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REVIEW ARTICLE

Structuring and restructuring COVID-19 Intensive Care Units: a systematic review

Estruturação e reestruturação das Unidades de Terapia Intensiva na COVID-19: revisão sistemática

Estructuración y reestructuración de las Unidades de Cuidados Intensivos en COVID-19: revisión sistemática

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ABSTRACT

Background and Objectives: the COVID-19 pandemic imposed restructuring and reorganization in healthcare services, particularly in Intensive Care Units (ICUs), due to the increased demand for hospital care for the thousands of severe cases of the disease. Thus, understanding this ICU reorganization process is useful for healthcare system planning and, consequently, for preventing system collapse in the face of impending pandemics. The objective was to identify elements related to the restructuring and organization of human resources, materials, and organization/structure processes in ICUs during the COVID-19 pandemic. **Methods:** this is a qualitative systematic review. Searches were conducted in the MEDLINE, PubMed, Scopus, Web of Science, and Embase databases. The results were exported to the Rayyan software for subsequent screening and blind selection by two independent researchers as well as for assessing the risk of bias and individual methodological quality of selected studies. **Results:** a total of 171 articles were found across the five databases, with five articles selected to be included in this review. The identified elements concerning the restructuring and organization of ICUs were the use and availability of personal protective equipment, oxygen, and oxygen therapy equipment, medications, psychological support for healthcare professionals, patient safety measures, and space maintenance. **Conclusion:** this review allowed for the compilation and synthesis of necessary elements for the restructuring and organization of ICUs during the pandemic, considering the need for managers to respond swiftly to the high demand brought on by COVID-19.

Keywords: *Intensive Care Units. COVID-19. Hospital Restructuring. Hospital Administration.*

RESUMO

Justificativa e Objetivos: a pandemia de COVID-19 impôs reestruturações e reorganizações nos serviços de saúde, principalmente nas Unidades de Terapia Intensiva (UTIs), devido ao aumento da demanda de assistência hospitalar para os milhares de casos graves da doença. Assim, compreender esse processo de reorganização das UTIs é útil para o planejamento do sistema de saúde e, consequentemente, a prevenção do colapso do sistema na iminência de pandemias. Objetivou-se identificar os elementos relacionados à reestruturação e estruturação dos recursos humanos, materiais e processos de organização/estruturação das UTIs durante a pandemia de COVID-19. **Métodos:** revisão sistemática qualitativa. Buscas foram realizadas nas bases de dados MEDLINE, PubMed, Scopus, *Web of Science* e Embase. Os resultados foram exportados para o *software* Rayyan para posterior triagem e seleção cega por dois pesquisadores independentes, bem como avaliação do risco de viés e da qualidade metodológica individual dos estudos selecionados. **Resultados:** foram encontrados 171 artigos nas cinco bases de dados, tendo sido selecionados cinco para compor esta revisão. Os elementos identificados referentes à reestruturação e estruturação das UTIs foram o uso e disponibilidade de equipamentos de proteção, oxigênio e equipamentos para oxigenoterapia, medicamentos, apoio psicológico aos profissionais, aspectos para a segurança do paciente e manutenção do espaço. **Conclusão:** esta revisão possibilitou unir e sintetizar elementos necessários na reestruturação e estruturação de UTIs durante a pandemia, tendo em vista a necessidade de agilidade entre os gestores em atender a grande demanda exigida na COVID-19.

Descritores: *Unidades de Terapia Intensiva. COVID-19. Reestruturação Hospitalar. Administração Hospitalar.*

RESUMEN

Justificación y Objetivos: la pandemia de COVID-19 impuso reestructuraciones y reorganizaciones en los servicios de salud, especialmente en las Unidades de Cuidados Intensivos (UCIs), debido al aumento de la demanda de asistencia hospitalaria para los miles de casos graves de la enfermedad. Por lo tanto, comprender este proceso de reorganización de las UCIs es útil para la planificación del sistema de salud y, en consecuencia, para prevenir el colapso del sistema en la inminencia de pandemias. El objetivo fue identificar los elementos relacionados con la reestructuración y estructuración de recursos humanos, materiales y procesos de organización/estructuración de las UCI durante la pandemia de COVID-19. **Métodos:** revisión sistemática cualitativa. Se realizaron búsquedas en las bases de datos MEDLINE, PubMed, Scopus, *Web of Science* y Embase. Los resultados se exportaron al *software* Rayyan para la posterior selección y cribado ciego por dos investigadores independientes, así como para la evaluación del riesgo de sesgo y la calidad metodológica individual de los estudios seleccionados. **Resultados:** se encontraron 171 artículos en las cinco bases de datos, cinco de los cuales fueron seleccionados para componer esta revisión. Los elementos identificados respecto a la reestructuración y estructuración de las UCI fueron el uso y disponibilidad de equipos de protección, oxígeno y equipos para oxigenoterapia, medicamentos, apoyo psicológico a los profesionales, aspectos para la seguridad del paciente y mantenimiento del espacio. **Conclusión:** esta revisión permitió unir y sintetizar los elementos necesarios para la reestructuración y organización de las UCIs durante la

pandemia, teniendo en cuenta la necesidad de agilidad por parte de los gestores para atender la alta demanda exigida por la COVID-19.

Palabras Clave: *Unidades de Cuidados Intensivos. COVID-19. Reestructuración Hospitalaria. Administración Hospitalaria.*

INTRODUCTION

Infection with the SARS-CoV-2 virus represented a new context for healthcare. Faced with the expectation of increased demand for hospital care, health systems worldwide presented a worrying overload, directly impacting quality of care[1]. Thus, interventions and restructuring of services were necessary, aiming for greater agility and effectiveness in serving the population and seeking to prevent the collapse of health systems in the face of the pandemic[2], mainly in the absence of effective vaccines and antivirals[3].

As a result, Intensive Care Units (ICUs) had an exponential increase in hospitalizations, indicating urgency in decision-making by health managers. They are in the ICUs, where the necessary support for caring for critical patients is found. In the absence of this hospital sector, a significant risk can be presented to patients when there is a need for hospitalization, as occurred in the calamities faced during the COVID-19 pandemic[4].

In the case of management in healthcare services, definitions were drawn up on the administration of these resources to assist in the process of coordinating the units, and these are differentiated into: human resources (HR), which concern the protection of the patient, the operator and the population, aspects of care; material resources (MR), which contrast physical-technical factors, quality improvement, equipment and accessories; organization/structure processes, which confront sectoral administrative bureaucratic actions[5].

The definitions aligned by Coppola[5] are based on benchmarking, a process of studying agreements and analyzing best management practices based on international laws and guidelines.

With this, an understanding of the ICU reorganization process emerged, focusing on Coppola's[5] definitions, which required the remediation of the emergency experienced by the world during the COVID-19 pandemic. It is worth highlighting that no previous studies bring together these elements of structuring and restructuring during the pandemic and that the reorganization of ICUs was a necessary action to achieve assistance.

Therefore, this study aimed to identify the elements related to structuring and restructuring ICU's HR, MR, and organization/structurE processes during the COVID-19 pandemic.

METHODS

Study design

A systematic literature review was carried out in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P)[6] and the JBI[7] methodological conduct guidelines. This review was submitted to the International Prospective Register of Systematic Reviews (PROSPERO), under approved Opinion CRD42022311926.

Research question

Coppola's (1999)[5] definitions were used as a reference to elaborate on the guiding research question, adopting the definitions of HR, MR, and organization/structure processes. The research question was formulated according to the PCC strategy (Population, Concept, and Context) (XX): P: ICU; C: elements relating to the structuring and restructuring of HR, MR and organization/structure processes; C: COVID-19 pandemic. Thus, the research question of this review was: what are the elements related to the structuring and restructuring of HR, MR, and organization/structure processes carried out in ICU during the COVID-19 pandemic?

Article search and selection strategy

The search was carried out in June 2022 and updated in 2022. The MEDLINE, PubMed, Scopus, Web of Science, and Embase databases were used. The MeSH (Medical Subject Headings) and Emtree (Embase Subject Headings) terms were used to select the controlled descriptors associated with the research question. The descriptors were associated with the Boolean operators "AND" and "OR," and parentheses and designations of the descriptors were also used to ensure a topic-sensitive search strategy (Table 1).

Table 1. Syntax of the search strategy in the databases, Ceará, Brazil, 2023

Databases	Search Strategy	No. of references
MEDLINE	(“Intensive Care Units”) AND (COVID-19 OR SARS-CoV-2) AND (“Hospital Restructuring”)	8
	(“Unidades de Terapia Intensiva”) AND (COVID-19 OR SARS-CoV-2) AND (“Reestruturação Hospitalar”)	3
	(“Unidades de Cuidados Intensivos” AND (COVID-19 OR SARS-CoV-2) AND (“Restructuration Hospitalière”)	0
PubMed	(“Intensive Care Units”[All Fields] OR “ICU Intensive Care Units”[All Fields] OR “Unit, Intensive Care”[All Fields] OR “Intensive Care Unit”[All Fields]) AND (“COVID-19”[All Fields] OR “SARS-CoV-2 Infection[All Fields]” OR “Infection, SARS-CoV-2"[All Fields]) AND (“Hospital Restructuring”[All Fields] OR “ Restructuring, Hospital”[All Fields] OR “Hospital Restructurings”[All Fields] OR “Restructurings, Hospital”[All Fields] OR “Reorganization, Hospital”[All Fields] OR “Hospital Reorganizations”[All Fields] OR “Reorganizations, Hospital”[All Fields] OR “Hospital Reorganization”[All Fields] OR “Hospital Diversification”[All Fields] OR “Diversification, Hospital”[All Fields])	8
Scopus	((“Intensive Care Units” OR “ICU Intensive Care Units” OR “Unit, Intensive Care” OR “Intensive Care Unit”) AND (COVID-19 OR SARS-CoV-2) AND (“Hospital Restructuring” OR “Restructuring, Hospital” OR “Hospital Restructurings” OR “Restructurings, Hospital” OR “Reorganization, Hospital” OR “Hospital Reorganizations” OR “Reorganizations, Hospital” OR “Hospital Reorganization” OR “Hospital Diversification” OR “Diversification, Hospital”))	10
Web of Science	((“Intensive Care Units” OR “ICU Intensive Care Units” OR “Unit, Intensive Care” OR “Intensive Care Unit”) AND (“COVID-19” OR “SARS-CoV-2 Infection” OR “Infection, SARS-CoV-2” OR “SARS CoV 2 Infection” OR “SARS-CoV-2 Infections” OR “2019 Novel Coronavirus Disease” OR “2019 Novel Coronavirus Infection” OR “2019-nCoV Disease” OR “2019 nCoV Disease” OR “2019-nCoV Diseases” OR “Disease, 2019-nCoV” OR “COVID-19 Virus Infection” OR “COVID 19 Virus Infection” OR “COVID-19 Virus Infections” OR “Infection, COVID-19 Virus” OR “Virus Infection, COVID-19” OR “Coronavirus Disease 2019” OR “Disease 2019, Coronavirus” OR “Coronavirus Disease-19” OR “Coronavirus Disease 19” OR “Severe Acute Respiratory Syndrome Coronavirus 2 Infection” OR “SARS Coronavirus 2 Infection” OR “COVID-19 Virus Disease” OR “COVID 19 Virus Disease” OR “COVID-19 Virus Diseases” OR “Disease, COVID-19 Virus” OR “Virus Disease, COVID-19” OR “2019-nCoV Infection” OR “2019 nCoV Infection” OR “2019-nCoV Infections” OR “Infection, 2019-nCoV” OR “COVID19” OR “COVID-19 Pandemic” OR “COVID 19 Pandemic” OR “Pandemic, COVID-19” OR “COVID-19 Pandemics”) AND (“Hospital Restructuring” OR “ Restructuring, Hospital” OR “Hospital Restructurings” OR “Restructurings, Hospital” OR “Reorganization, Hospital” OR “Hospital Reorganizations” OR “Reorganizations, Hospital” OR “Hospital Reorganization” OR “Hospital Diversification” OR “Diversification, Hospital”))	3
Embase	(‘intensive care units’ OR ‘ICU intensive care units’ OR ‘unit, intensive care’ OR ‘intensive care unit’) AND (‘covid-19’ OR ‘sars-cov-2 infection’ OR ‘infection, sars-cov-2’ OR ‘sars cov 2 infection’ OR ‘sars-cov-2 infections’ OR ‘2019 novel coronavirus disease’ OR ‘2019 novel coronavirus infection’ OR ‘2019-ncov disease’ OR ‘2019 ncov disease’ OR ‘2019-ncov diseases’ OR ‘disease, 2019-ncov’ OR ‘covid-19 virus infection’ OR ‘covid 19 virus infection’ OR ‘covid-19 virus infections’ OR ‘Infection, covid-19 virus’ OR ‘virus infection, covid-19’ OR ‘coronavirus disease 2019’ OR ‘disease 2019, coronavirus’ OR ‘coronavirus disease-19’ OR ‘coronavirus disease 19’ OR ‘severe acute respiratory syndrome coronavirus 2 infection’ OR ‘SARS coronavirus 2 infection’ OR ‘covid-19 virus disease’ OR ‘covid 19 virus disease’ OR ‘covid-19 virus diseases’ OR ‘disease, covid-19 virus’ OR ‘virus disease, covid-19’ OR ‘2019-ncov infection’ OR ‘2019 ncov infection’ OR ‘2019-ncov infections’ OR ‘infection, 2019-ncov” or “covid19’ OR ‘covid-19 pandemic’ OR ‘covid 19 pandemic’ OR ‘pandemic, covid-19’ OR ‘covid-19 pandemics’) AND (‘hospital restructuring’ OR ‘restructuring, hospital’ OR ‘hospital restructurings’ OR ‘restructurings, hospital’ OR ‘reorganization, hospital’ OR ‘hospital reorganizations’ OR ‘reorganizations, hospital’ OR ‘hospital reorganization’ OR ‘hospital diversification’ OR ‘diversification, hospital’)	139
Total		171

Inclusion and exclusion criteria

Studies with data on the structuring and restructuring of ICUs in terms of HR, MR, and organization/structure processes during the COVID-19 pandemic, published between 2019 and 2022 (justifying the time restriction by the discovery of the SARS-CoV-2 virus in 2019), records in English, Portuguese, and Spanish, available in full text, and published as original articles, were included. Review articles, commentaries, letters to the editor and non-peer-reviewed articles (in press) were excluded.

Study categorization

Studies containing information on the structuring and restructuring of ICU during the COVID-19 pandemic that dealt with HR, MR and organization/structure processes carried out in the units were considered eligible.

There was a time cut of articles published between 2019 and 2022, justified by the discovery of the SARS-CoV-2 virus that occurred in 2019.

Study selection

The references were exported to the Rayyan software. Studies were analyzed independently, based on the inclusion and exclusion criteria. Regarding divergences in assessing titles and abstracts, these were resolved by consensus at a subsequent meeting. Ultimately, the eligible preliminary studies had their full texts assessed independently and double-blindly by two reviewers, seeking to meet the eligibility criteria. The divergences found were resolved by consensus in a second meeting. Excluded studies were registered in a separate database, explaining the reasons for exclusion.

Data collect

After selecting the studies, they were analyzed by two unblinded reviewers, and categorization information was extracted from studies (article, author/year, journal, country and title), which is shown in Table 2 of the results section. The data extracted allowed us to understand the specificities of the populations, context, geographical location, study methods and phenomena of interest relevant to the review question and specific objectives. With regard to the elements related to the research question, related to the aspects defined by Coppola[5], Table 3 was presented (article, HR, MR and organization/structure processes). Any disagreement among reviewers was resolved through discussion of the findings.

Risk of bias

The risk of bias was assessed by two authors independently, using tools recommended for qualitative studies[7]. The risk of bias was considered high when the study obtained 49% "yes" answers, moderate, when the study obtained 50% to 69% "yes" answers, and low, when the study reached more than 70% "yes"[9].

Data analysis

The results presented in the articles covering HR, MR and organization/structure processes were transcribed and prepared into a text *corpus* for lexicographic textual analysis, using the software *Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires* (IRaMuTeQ). IRaMuTeQ is a free open-source software created by Pierre Ratinaud, in 2009, with GNU GPL(v2) license, which allows the statistical analysis of the text *corpus*[10]. Two researchers interpreted the data that resulted from the analysis.

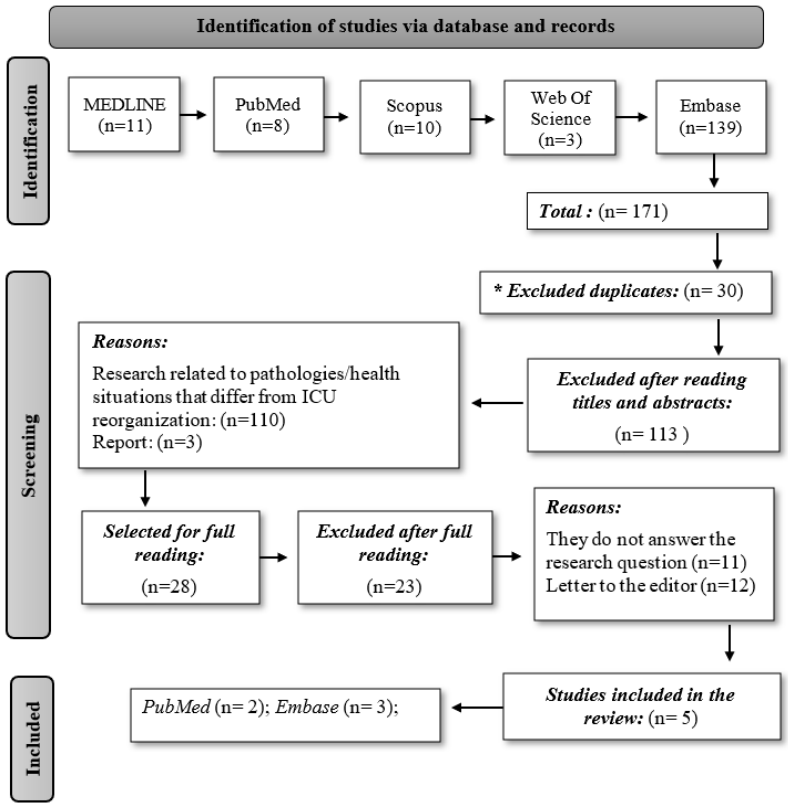
Similarity analysis in IRaMuTeQ is a technique that identifies and graphically represents the relationships among words based on the frequency of their co-occurrences in a text. This analysis constructs a network where words are the nodes and the connections among them reflect the frequency with which they appear together in a specific context window, revealing the text's structure and highlighting the main themes. It helps to visualize the semantic proximity and the relative importance of words within the analyzed *corpus*[10].

Therefore, this method involved *corpus* preparation, including text collection, cleaning, and normalization. Subsequently, the texts were tokenized and segmented for co-occurrence analysis, which was calculated, resulting in a matrix that represents how often the words appeared together in a defined context window. Based on these co-occurrences, similarity measures such as the Jaccard coefficient or Euclidean distance were calculated to quantify the semantic proximity among words. The similarity network was then constructed, where words are nodes and their connections reflect the strength of the co-occurrences.

RESULTS

During the first phase of study selection, 171 articles were found, with 30 articles duplicates were excluded, and 113 articles were analyzed by title and abstract, of which

110 were research related to pathologies/health situations that differ from ICU reorganization, and three were reports and were excluded from the study. Twenty-eight were selected for full reading; 11 did not answer the research question, i.e. did not contain elements of ICU restructuring; and 12 were letters to the editor, leaving five studies selected for qualitative analysis (Figure 1).



*Exclusion done by Rayyan revision manager.

Figure 1. PRISMA flow diagram, which describes the process of searching, identifying, including and excluding articles

Characteristics of eligible studies

Most of studies were published in 2021[12,4,13], mainly in Spain[13,14] and mostly indexed in Embase, in different journals. Regarding the identification of resources related to the reorganization of ICUs, the five studies showed significant responses within the definitions of resources described by Coppola[5].

Table 2. Study characterization, Brazil, 2023

Article	Author/year	Journal	Country	Title
2	Borel *et al*. 2021	Embase/ *Annales Francaises de Medecine d'Urgence*	France	Transformation of a hospital restaurant into an orientation intensive care unit
5	Nunez-Villaveiran *et al*. 2020	Embase/ Disaster medicine and public health preparedness	Spain	All for One and One for All: Voluntary Physicians in the Intensive Medicine

				Units During the COVID-19 Outbreak in Spain
1	Shaparin *et al*. 2021	PubMed/ Best Practice & Research Clinical Anaesthesiology	 United States	Adaptation and restructuring of an academic anesthesiology department during the COVID-19 pandemic in New York City: Challenges and lessons learned
3	Singh *et al*. 2021	Embase/ Trends in Anaesthesia and Critical Care	 India	Challenges faced in establishing a dedicated 250 bed COVID-19 intensive care unit in a temporary structure
4	Vilallonga *et al*. 2020	PubMed/ Langenbeck's Archives of Surgery	 Spain	Transforming a surgical department during the outbreak of new coronavirus pandemic. Clinical implications

Table 3. Extraction of what refers to human resources, material resources and organization/structure processes, Brazil, 2023

Article	Human resources	Material resources	Organization/structure processes
1	● **For professionals** Train and promote leadership for those with recent ICU experience; provide up-to-date education on equipment decontamination and use of protective equipment; increase staff well-being to deal with increased demand and foster resilience for future increases. ● **For patients** Recruitment of employees from the anesthesiology department for COVID-19 ICUs, enabling better assistance; selection of COVID-19 patients based on severity depending on facility capabilities; filter and disseminate relevant, high-quality information related to COVID-19.	Plan the adequate supply of personal protective equipment (PPE); existing oxygen supply was equipped to serve 1,200 patients; availability of various medications; promptly guarantee equipment such as anesthesia circuit filters, intubation boxes and other airway management equipment.	Ensuring ICU beds dedicated to the care of positive or unknown patients for COVID-19; 16-room stand-alone outpatient surgery center that has been converted into a COVID-19 ICU inpatient facility and 60 beds on the floor.
2	● **For professionals** Due to the need for a long working day, the unit's structure allowed each person to adapt as quickly as possible to a new environment, through local signs; operational care teams for disease prevention; the presence of psychologists. ● **For patients** Provide safe care in terms of quality of care; all medical, paramedical and administrative procedures have been written down and standardized as much as possible.	The restructuring process required an adaptation of the facilities to supply medical needs and lighting equipment; creation of an oxygen plant; all beds were equipped with a standardized respirator, a multiparameter monitor and four electric syringe pumps; rapid diagnostic equipment for COVID-19; portable X-ray machine and an ultrasound machine; equipment for difficult intubation; intubation kits containing video laryngoscope, videolaryngoscopy blades, intubation probe, cold light laryngoscope, blades nº 3 and 4, Guedel cannula nº 2, 20 ml syringe, clamp, plaster roll, PFF2 mask + glasses.	All medical, paramedical and administrative procedures have been written down and standardized as much as possible; in order to facilitate the location of personnel, the locations were color-coded and a care cart was set up for each group of four patients. There was the transformation of a hospital restaurant into a unit with 43 beds for critical care for patients with COVID-19.
3	● **For professionals** All healthcare workers wearing full PPE; reasonably acclimatized environment for work. ● **For patients** Indoor environment with climate control; infection control team.	The adhesion of the most adequate number of critical equipment available in a short period of time; medications and laboratory objects; electricity and air conditioning; in addition to powering the generator, nasal cannulas, infusion pumps and patient monitors would continue to function even in the event of a power failure; measures to reduce noise levels inside the ICU, moving noise-generating machinery away from the patient care area and the use of barriers; the ICU water supply was provided by sources; disinfection and correct disposal of biomedical waste.	Construction of a 25,000 square meter temporary hospital with 250 ICU beds, created to increase COVID-19 care ICU beds in the city by 11%.

4	● **For professionals** 90% of professionals were trained to deal with matters related to COVID-19; control of the physical and emotional overload of professionals; use of PPE; physicians from different specialties (surgical and non-surgical) were reassigned to work in multidisciplinary teams led by infectious disease specialists, internal medicine or pulmonology. ● **For patients** Decreased waiting time for the ICU; patient safety protocols; protect patients with and without COVID-19 from staff and vice versa.	Improvement in the quality of instruments and equipment to meet the needs of new beds;	In addition to the 103 ICU beds, 120 new beds were created to meet the high demand of patients with COVID-19; reformulation of hospital wards, decrease in the number of surgical procedures and increase in ICU beds.
5	● **For professionals** Non-critical care staff would benefit from basic adult critical care courses; strategies such as health worker education, provision of adequate PPE, availability of adequate treatment (or prophylaxis) for various hazardous agents, and ensuring infection control. ● **For patients** Critical care staff has been expanded with non-critical care physicians working as “force multipliers”, intensivists and critical care nurses.	Need to acquire new equipment, such as equipment for diagnosing COVID-19, new ultrasound and portable X-ray devices.	Research with doctors from 17 regions of Spain, totaling 258 ICUs studied, in which the capacity of ICU beds during the pandemic outbreak increased by 160%.

Risk of individual studies bias

As for methodological quality, most studies were categorized as having high methodological quality[10]. Of the five articles included[4,11,13], four had 80% positive instrument assessments, and only one had 70%.

Data analysis

Similarity analysis led to the composition of six core words, represented by the words COVID-19, patient, care, bed, ICU, and equipment. The branching among the six cores reveals how the terms are strongly interconnected and convey the notion of the aspects of resource management during the COVID-19 pandemic.

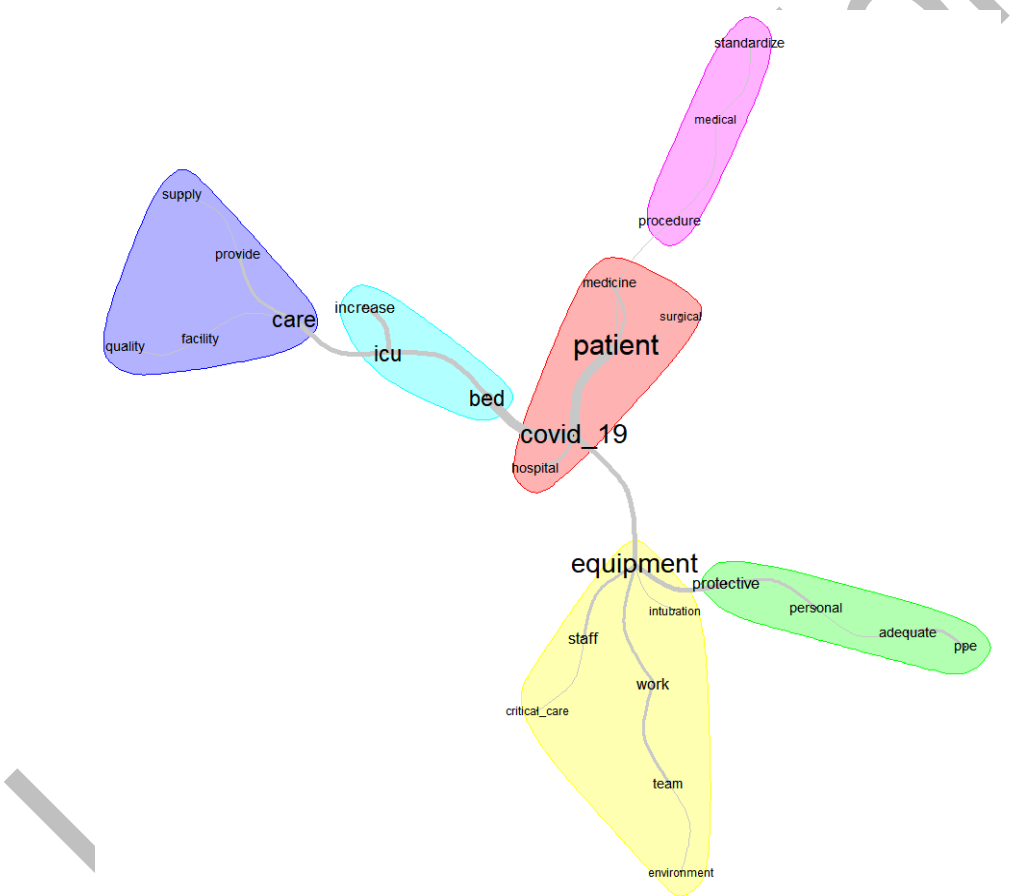


Figure 2. Similarity analysis tree among words from the text *corpus*, Brazil, 2023

The word COVID-19 presented as central, concerns the pandemic moment, strongly linked to the word patient. The word equipment covers two cores, with important terms in the restructuring process, linking the importance of protection and the use of PPE as well as intubation and the teamwork process in intensive care. Another analysis considered is the connection of the words bed, ICU and increase, which are aspects observed in all studies as the purpose of administration and increasing beds to meet the

great demand of the pandemic. The branch to the nucleus encompassing the word care presents links that direct quality assistance and strengthen this action.

DISCUSSION

During the COVID-19 pandemic, HR in health systems were impacted. Studies report losses in the mental health of professionals working on the front line related to the high flow of work, exhausting routine, impaired sleep, stress in work settings, among other factors[14]. In the restructuring process, managers were concerned about developing actions that would minimize damage to professionals' mental health, such as psychological care, hiring more professionals, overload control, and an air-conditioned environment [4,11,14].

The correct use of PPE is an action to prevent the spread and contagion of the SARS-CoV-2 virus and should be encouraged throughout work settings, especially for professionals who work on the front line in ICUs[15]. The availability of this equipment must be carried out by hospital units as well as the implementation of protocols for its use[11,12].

Training professionals for ICU care was mentioned by Shaparin *et al.*[12] as a necessary activity, but the author makes it clear that there was no large-scale training, due to the high demand of patients in need of care, but to assist in this process, those who had expertise in critical care played a role of leadership in the units. This action is a strategy to avoid the occurrence of errors in practice or handling of some equipment, and consequently, provides patient safety[13].

To meet hospitals' demands and needs, prioritization scales were carried out, from the most severe to the least severe care[11,13]. In the COVID-19 scenario, severity protocols helped in the flow of care, providing critical patients with the immediate intervention compared to those who were not so serious. This action also made it possible to reduce the burden on ICU professionals[16].

For Do Prado *et al.*[17], worker safety is considered part of patient safety, since adequate resources, prepared professionals, a favorable environment, and administrative protocols show improvement, both in the development of care and in patient health outcomes.

MR guarantee in ICUs enables the proper functioning and provision of quality service, since, to provide care to critically ill patients, there is a need for demand for adequate materials, ensuring the supply of all areas of restructuring, preventing the service suffers interruptions that are harmful to professionals and patients[18]. This resource is directly linked to the particularities of HR so that material, logistics, and supplies can be managed, and it is necessary to have good functioning to meet patients' and professionals' interests[19].

Professional protection through the reduction of risk exposure in work settings is a guarantee of quality care[20]. Therefore, when it comes to the availability of PPE, there are reported difficulties in ensuring the maintenance of this equipment, especially personal protective masks[11]. After the guidance of the World Health Organization on the use of masks by the general population, to contain the infection by the virus that causes COVID-19[21], there was a collapse in the distribution of these materials, causing an overload in the supplying companies and lack in hospitals. However, the guarantee of use by professionals was reported in most studies[11,12,14].

In ICU, oxygen therapy makes it possible to maintain the body's metabolic balance, improve tissue and organ oxygenation, correct hypoxemia, and plays a fundamental role for patients with airway infections[22]. This resource proved to be of great value in ICUs[23]. Some of those presented in this review developed the creation of their oxygen plants and ensured the supply of this resource throughout the pandemic[4,13]. To supply oxygen, auxiliary materials are needed, such as multiparameter monitors, laryngoscope, laryngoscopy blades, intubation probe, cold light laryngoscope, blades nº 3 and 4, Guedel cannula, 20 ml syringe, clip, high flow, face masks and glasses[4].

Electricity is a resource present in ICUs that cannot be scarce, since the operation of the entire care process requires electricity, as for the use of monitoring equipment, lung fans, defibrillators, lighting, and air conditioning of the environment was maintained through generators for ICU maintenance[12,13].

MR security in the restructuring process aims to optimize professional work, ensuring more accurate monitoring of patients and progress in clinical results. This process of maintaining materials must be assessed by managers to maintain the perpetuation of instruments with the profile of this care ward[22].

This method revealed sectoral bureaucratic-administrative resources, which made up the process of structuring and restructuring the units. The main objective is to detail changes or the creation of new sectors resulting from the COVID-19 pandemic.

The guarantee of adequate beds for the care of critically ill patients, either through the expansion of existing hospital units or the development of new emergency units.

Shaparin *et al.*[12] reported a 16-room sector shift from a surgical and anesthesiology wing to a 60-bed ICU COVID-19 unit in New York. The authors stated that the restructuring process was successful, and point to safety and commitment to well-being, preserving the quality of patient care. This process also made it possible to maximize professionals' experience and effective communication. Even during the subsequent waves of COVID-19, the hospital maintained subspecialty availability for emergency procedures in operating rooms.

Similar aspects were observed in the study by Borel *et al.*[4] However, the changes took place in a hospital restaurant for employees, which was transformed into a 43-bed wing for critical care of COVID-19 patients in Paris. For this, engineers and doctors guided the implementation of this reform, which took place in 15 days.

In mid-2020, shortly after the pandemic was declared, in New Delhi, construction began on a hospital center with a temporary ICU of 25,000 square meters, with 250 beds. Sing *et al.*[13] stated that the unit had a high structural level. The ICU was integrated in an accessible way to other wards of the hospital, allowing access to the wards, which were occupied by patients who were discharged from the ICUs. The entire restructuring process took place in 15 days, similar in time to the project by Borel *et al.*[4]

Due to the reduction in the performance of elective surgeries in a tertiary hospital in Spain, its surgical wards were transformed into ICUs for patients with COVID-19. Vilallonga *et al.*[13] reported the needs analysis process with the increased demand for critical care and the exhaustion of the 103 existing beds. The decrease in surgeries made it possible to create 120 new beds for high demand. The authors reported that this action avoided the increase in mortality rates, optimizing the surgical space as much as possible.

In this scenario, there was a great capacity for expansion in ICU beds in Spain. Nunez-Villaveiran *et al.*[14] reported a 160% increase in beds in different hospital units resulting from COVID-19 infection. These actions are part of the human disaster prevention plan, as intensive care resources have been increased to accommodate large numbers of critically ill patients.

The limitation of this review is identified by the specificity of the subject and consequent reduced production on the topic. Moreover, we limited the language of the studies and only included studies available online. However, an exhaustive analysis of the elements identified was carried out, which improved the results.

The study could serve as a guide for managers and healthcare professionals to understand the process of reorganizing ICUs, aimed at caring for patients with COVID-19.

CONCLUSION

The main elements necessary for structuring and restructuring ICU to meet the pandemic scenario demands are HR: professional training to care for patients with COVID-19 and correct use of PPE, an increase in the number of healthcare professionals, an increase in strategies for team and patient well-being, relocation of professionals among care sectors, presence of psychologists in services to assist professionals and greater adherence to the use of PPE; MR: increased supply of adequate PPE, increased supply of oxygen, increased supply of medications and increased need for equipment such as anesthesia circuit filters, mechanical ventilators, intubation boxes and other equipment for airway management; and organization/structure processes: increased demand for hospitalization beds, including ICU, and adaptation of facilities for COVID-19 hospitalization sectors.

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