



REVIEW ARTICLE

Identification of the essential and critical factors of decision-making for COVID-19 patient management: a mixed-method study

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Abstract

Background: Understanding the contributing factors for decision-making based on the disease stage is highly crucial to improving patient care.

Aim: This study aimed to identify the critical and essential factors to enhance clinical decision-making for COVID-19 patients.

Methods: This mixed-method research was conducted in two phases. In the first phase, a systematic literature review was performed using defined search strategies across four databases, including PubMed, Scopus, Web of Science, and IEEE. A total of 136 studies were obtained. Next, a questionnaire-based survey was conducted to validate the findings from the review and to categorize the factors into essential and critical factors. The content validity ratio was used to categorize the factors accordingly. The identified factors were classified into six main categories based on the stages of care and the corresponding decision-making.

Results: The expert panel consisted of 10 clinicians from various fields. The potential factors were categorized into six categories. A total of 293 factors were found in the literature review. The findings of the consensus survey revealed 10 factors related to the decisions on the length of stay, eight factors for ward referral decisions, one factor for decisions on home referrals, six factors for deterioration diagnosis decisions, two factors for discharge decisions, and 10 factors for decisions on intensive care unit referrals. In addition, the study identified respiratory rate, oxygen saturation at administration, arterial oxygen pressure, sequential organ failure assessment score, and glomerular filtration rate as significant decision-making factors for COVID-19 patient management.

Conclusion: For medical emergencies (e.g., COVID-19 management), fewer but more significant factors may increase the efficiency of decision-making, thereby improving the quality of patient management. On this basis, this study identified the essential and critical factors for decision-making at different stages of COVID-19 patient management.

Relevance for Patients: This study identified the most important factors in diagnosing the deterioration of COVID-19 patients to improve the treatment outcome of COVID-19 patients.

1. Introduction

The COVID-19 pandemic has been known as a global challenge that requires inclusive approaches to control. COVID-19 is caused by a new virus that was officially named

severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1,2]. Most people infected with this virus experienced mild to moderate respiratory diseases. Besides epidemiological policies, patient-centric decision-making has been highly crucial to control the COVID-19 pandemic. Particularly, at the pandemic peak, physicians had to make crucial decisions, based on widely recognized factors, for patient management within a short time [3,4].

However, COVID-19 management is highly inconsistent due to symptom variations, ranging from mild to severe symptoms [5,6]. Therefore, the management of COVID-19 patients is a multi-criteria decision-making problem due to the complexities of COVID-19 [7]. There are different decisions to be made for each patient based on their condition [8]. These decisions could include referrals to the intensive care unit (ICU) or isolation at home. A COVID-19 patient may be assigned to a specific stage, typically inclusive of discharge, ambulatory, inpatients, referral to the ICU, or death due to COVID-19 infection [9]. In these circumstances, identifying the necessary factors can be significantly effective in making the best decision.

Nonetheless, information is the key element for decision-making, and decisions are made based on the most influential factors. Likewise, more data may not result in the best decision being made, but the most effective data provides the best care and safety for patients. Hence, we aim to identify the most fundamental factors for the best decision-making in COVID-19. In times of emergency, decision-making is critical, and the most influential factors result in the best decision-making [10]. In such situations, heuristic decision-making is adopted, whereby humans process information in a less complex way to reach better decisions more efficiently. The heuristic approach can be more accurate for complex problems and is one of the most important discoveries of recent decades [11]. This type of decision-making is suitable for COVID-19 as heuristics account for the uncertainty and risky conditions of COVID-19. Therefore, it is essential to prioritize the effective factors, especially during an influx of patients. The priority of the factors should account for the patient's condition and the presently available evidence to ensure that clinical experts can make optimal, timely, and accurate decisions [12]. While previous studies have determined the general factors affecting the status of COVID-19 patients [13-16], our study further identified the critical and essential factors for optimal decision-making and rapid management of COVID-19 cases based on disease severity. Recent studies have revealed that different approaches were considered to manage and prioritize infected patients, varying from home isolation to ICU admission [17,18]. Thus, the effective factors regarding clinical decision-making and different approaches to managing admitted patients can be divided into six categories, comprised of (i) effective factors related to the length of stay, (ii) effective factors related to ward referrals, (iii) effective factors related to home referrals or home isolation, (iv) effective factors related to deterioration diagnosis, (v) effective factors related to identifying the discharge time, and (vi) effective factors related to ICU referrals [19-25]. Thus, the main objective of our study was to determine the essential and critical factors for

decision-making based on case severity and disease stage through a systematic review and the opinions of clinicians.

2. Methods

This mixed-method study was conducted in two main phases, including a systematic review and a questionnaire-based survey for a panel of clinical experts. We employed a combination of quantitative and qualitative analyses within the same study, enabling the exploration of diverse perspectives and relationships that exist between the complex layers of our multifaceted research questions [26].

2.1. Research question

This study was based on the following research question: What are the critical and essential factors for optimal decision-making and rapid management of COVID-19 cases based on disease severity?

2.2. Systematic literature review

2.2.1. Search strategy

Articles from PubMed, Scopus, Web of Science, and IEEE databases were searched from December 2019 to December 2022. The searched keywords included “triage,” “classification,” “scoring system,” “forecasting,” “predict,” “prediction,” “ICU,” “critical care unit,” “severe acute respiratory syndrome coronavirus,” “COVID-19,” “SARS-CoV-2,” “2019 novel coronavirus,” “Wuhan coronavirus,” and “novel coronavirus.” The patient/population, intervention, comparison, and outcomes model was used to define the search strategy [27]. This search was restricted to English language papers. The search strategy is provided in Table A1.

2.2.2. Inclusion criteria

The inclusion criteria were articles published in English and focused on decision-making regarding COVID-19.

2.2.3. Selection process

Conference abstracts, letters to editors, papers with unavailable full text, and papers with insufficient details about the data elements (i.e., factors) were excluded from this review. This systematic review was conducted based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) checklist [28].

2.2.4. Data extraction

After duplicate articles were removed, the article citations were imported to EndNote. In the first phase, all titles and abstracts of the articles were independently examined by four authors based on our main objective to select relevant studies. Another author reviewed a sample of studies at random to validate the process. Next, all of the articles were categorized into six main categories, i.e., decision-making for patient ward referrals, patient ICU referrals at the golden time, length of stay in the in ward and/or the ICU, patient deterioration diagnosis, and patient discharge. These categories

of possible outcomes for each patient were defined based on the clinicians' views and agreement. The six potential areas of decision-making were considered through expert consultation to classify the influential factors extracted from the reviewed publications. The flow of the literature review process is displayed in Figure 1.

2.2.5. Identifying potential factors and questionnaire preparation

To determine the essential and critical factors of decision-making for COVID-19 patients based on the severity, a datasheet/form (prepared based on the PRISMA checklist) was used to identify data elements (i.e., factors) in the articles of the systematic review. This datasheet included four sections; name of the data element, *P*-value, category, and description.

The full-text eligible studies were assessed thoroughly by four reviewers to extract potential datasets related to each category. If the *P*-value was reportedly <0.05 , the factor was considered as a potential data element. If there was a disagreement between the authors in the selection of relevant studies, the final decision was made by another author (i.e., S.R.N.K.).

Thereafter, a five-point Likert-based questionnaire was created based on the potential factors identified through the literature review. The questionnaire was finalized with reference to the factors identified from the systematic review and the six outcomes. The questionnaire consisted of two parts; the demographic characteristics of experts and a list of factors that was scaled according to the Likert score.

2.3. Expert consensus and questionnaire-based survey

Expert consensus refers to the collective opinions of clinical experts on a clinical topic and it is employed to provide quantitative and reliable data (e.g., recommendations of best practices) in clinical areas that are not well-defined by research [29,30].

2.3.1. Validating the contents of the questionnaire

The clinical experts who participated in the survey were affiliated with various medical universities, clinics, and hospitals in Iran. The selected participants in this study comprised specialized physicians in internal medicine, pulmonary and infectious disease, emergency medicine, and related clinical fields with experience in COVID-19 patient management for more than 6 months.

Five clinical experts were invited to assess the grammar, language, and item allocations for validating the questionnaire. The experts were requested to suggest a correction for items that they deemed were incorrect. Each question (data element) was to be evaluated by the participants over a five-point scale, ranging from "essential" (score: 1) to "highly critical" (score: 5).

2.3.2. Recruitment of experts for consensus-based survey

Some criteria referred to specific clinical experts, warranting their invitation to the study. These clinical experts had experience working in COVID-19 wards or ICUs in multiple hospitals in Iran. In addition, a general practitioner with relevant experience

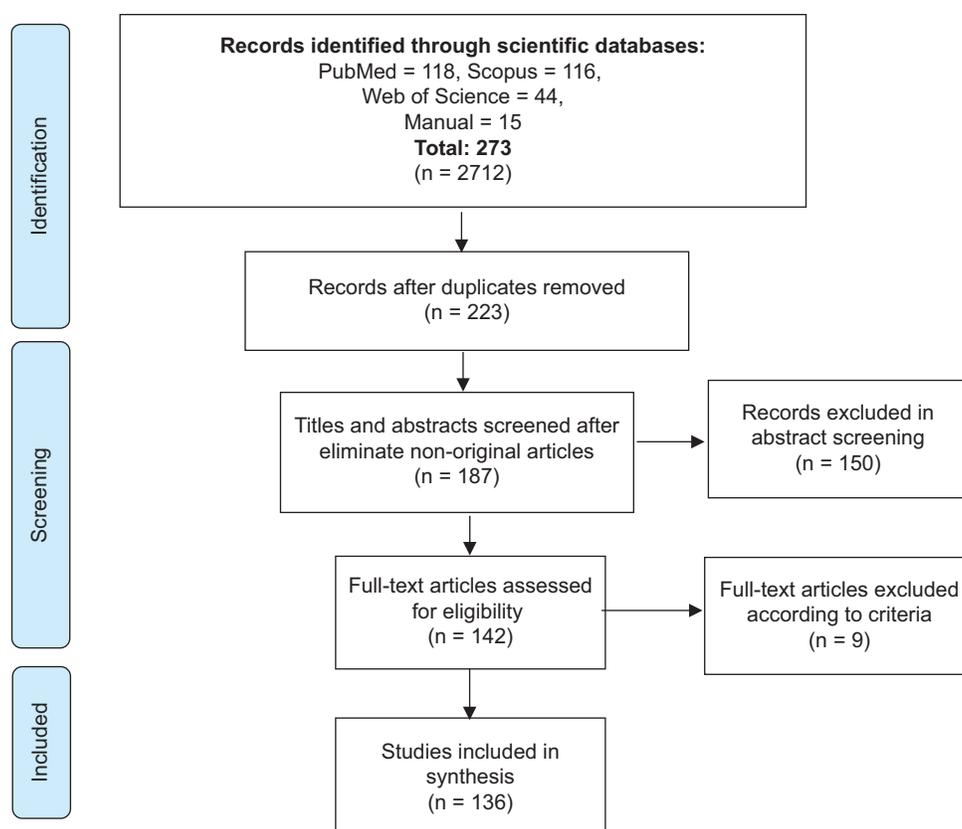


Figure 1. The flow of the literature review process.

and interest in the study would be invited to participate in the study as well. With reference to the Lawshe table [31], the number of participants was limited to 10 clinical experts for an optimal content validity ratio (CVR) during expert agreement analysis.

2.3.3. Conducting the questionnaire-based survey

We conducted the questionnaire-based survey by initially sharing an online link to the questionnaire with the clinical experts through email or social network. The objective of the survey was explained to the clinical experts through the same email or content of the message (if the experts were contacted via social network). The clinical experts would confirm their participation with a declaration. CVR [31] was utilized to quantitatively evaluate content validity, and the content validity index (CVI) was calculated for each data element. The CVR corresponded to the essentiality or effectiveness of each item in clinical decision-making for COVID-19 patients.

The critical threshold of CVR refers to the minimum CVR critical value for each item. Based on Lawshe’s table [32], the critical threshold of CVR was set at 0.62 per the number of clinical experts (i.e., 10 clinical experts in this case).

2.3.4. Analysis of panel results

The literature review generated a list of factors that could effectively decide a patient’s outcome. Herein, we added several criteria when interpreting the results. If the CVR of an item was greater or equal to the CVR threshold, the item was considered “critical.” Items with CVR between zero to the threshold value

(i.e., 0.62) were considered “essential,” implying an agreement from more than half of the clinical experts on the particular item. A sub-zero CVR would indicate that less than half of the clinical experts considered an item “essential,” and the item would subsequently be rejected [33,34]. All of the results were analyzed using IBM statistical package for the social sciences v20.

3. Results

This study was conducted in various steps, and the results of each step, with the identified factors and their frequency, are represented in Figure 2.

The possible outcomes identified from the literature review in the first step were divided into six possible categories (as follows):

- (i) Length of stay: The length of stay is a clinical metric that measures the time elapsed between a patient’s hospital admittance and discharge [35].
- (ii) Ward referrals: Ward referrals involve directing a patient to a different hospital ward based on their specific medical condition.
- (iii) Home referrals: Home referrals involve recommending and arranging for patients to receive care in the comfort of their own homes instead of being admitted to a medical facility.
- (iv) Deterioration diagnosis: Deterioration diagnosis indicates the worsening of a patient’s health condition which can happen at any point while they are hospitalized.
- (v) Discharge: Discharge is when a patient is permitted to leave the hospital following the receipt of treatment and care.
- (vi) ICU referrals: ICU referrals entail recognizing patients in need of specialized care and moving them to the ICU for treatment.

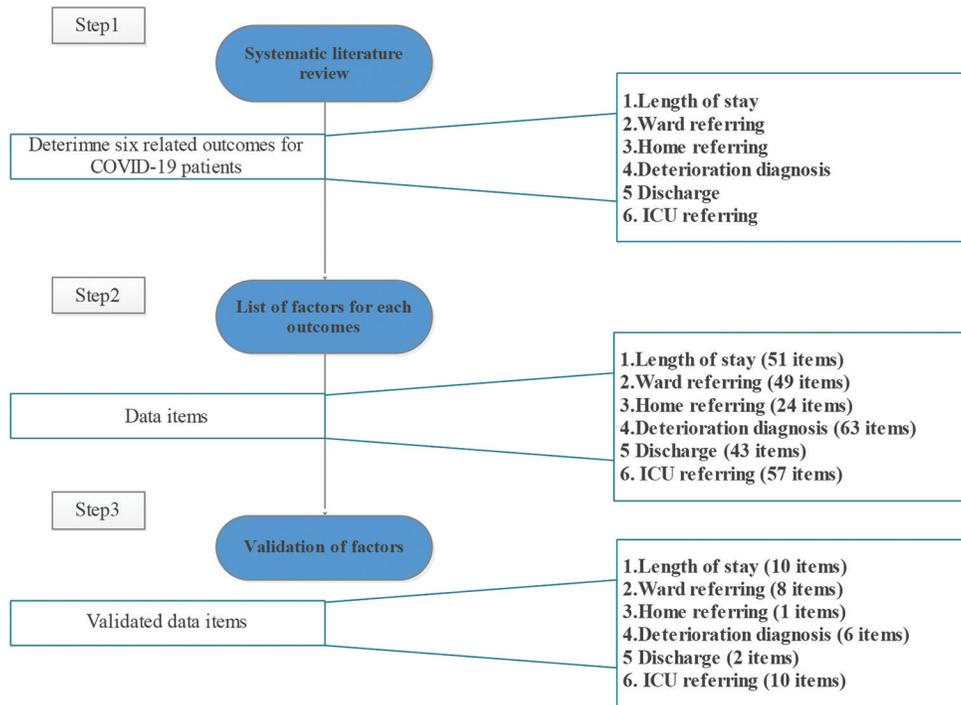


Figure 2. The study process included a systematic review and the validation analysis of factors affecting the physicians’ decision-making for COVID-19 patients.

In the second step, the factors were validated concerning each outcome via CVI calculation, and the critical factors were determined.

3.1. Literature review to identify the effective factors

Overall, 273 articles were obtained from the literature search. Fifty duplicate studies were removed accordingly. After assessing the title, abstract, and full text of the articles and excluding the irrelevant studies, the remaining 136 articles were further evaluated. The articles were evaluated for the relevant factors (e.g., effective factors and clinical tests in COVID-19 management) based on predefined categories regarding decision-making. The general characteristics of the evaluated articles are displayed in [Table 1](#).

From the literature review, a total of 293 demographic and clinical factors, considered effective in clinical decision-making at different stages of COVID-19, were identified. Among them, 51 factors were related to the length of stay, 50 factors were related to ward referrals, 24 factors were related to home referrals, 63 factors were related to deterioration diagnosis, 43 factors were related to discharge, and 62 factors were related to ICU referrals. It should also be noted that several factors are common in various areas.

3.2. Clinical expert panel data analysis

The clinical expert panel included one subspecialist, six specialists, and three general practitioners with experience working in COVID-19 wards or ICUs in referral academic hospitals in Iran. Six of the participants worked in Tehran, while the others worked in Kerman, Varamin, Yasuj, and Dehdasht. [Table 2](#) summarizes the characteristics of these clinical experts based on gender, medical specialty, clinical experience, and the number of COVID-19 patients visited from March 2020 to December 2022.

3.3. Essential and critical factors

Based on the calculated CVRs of 258 items, 159 items were identified as essential factors, and 28 items were identified as critical factors in the six outcome categories. A total of 71 items were rejected based on our criteria described in Section 2.3.5. The full results are displayed in [Tables A2-A7](#).

The first category of factors was associated with decision-making regarding the length of stay in the hospital ([Table A2](#)). From a total of 51 factors, 10 were considered critical and 41 were considered essential. The critical factors were the history of cancer or malignancy, history of any cardiovascular disease, history of renal function impairment or chronic kidney disease, history of respiratory disease (e.g., asthma and chronic obstructive pulmonary diseases [COPD]), history of using immunosuppressive drugs, respiratory rate (RR), C-reactive protein, glomerular filtration rate (GFR), oxygen saturation (SpO₂) at admission, and the sequential organ failure assessment score.

The second category (i.e., ward referrals) included 49 factors ([Table A3](#)), of which eight factors were considered critical. The accepted factors were the history of diabetes mellitus, history

Table 1. General characteristics (i.e., type of clinical decision and country) of the evaluated articles

Characteristic	Number of articles (relative to all articles [%])
Type of clinical decision	
Length of stay	12 (8.89)
Ward referrals	9 (6.67)
Home referrals	4 (2.96)
Deterioration	98 (72.59)
Discharge	15 (11.11)
ICU referrals	30 (22.22)
Country	
China	53 (39.26)
United States of America	22 (16.30)
Italy	17 (12.59)
France	9 (6.67)
Turkey	6 (4.44)
Iran	4 (2.96)
Belgium	2 (1.48)
Canada	3 (1.48)
Germany	4 (1.48)
Greece	5 (1.48)
Japan	6 (1.48)
Pakistan	7 (1.48)
Spain	8 (1.48)
United Kingdom	9 (1.48)
Australia and New Zealand	1 (0.74)
Israel	1 (0.74)
Korea	1 (0.74)
Netherlands	1 (0.74)
Singapore	1 (0.74)

Abbreviation: ICU: Intensive care unit.

of cancer or malignancy, history of any cardiovascular disease, history of renal function impairment or chronic kidney disease, history of respiratory diseases (e.g., asthma and COPD), RR, SpO₂ at admission, and arterial oxygen pressure (PaO₂). A total of 24 factors were reported for home referrals or home isolation, of which one factor (i.e., SpO₂) was considered critical, while the other 23 factors were deemed essential ([Table A4](#)).

The fourth category of decision-making was related to the factors in deterioration diagnosis ([Table A5](#)). This category reported 63 factors, including six critical factors and 57 essential factors. The critical factors for this decision-making were the history of respiratory disease (e.g., asthma, COPD, and other similar diseases), RR, D-dimers, SpO₂ at admission, venous blood pH, and PaO₂.

The discharge category (with a total of 43 factors) reported two critical elements, including RR and GFR ([Table A6](#)).

The sixth category was ICU referrals with 57 factors in total ([Table A7](#)). Among them, there were 47 essential factors and 10 critical factors. The critical factors were body mass index or obesity, history of cancer or malignancy, history of renal function impairment or chronic kidney disease, history of respiratory disease (e.g., asthma, COPD, and other similar diseases), RR,

Table 2. Characteristics of the panelists

Domain	Frequency (relative to the total domain frequency [%])	Range
Gender		
Male	7 (70)	N/A
Female	3 (30)	
Specialty		
Pulmonology	1 (10)	N/A
Anesthesia and intensivist	1 (10)	
Emergency medicine	2 (20)	
Pharmacotherapy	1 (10)	
Obstetrics and gynecology	1 (10)	
Otorhinolaryngology	1 (10)	
General practice	3 (30)	
Clinical experience (years)		
<10	4 (40)	5 – 35
11 – 20	3 (30)	years
21 – 30	1 (10)	
>30	2 (20)	
Number of COVID-19 patients visited by the participant		
<50	3 (30)	10 – 2000
50 – 150	4 (40)	
151 – 300	1 (10)	
300 – 450	0	
>450	2 (20)	

creatinine (Cr), serum Cr, GFR, SpO₂, and PaO₂. The critical factors of the six outcomes are displayed in Table 3.

4. Discussion

4.1. Purpose of the study

Due to the complex nature of COVID-19, identifying the effective factors of decision-making for patient outcomes is an essential requirement of the current healthcare systems. Through this survey, the effective factors were identified with a combination of literature review and expert consensus. As patients experience different symptoms after COVID-19 infection, all possible factors should be considered for appropriate treatment and accurate clinical decision-making at each COVID-19 progression stage. Hence, the results were presented based on different stages in the decision-making process.

4.2. Brief information about the key findings

Among the critical factors, SpO₂ was implicated in five out of the six decision-making outcomes for COVID-19 cases. Evidence has revealed that low blood oxygen or hypoxia is a warning sign of severe COVID-19, correlating to the severity of the disease [36]. RR is another critical factor implicated in five out of the six decision-making outcomes, indicating an important role in determining the status of the patients [37].

Several studies have been conducted regarding COVID-19 and the effective risk factors in clinical decision-making. Most

of the published studies have focused on specific domains of the patient's condition, whereas different possible aspects of clinical decision-making were considered in the present study. The study by Pijls *et al.* [38] focused solely on the demographic factors influencing the severity of COVID-19. In contrast, we investigated a wide range of clinical factors that could be effective in inpatient assessment.

The results of our study could support the policymakers in preparing the required equipment, such as an oximeter and mechanical ventilation. The oximeter should be accessible for patient monitoring in the ward and at home. In addition, a Bluetooth pulse oximeter with a telehealth system via mobile platforms can be used to check a patient's condition as SpO₂ is a critical factor for decision-making in most domains [39]. Therefore, an effective patient management strategy can be developed by prioritizing the critical factors and subsequently the essential factors.

Medical history was recognized as a critical factor in our survey. Consequently, timely access to the patient's medical records could improve clinical decisions about the patient's condition. Current electronic health records (EHRs) can provide timely information and real-time monitoring for the early detection and management of severe diseases [40]. Given the COVID-19 pandemic, several health-care organizations have rapidly implemented EHRs in their hospitals to improve patient safety management [41,42].

Likewise, the lack of evidence-based recommendations has led to clinicians having to review a vast amount of clinical information just to manage the patients better. Nonetheless, the high rate of infected patients is a major challenge for healthcare providers [43]. In response, several researchers have developed decision-aid tools to address the issue [44,45].

4.3. Recommendations for future studies

This survey could account for the initial step of developing clinical decision support systems (CDSSs) for decision-making based on disease severity to aid physicians in making more accurate decisions within a shorter time [46]. In this regard, Sherimon *et al.* developed a CDSS to combat COVID-19 in primary healthcare to aid clinicians with real-time diagnosis [47]. Despite the effectiveness of such systems, the development process is complex and comprises different stages. Moreover, the early stages of CDSS development commonly involve determining the minimum data sets, as was conducted in this study.

From the point of view of clinical experts, this study investigated the effective demographic and clinical factors of common COVID-19 outcomes. However, this study did not account for cultural and climatic factors that may also effectively affect patient outcomes, warranting further investigation of these factors in future studies.

SARS-CoV-2, the pathogen that causes COVID-19, is still spreading rapidly in many countries around the world. Additionally, there are signs indicating that COVID-19 will become endemic with time but not eradicated. Despite the reduction in the spread of the virus, the identified effective factors may facilitate better management of COVID-19, especially in the upcoming endemic phase, as well as in future pandemics.

Table 3. The critical factors of six outcomes related to COVID-19 patients

Factors	Decision-making outcomes					
	Length of stay	Ward referrals	Home referrals	Deterioration diagnosis	Discharge	ICU referrals
History of disease (e.g., respiratory diseases, cancer, and chronic diseases)	√	√		√		√
History of immunosuppressive drug use	√					
BMI						√
GFR	√				√	√
CRP	√					
Respiratory rate	√	√		√	√	√
SpO ₂ at admission	√	√		√		
PaO ₂		√		√		√
SOFA score	√	√				
Venous blood pH				√		
Creatinine						√
D-dimers				√		
SpO ₂			√			√

Abbreviations: BMI: Body mass index; CRP: C-reactive protein; GFR: Glomerular filtration rate; ICU: Intensive care unit; PaO₂: Arterial oxygen pressure; SOFA: Sequential organ failure assessment; SpO₂: Oxygen saturation.

This study also demonstrated that relevant information and datasets can be collected and analyzed using data mining methods to determine the predictive factors, thereby highlighting the use of machine learning in future studies.

4.4. Limitations

This study had several limitations. Since this research was conducted during the COVID-19 pandemic, many clinicians opted out of completing the questionnaire due to high stress levels and heavy workloads. For this reason, the number of respondents and participants in this study was limited. Besides that, the clinical experts responded to the questionnaire solely based on their experience with patient management in Iran. In addition, the questionnaire may not be complete as it was prepared without the appropriate factor categorization.

5. Conclusion

The findings of this study could be useful guidance or reference for researchers involved in COVID-19 management studies. The effective factors could be useful for both clinical decision-makers and specialists in health informatics (e.g., design decision-making systems) for the effective management of COVID-19 patients. In practice, our findings could increase awareness among clinical staff regarding the priority of different factors in the decision-making process.

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Conflict of Interest

The authors declare no conflicts of interest with regard to the content presented in this work.

Ethics Approval and Consent to Participate

This work was approved by the Tehran University of Medical Sciences ethics committee with the ethics code: IR.TUMS.VCR.REC.1399.188. Written informed consent was obtained from the participants.

Consent for Publication

Written informed consent was obtained from the participants.

Availability of Data

The minimum datasets questionnaire for COVID-19 decision-making and other relevant data are available from the corresponding author upon reasonable request.

References

- [1] Wu Y, Ho W, Huang Y, Jin DY, Li S, Liu SL, *et al.* SARS-CoV-2 is an Appropriate Name for the New Coronavirus. *Lancet* 2020;395:949-50.
doi: 10.1016/S0140-6736(20)30557-2
- [2] Mandal B. The Global Emergence of Severe Acute Respiratory Syndrome Coronavirus 2 in Human. *Virusdisease* 2020;31:67-70.
doi: 10.1007/s13337-020-00613-y
- [3] Killeen GF, Kiware SS. Why Lockdown? Why National Unity? Why Global Solidarity? Simplified Arithmetic Tools

- for Decision-Makers, Health Professionals, Journalists and the General Public to Explore Containment Options for the 2019 Novel Coronavirus. *Infect Dis Model* 2020;5:442-58. doi: 10.1016/j.idm.2020.06.006
- [4] Gambrell E. *Critical Thinking in Clinical Practice: Improving the Quality of Judgments and Decisions*. United States: Wiley; 2006.
- [5] Merow C, Urban MC. Seasonality and Uncertainty in Global COVID-19 Growth Rates. *Proc Nat Acad Sci U S A* 2020;117:27456-64. doi: 10.1073/pnas.2008590117
- [6] Koffman J, Gross J, Etkind SN, Selman L. Uncertainty and COVID-19: How are we to Respond? *J R Soc Med* 2020;113:211-6. doi: 10.1177/0141076820930665
- [7] Alsalem MA, Alamoodi AH, Albahri OS, Dawood KA, Mohammed RT, Alnoor A, *et al*. Multi-Criteria Decision-Making for Coronavirus Disease 2019 Applications: A Theoretical Analysis Review. *Artif Intell Rev* 2022;55:4979-5062. doi: 10.1007/s10462-021-10124-x
- [8] Raboisson D, Lhermie G. Living with COVID-19: A Systemic and Multi-Criteria Approach to Enact Evidence-Based Health Policy. *Front Public Health* 2020;8:294. doi: 10.3389/fpubh.2020.00294
- [9] Oliveira E, Parikh A, Lopez-Ruiz A, Carrilo M, Goldberg J, Cearras M, *et al*. ICU Outcomes and Survival in Patients with Severe COVID-19 in the Largest Health Care System in Central Florida. *PLoS One* 2021;16:e0249038. doi: 10.1371/journal.pone.0249038
- [10] Bijani M, Abedi S, Karimi S, Tehranineshat B. Major Challenges and Barriers in Clinical Decision-Making as Perceived by Emergency Medical Services Personnel: A Qualitative Content Analysis. *BMC Emerg Med* 2021;21:11. doi: 10.1186/s12873-021-00408-4
- [11] Marewski JN, Gigerenzer G. Heuristic Decision Making in Medicine. *Dialogues Clin Neurosci* 2012;14:77-89. doi: 10.31887/DCNS.2012.14.1/jmarewski
- [12] Rousseau DM. Making Evidence-Based Organizational Decisions in an Uncertain World. *Organ Dyn* 2018;47:135-46. doi: 10.1016/j.orgdyn.2020.100756
- [13] Jordan RE, Adab P, Cheng K. Covid-19: Risk Factors for Severe Disease and Death. *BMJ* 2020;368:m1198. doi: 10.1136/bmj.m1198
- [14] Caramelo F, Ferreira N, Oliveiros B. Estimation of Risk Factors for COVID-19 Mortality-Preliminary Results. *MedRxiv*; 2020.
- [15] Rod J, Oviedo-Trespalacios O, Cortes-Ramirez J. A Brief-Review of the Risk Factors for Covid-19 Severity. *Rev Saude Publica* 2020;54:60. doi: 10.11606/s1518-8787.2020054002481
- [16] Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE, *et al*. Factors Associated with COVID-19-related death using OpenSAFELY. *Nature* 2020;584:430. doi: 10.1038/s41586-020-2521-4
- [17] Aggour M, Tran Chi C, Fiehler J. Patient Prioritization and Management During the COVID-19 Pandemic. *Interv Neuroradiol* 2021;27 1 Suppl:19-23. doi: 10.1177/15910199211035302
- [18] De Nardo P, Gentilotti E, Mazzaferri F, Cremonini E, Hansen P, Goossens H, *et al*. Multi-Criteria Decision Analysis to Prioritize Hospital Admission of Patients Affected by COVID-19 in Low-Resource Settings with Hospital-Bed Shortage. *Int J Infect Dis* 2020;98:494-500. doi: 10.1016/j.ijid.2020.06.082
- [19] Bringedal BH, Rø KI, Bååthe F, Miljeteig I, Magelssen M. Guidelines and clinical priority setting during the COVID-19 pandemic-Norwegian doctors' experiences. *BMC Health Serv Res* 2022;22:1192. doi: 10.1186/s12913-022-08582-2
- [20] Özkan B, Özceylan E, Kabak M, Dikmen AU. Evaluation of Criteria and COVID-19 Patients for Intensive Care Unit Admission in the Era of Pandemic: A Multi-Criteria Decision Making Approach. *Comput Methods Programs Biomed* 2021;209:106348. doi: 10.1016/j.cmpb.2021.106348
- [21] Hosseini Sarkhosh SM, Taghvaei M, Allameh SF. Prioritization of COVID-19 Patients for Admission in the Intensive Care Unit in the Context of Hospital Bed Shortages: An Integrated Multi-criteria Decision Making Approach. *Q J Manage Strategies Health Syst* 2022;7:125-39.
- [22] Ceruti S, Glotta A, Biggiogero M, Maida PA, Marzano M, Urso P, *et al*. Admission Criteria in Critically ill COVID-19 Patients: A Physiology-Based Approach. *PLoS One* 2021;16:e0260318. doi: 10.1371/journal.pone.0260318
- [23] Hsu CH, Chiu CL, Lin YT, Yu AY, Kang YT, Cherng M, *et al*. Triage Admission Protocol with a Centralized Quarantine Unit for Patients after Acute Care Surgery During the COVID-19 Pandemic: A Tertiary Center Experience in Taiwan. *PLoS One* 2022;17:e0263688. doi: 10.1371/journal.pone.0263688
- [24] Metlay JP, Armstrong KA. Clinical Decision Making During the COVID-19 Pandemic. *Ann Intern Med* 2021;174:691-3. doi: 10.7326/M20-8179
- [25] Lo Bianco G, Di Pietro S, Mazzuca E, Imburgia A, Tarantino L, Accurso G, *et al*. Multidisciplinary Approach to the Diagnosis and In-Hospital Management of COVID-19 Infection: A Narrative Review. *Front Pharmacol* 2020;11:572168.

- doi: 10.3389/fphar.2020.572168
- [26] Shorten A, Smith J. Mixed Methods Research: Expanding the Evidence Base. *Evid Based Nurs* 2017;20:74-5.
doi: 10.1136/eb-2017-102699
- [27] Wallace BC, Kuiper J, Sharma A, Zhu M, Marshall IJ. Extracting PICO Sentences from Clinical Trial Reports using Supervised Distant Supervision. *J Mach Learn Res* 2016;17:132.
- [28] Moher D, Liberati A, Tetzlaff J, Altman DG, The PG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med* 2009;6:e1000097.
doi: 10.1371/journal.pmed.1000097
- [29] Kahn DA, Docherty JP, Carpenter D, Frances A. Consensus Methods in Practice Guideline Development: A Review and Description of a New Method. *Psychopharmacol Bull* 1997;33:631-9.
- [30] Velligan DI, Weiden PJ, Sajatovic M, Scott J, Carpenter D, Ross R, *et al.* The Expert Consensus Guideline Series: Adherence Problems in Patients with Serious and Persistent Mental Illness. *J Clin Psychiatry* 2009;70 Suppl 4:1-46, quiz 7-8.
- [31] Ayre C, Scally AJ. Critical Values for Lawshe's Content Validity Ratio: Revisiting the original methods of Calculation. *Meas Eval Couns Dev* 2014;47:79-86.
- [32] Lawshe CH. A Quantitative Approach to Content Validity. *Pers Psychol* 1975;28:563-75.
doi: 10.1111/j.1744-6570.1975.tb01393.x
- [33] Khazae-Pool M, Shoghli A, Pashaei T, Ponnet K. Psychometric Properties of the Persian Version of the Cancer Attitude Inventory. *BMC Public Health* 2019;19:1402.
doi: 10.1186/s12889-019-7756-3
- [34] Zamanzadeh V, Ghahramanian A, Rassouli M, Abbaszadeh A, Alavi-Majd H, Nikanfar AR. Design and Implementation Content Validity Study: Development of an Instrument for Measuring Patient-Centered Communication. *J Caring Sci* 2015;4:165-78.
doi: 10.15171/jcs.2015.017
- [35] Ayyoubzadeh SM, Ghazisaeedi M, Rostam Niakan Kalhori S, Hassaniazad M, Baniyasi T, Maghooli K, *et al.* A Study of Factors Related to Patients' Length of Stay Using Data Mining Techniques in a General Hospital in Southern Iran. *Health Inf Sci Syst* 2020;8:9.
doi: 10.1007/s13755-020-0099-8
- [36] Mukhtar A, Rady A, Hasanin A, Lotfy A, El Adawy A, Hussein A, *et al.* Admission SpO₂ and ROX Index Predict Outcome in Patients with COVID-19. *Am J Emerg Med* 2021;50:106-10.
doi: 10.1016/j.ajem.2021.07.049
- [37] Miller DJ, Capodilupo JV, Lastella M, Sargent C, Roach GD, Lee VH, *et al.* Analyzing Changes in Respiratory Rate to Predict the Risk of COVID-19 Infection. *PLoS One* 2020;15:e0243693.
doi: 10.1371/journal.pone.024369
- [38] Pijls BG, Jolani S, Atherley A, Derckx RT, Dijkstra JI, Franssen GH, *et al.* Demographic Risk Factors for COVID-19 Infection, Severity, ICU Admission and Death: A Meta-Analysis of 59 Studies. *BMJ Open* 2021;11:e044640.
doi: 10.1136/bmjopen-2020-044640
- [39] McKinstry B, Alexander H, Maxwell G, Blaikie L, Patel S, Guthrie B. The Use of Telemonitoring in Managing the COVID-19 Pandemic: Pilot Implementation Study. *JMIR Form Res* 2021;5:e20131.
doi: 10.2196/20131
- [40] Pryor R, Atkinson C, Cooper K, Doll M, Godbout E, Stevens MP, *et al.* The Electronic Medical Record and COVID-19: Is it up to the Challenge? *Am J Infect Control* 2020;48:966-7.
doi: 10.1016/j.ajic.2020.05.002
- [41] Madhavan S, Bastarache L, Brown JS, Butte AJ, Dorr DA, Embi PJ, *et al.* Use of Electronic Health Records to Support a Public Health Response to the COVID-19 pandemic in the United States: A perspective from 15 academic medical centers. *J Am Med Inform Assoc* 2020;28:393-401.
doi: 10.1093/jamia/ocaa287
- [42] Philips K, Uong A, Buckenmyer T, Cabana MD, Hsu D, Katyal C, *et al.* Rapid Implementation of an Adult Coronavirus Disease 2019 Unit in a Children's Hospital. *J Pediatr* 2020;222:22-7.
doi: 10.1016/j.jpeds.2020.04.060
- [43] Carley S, Horner D, Body R, Mackway-Jones K. Evidence-based medicine and COVID-19: What to believe and when to change. *Emerg Med J* 2020;37:572-5.
doi: 10.1136/emmermed-2020-210098
- [44] Nan S, Tang T, Feng H, Wang Y, Li M, Lu X, *et al.* A Computer-Interpretable Guideline for COVID-19: Rapid Development and Dissemination. *JMIR Med Inform* 2020;8:e21628.
doi: 10.2196/21628
- [45] Wu G, Yang P, Xie Y, Woodruff HC, Rao X, Guiot J, *et al.* Development of a Clinical Decision Support System for Severity Risk Prediction and Triage of COVID-19 Patients at Hospital Admission: An International Multicentre Study. *Eur Respir J* 2020;56:2001104.
doi: 10.1183/13993003.011104-2020
- [46] Karim H, Ravandi MH, Zandesh Z, Naserpoor A, Yasini M, Kalhori SR, *et al.* A unique framework for the Persian Clinical Guidelines: Addressing an Evidence-Based CDSS Development Need. *BMJ Evid Based Med* 2020;25:22-6.
doi: 10.1136/bmjebm-2019-111187
- [47] Sherimon V, Puliprathu Cherian S, Mathew R, Kumar SM,

- Nair RV, Shaikh K, *et al.* Clinical Decision Support for Primary Health Centers to Combat COVID-19 Pandemic. In: Intelligent Systems. Germany: Springer; 2021. p. 481-90.
- [48] Mellitus D. Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 2005;28:S5-10.
doi: 10.2337/diacare.28.suppl_1.s37
- [49] Garg AD, Agostinis P. Cell Death and Immunity in Cancer: From Danger Signals to Mimicry of Pathogen Defense Responses. *Immunol Rev* 2017;280:126-48.
doi: 10.1111/imr.12574
- [50] Miller KD, Nogueira L, Mariotto AB, Rowland JH, Yabroff KR, Alfano CM, *et al.* Cancer Treatment and Survivorship Statistics, 2019. *CA Cancer J Clin* 2019;69:363-85.
doi: 10.3322/caac.21565
- [51] Timmis A, Townsend N, Gale CP, Torbica A, Lettino M, Petersen SE, *et al.* European Society of Cardiology: Cardiovascular Disease Statistics 2019. *Eur Heart J* 2019;41:12-85.
doi: 10.1093/eurheartj/ehz859
- [52] Zhang L, Wang F, Wang L, Wang W, Liu B, Liu J, *et al.* Prevalence of Chronic Kidney Disease in China: A Cross-Sectional Survey. *Lancet* 2012;379:815-22.
doi: 10.1016/S0140-6736(12)60033-6
- [53] Hansell DM. Classification of Diffuse Lung Diseases: Why and How. *Radiology* 2013;268:628-40.
doi: 10.1148/radiol.13120908
- [54] Rosselli M, MacNaughtan J, Jalan R, Pinzani M. Beyond Scoring: A Modern Interpretation of Disease Progression in Chronic Liver Disease. *Gut* 2013;62:1234-41.
doi: 10.1136/gutjnl-2012-302826
- [55] Rose NR. Autoimmune Diseases. In: Quah SR, editor. *International Encyclopedia of Public Health*. 2nd ed. Oxford: Academic Press; 2017. p. 192-5.
- [56] Krensky M, Bennett M, Vincenti F. In: Brunton LL, editor. *Immunosuppressants, Tolerogens, and Immunostimulants*. McGraw-Hill Education; 2011. p. 1005-31.
- [57] Schiffrin EL, Flack JM, Ito S, Muntner P, Webb RC. Hypertension and COVID-19. United States. Country in North America. Oxford University Press; 2020.
- [58] Valderas JM, Starfield B, Sibbald B, Salisbury C, Roland M. Defining Comorbidity: Implications for Understanding Health and Health Services. *Ann Fam Med* 2009;7:357-63.
doi: 10.1370/afm.983
- [59] George-Gay B, Parker K. Understanding the Complete Blood Count with Differential. *J Perianesth Nurs* 2003;18:96-114, quiz 115-7.
doi: 10.1053/jpan.2003.50013
- [60] Walker HK, Hall WD, Hurst JW. *Clinical Methods: The History, Physical, and Laboratory Examinations*. Boston: Butterworths; 1990.
- [61] Tanaka T, Narazaki M, Kishimoto T. IL-6 in Inflammation, Immunity, and Disease. *Cold Spring Harb Perspect Biol* 2014;6:a016295.
doi: 10.1101/cshperspect.a016295
- [62] Lala V, Goyal A, Bansal P, Minter DA. Liver Function Tests. In: *StatPearls*. Treasure Island, FL: StatPearls; 2021.
- [63] Cai Q, Huang D, Yu H, Zhu Z, Xia Z, Su Y, *et al.* COVID-19: Abnormal Liver Function Tests. *J Hepatol* 2020;73:566-74.
doi: 10.1016/j.jhep.2020.04.006
- [64] Takeda Y, Takeda Y, Tomimoto S, Tani T, Narita H, Kimura G. Bilirubin as a Prognostic Marker in Patients with Pulmonary Arterial Hypertension. *BMC Pulmonary Med* 2010;10:22.
doi: 10.1186/1471-2466-10-22
- [65] Lala V, Goyal A, Farhana A, Lappin SL. Biochemistry, Lactate Dehydrogenase. In: *StatPearls*. Treasure Island, FL: StatPearls Publishing; 2021.
- [66] Du Clos TW, Mold C. C-Reactive Protein: An Activator of Innate Immunity and a Modulator of Adaptive Immunity. *Immunol Res* 2004;30:261-77.
doi: 10.1385/IR:30:3:261
- [67] Creamer AW, Kent AE, Albur M. Procalcitonin in Respiratory Disease: Use as a Biomarker for Diagnosis and Guiding Antibiotic Therapy. *Breathe (Sheff)* 2019;15:296-304.
doi: 10.1183/20734735.0258-2019
- [68] Knovich MA, Storey JA, Coffman LG, Torti SV, Torti FM. Ferritin for the Clinician. *Blood Rev* 2009;23:95-104.
doi: 10.1016/j.blre.2008.08.001
- [69] Sharma S, Jackson PG, Makan J. Cardiac Troponins. *J Clin Pathol* 2004;57:1025-6.
doi: 10.1136/jcp.2003.015420
- [70] Tripodi A. D-Dimer Testing in Laboratory Practice. *Clin Chem* 2011;57:1256-62.
doi: 10.1373/clinchem.2011.166249
- [71] Hepner M, Karlaftis V. Antithrombin. *Methods Mol Biol* 2013;992:355-64.
doi: 10.1007/978-1-62703-339-8_28
- [72] Herrick S, Blanc-Brude O, Gray A, Laurent G. Fibrinogen. *Int J Biochem Cell Biol* 1999;31:741-6.
doi: 10.1016/s1357-2725(99)00032-1
- [73] Inker LA, Levey AS, Coresh J. Estimated Glomerular Filtration Rate from a Panel of Filtration Markers-Hope for Increased Accuracy Beyond Measured Glomerular Filtration Rate? *Adv Chronic Kidney Dis* 2018;25:67-75.
doi: 10.1053/j.ackd.2017.10.004
- [74] Magee F, Wilson A, Bailey M, Pilcher D, Gabbe B, Bellomo R. Comparison of Intensive Care and Trauma-specific Scoring Systems in Critically Ill Patients. *Injury* 2021;52:2543-50.
doi: 10.1016/j.injury.2021.03.049

- [75] Hewett JN, Rodgers GW, Chase JG, Le Compte AJ, Pretty CG, Shaw GM. Assessment of SOFA Score as a Diagnostic Indicator in Intensive Care Medicine. *IFAC Proc Vol* 2012;45:467-72.
- [76] Nguyen Y, Corre F, Honsel V, Curac S, Zarrouk V, Fantin B, *et al.* Applicability of the CURB-65 Pneumonia Severity Score for Outpatient Treatment of COVID-19. *J Infect* 2020;81:e96-8.
doi: 10.1016/j.jinf.2020.05.049
- [77] Gupta GP, Nair RR, Jeyanthi R. An ANN based SpO₂ Measurement for Clinical Management Systems. *Energy Proced* 2017;117:393-400.
- [78] Zhang JM, An J. Cytokines, Inflammation, and Pain. *Int Anesthesiol Clin* 2007;45:27-37.
doi: 10.1097/AIA.0b013e318034194e
- [79] Cao Z, Jia Y, Zhu B. BNP and NT-proBNP as Diagnostic Biomarkers for Cardiac Dysfunction in Both Clinical and Forensic Medicine. *Int J Mol Sci* 2019;20:1820.
doi: 10.3390/ijms20081820
- [80] Dolak İ, Keçili R, Onat R, Ziyadanoğulları B, Ersöz A, Say R. Molecularly Imprinted Affinity Cryogels for the Selective Recognition of Myoglobin in Blood Serum. *J Mol Struct* 2018;1174:171-6.
doi: 10.1016/j.molstruc.2018.03.126

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Appendix

Table A1. Search strategies for each database

Database	Search strategies	Number of studies
PubMed	((“Triage”[Mesh]) OR (“Triage”[Title/Abstract]) OR (“Triages”[Title/Abstract]) OR (“patient classification”[Title/Abstract]) OR (“disease severity”[Title/Abstract]) OR (“disease severity scale”[Title/Abstract])) AND ((“Forecasting”[Mesh]) OR (“Forecasting”[Title/Abstract]) OR (“predict*”[Title/Abstract]) OR (“Prediction”[Title/Abstract]) OR (“scoring system”[Title/Abstract]) OR (“scoring”[Title/Abstract]) OR (“scale”[Title/Abstract])) AND ((“Care Unit, Intensive”[Title/Abstract]) OR (“Care Units, Intensive”[Title/Abstract]) OR (“Intensive Care Unit”[Title/Abstract]) OR (“Unit, Intensive Care”[Title/Abstract]) OR (“Disease Severity”[Title/Abstract]) OR (“Units, Intensive Care”[Title/Abstract]) OR (“Intensive Care Units”[Mesh])) AND ((“severe acute respiratory syndrome coronavirus 2” [Supplementary Concept]) OR (“COVID-19”[Title/Abstract]) OR (“SARS-CoV-2”[Title/Abstract]) OR (“2019 novel coronavirus”[Title/Abstract]) OR (“2019-nCoV”[Title/Abstract]) OR (“Wuhan coronavirus”[Title/Abstract]) OR (“novel coronavirus”[Title/Abstract]))	118
Scopus	(((TITLE-ABS-KEY (triage) OR TITLE-ABS-KEY (“patient classification”) OR TITLE-ABS-KEY (triages))) OR ((TITLE-ABS-KEY (“disease severity”) OR TITLE-ABS-KEY (“disease severity scale”)))) AND ((TITLE-ABS-KEY (forecast*) OR TITLE-ABS-KEY (predict*) OR TITLE-ABS-KEY (prediction) OR TITLE-ABS-KEY (“scoring system”) OR TITLE-ABS-KEY (scoring) OR TITLE-ABS-KEY (scale))) AND ((TITLE-ABS-KEY (“Care Unit, Intensive”) OR TITLE-ABS-KEY (“Care Units, Intensive”) OR TITLE-ABS-KEY (“Intensive Care Unit”) OR TITLE-ABS-KEY (“Unit, Intensive Care”) OR TITLE-ABS-KEY (“Units, Intensive Care”) OR TITLE-ABS-KEY (“Intensive Care Units”))) AND ((TITLE-ABS-KEY (“severe acute respiratory syndrome coronavirus 2”) OR TITLE-ABS-KEY (“COVID-19”) OR TITLE-ABS-KEY (“SARS-CoV-2”) OR TITLE-ABS-KEY (“2019 novel coronavirus”) OR TITLE-ABS-KEY (“2019-nCoV”) OR TITLE-ABS-KEY (“Wuhan coronavirus”) OR TITLE-ABS-KEY (“novel coronavirus”)))	116
Web of Science	1. TS = (“Triage”) OR (“Triages”) OR (“patient classification”) OR (“disease severity”) OR (“disease severity scale”) From 2010 to 2020 2. TS = (“Intensive Care Unit”) OR (“Care Unit, Intensive”) OR (“Intensive Care unit”) OR (“Unit, Intensive Care”) OR (“Units, Intensive Care”) OR (“Care Units, Intensive”) OR (“Intensive Care Units”) 3. TS = (“severe acute respiratory syndrome coronavirus 2”) OR (“COVID-19”) OR (“SARS-CoV-2”) OR (“2019 novel coronavirus”) OR (“2019-nCoV”) OR (“Wuhan coronavirus”) OR (“novel coronavirus”) OR (“coronavirus”) Total=1 AND 2 AND 3	44

Table A2. The contributing factors in clinical decision-making towards the length of hospital stay of COVID-19 patients

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
Demographics and medical history	Age	Age refers to the patient’s age based on the year.	0.4	Essential
	Sex	Sex refers to the gender of the patient.	-0.4	Rejected
	BMI or obesity	BMI is a measure of body fat based on height and weight that applies to adult men and women.	0.4	Essential
	History of diabetes mellitus	Diabetes mellitus is a metabolic disorder characterized by elevated blood sugar levels over a long period [48].	0.6	Essential
	History of cancer or malignancy	Cancer is the abnormal growth of cells. The term malignancy refers to the presence of cancerous cells that can spread to other sites in the body [49,50].	1	Critical
	CVD	CVD is any disease of the heart or any disorder associated with blood vessels [51].	0.8	Critical
	History of renal function impairment or CKD	CKD is the presence of kidney damage or an eGFR of <60 mL/min per 1.73 m ² for more than two months [52].	0.8	Critical
	History of respiratory disease	The most common respiratory diseases include COPD, asthma, pneumonia, pulmonary fibrosis, and lung cancer [53].	0.8	Critical
	History of liver disease	Liver/hepatic disease is a type of damage to or disease of the liver that can be chronic or acute [54].	0.6	Essential
	History of autoimmune disease	An autoimmune disease refers to any condition in which the immune system mistakenly attacks the body [55].	0.6	Essential
	History of immunosuppressive drug use	Immunosuppressive drugs are a type of drug that suppresses or reduces the strength of the body’s immune system [56].	0.8	Critical
	History of hypertension	Hypertension refers to high blood pressure, which increases the risk of heart disease, stroke, and sometimes death [57].	0.2	Essential
	Other chronic conditions or co-morbidity	Comorbidity is defined as the concurrence of more than one disorder in an individual [58].	0	Essential

(Cont’d...)

Table A2. (Continued)

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
Signs and symptoms	Fever	Fever refers to a high body temperature (over 37.5°C [99.5°F]).	-0.2	Rejected
	Fatigue	Fatigue describes the feeling of tiredness or lack of energy.	0	Essential
	Myalgia and/or arthralgia	Myalgia refers to pain in a muscle or group of muscles. Arthralgia refers to joint stiffness and pain.	-0.2	Rejected
	Vomiting or nausea	Vomiting refers to the excretion of gastric contents through the mouth.	-0.2	Rejected
	Sore throat	A sore throat is the feeling of pain or scratchiness in the throat.	-0.6	Rejected
	RR	RR is one of the main vital signs, referring to the number of breaths a person takes per minute.	0.8	Critical
	Body temperature at admission	Body temperature at admission refers to the patient's body temperature measurement during the first visit.	0	Essential
WBC count	WBC/leukocyte count	Leukocytes play a pivotal role in inflammation and infection [59].	0.2	Essential
	Neutrophil count	Neutrophils are a type of WBC that increase in response to an acute infection [59].	0.2	Essential
	Lymphocyte count	Lymphocytes are a type of WBC with an anti-infection ability and can respond to specific microorganisms [59].	0.4	Essential
	Eosinophil count	Eosinophils are a type of WBC with a histamine-neutralizing effect [59].	-0.8	Rejected
	Monocyte count	Monocytes are a type of WBC that transform into macrophages, which play important roles in both innate and acquired immunities [59].	-0.8	Rejected
Basic metabolic panel	Cr	Cr is an indicator of kidney function [59].	0.6	Essential
	BUN	The nitrogen content of urea is a primary metabolite derived from dietary and tissue proteins [60].	0	Essential
	Glucose	Glucose has a six-carbon structure and is the main source of energy in the body [60].	0	Essential
Cytokines	IL-6	IL-6 is an inflammatory and acute phase response marker [61].	0.2	Essential
Enzymes and biomarkers	Albumin	Albumin is the most abundant protein in blood [60].	-0.6	Rejected
	AST	AST is a good indicator of liver diseases, such as cirrhosis [62].	-0.4	Rejected
	ALT	ALT is an indicator of liver diseases. It is a more specific marker of liver diseases and infection than AST [63].	-0.2	Rejected
	Total bilirubin	Bilirubin is produced in the hemolysis of RBCs [64].	-0.4	Rejected
	LDH	LDH is an enzyme with increased levels of hemolysis, necrosis, pneumonia, and acidosis [65].	0.6	Essential
	CRP	CRP is an indicator of infection and acute inflammation [66].	0.8	Critical
	PCT	PCT is a protein that indicates bacterial infection and sepsis [67].	0	Essential
	Ferritin	Ferritin is an iron-storage protein and an indicator of artery and inflammatory diseases [68].	0.2	Essential
Cardiac biomarkers and tests for the cardiovascular system	Cardiac troponin	Cardiac troponin is the main marker for cardiac infarction [69].	0.4	Essential
	CK	CK is an indicator of muscle, brain, and heart damage [60].	0	Essential
	D-dimers	D-dimers are byproducts of a blood clot and can indicate thrombosis [70].	0.6	Essential
Coagulation screening	AT	AT activity is measured to diagnose thrombotic disorders [71].	0	Essential
	PT	PT measures the function of the external coagulation pathway [60].	0.2	Essential
	APTT	APTT evaluates the internal coagulation pathway [60].	0.4	Essential
	FDPs	FDP measurements indicate fibrinolysis [60].	0.2	Essential
	Fibrinogen	Fibrinogen is a preceding substance that transforms into fibrin [72].	0	Essential
	Platelet count	Platelet count in the blood can cause coagulation formation [59].	0.2	Essential
Other factors	GFR	Indicates the flow of plasma from the glomerulus into Bowman's space in a specific period [73].	1	Critical
	Performance score (e.g., APACHE and ANZROD)	APACHE and ANZROD are different types of illness prognostic scoring systems in intensive care units [74].	0.4	Essential
	SpO ₂ at admission	SpO ₂ at admission refers to the pulse oximetry-derived SpO ₂ in room air at the first hospital admission [36].	1	Critical
	SOFA score	The SOFA score is used as a diagnostic indicator [75].	0.8	Critical
	CURB-65 score	The CURB-65 score is a scoring system that plays a role in patient mortality [76].	0.6	Essential

Abbreviations: ALT: Alanine transaminase; ANZROD: Australian and New Zealand risk of death; APACHE: Acute physiology and chronic health evaluation; APTT: Activated partial thromboplastin time; AST: Aspartate transaminase; AT: Anti-thrombin; BMI: Body mass index; BUN: Blood urea nitrogen; CK: Creatine kinase; CKD: Chronic kidney disease; COPD: Chronic obstructive pulmonary disease; Cr: Creatinine; CRP: C-reactive protein; CURB-65: Confusion blood urea >42.8 mg/dL, RR>30/min, blood pressure<90/60 mmHg, age>65; CVD: Cardiovascular disease; CVR: Content validity ratio; eGFR: Estimated glomerular filtration rate; FDP: Fibrin degradation product; GFR: Glomerular filtration rate; IL-6: Interleukin-6; LDH: Lactate dehydrogenase; PCT: Procalcitonin; PT: Prothrombin; RBC: Red blood cell; RR: Respiratory rate; SOFA: Sequential organ failure assessment; SpO₂: Oxygen saturation; WBC: White blood cell.

Table A3. The contributing factors in clinical decision-making on ward referrals of COVID-19 patients

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
Demographics and medical history	Age	Age refers to the patient's age based on the year.	0.6	Essential
	Sex	Sex refers to the gender of the patient.	-0.8	Rejected
	BMI or obesity	BMI is a measure of body fat based on height and weight that applies to adult men and women.	0.4	Essential
	History of diabetes mellitus	Diabetes mellitus is a metabolic disorder characterized by elevated blood sugar levels over a long period [48].	0.8	Critical
	History of cancer or malignancy	Cancer is the abnormal growth of cells. The term malignancy refers to the presence of cancerous cells that can spread to other sites in the body [49,50].	1	Critical
	History of any CVD	CVD is any disease of the heart or any disorder associated with blood vessels [51].	0.8	Critical
	History of renal function impairment or CKD	CKD is the presence of kidney damage or an eGFR of <60 mL/min/1.73 m ² for more than 2 months [52].	0.8	Critical
	History of respiratory disease	The most common respiratory diseases include COPD, asthma, pneumonia, pulmonary fibrosis, and lung cancer [53].	1	Critical
	History of liver disease	Liver/hepatic disease is a type of damage to or disease of the liver that can be chronic or acute [54].	0.6	Essential
	History of autoimmune disease	An autoimmune disease refers to any condition in which the immune system mistakenly attacks the body [55].	0.6	Essential
	History of immunosuppressive drug use	Immunosuppressive drugs are a type of drug that suppresses or reduces the strength of the body's immune system [56].	0.6	Essential
History of hypertension	Hypertension refers to high blood pressure, which increases the risk of heart disease, stroke, and sometimes death [57].	0	Essential	
Other chronic conditions or co-morbidity	Comorbidity is defined as the concurrence of more than one disorder in an individual [58].	0.4	Essential	
Signs and symptoms	Fever	Fever refers to a high body temperature (over 37.5°C [99.5°F]).	0.2	Essential
	Fatigue	Fatigue describes the feeling of tiredness or lack of energy.	-0.4	Rejected
	Myalgia and/or arthralgia	Myalgia refers to pain in a muscle or group of muscles. Arthralgia refers to joint stiffness and pain.	-0.6	Rejected
	Vomiting or nausea	Vomiting refers to the excretion of gastric contents through the mouth.	-0.2	Rejected
	Sore throat	A sore throat is the feeling of pain or scratchiness in the throat.	-0.8	Rejected
	RR	RR is one of the main vital signs, referring to the number of breaths a person takes per minute	1	Critical
	Body temperature at admission	Body temperature at admission refers to the patient's body temperature measurement during the first visit.	-0.4	Rejected
WBC count	WBC/leukocyte count	Leukocytes play a pivotal role in inflammation and infection [59].	0.4	Essential
	Neutrophil count	Neutrophils are a type of WBC that increase in response to an acute infection [59].	0.2	Essential
	Lymphocyte count	Lymphocytes are a type of WBC with an anti-infection ability and can respond to specific microorganisms [59].	0.4	Essential
	Eosinophil count	Eosinophils are a type of WBC with a histamine-neutralizing effect [59].	-0.6	Rejected
	Monocyte count	Monocytes are a type of WBC that transform into macrophages, which play important roles in both innate and acquired immunities [59].	-0.6	Rejected
Basic metabolic panel	Cr	Cr is an indicator of kidney function [59].	0.6	Essential
Cytokines	IL-6	IL-6 is an inflammatory and acute phase response marker [61].	0	Essential
Enzymes and biomarkers	Albumin	Albumin is the most abundant protein in blood [60].	-0.4	Rejected
	AST	AST is a good indicator of liver diseases, such as cirrhosis [62].	0	Essential
	ALT	ALT is an indicator of liver diseases. It is a more specific marker of liver diseases and infection than AST [63].	0	Essential

(Cont'd...)

Table A3. (Continued)

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
	Total bilirubin	Bilirubin is produced in the hemolysis of RBCs [64].	0	Essential
	LDH	LDH is an enzyme with increased levels of hemolysis, necrosis, pneumonia, and acidosis [65].	0.4	Essential
	CRP	CRP is an indicator of infection and acute inflammation [66].	0.4	Essential
	PCT	PCT is a protein that indicates bacterial infection and sepsis [67].	-0.4	Essential
	Ferritin	Ferritin is an iron-storage protein and an indicator of artery and inflammatory diseases [68].	0	Essential
Cardiac biomarkers and tests for the cardiovascular system	Cardiac troponin	Cardiac troponin is the main marker for cardiac infarction [69]	0.4	Essential
	CK	CK is an indicator of muscle, brain, and heart damage [60].	0.2	Essential
	D-dimers	D-dimers are byproducts of a blood clot and can indicate thrombosis [70].	0.6	Essential
Coagulation screening	Anti-thrombin (AT)	AT activity is measured to diagnose thrombotic disorders [71].	0	Essential
	APTT	APTT evaluates the internal coagulation pathway [60].	0	Essential
	FDPs	FDP measurements indicate fibrinolysis [60].	0.2	Essential
	Fibrinogen	Fibrinogen is a preceding substance that transforms into fibrin [72].	0.2	Essential
Other factors	GFR	Indicates the flow of plasma from the glomerulus into Bowman's space in a specific period [73].	0.6	Essential
	Performance score (e.g., APACHE and ANZROD)	APACHE and ANZROD are different types of illness prognostic scoring systems in intensive care units [74].	0.2	Essential
	SpO ₂ at admission	SpO ₂ at admission refers to the pulse oximetry-derived SpO ₂ in room air at the first hospital admission [36].	0.8	Critical
	SOFA score	The SOFA score is used as a diagnostic indicator [75].	0.6	Essential
	CURB-65 score	The CURB-65 score is a scoring system that plays a role in patient mortality [76].	0.6	Essential
	Blood pH	The pH of blood refers to its acidity. The typical pH of blood in the arteries ranges from 7.35 to 7.45.	0.4	Essential
	PaO ₂	PaO ₂ refers to the partial pressure of oxygen.	1	Critical

Abbreviations: ALT: Alanine transaminase; ANZROD: Australian and New Zealand risk of death; APACHE: Acute physiology and chronic health evaluation; APTT: Activated partial thromboplastin time; AST: Aspartate transaminase; AT: Anti-thrombin; BMI: Body mass index; CK: Creatine kinase; CKD: Chronic kidney disease; COPD: Chronic obstructive pulmonary disease; Cr: Creatinine; CRP: C-reactive protein; CURB-65: Confusion, blood urea > 42.8 mg/dL, RR > 30/min, blood pressure < 90/60 mmHg, age > 65; CVD: Cardiovascular disease; CVR: Content validity ratio; eGFR: Estimated glomerular filtration rate; FDP: Fibrin degradation product; GFR: Glomerular filtration rate; IL-6: Interleukin-6; LDH: Lactate dehydrogenase; PaO₂: Arterial oxygen pressure; PCT: Procalcitonin; RBC: Red blood cell; RR: Respiratory rate; SOFA: Sequential organ failure assessment; SpO₂: Oxygen saturation; WBC: White blood cell.

Table A4. The contributing factors in clinical decision-making on home isolation of COVID-19 patients

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
Demographics and medical history	Age	Age refers to the patient's age based on the year.	0.6	Essential
	Sex	Sex refers to the gender of the patient.	-0.8	Rejected
	BMI or obesity	BMI is a measure of body fat based on height and weight that applies to adult men and women.	0.4	Essential
	History of diabetes mellitus	Diabetes mellitus is a metabolic disorder characterized by elevated blood sugar levels over a long period [48].	0.4	Essential
	History of cancer or malignancy	Cancer is the abnormal growth of cells. The term malignancy refers to the presence of cancerous cells that can spread to other sites in the body [49,50].	0.4	Essential
	History of any CVD	CVD is any disease of the heart or any disorder associated with blood vessels [51].	0.6	Essential
	History of renal function impairment or CKD	CKD is the presence of kidney damage or an eGFR of < 60 mL/min per 1.73 m ² for more than 2 months [52].	0.2	Essential
	History of respiratory disease	The most common respiratory diseases include COPD, asthma, pneumonia, pulmonary fibrosis, and lung cancer [53].	0.6	Essential
	History of liver disease	Liver/hepatic disease is a type of damage to or disease of the liver that can be chronic or acute [54].	0.2	Essential
	History of autoimmune disease	An autoimmune disease refers to any condition in which the immune system mistakenly attacks the body [55].	0	Essential
History of immunosuppressive drug use	Immunosuppressive drugs are a type of drug that suppresses or reduces the strength of the body's immune system [56].	0.4	Essential	
History of hypertension	Hypertension refers to high blood pressure, which increases the risk of heart disease, stroke, and sometimes death [57].	-0.2	Rejected	
Other chronic conditions or co-morbidity	Comorbidity is defined as the concurrence of more than one disorder in an individual [58].	0.2	Essential	
WBC count	WBC/leukocyte count	Leukocytes play a pivotal role in inflammation and infection [59].	0.6	Essential
	Lymphocyte count	Lymphocytes are a type of WBC with an anti-infection ability and can respond to specific microorganisms [59].	0.4	Essential
Basic metabolic panel	Cr	Cr is an indicator of kidney function [59].	0.6	Essential
Cytokines	IL-6	IL-6 is an inflammatory and acute phase response marker [61].	0	Essential
Enzymes and biomarkers	CRP	CRP is an indicator of infection and acute inflammation [66].	0.4	Essential
	PCT	PCT is a protein that indicates bacterial infection and sepsis [67].	0.2	Essential
	Ferritin	Ferritin is an iron-storage protein and an indicator of artery and inflammatory diseases [68].	0	Essential
Cardiac biomarkers and tests for the cardiovascular system	D-dimers	D-dimers are byproducts of a blood clot and can indicate thrombosis [70].	0.4	Essential
Other factors	GFR	Indicates the flow of plasma from the glomerulus into Bowman's space in a specific period [73].	0.6	Essential
	Performance score (e.g., APACHE and ANZROD)	APACHE and ANZROD are different types of illness prognostic scoring systems in intensive care units [74].	0.6	Essential
	SpO ₂	SpO ₂ is the percentage of oxygenated hemoglobin in a patient's blood [77].	1	Critical

Abbreviations: ANZROD: Australian and New Zealand Risk of Death; APACHE: Acute physiology and chronic health evaluation; BMI: Body mass index; CKD: Chronic kidney disease; COPD: Chronic obstructive pulmonary disease; Cr: Creatinine; CRP: C-reactive protein; CVD: Cardiovascular disease; CVR: Content validity ratio; eGFR: Estimated glomerular filtration rate; GFR: Glomerular filtration rate; IL-6: Interleukin-6; PCT: Procalcitonin; SpO₂: Oxygen saturation; WBC: White blood cell.

Table A5. The contributing factors in the clinical decision-making on deterioration diagnosis of COVID-19 patients

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
Demographics and medical history	Age	Age refers to the patient's age based on the year.	0.4	Essential
	Sex	Sex refers to the gender of the patient.	-0.8	Rejected
	BMI or obesity	BMI is a measure of body fat based on height and weight that applies to adult men and women.	0.4	Essential
	History of diabetes mellitus	Diabetes mellitus is a metabolic disorder characterized by elevated blood sugar levels over a long period [48].	0.6	Essential
	History of cancer or malignancy	Cancer is the abnormal growth of cells. The term malignancy refers to the presence of cancerous cells that can spread to other sites in the body [49,50].	0.4	Essential
	History of any CVD	CVD is any disease of the heart or any disorder associated with blood vessels [51].	0.4	Essential
	History of renal function impairment or CKD	CKD is the presence of kidney damage or an eGFR of < 60 mL/min per 1.73 m ² for more than 2 months [52].	0.4	Essential
	History of respiratory disease	The most common respiratory diseases include COPD, asthma, pneumonia, pulmonary fibrosis, and lung cancer [53].	0.8	Critical
	History of liver disease	Liver/hepatic disease is a type of damage to or disease of the liver that can be chronic or acute [54].	0	Essential
	History of autoimmune disease	An autoimmune disease refers to any condition in which the immune system mistakenly attacks the body [55].	0.4	Essential
	History of immunosuppressive drug use	Immunosuppressive drugs are a type of drug that suppresses or reduces the strength of the body's immune system [56].	0.4	Essential
	History of hypertension	Hypertension refers to high blood pressure, which increases the risk of heart disease, stroke, and sometimes death [57].	0	Essential
Other chronic conditions or co-morbidity	Comorbidity is defined as the concurrence of more than one disorder in an individual [58].	0.2	Essential	
Signs and symptoms	Fever	Fever refers to a high body temperature (over 37.5°C [99.5°F]).	0.4	Essential
	Fatigue	Fatigue describes the feeling of tiredness or lack of energy.	-0.2	Rejected
	Myalgia and/or arthralgia	Myalgia refers to pain in a muscle or group of muscles. Arthralgia refers to joint stiffness and pain.	-0.2	Rejected
	Vomiting or nausea	Vomiting refers to the excretion of gastric contents through the mouth.	-0.6	Rejected
	Sore throat	A sore throat is the feeling of pain or scratchiness in the throat.	-1	Rejected
	RR	RR is one of the main vital signs, referring to the number of breaths a person takes per minute	1	Critical
	Body temperature at admission	Body temperature at admission refers to the patient's body temperature measurement during the first visit.	0.4	Essential
WBC count	WBC/leukocyte count	Leukocytes play a pivotal role in inflammation and infection [59].	0.4	Essential
	Neutrophil count	Neutrophils are a type of WBC that increase in response to an acute infection [59].	0.2	Essential
	Lymphocyte count	Lymphocytes are a type of WBC with an anti-infection ability and can respond to specific microorganisms [59].	0.4	Essential
	Eosinophil count	Eosinophils are a type of WBC with a histamine-neutralizing effect [59].	-1	Rejected
	Monocyte count	Monocytes are a type of WBC that transform into macrophages, which play important roles in both innate and acquired immunities [59].	-1	Rejected
	Thrombocyte count	Thrombocytosis refers to a higher-than-normal platelet count.	-0.2	Rejected
Basic metabolic panel	Cr	Cr is an indicator of kidney function (59).	0.4	Essential
	BUN	The nitrogen content of urea is a primary metabolite derived from dietary and tissue proteins [60].	0.2	Essential
Cytokines	IL-6	IL-6 is an inflammatory and acute phase response marker [61].	0	Essential
	CD8 cell count	CD8 is a marker of cytotoxic T cells [59].	-0.2	Rejected
	TNF-alpha	TNF-alpha is a proinflammatory pain-causing cytokine [78].	-0.2	Rejected

(Cont'd...)

Table A5. (Continued)

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
	IL-1	IL-1 is a costimulatory molecule in the acute phase response [78].	-0.8	Rejected
	IL-2	IL-2 is involved in the proliferation of B-cells and activated T-cells [78].	-0.6	Rejected
	IL-2R	IL-2Rs are neoplasm, autoimmune disorder, and inflammation indicators [78].	-0.6	Rejected
	IL-8	IL-8 is a neutrophil and T-cell chemoattractant [78].	-0.6	Rejected
	IL-10	IL-10 is a cytokine production inhibitor [78].	-0.8	Rejected
Enzymes and biomarkers	Albumin	Albumin is the most abundant protein in blood [60].	-0.2	Rejected
	AST	AST is a good indicator of liver diseases, such as cirrhosis [62].	0	Essential
	ALT	ALT is an indicator of liver diseases. It is a more specific marker of liver diseases and infection than AST [63].	0.2	Essential
	Total bilirubin	Bilirubin is produced in the hemolysis of RBCs [64].	-0.2	Rejected
	LDH	LDH is an enzyme with increased levels of hemolysis, necrosis, pneumonia, and acidosis [65].	0.6	Essential
	CRP	CRP is an indicator of infection and acute inflammation [66].	0.6	Essential
	PCT	PCT is a protein that indicates bacterial infection and sepsis [67].	0.2	Essential
	Ferritin	Ferritin is an iron-storage protein and an indicator of artery and inflammatory diseases [68].	0	Essential
Cardiac biomarkers and tests for the cardiovascular system	Cardiac troponin	Cardiac troponin is the main marker for cardiac infarction [69].	0.6	Essential
	NP-proBNP	NT-proBNP is an essential protein for the production of BNP hormones [79].	0.4	Essential
	CK	CK is an indicator of muscle, brain, and heart damage [60].	-0.2	Rejected
	Myoglobin	Myoglobin is a muscle oxygen storage protein [80].	-0.6	Rejected
	D-dimers	D-dimers are byproducts of a blood clot and can indicate thrombosis [70].	0.8	Critical
Coagulation screening	AT	AT activity is measured to diagnose thrombotic disorders [71].	-0.2	Rejected
	PT	PT measures the function of the external coagulation pathway [60].	-0.2	Rejected
	APTT	APTT evaluates the internal coagulation pathway [60].	-0.2	Rejected
	FDPs	FDP measurements indicate fibrinolysis [60].	0	Essential
	Fibrinogen	Fibrinogen is a preceding substance that transforms into fibrin [72].	-0.2	Rejected
Other factors	Platelet count	Platelet in the blood causes coagulation formation [58].	0.4	Essential
	GFR	Indicates the flow of plasma from the glomerulus into Bowman's space in a specific period [73].	0.4	Essential
	Performance score (e.g., APACHE and ANZROD)	APACHE and ANZROD are different types of illness prognostic scoring systems in intensive care units [74].	0.2	Essential
	SpO ₂ at admission	SpO ₂ at admission refers to the pulse oximetry-derived SpO ₂ in room air at the first hospital admission [36].	1	Critical
	SOFA score	The SOFA score is used as a diagnostic indicator [75].	0.4	Essential
	CURB-65 score	The CURB-65 score is a scoring system that plays a role in patient mortality [76].	0.4	Essential
	Blood pH	The pH of blood refers to its acidity. The typical pH of blood in the arteries ranges from 7.35 to 7.45.	0.8	Critical
	PaO ₂	PaO ₂ refers to the partial pressure of oxygen.	1	Critical

Abbreviations: ALT: Alanine transaminase; ANZROD: Australian and New Zealand risk of death; APACHE: Acute physiology and chronic health evaluation; APTT: Activated partial thromboplastin time; AST: Aspartate transaminase; AT: Anti-thrombin; BMI: Body mass index; BUN: Blood urea nitrogen; CK: Creatine kinase; CKD: Chronic kidney disease; COPD: Chronic obstructive pulmonary disease; CRP: C-reactive protein; CURB-65: Confusion, blood urea > 42.8 mg/dL, RR > 30/min, blood pressure < 90/60 mmHg, age > 65; CVD: Cardiovascular disease; CVR: Content validity ratio; eGFR: Estimated glomerular filtration rate; FDP: Fibrin degradation product; GFR: Glomerular filtration rate; IL-1: Interleukin-1; IL-2: Interleukin-2; IL-2R: Interleukin-2R; IL-6: Interleukin-6; IL-8: Interleukin-8; IL-10: Interleukin-10; LDH: Lactate dehydrogenase; NP-proBNP: N-terminal pro b-type natriuretic peptide; PaO₂: Arterial oxygen pressure; PCT: Procalcitonin; PT: Prothrombin; RBC: Red blood cell; RR: Respiratory rate; SOFA: Sequential organ failure assessment; SpO₂: Oxygen saturation; TNF-alpha: Tumor necrosis factor-alpha; WBC: White blood cell.

Table A6. The contributing factors in the clinical decision-making on discharging COVID-19 patients

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
Demographics and medical history	Age	Age refers to the patient's age based on the year.	0.2	Essential
	Sex	Sex refers to the gender of the patient.	-1	Rejected
	BMI or obesity	BMI is a measure of body fat based on height and weight that applies to adult men and women.	0.2	Essential
	History of diabetes mellitus	Diabetes mellitus is a metabolic disorder characterized by elevated blood sugar levels over a long period [48].	0.6	Essential
	History of cancer or malignancy	Cancer is the abnormal growth of cells. The term malignancy refers to the presence of cancerous cells that can spread to other sites in the body [49,50].	0.4	Essential
	History of any CVD	CVD is any disease of the heart or any disorder associated with blood vessels [51].	0.2	Essential
	History of renal function impairment or CKD	CKD is the presence of kidney damage or an eGFR of < 60 mL/min per 1.73 m ² for more than 2 months [52].	0.4	Essential
	History of respiratory disease	The most common respiratory diseases include COPD, asthma, pneumonia, pulmonary fibrosis, and lung cancer [53].	0.6	Essential
	History of liver disease	Liver/hepatic disease is a type of damage to or disease of the liver that can be chronic or acute [54].	0.2	Essential
	History of autoimmune disease	An autoimmune disease refers to any condition in which the immune system mistakenly attacks the body [55].	0.2	Essential
	History of immunosuppressive drug use	Immunosuppressive drugs are a type of drug that suppresses or reduces the strength of the body's immune system [56].	0.6	Essential
History of hypertension	Hypertension refers to high blood pressure, which increases the risk of heart disease, stroke, and sometimes death [57].	0	Essential	
Other chronic conditions or co-morbidity	Comorbidity is defined as the concurrence of more than one disorder in an individual [58].	0.2	Essential	
Signs and symptoms	Fever	Fever refers to a high body temperature (over 37.5°C [99.5°F]).	0.4	Essential
	Fatigue	Fatigue describes the feeling of tiredness or lack of energy.	-0.4	Rejected
	Myalgia and/or arthralgia	Myalgia refers to pain in a muscle or group of muscles. Arthralgia refers to joint stiffness and pain.	-0.8	Rejected
	Vomiting or nausea	Vomiting refers to the excretion of gastric contents through the mouth.	0	Essential
	Sore throat	A sore throat is the feeling of pain or scratchiness in the throat.	-1	Rejected
	RR	RR is one of the main vital signs, referring to the number of breaths a person takes per minute	1	Critical
	Body temperature at admission	Body temperature at admission refers to the patient's body temperature measurement during the first visit.	-0.6	Rejected
WBC count	WBC/leukocyte count	Leukocytes play a pivotal role in inflammation and infection [59].	0.6	Essential
	Neutrophil count	Neutrophils are a type of WBC that increase in response to an acute infection [59].	0	Essential
	Lymphocyte count	Lymphocytes are a type of WBC with an anti-infection ability and can respond to specific microorganisms [59].	0.6	Essential
	Eosinophil count	Eosinophils are a type of WBC with a histamine-neutralizing effect [59].	-0.8	Rejected
	Monocyte count	Monocytes are a type of WBC that transform into macrophages, which play important roles in both innate and acquired immunities [59].	-0.8	Rejected
	Thrombocyte count	Thrombocytosis refers to a higher-than-normal platelet count.	-0.2	Rejected
Basic metabolic panel	BUN	The nitrogen content of urea is a primary metabolite derived from dietary and tissue proteins [60].	0.4	Essential
Cytokines	IL-6	IL-6 is an inflammatory and acute phase response marker [61].	0	Essential
	TNF-alpha	TNF-alpha is a proinflammatory pain-causing cytokine [78].	0	Essential
	IL-8	IL-8 is a neutrophil and T-cell chemoattractant [78].	-0.4	Rejected
Enzymes and biomarkers	Albumin	Albumin is the most abundant protein in blood [60].	-0.6	Rejected
	LDH	LDH is an enzyme with increased levels of hemolysis, necrosis, pneumonia, and acidosis [65].	0.4	Essential
	CRP	CRP is an indicator of infection and acute inflammation [66].	-0.2	Rejected

(Cont'd...)

Table A6. (Continued)

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
	PCT	PCT is a protein that indicates bacterial infection and sepsis [67].	0.2	Essential
	Ferritin	Ferritin is an iron-storage protein and an indicator of artery and inflammatory diseases [68].	-0.2	Rejected
Cardiac biomarkers and tests for the cardiovascular system	Cardiac troponin	Cardiac troponin is the main marker for cardiac infarction [69]	0.4	Essential
	D-dimers	D-dimers are byproducts of a blood clot and can indicate thrombosis [70].	0.6	Essential
Coagulation screening	AT	AT activity is measured to diagnose thrombotic disorders [71].	-0.2	Rejected
	PT	PT measures the function of the external coagulation pathway [60].	0	Essential
	Fibrinogen	Fibrinogen is a preceding substance that transforms into fibrin [72].	0	Essential
Other factors	GFR	Indicates the flow of plasma from the glomerulus into Bowman's space in a specific period [73].	0.8	Critical
	SpO ₂ at admission	SpO ₂ at admission refers to the pulse oximetry-derived SpO ₂ in room air at the first hospital admission [36].	0.2	Essential
	CURB-65 score	The CURB-65 score is a scoring system that plays a role in patient mortality [76].	0.4	Essential

Abbreviations: AT: Anti-thrombin; BMI: Body mass index; BUN: Blood urea nitrogen; CKD: Chronic kidney disease; COPD: Chronic obstructive pulmonary disease; CRP: C-reactive protein; CURB-65: Confusion, blood urea > 42.8 mg/dL, RR > 30/min, blood pressure < 90/60 mmHg, age > 65; CVD: Cardiovascular disease; CVR: Content validity ratio; eGFR: Estimated glomerular filtration rate; GFR: Glomerular filtration rate; IL-6: Interleukin-6; IL-8: Interleukin-8; LDH: Lactate dehydrogenase; PCT: Procalcitonin; PT: Prothrombin; RR: Respiratory rate; SpO₂: Oxygen saturation; TNF-alpha: Tumor necrosis factor-alpha; WBC: White blood cell.

Table A7. The contributing factors in clinical decision-making on ICU referrals of COVID-19 patients

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
Demographics and medical history	Age	Age refers to the patient's age based on the year.	0.4	Essential
	Sex	Sex refers to the gender of the patient.	-1	Rejected
	BMI or obesity	BMI is a measure of body fat based on height and weight that applies to adult men and women.	0.8	Critical
	History of diabetes mellitus	Diabetes mellitus is a metabolic disorder characterized by elevated blood sugar levels over a long period [48].	0.4	Essential
	History of cancer or malignancy	Cancer is the abnormal growth of cells. The term malignancy refers to the presence of cancerous cells that can spread to other sites in the body [49,50].	0.8	Critical
	History of any CVD	CVD is any disease of the heart or any disorder associated with blood vessels [51].	0.4	Essential
	History of renal function impairment or CKD	CKD is the presence of kidney damage or an eGFR of < 60 mL/min per 1.73 m ² for more than 2 months [52].	1	Critical
	History of respiratory disease	The most common respiratory diseases include COPD, asthma, pneumonia, pulmonary fibrosis, and lung cancer [53].	1	Critical
	History of liver disease	Liver/hepatic disease is a type of damage to or disease of the liver that can be chronic or acute [54].	0.6	Essential
	History of autoimmune disease	An autoimmune disease refers to any condition in which the immune system mistakenly attacks the body [55].	0.6	Essential
Signs and symptoms	History of immunosuppressive drug use	Immunosuppressive drugs are a type of drug that suppresses or reduces the strength of the body's immune system [56].	0.2	Essential
	History of hypertension	Hypertension refers to high blood pressure, which increases the risk of heart disease, stroke, and sometimes death [57].	0	Essential
	Other chronic conditions or co-morbidity	Comorbidity is defined as the concurrence of more than one disorder in an individual [58].	0.4	Essential
	RR	RR is one of the main vital signs, referring to the number of breaths a person takes per minute	0.8	Critical
	Body temperature at admission	Body temperature at admission refers to the patient's body temperature measurement during the first visit.	-0.4	Rejected

(Cont'd...)

Table A7. (Continued)

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
WBC count	WBC/leukocyte count	Leukocytes play a pivotal role in inflammation and infection [59].	0.4	Essential
	Neutrophil count	Neutrophils are a type of WBC that increase in response to an acute infection [59].	0	Essential
	Lymphocyte count	Lymphocytes are a type of WBC with an anti-infection ability and can respond to specific microorganisms [59].	0.4	Essential
	Eosinophil count	Eosinophils are a type of WBC with a histamine-neutralizing effect [59].	-0.4	Rejected
	Monocyte count	Monocytes are a type of WBC that transform into macrophages, which play important roles in both innate and acquired immunities [59].	-0.6	Rejected
Basic metabolic panel	Cr	Cr is an indicator of kidney function [59].	0.8	Critical
	BUN	The nitrogen content of urea is a primary metabolite derived from dietary and tissue proteins [60].	0	Essential
	Glucose	Glucose has a six-carbon structure and is the main source of energy in the body [60].	0	Essential
Cytokines	IL-6	IL-6 is an inflammatory and acute phase response marker [61].	0	Essential
	CD8 cell count	CD8 is a marker of cytotoxic T cells [59].	-0.4	Rejected
	TNF-alpha	TNF-alpha is a proinflammatory pain-causing cytokine [78].	-0.2	Rejected
	IL-1	IL-1 is a costimulatory molecule in the acute phase response [78].	-0.6	Rejected
	IL-2	IL-2 is involved in the proliferation of B-cells and activated T-cells [78].	-0.8	Rejected
	IL-2R	IL-2Rs are neoplasm, autoimmune disorder, and inflammation indicators [78].	-0.8	Rejected
	IL-8	IL-8 is a neutrophil and T-cell chemoattractant [78].	-0.6	Rejected
	IL-10	IL-10 is a cytokine production inhibitor [78].	-0.8	Rejected
Enzymes and biomarkers	Albumin	Albumin is the most abundant protein in blood [60].	-0.4	Rejected
	AST	AST is a good indicator of liver diseases, such as cirrhosis [62].	0	Essential
	ALT	ALT is an indicator of liver diseases. It is a more specific marker of liver diseases and infection than AST [63].	0	Essential
	Total bilirubin	Bilirubin is produced in the hemolysis of RBCs [64].	-0.4	Rejected
	LDH	LDH is an enzyme with increased levels of hemolysis, necrosis, pneumonia, and acidosis [65].	1	Critical
	Serum Cr	A serum (blood) Cr test is a blood test used to evaluate the efficiency of the kidney for blood filtration.	0.4	Essential
	CRP	CRP is an indicator of infection and acute inflammation [66].	0.2	Essential
	PCT	PCT is a protein that indicates bacterial infection and sepsis [67].	-0.2	Rejected
	Ferritin	Ferritin is an iron-storage protein and an indicator of artery and inflammatory diseases [68].	-0.2	Rejected
Cardiac biomarkers and tests for the cardiovascular system	Cardiac troponin	Cardiac troponin is the main marker for cardiac infarction [69]	0.2	Essential
	CK	CK is an indicator of muscle, brain, and heart damage [60].	-0.2	Rejected
	D-dimers	D-dimers are byproducts of a blood clot and can indicate thrombosis [70].	0.2	Essential
	Myoglobin	Myoglobin is a muscle oxygen storage protein [80].	-0.4	Rejected
Coagulation screening	AT	AT activity is measured to diagnose thrombotic disorders [71].	-0.2	Rejected
	PT	PT measures the function of the external coagulation pathway [60].	-0.2	Rejected
	APTT	APTT evaluates the internal coagulation pathway [60].	-0.2	Rejected
	FDPs	FDP measurements indicate fibrinolysis [60].	-0.4	Rejected
	Fibrinogen	Fibrinogen is a preceding substance that transforms into fibrin [72].	-0.2	Rejected
Other factors	GFR	Indicates the flow of plasma from the glomerulus into Bowman's space in a specific period [73].	1	Critical
	Performance score (e.g., APACHE and ANZROD)	APACHE and ANZROD are different types of illness prognostic scoring systems in ICUs [74].	0.2	Essential
	SpO ₂	SpO ₂ is the percentage of oxygenated hemoglobin in a patient's blood [77].	0.8	Critical
	Sequential organ failure assessment (SOFA) score	The SOFA score is used as a diagnostic indicator [75].	0.4	Essential

(Cont'd...)

Table A7. (Continued)

Factors	Data set	Definition	CVR	CVR assessment (critical, essential, or rejected)
	CURB-65 score	The CURB-65 score is a scoring system that plays a role in patient mortality [76].	0.4	Essential
	Blood pH	The pH of blood refers to its acidity. The typical pH of blood in the arteries ranges from 7.35 to 7.45.	0.6	Essential
	PaO ₂	PaO ₂ refers to the partial pressure of oxygen.	1	Critical

Abbreviations: ALT: Alanine transaminase; ANZROD: Australian and New Zealand risk of death; APACHE: Acute physiology and chronic health evaluation; APTT: Activated partial thromboplastin time; AST: Aspartate transaminase; AT: Anti-thrombin; BMI: Body mass index; BUN: Blood urea nitrogen; CK: Creatine kinase; CKD: Chronic kidney disease; COPD: Chronic obstructive pulmonary disease; Cr: Creatinine; CRP: C-reactive protein; CURB-65: Confusion, blood urea > 42.8 mg/dL, RR > 30/min, blood pressure < 90/60 mmHg, age > 65; CVD: Cardiovascular disease; CVR: Content validity ratio; eGFR: Estimated glomerular filtration rate; FDP: Fibrin degradation product; GFR: Glomerular filtration rate; IL-1: Interleukin-1; IL-2: Interleukin-2; IL-2R: Interleukin-2R; IL-6: Interleukin-6; IL-8: Interleukin-8; IL-10: Interleukin-10; LDH: Lactate dehydrogenase; PaO₂: Arterial oxygen pressure; PCT: Procalcitonin; PT: Prothrombin; RBC: Red blood cell; RR: Respiratory rate; SOFA: Sequential organ failure assessment; SpO₂: Oxygen saturation; TNF-alpha: Tumor necrosis factor-alpha; WBC: White blood cell; ICU: Intensive care unit.