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IMPROVING THE PRIORITIZATION PROCEDURE OF PATIENTS WITH COVID-19 IN HOSPITALS BASED ON DECISION-MAKING TECHNIQUES: A SYSTEMATIC REVIEW.

Abstract **- Coronavirus-specific antibodies can be detected in the blood of people who have recently recovered from coronavirus disease-2019 (COVID-19). Convalescent-Plasma (CP) transfusion process proved that it's among the most efficient protocols, and it's used in hospitals to treat various infections and diseases. Several medical issues have been addressed due to the growing interest in creating Artificial Intelligence (AI) applications. However, considering the virus's enormous potential harm to global public health, such uses are insufficient. This proposed systematic review and meta-analysis aims to obtain an overview of COVID-19, highlight the limits of decision-making approaches, and give healthcare professionals information about the technique's advantages. Between 2016 and 2021, five databases, namely IEEE Xplore, Web of Science, PubMed, Science Direct, and Scopus, were utilized to run four sequences of search queries. As a result, 477 studies are found to be relevant. Only six studies were thoroughly examined and included in this review after screening articles and using proper inclusion criteria, highlighting the lack of research on this crucial topic. Studies' findings were reviewed to identify the gaps in all the evaluated papers. Motivations, problems, constraints, suggestions, and case examples were thoroughly examined. This study seeks to answer how we support the researchers with collected information for managing transfusion of the highest quality CP to the most critical COVID-19 patients across telemedicine hospitals.**

Keywords: Convalescent-Plasma, COVID-19, MCDM, Telemedicine, Prioritization.

I. INTRODUCTION

The COVID-19 pandemic represents the biggest tremor to the world in decades, resulting in an unexpected impact across all major life [1]. Researchers from several nations have lately contributed to various technologies that aid physicians and healthcare practitioners in combating the epidemic [2]. To combat the COVID-19 pandemic, worldwide telemedicine implementation and integration inside hospitals have recently been incorporated to maximize care while decreasing exposures and viral transmission [3], [4]. Telemedicine is a sort of information technology that enables medical consultations outside of hospitals, utilizing digital imaging and other clinical services [5]–[8]. The transfusion convalescent plasma (CP) technique helps serve sick people boost their immunity [9]–[13]. The prioritizing solution must be able to combine the work process of patient and donor across various facilities at the same time. Meanwhile, a priority process is frequently used to guarantee that CP is provided promptly and appropriately [14]. The primary contributions of this research are exploring the COVID-19 patients and donors by reviewing articles on decision-making and prioritization of patients/donors across telemedicine hospitals, and how previous research has addressed the usage of those methods. This study also seeks to collect a variety of literature-based data pertinent to patient/donor prioritizing in telemedicine hospitals, such as datasets used, framework criteria, telemedicine environments used, and methodology used to solve the problem, detailed in a separate table. The review protocol specifies the procedures to be followed during the review. The review technique, inclusion and exclusion criteria, search strategy, research selection, data extraction, and distribution strategies should all be [15]–[17]. As will be briefly mentioned in the following section, specifying the procedures in advance decreases the chance of bias being introduced into the review.

II. SYSTEMATIC REVIEW PROTOCOL

This section provides the systematic review protocol used in the study. The following subsections describe the systematic review method, search strategy, inclusion criteria, exclusion criteria, study selection and results.

A. Method

This study was based on a systematic literature review (SLR), which follows the "Preferred Reporting Items for Systematic reviews and Meta-Analyses" (PRISMA) guideline [15]. The justification for conducting such kind of review is collecting reliable studies from many databases. The following five important digital databases were chosen and searched: (a) Science Direct, which offers access to a variety of journals in a variety of scientific fields, including medical, science, and technology; (b) IEEEXplore, which offers a variety of engineering and technology-related periodicals; (c) Web of Science, which provides access to papers from a variety of fields. (d) PubMed is widely regarded as the best resource for medical and biological research. (e) Scopus is a trusted resource in various fields, including medicine, health, science, technology, and engineering.

B. *Search Strategy*

Between 2016 and 2021, a complete search for English language publications was conducted in SD, IEEE, Scopus, PubMed, and ISI/WoS. These indexes were chosen because of their broad coverage. Most researches were relevant to our investigation since "CP transfusion" trends have been very active in telemedicine applications and medical healthcare services in recent years. This research utilized Boolean query search using various keywords associated with pervasive 'Convalescent plasma transfusion' (e.g. "convalescent plasma" OR "laboratory characteristics") with the coronavirus keywords (e.g. "COVID-19" OR "SARS-CoV-2") and keywords that considered all these terms developed under the concept of telemedicine (e.g. "telemedicine" and "management"). However, to cover the wide space of search queries, this study uses four queries to obtain more reliable studies, as shown in TABLE 1.In other words, these queries are used to strengthen the search for different telemedicine and healthcare studies for rescuing COVID-19 patients within all these terms based on centralized/decentralized telemedicine hospitals.

Table (1) Literature review queries

Sequence	Query Details Terms	Databases Result	Final Results
1st query	("convalescent plasma" OR "laboratory characteristics") AND ("COVID-19" OR "SARS-CoV-2") AND ("prioritization" OR "prioritisation")	IEEE=6 PubMed=13 SD=27 Scopus=8 WOS=2	56-4 (duplicate)=52 Articles
2nd query	("convalescent plasma" OR "laboratory characteristics") AND ("COVID-19" OR "SARS-CoV-2") AND "telemedicine"	IEEE=3 PubMed=2 SD=15 Scopus=18 WOS=5	43-7(duplicate)=36 Articles
3rd query	("convalescent plasma" OR "laboratory characteristics") AND ("COVID-19" OR "SARS-CoV-2") AND "management"	IEEE=17 PubMed=76 SD=166 Scopus=97 WOS=79	434-100(duplicate)=334 Articles
4th query	"plasma" AND ("COVID-19" OR "SARS-CoV-2") AND "telemedicine"	IEEE=9 PubMed=6 SD=38 Scopus=13 WOS=8	74-19(duplicate)=55 Articles

C. *Inclusion Criteria and Exclusion Criteria*

1. The primary goal is to research to improve the CP transfusion procedure between donors and patients with COVID-19. 2. The article is written in English and is either a journal article or a presentation presented at a conference. 3.

These studies' case-control context analysis is developed under or supports telemedicine architecture management.

This study's exclusion criteria include investigations that aren't written in English. In addition, studies that focuses on the CP transfusion process but are unrelated to the prioritized area, and vice versa, are excluded. Papers that presented a technology but did not provide a clear scientific path for advancement were also eliminated.

D. *Selection of Study*

After deleting duplicate articles, the next step was to examine the titles and abstracts of publications to see if they met the criteria (i.e., inclusion/exclusion). The individual full text reads for possibly linked publications were then evaluated. Then, review the entire process, including the extracted table of data elements within the relevant studies. Consultations with the supervisors were used to resolve disagreements. The supervisors evaluated and validated all of the studies included in the research.

E. *SLR Results*

Initially, the study selection phases began with about 477 papers from the five databases. When the duplication screening ended, a total of (n = 69) papers were excluded; hence the reminder is (n = 409) articles. The second screening phase consisted of scanning titles and abstracts, yielding a total of (n = 139) papers. The next step in the screening process was to read the entire text of the articles identified in the previous step. Based on our criteria, a total of 6 papers were reviewed and considered to be relevant to the review. The flowchart for the schematic approach phase is shown in Fig. 1.

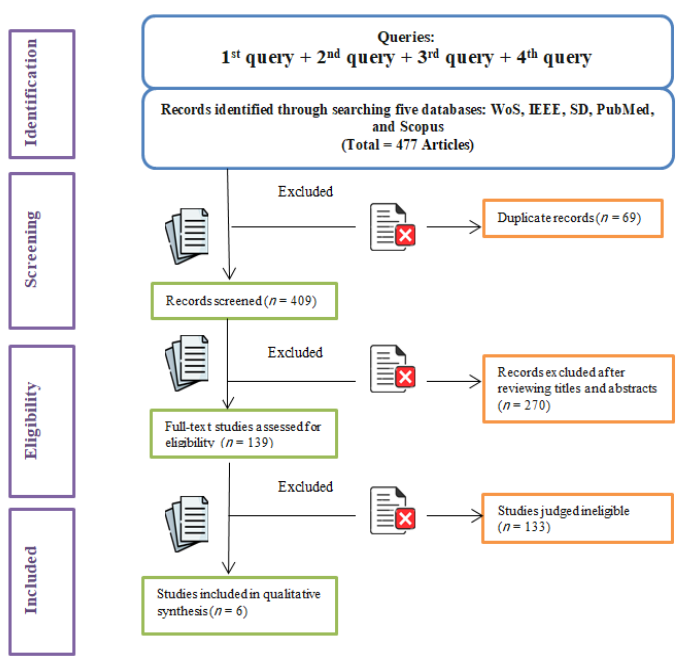

Figure (1) Flowchart for schematic approach phases

III. Discussion

According to the literature, little attention was given to a CP and prioritization solution for patients with COVID-19 as a case study [18]–[22]. The study of [23] presented multi integration decision-making methodology that helps health authorities to prioritize COVID-19 patients considering the biological laboratory examination. The study's goal is to provide preferred intensive care facilities and help indoor healthcare practitioners manage their patients' health issues (i.e. clinics and hospitals). The experiment was divided into three stages (i.e. collecting data on COVID-19 patients, setting the subjective weights for the criteria and prioritizing patients). The researchers provided integrated approaches in [30] to detect and prioritize the health status of COVID-19 patients based on multi-laboratory criteria while taking asymptomatic carriers into account. This approach evaluated discrimination processes against asymptomatic carriers to provide a realistic suggestion to patients before they were discharged from hospitals to ensure that they met the standards. There were four stages to the current approach (i.e. develop a new decision matrix, set the objective weight using entropy, TOPSIS is adapted to prioritize patients, and finally, objective validation is performed). The study [31] suggested a rescue approach based on biological needs to transfusion the best CP to the most critically ill of COVID-19 patients. Machine learning and innovative multi-criteria decision-making (MCDM) methodologies were applied in the research. The suggested framework is divided into two parts that must be completed in order (i.e. testing and development). The most susceptible patients are divided into four blood types and matched to a tested CP list from the test phase on the donor side. After then, the contracted CP decision matrix is used to rank the CP testing list. This study [10] attempted to swiftly create a sustainable CP transfusion program for a regional network of healthcare providers. A regional collaborative group was created to address the challenges that must be overcome before a CP transfusion program can be launched. A diverse group of healthcare professionals, including physicians (transfusion medicine, infectious disease, and critical care), laboratory technicians, pharmacists, nurses, and information technology (IT) professionals. In the same context, the work of [24] identified the significantly high-risk factors that cause the spread of COVID-19 using MCDM. A new technique for continuous monitoring of death from confirmed instances of coronavirus-based prediction model was created. This study used the architecture to determine the link between the input and output indexes. When and whenever a new option is discovered, an automated framework may be constructed to quantify site selection potential. Additionally, the study defined the methodology for the optimal COVID-19 diagnostic model [21]. The researchers presented an intelligent technique to assist healthcare companies in selecting the "COVID-19" diagnosing system. The MCDM approach assesses and benchmarks the various "COVID19" diagnostic models against the evaluation criteria. The use of MCDM approaches can successfully address the benchmarking and selection issues associated with "COVID19" diagnosis models. Collectively, these studies outline a critical role of the CP transfusion process using different prioritization methods. Table (2) summarizes the extracted information from the related previews studies.

IV. CRITICAL REVIEW AND GAP ANALYSES

This section represents a critical review and analysis of the studies that resulted in paragraph (2.5) discussed in the previous section, which focused on COVID-19 CP and prioritization studies. The criticism of the academic literature is presented as claimed points in this section as follows:

Dataset availability: One of the limitations of previous research is the lack of "COVID-19" dataset availability for patients and donors, as mentioned in Table (2). Most studies of "COVID-19" have only been carried out in a small number of patients dataset and lacking for donors dataset [13], [24], [27]. Other studies conducted their works without using a clear dataset to represent the results of their framework [26]. Yet, no "COVID-19" dataset has been suggested to serve the topic of this research [21], [28]–[30].

Criteria used: Previously published studies show variety in the number and criteria types. In this context, determining the most important criteria that may affect choosing the most severe patients is questionable [25] [31]–[34]. The study of [13] used eleven biomarkers criteria. Another study used Eight biological laboratory examinations [23], whereas [21] mentioned many evaluation criteria. So the decision for the patient's health condition based on the most important criteria should be considered. Thus, the affected criteria should be identified for the required dataset.

Telemedicine in centralized/decentralized architectures utilization: As previously mentioned in TABLE 2, [26] applied their paradigm to indoor/outdoor hospitals using telemedicine. The study [10] used multiple hospitals in the health system composed of 23 network hospitals, 300 physician offices, and a variety of other health care services spanning four states. However, the researchers in many studies typically only investigated the framework for indoor healthcare providers [23] or indoor/outdoor hospitals [25] without a clear managing framework of how to achieve the transfusion process among patients and donors.

V.ANALYSIS OF CHARACTERISTICS

According to the information gathered from academic literature research on COVID-19 and the CP transfusion procedure, three features are provided in the following subsections. The motivations for using different prioritization framework methods to explore meaningful techniques for COVID-19; the potential challenges to allowing CP transfusion to rescue the most severe COVID-19 patients; and recommendations to alleviate challenges related to patients/donors prioritization methods for COVID-19 rescue.

Table (2) Extracted information from th

Ref.	dataset size	Criteria used	No. of Criteria and types	Method used	Environment
[23]	Six patients with COVID-19 (included 1 Asymptomatic Carrier with COVID-19)	CRP, eosinophil ratios, eosinophils, white blood cell count, lymphocyte ratios, lymphocytes, neutrophil ratios, neutrophils	Eight biological laboratory examinations	Integration of AHP-VIKOR methods based in both individual and GDM contexts	Indoor healthcare providers (i.e. clinic, and hospital)
[25]	56 patients (included 8 asymptomatic carriers with COVID-19)	White blood cell count, count of Neutrophil, count of Lymphocyte, Haemoglobin, count of Blood platelet, Albumin, C-reactive protein, Interleukin 6	Eight laboratory criteria	Two feature selection approaches: -automatic mechanisms ANOVA, X2, and Relief) and knowledge-driven -ENTROPY–TOPSIS	Indoor/outdoor hospitals
[26]		Albumin, IgM/IgG, cytokine/chemokines, peroxiredoxin II, C-reactive protein, PaO 2 /FiO 2.	Six serological/protein biomarkers criteria	Novel MCDM method called subjective and objective decision by opinion score method (SODOSM).	Indoor/outdoor hospitals over a telemedicine environment
[13]	294 Donors	IgG and IgM ELISA assays for antibody to SARS-CoV-2 nucleocapsid antigen, spike proteins (S1 + S2), and spike protein binding domain.	Eleven criteria	-rank patients in a tiered prioritization scheme -SOFA (Sequential Organ Failure Assessment) Scoring -Multi-principle Strategy to Allocate Critical Care/Ventilators/Supplies	Multiple hospitals in regional health care delivery system network, SSM Health
[24]	Confirmed and death cases collected from website of (WHO) and some Government report between 31-Dec- 2019 to 05-Apr-2020.	Important risk factors of COVID-19	-	TOPSIS GMDH (Group Method of Data Handling)	Hospitals

[21]	50 X-ray images(25 positive COVIDE-19 cases, 25 normal cases)	Main criteria: (i) Time complexity and (ii) group reliability. Sub-criteria: Precision, f1-score, recall, average-accuracy, error rate, true positive (TP), true negative (TN), false positive (FP), and false negative (FN).	Ten evaluation criteria	Entropy–TOPSIS and The SVM (linear) classifier	Medical organizations

A. Motivations

Because of their substantial influence on human existence in terms of social, scientific, medical, and engineering-based applications, research fields in AI, such as the MCDM approach, have been quickly developed. As a result, this section explains why studies on the prioritization of COVID-19 patients and donors were done. The growing number of individuals infected with this virus is confounding medical policy in terms of how to give healthcare in the most difficult situations [9], [12], [13]. Decision-making can support accurate differentiation and prioritization of a large scale of patients infected with COVID-19 based on multi-laboratory examination attributes [23]. Prioritization of all health conditions of the increasing number of infected patients complicates the medical services providers [25]. No study has presented sequential intelligent automation prioritization framework solutions to COVID-19 patients or CP recipients [26]. On the other hand, CP represents an appealing practice for treating COVID-19 patients [11]. In fact, research that looked at evaluating and benchmarking COVID diagnostic algorithms was not carried out [21].

B. Challenges and Limitations

COVID-19 has spread throughout the planet, posing a threat to human existence. As a result, several experiments have been conducted to establish an intelligent rescue framework that uses AI to manage the pandemic. Furthermore, the academic literature has identified many problems and research limits that COVID-19 diagnostic models. According to the findings of the studies [13], [14], and [16], a prioritizing framework should be performed and executed in must be addressed in the future. Beginning with the issues of donor selection plasma criteria and ensuring compliance with national health laws and well-established standard regular processes [26],[11]. Nevertheless, the differentiation among mild and critical patients with COVID-19 via serological protein criteria can be added to the challenges faced in research [23], [25]. Another challenge is proposing a methodology to select risk health conditions and prioritize patients dependent on multi-laboratory examinations [23]. In the transfusion of the most appropriate CP to the most serious COVID-19 patients, MCDM issues should be considered [26]. The small number of substantial datasets for COVID-19 in the academic literature is a critical task for AI researchers since it limits their comprehension of the virus's characteristics [14], [16].

C. Recommendations

This study attempted to address and reduce some of the issues raised in the academic papers and provide recommendations for further research. Studies such as [23] and [25] suggested increasing the dataset sample to show the effectiveness of the priority process in deep analysis. Moreover, the study [23] recommended adapting more criteria to maximize the decision matrix with more patients' data. Implementing the MCDM proposed framework to serve and help the healthcare sector fight COVID-19 is recommended [26]. The study of [21] suggested applying the proposed methodology to evaluate and benchmark the other types of

indoor/outdoor hospitals over a telemedicine environment in various architectures.

VI. Conclusion

The pandemic of "COVID-19" represented a difficult challenge, which required fast, collaborative management and decision-making. The CP transfusion procedure significantly improves the infected patients' immunity. The small number of studies in the literature is a serious concern that directly affects fighting the spread of this virus. However, the whole picture of monitoring and prioritizing patients/donors with COVID-19 concerning affiliated hospitals is not currently available. To meet the present demands, a sustainable health system and the finest social care must investigate further changes. In addition, challenges are arising since more patients/donors of COVID-19 are admitted to hospitals very often. The issue of a fair managing and efficient distribution of CP among patients and donors regarding distributed hospital processes at the same time is still not considered. Systematic reviews are detailed examinations of the evidence to assist physicians and other decision-makers in making informed healthcare decisions. The protocol lays out the approaches that will be utilized in the review in advance, with the target of decreasing bias. Building a prioritization healthcare framework is recommended to increase service availability, exchange medical resources, and avoid a severe scarcity of CP, allowing doctors to speed up COVID-19 therapy.

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