COVID or COVID period, penalized Poisson regression models with Jeffreys prior were also fitted, without and with adjustment for age, sex, BMI, and number of comorbidities [25]. For all the Poisson regression models, the estimates and 95% confidence intervals for the incidence rate ratios (IRRs) of post-COVID *vs* COVID period were reported, together with the corresponding Wald tests p-values. All the statistical tests were two-sided, with a significance level of 0.05.
Statistical analyses were performed using the statistical software R v.4.0.0 [26]; the brglm2 R package was used for fitting the Poisson models.

Ethical aspects

The research protocol was approved by the Ethics Committee of the Teaching Hospital (Approval number 021.2020). The anonymity of the patients was ensured by attributing an individual code.

Results

Overall, 679 patients were observed. Of these, 7 patients were excluded from the study because they stayed in the ICU for less than one day. The data of a total of 672 patients were included for the analyses, 560 were admitted during the pre-COVID period and 112 during the COVID period. All the characteristics of the sample are shown in Table I.
Regarding the percentages of spontaneously breathing patients, these were 40.9% (n = 229) in the pre-COVID group, and 1.8% (n = 2) in the COVID group; patients undergoing non-invasive ventilation (NIV) were 21.9% (n = 123) in the pre-COVID group and 58.9% (n = 66) in the COVID group; instead the percentages of mechanically ventilated patients were similar between the two groups, 37.2% (n = 208) in the pre-COVID group and 39.3% (n = 44) in the COVID group.
The median age of the patients was 68 years (interquartile range 56-76 years) for pre-COVID patients and 69 years (interquartile range 57-76 years) for COVID patients.
Compared to the pre-COVID group, the COVID group was characterized by a higher proportion of males (329 (58.8%) and 82 (73.2%,) respectively), lower median BMI values (24 and 22, respectively), more comorbidities (2-3 comorbidities, respectively 16.6 and 26.8%), of the Sequential Organ Failure Assessment (SOFA) (1 and 2, respectively), the Simplified Acute Physiology Score (SAPS) II (20 and 26, respectively), and a worse Braden Scale score (16 and 14, respectively). Length of stay in the ICU was longer in the COVID patient group than in the pre-COVID group (median values: 1 day and 5 days, respectively).

Tab. I. Characteristics of the patients and outcomes; overall and by period of admission.

	All (n = 672)		Pre-COVID (n = 560)		COVID (n = 112)		*P-value**
	n	(%)	n	(%)	n	(%)	
Sex							0.004
Female	261	(38.8)	231	(41.2)	30	(26.8)	
Male	411	(61.2)	329	(58.8)	82	(73.2)	
Ethnicity							0.13
Caucasian	664	(98.8)	555	(99.1)	109	(97.3)	
Non-Caucasian	8	(1.2)	5	(0.9)	3	(2.7)	
BMI (kg/m²)†	24	(21 to 26)	24	(22 to 27)	22	(21 to 26)	0.02
Weight (kg)†	85	(80 to 95)	90	(80 to 95)	80	(80 to 91)	0.14
Age (years)†	68	(57 to 76)	68	(56 to 76)	69	(57 to 76)	0.68
Number of comorbidities							0.02
0	192	(28.6)	159	(28.4)	33	(29.5)	
1	357	(53.1)	308	(55.0)	49	(43.8)	
2-3	123	(18.3)	93	(16.6)	30	(26.8)	
SOFA score†	1	(0 to 1)	1	(0 to 1)	2	(1 to 5)	< 0.001
SAPS II score†	21	(19 to 23)	20	(19 to 22)	26	(21 to 35)	< 0.001
Braden score†	16	(16 to 16)	16	(16 to 16)	14	(14 to 16)	< 0.001
Length of stay in ICU (days)†	1	(1 to 2)	1	(1 to 2)	5	(1 to 15)	< 0.001

* Fisher's exact test for categorical variables and Kruskal-Wallis test for continuous variables. † Median (interquartile range). ‡ Composite event: any of falls, physical restraint, pressure ulcers, pneumonia, bloodstream infections or gastrointestinal infections.
Pre: admission to hospital before 1st March 2020; post: admission to hospital at or after 1st March 2020.

Tab. II. Patients' outcomes; overall and by period of admission.

	All (n = 672)		Pre-COVID (n = 560)		COVID (n = 112)		Mean Difference	P-value*
	n	(%)	n	(%)	n	(%)		
Falls								
No	670	(99.7)	558	(99.6)	112	(100.0)	9.21	< 0.001
Yes	2	(0.3)	2	(0.4)	0	(0.0)		
Physical restraint								
No	664	(98.8)	554	(98.9)	110	(98.2)	15.1	0.027
Yes	8	(1.2)	6	(1.1)	2	(1.8)		
Pressure ulcers								
No	646	(96.1)	543	(97.0)	103	(92.0)	7.3	< 0.001
Yes	26	(3.9)	17	(3.0)	9	(8.0)		
Pneumonia								
No	666	(99.1)	558	(99.6)	108	(96.4)	11.4	0.018
Yes	6	(0.9)	2	(0.4)	4	(3.6)		
Bloodstream infections								
No	667	(99.3)	560	(100.0)	107	(95.5)	5.1	0.021
Yes	5	(0.7)	0	(0.0)	5	(4.5)		
Gastrointestinal infections								
No	671	(99.9)	559	(99.8)	112	(100.0)	7.2	0.012
Yes	1	(0.1)	1	(0.2)	0	(0.0)		
Composite event‡								
No	632	(94.0)	537	(95.9)	95	(84.8)	5.7	0.003
Yes	40	(6.0)	23	(4.1)	17	(15.2)		

* Fisher's exact test for categorical variables and Kruskal-Wallis test for continuous variables. † Median (interquartile range). ‡ Composite event: any of falls, physical restraint, pressure ulcers, pneumonia, bloodstream infections or gastrointestinal infections.
Pre: admission to hospital before 1st March 2020; post: admission to hospital at or after 1st March 2020.

Tab. III. Incidence rate ratios in COVID *vs* pre-COVID patients.

Outcome	Model 1*		Model 2†		Model 3‡	
	IRR (95% CI)	p	IRR (95% CI)	p	IRR (95% CI)	p
Falls	Not applicable		0.30 (0.01 to 6.15)	*0.43*	0.53 (0.05 to 5.72)	*0.60*
Physical restraint	0.49 (0.10 to 2.44)	*0.39*	0.57 (0.13 to 2.44)	*0.45*	0.72 (0.18 to 2.91)	*0.65*
Pressure ulcers	0.78 (0.35 to 1.75)	*0.55*	0.80 (0.36 to 1.77)	*0.58*	0.70 (0.32 to 1.53)	*0.37*
Pneumonia	2.95 (0.54 to 16.12)	*0.21*	2.66 (0.57 to 12.47)	*0.22*	1.30 (0.34 to 5.01)	*0.70*
Bloodstream infections	Not applicable		16.24 (0.90 to 293.71)	*0.06*	14.81 (1.32 to 166.08)	*0.03*
Gastrointestinal infections	Not applicable		0.49 (0.02 to 12.08)	*0.66*	0.31 (0.03 to 2.87)	*0.30*
Composite event§	1.09 (0.58 to 2.04)	*0.78*	1.10 (0.59 to 2.04)	*0.76*	1.00 (0.53 to 1.86)	*0.99*

* Unadjusted Poisson regression model. † Unadjusted penalized Poisson regression model. ‡ Penalized Poisson regression model adjusted for sex, age, BMI and number of comorbidities. § Composite event: any of falls, physical restraint, pressure ulcers, pneumonia, bloodstream infections or gastrointestinal infections.
Pre: admission to hospital before 1 March 2020; Post: admission to hospital on or after 1st March 2020; IRR: incidence rate ratio.

During ICU admission, 47 deaths occurred in the pre-COVID group and 32 deaths in the COVID group, respectively; the corresponding mortality rates were 6.6 (95% CI = 5.0 to 8.8) and 15.1 (95% CI = 10.7 to 21.4) per 1000 person-days, resulting in a COVID *vs*. pre-COVID incidence rate (IRR) ratio of 2.3 (95% CI = 1.5 to 3.6, p < 0.001).

The percentages of outcomes regarding falls (0.0 and 0.4%, respectively), physical restraint (1.8 and 1.1%, respectively), and pressure ulcers (8.0 and 3.0%, respectively) were similar in the COVID and in the pre-COVID group (Tab. II).

During the ICU admissions, no events were observed for urinary tract infections, local central vascular catheter associated infections, or local peripheral vascular catheter associated infections. After adjusting for gender, age, BMI, and number of comorbidities, the incidence of bloodstream infections was significantly higher in the COVID group than in the pre-COVID group (IRR = 14.81, 95% CI = 1.31 -166.08, p = 0.03). There were no statistically significant differences in the incidence between the two groups regarding other evaluated outcomes. No evidence of association with the COVID group was found for all the other outcomes (Tab. III).

Discussion

The study compared patients admitted to the ICU in the pre-COVID period with those in the COVID period to evaluate the effects of staff and environment reorganization in the ICU for COVID-19 patients in terms of nursing sensitive outcomes. Due to the unpredictability of the pandemic, it was not possible to select the participants to be included in the study, therefore the patients' characteristics were not homogeneous across the two groups.
The predominant number of males in our COVID group confirmed the 3-to-1 ration between males and females reported in the epidemiological studies conducted in Chinese ICUs [7, 27-29]. In fact, males were not at a greater risk of developing serious conditions females but were 1.55 times more likely to be admitted to an ICU than females.

Ventilatory therapy

The percentage of patients undergoing NIV was significantly higher in the COVID group confirming the data already reported in the literature [30-32]. The use of NIV – a potentially life-saving ventilatory treatment, strongly recommended by the treatment guidelines in patients with severe conditions of respiratory insufficiency due to COVID-19 [12] – was possible in our study setting, thanks to the reduced risk for health workers and the surrounding environment of being contaminated by the aerosol evacuation systems used for the COVID-19 patients, because the premises were already previously used as operating rooms, and offered negative-pressure isolation of the surrounding environment with at least 12 air changes per hour [32, 33].

Comorbidities

The higher number of comorbidities observed in our COVID group is in line with those reported in the literature. Chronic obstructive pulmonary disease (COPD), cardiovascular disease (CVD) and hypertension were the comorbidities mostly associated with ICU admission. Patients affected by dyspnoea were 6.6 times more likely to be admitted to the ICU than those without dyspnoea. Although COPD was relatively rare, in other studies it was found to be by far the strongest comorbidity for admission to the ICU. Patients affected by cardiovascular diseases and hypertension had respectively a 4.4 and 3.7-fold higher probability of being admitted to the ICU than patients without comorbidities [34].

Mortality rates

The COVID versus pre-COVID mortality rate ratio (Incidence of Relative Risk, IRR) of 2.3 (95% CI = 1.5 to 3.6, $p < 0.001$) was in line with the SOFA (1 pre-COVID and 2 COVID respectively) and the SAPS II (20 pre-COVID and 26 COVID respectively) predictive indices, which are commonly used for classifying disease severity, measuring risk of death, and choosing the best treatment for ICU patients.
The mortality rates observed in the COVID group were similar to those of the Spanish [35] and the northern Italian [36] studies, and to the average rate reported in the Quah review [37]. They were higher than those of the German studies [38], and lower than the US [39, 40], Chinese [10, 39, 40] and British [41] studies.

Pressure ulcers

Although the risk index for the development of pressure ulcers (Braden Scale) found in the COVID group was lower (= higher risk) than in the pre-COVID group (16 in the COVID and 14 in the pre-COVID group) and length of stay was longer in the COVID group compared to the pre-COVID group (1 day and 5 days, respectively), the IRR of the COVID versus the pre-COVID group was 0.70 (95% CI = 0.32 to 1.53) with no statistically significant difference ($p = 0.37$).
This could be due to the frequent mobilization of mechanically ventilated patients or patients undergoing NIV who, for therapeutic purposes, were in supine and prone positions with regular cycles and timings established according to recommendations [42]. The availability of an anti-decubitus mattress on each bed, more attention placed on the use of anti-decubitus materials and devices due to pronation-supination movements, may have contributed to preventing this phenomenon.

Bloodstream infections

The incidence of bloodstream infections was higher in the COVID group compared to the pre-COVID group (IRR = 14.81, 95% IC = 1.31-166.08, $p = 0.03$) thus confirming the results obtained by other similar studies both in Italy [43, 44] and in other countries [45, 46]. The risk that multidrug-resistant bacteria (MDRB) could spread during a viral pandemic had been theoretically studied and predicted, but no real data were available in relation to this phenomenon because previous pandemics had occurred before the era of antimicrobial resistance. Experts have expressed their concerns about the spread of MDRB during the COVID-19 pandemic, and preliminary studies and reports indicate an increase of such infections in COVID patients admitted to ICUs [47].
The higher incidence of bloodstream infections could be due to several factors related to the pandemic: the shortage of personal protective equipment PPE [48]; excessive emotional and physical workload of health workers in the ICU; overcrowded ICUs [49]; higher numbers of unexperienced staff leading to poorer adherence to preventive measures and infection control; and excessive use of antibiotic treatments [47, 50-52]. In addition, protective equipment used by the health workers increased the feeling of protection to and from the patients, triggering a greater risk of contamination in the event they did not change their protective equipment when caring for another patient.

Limits

The study has some limitations, like the differences of the patients' characteristics between the two groups, which was not possible to avoid due to the unpredictability of the pandemic. In addition, no data were available regarding observations regarding staff compliance with infection prevention measures. These data would have enabled a better understanding of the observed phenomenon.

Conclusion

The study showed how the selected nursing sensitive outcomes maintained similar values in the pre-COVID and COVID patient groups. The reorganization of the ICU for COVID-19 patients – despite it was thorough and carried out in an extremely limited amount of time – with additional health staffing, it responded effectively to the health needs generated by the pandemic.
This reorganization did not affect the quality of care, which was similar to that provided in the pre-COVID period. Healthcare-related infections, especially bloodstream infections, were comparable to those of other similar studies.
This result must be considered an important alarm signal. Conditions of excessive workload, stress and the presence of less experienced staff increase patients' risk of being contaminated by multi-resistant bacteria.

Ethics approval and consent to participate

The research protocol was approved by the Ethics Committee of Pisa Teaching Hospital (Approval number 021.2020).

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors of this manuscript have no competing interests as defined by the editorial policy of Journal of Preventive Medicine and Hygiene. They moreover have no other interests that may have influenced the results and discussion of this paper.

Funding

This research received no specific grant from any funding agency in the public, commercial or non-profit sectors.

Authors' contributions

NP: Conceptualization; NP, MP, MM: writing-Original draft preparation; MF: Statistical analysis; MP, FU, AB, MS: investigation; FU, MS: visualization; AB: methodology; LB: formal analysis; FF: supervision.

Acknowledgements

The authors thank the following nurses for their help in collecting the data and their support in general: Salvatore Pagliaro, Antonio Fallacara, Nunzio De Feo, Giordano Bargagna, Maria Grazia Orsi, and Sabrina Inghirami.

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Received on April 01, 2022. Accepted on July 27, 2022.

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How to cite this article: Pagnucci N, Fornili M, Pradal M, Uccelli F, Bovone A, Meini M, Scateni M, Baglietto L, Forfori F. Reorganization of Intensive Care Units for the COVID-19 pandemic: effects on nursing sensitive outcomes. J Prev Med Hyg 2022;63:E383-E390. https://doi.org/10.15167/2421-4248/jpmh2022.63.3.2557