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# A Probabilistic Hesitant Fuzzy MCDM Approach to Selecting Treatment Policy For COVID-19

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**ABSTRACT**

The global significant rise in the number of sick individuals and fatalities has made the ongoing struggle against the severe and lethal COVID-19 pandemic a global effort. There are several ongoing therapies for COVID-19, and more are being developed. However, selecting the best therapy option for COVID-19 patients is still needed. Patients may easily choose from the available COVID-19 therapies using the multi-criteria decision-making method. As a result, the present study provides an MCDM method that is created to determine COVID-19 therapies. Probabilistic Hesitant Fuzzy Set numbers, values, and ambiguity are introduced. Theorems and characteristics of PHFS numbers are also investigated in depth. The Complex Proportional Assessment technique is used, based on the PHFS, for dealing with ambiguity issues. This study uses ten criteria and three treatment methods: antibacterial medication and plasma treatment, vaccinations, as well as quarantine and in-house isolation. The study results reveal that quarantine and isolation at home mark the most effective treatment, followed by vaccinations with antibiotics and plasma therapy.

## 1. Introduction

The spread of COVID-19 was unprecedented. It is a virus that appeared in China in December of this year. The WHO officially declared a pandemic in January 2020, and it quickly grew from that point onwards. In the first week of March 2020, almost four hundred thousand cases were verified across 130 countries. By the end of January 2021, the number of reported cases increased to over 100,819,363 across 250 countries, with over 2,176,159 fatalities. Fever, tiredness, a dry cough, fatigue, muscle soreness, and dyspnea were the most frequently reported symptoms in people with COVID-19 [1-2]. Those exposed to COVID-19 had milder forms of the illness, while in some cases, the disease developed asymptomatically. Common signs included elevated temperature, a hacking cough, and difficulty breathing. Pneumonia and other respiratory illnesses were complications of the infection. In certain infrequent circumstances, the condition was deadly. The virus was transmitted

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by respiratory tract infections and direct contact with contaminated surfaces. The virus could also survive on hard surfaces [3-4].

Decision theory is a significant area of study in numerous scientific disciplines, focusing on making decisions in uncertain situations. This area is considered the core of decision theory. Decisions are made by means of option assessment, followed by the selection of the most advantageous option [5-7]. The concept of Multi-criteria decision-making (MCDM) provides a range of methods for making decisions. It involves assessing and ranking different alternatives based on their values in multiple attributes, in order to determine the best choice. MCDM has been used in decision-making processes across various domains. In traditional multiple decision-making scenarios, decision-makers usually express their preferences through deterministic measurements. Solving MCDM problems can be difficult because of time constraints, limitations to the decision-maker's abilities, and the increasing uncertainty and complexity of issues, ultimately making obtaining precise measurements challenging. Zadeh [8] introduced the concept of utilizing fuzzy sets to manage ambiguous data. This method helps define attribute values for MCDM problems that involve uncertainty. In certain MCDM situations, relying solely on a fuzzy set may not effectively communicate vague, ambiguous, incomplete, or indeterminate information [9]. Various fuzzy sets have been developed to address these issues efficiently [10-12].

The present study uses the probability hesitant fuzzy set (PHFS) environment with multi-criteria decision-making (MCDM) methodologies to determine the best preventive measures. Complex issues may be approached from multiple angles using MCDM, as decision-making process. It has been built to assess several options while considering several factors simultaneously. It is crucial to determine the efficacy of COVID-19 therapies [13-14]. Using this strategy, decision-makers may improve their chances of making informed and rational decisions. Moreover, there is a plethora of MCDM methods that have been used in various settings. These methods have been tried and evaluated for different sorts of problems, yielding credible and validated outcomes. Decision-makers may be more logical and grounded in science when they use specialized techniques and technical knowledge. This strategy helps address a decision-making issue that regularly calls for considering various factors [15-16]. As an improvement upon the hesitant fuzzy set (HFS), the PHFS enables decision-makers to convey their thoughts more freely by factoring in dubious encounters into the decision-making procedures. Given the alternatives available, choosing the most effective alternative to reduce COVID-19 infections is essential [17-18]. The COPRAS technique was selected after being compared to the other available options. Reasons for this include its efficiency in handling discrete choice issues with conflicting criteria, its ability to undergo scrutiny with little computing overhead, and its usefulness to saving the patient's life [19-20]. To determine which amylase source is most suited for producing biodegradable dynamic plastics, this study adopts the COPRAS method to rank and choose the most effective method of treating COVID-19 [21-22]. Figure 1 shows the framework of this study. This study uses PHF to build the decision matrix for the COVID-19 crisis, then, applies the proposed COPRAS method under a fuzzy environment. Then, the best treatment way is selected from the three available ways: the first is home isolation, with a 2-meter distance between people, the second is plasma, and the third is vacancies.

This paper is organized into sections. In Section 2, the study explores the link between COVID-19 and finance. Section 3 details the methodology used to address COVID-19 and healthcare, along with an examination of how resilience frameworks can enhance safety and health in the workplace during the pandemic. Definitions of the hesitant fuzzy set (HFS) and Probabilistic HFS are presented in Section 4. Additionally, Section 5 highlights the Suggested Complex Proportional Assessment method. Section 6 demonstrates the efficiency and significance of the proposed algorithm through the presentation of Results and Discussion. Finally, the paper outlines the study conclusions in Section 7.

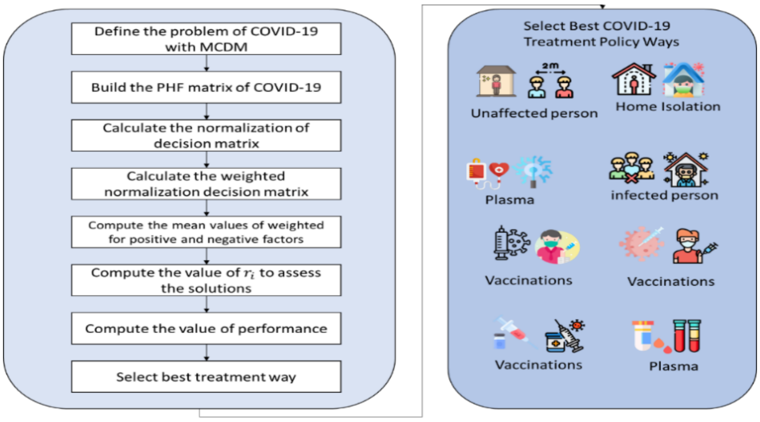


**Fig. 1.** Framework of the best selection way of treating COVID-19.

## 2. Methodology

### 2.1 COVID-19 and Financial

Worldwide, the COVID-19 pandemic has posed a significant problem for governments and corporations, endangering lives, and causing far-reaching consequences for the economy and society at large. The deterioration of the healthcare system can be attributed to the lack of essential tools, preventative measures, and standard operating procedures (SOPs). As a result, healthcare providers struggled to manage the growing number of patients, and authorities found it challenging to contain the sudden viral outbreaks. Since a pandemic like the one engendered by COVID-19 had not occurred in many years, the world could not deal with such an unexpected scenario. Organizations across all industries were affected by the global COVID-19 pandemic, resulting in the closure of firms, lockdowns, and decreased commercial activity due to preventive efforts like social distancing practices. Even though the pandemic is no longer an immediate threat, the global economy still bears the effects of the COVID-19 outbreak. This may worsen the situation if commodity costs, and supply chain bottlenecks rise. Previous research has examined the impact of disasters on business output, such as the effect of the COVID-19 epidemic [23-24].

### 2.2 COVID-19 and Healthcare

COVID-19 is a new, rapidly spreading viral illness. On March 11, 2020, the WHO proclaimed the coronavirus pandemic a worldwide pandemic. COVID-19 has been widely publicized at this point. High patient loads have resulted in stress and illness among medical staff. The danger of catching COVID-19 is especially significant for frontline healthcare workers who treat patients with the virus. Furthermore, healthcare workers face ethical harm and psychological issues because of the high number of patients and direct care for COVID-19 patients. This anxiety manifests in several ways, including increased mental and physical strain [25-26].

A person's health, psychological and behavioral factors, career success, mental agility, and security may all be impacted by stress experienced on the job. Stress at work has been shown to increase the likelihood of making mistakes on the job. A person's mental health might suffer due to work-related stress [27]. In addition, work challenges can potentially impact the quality of personal and professional relationships. Additionally, it is essential to maintain healthy relationships in both areas to achieve overall well-being. Job features, role-related aspects, organizational structure, environment, communication, connections, and duties are all examples of corporate drivers of work-related stress. Prior research suggested that resilient individuals could better keep their mental health in check since resilient people experience less stress and burnout at work [28-29].

The topic of resilience spans several fields of study and has many dimensions. Personal and organizational resilience are both discussed in the available research. Emotional resilience is defined as the ability to bounce back quickly and effectively from stressful situations. Personal resilience may be helpful in the face of stresses like work-related strain. Staff productivity increases when individuals exhibit resilience because it decreases negative behaviors and enhances stress management. Researchers found that those who scored higher on the resilience scale had fewer signs of depression, better safety efficiency, reduced work-related stress, more coping skills, fewer quit attempts, and more openness to change. In addition, there are strong connections between organizational dedication, workplace joy, satisfaction with work, and personal resilience, as discussed in the existing literature.

Moreover, the ability to bounce back quickly from adversity is an indicator of resilience. The concept of resilience is central to any analysis of stress. Resilience is the ability to bounce back from setbacks and maintain good functioning in the presence of challenging circumstances. Organizational resilience is the capacity of an organization to detect and respond to emerging risks, recover quickly from setbacks, and thrive in the face of uncertainty and change. The ability to flourish and endure in the face of unforeseen disruptions may be significantly enhanced by fostering individual and organizational resilience [30-31]. Work-related safety and health may improve using resilience frameworks during the COVID-19 pandemic [32]. Worker security performance is strongly influenced by factors including leadership dedication, readiness, awareness, monitoring culture, and learning. In addition, various researchers attested to the beneficial impact of resilience structures in improving and maintaining the security of complicated configurations. To be resilient is to take an active role in finding what is correct. The capacity to recover quickly from setbacks is a hallmark of resilient systems that have been built with various tools, skill sets, and organizational architectures in mind. Resilient organizations and individuals are better equipped to deal with adversity in a high-risk setting. People deal with stress caused by the unknown by modifying their actions accordingly. Therefore, resilience, a rapidly developing notion, may boost the efficiency of essential businesses. The resilience method may also enhance both individual and system security in high-hazard settings [33-34].

The COVID-19 pandemic has struck providers of medical services. There is a significant frequency of burnout among healthcare personnel due to their high-stress levels, psychological suffering, large workloads, intense job pressure, and long hours [35]. The resilience of healthcare workers in the face of COVID-19 and prolonged stress is crucial to an appropriate reaction to high-pressure settings. Another essential element is the robustness of medical institutions in the face of the COVID-19 pandemic. “Health-system resilience” refers to the ability of healthcare facilities to anticipate and successfully react to crises, while sustaining the provision of essential services in the face of a pandemic. Tracking, anticipation, reaction, and learning are the four capabilities that make up a resilient network [36-39].

## 2.3 Preliminaries

This section provides definitions of the hesitant fuzzy set (HFS) and Probabilistic HFS (PHFS) [21]:

### *2.3.1 Definition one*

HFS can be defined using the universal set ($\mathcal{R}$) in $[0,1]$ by:

$$S = \{< y, s(y) >/y \in \mathcal{R}\} \tag{1}$$

The HFS can be defined by the possible membership degree component $y \in \mathcal{R}$ if $g(y) \in [0,1]$

$$S = \{< y, \cup_{s \in s(y)}\{s\} >/y \in \mathcal{R}\} \quad (2)$$

*2.3.2 Definition two*

This definition introduces some HFS operations by considering three HFS: $s = \cup_{s \in s(y)}\{s\}, s_1 = \cup_{s_1 \in s_1(y)}\{s_1\},, s_2 = \cup_{s_2 \in s_2(y)}\{s_2\}$, then the HFS operations are:

$$s^c = \cup_{g \in s}\{1 - s\} \quad (3)$$
$$s_1 \cup s_2 = \cup_{s_1 \in s_1, s_2 \in s_2} max\,\{s_1, s_1\} \quad (4)$$
$$s_1 \cap s_2 = \cup_{s_1 \in s_1, s_2 \in s_2} min\,\{s_1, s_1\} \quad (5)$$
$$s^g = \cup_{s \in s}\{s^g\} \quad (6)$$
$$gs = \cup_{s \in s}\{1 - (1 - s)^g\} \;\; g > 0 \quad (7)$$
$$s_1 \oplus s_2 = \cup_{s_1 \in s_1, s_2 \in s_2}\{s_1 + s_2 - s_1 s_2\} \quad (8)$$
$$s_1 \otimes s_2 = \cup_{s_1 \in s_1, s_2 \in s_2}\{s_1 s_2\} \quad (9)$$

*2.3.3 Definition three*

PHFS can be defined as each element in HFS treated as a value with a probabilistic value by:

$$\alpha S = \{< y, \alpha s(y) >: y \in \mathcal{R}\} \quad (10)$$
$$\alpha S = \{< y, \cup_{< s(y), \alpha(y > \in \alpha s(y)}, \{s(y), \alpha(y)\} >/y \in \mathcal{R}\} \quad (11)$$

Where $\alpha s(y)$ refers to the probabilistic value with the membership value of y, $\alpha(y) \in [0,1]$, and $\sum_{\alpha s(y)} \alpha(y) = 1$ with all values of $y \in \mathcal{R}$

*2.3.4 Definition four*

This definition introduces some PHFS operations by considering three PHFS: $\alpha s = \cup_{< s, \alpha > \in \alpha s}\{< s, \alpha >\}, \alpha s_1 = \cup_{< \alpha, s_1 > \in \alpha s_1}\{< s_1, \alpha >\}, \alpha s_2 = \cup_{< s_2, \alpha > \in \alpha s_2}\{< s_2, \alpha >\}$, then the PHFS operations are:

$$\alpha s^g = \cup_{< s, \alpha > \in \alpha s}\{s^g, \alpha\} \;\; g > 0 \quad (12)$$
$$g^\alpha s == \cup_{< s, \alpha > \in \alpha s}\{(1 - (1 - s)^g), \alpha\} \quad (13)$$
$$\alpha s_1 \oplus \alpha s_1 == \cup_{< s_1, \alpha_1 > \in \alpha s_1, < s_2, \alpha_2 > \in \alpha s_2}\{< 1 - (1 - s_1)(1 - s_2), \alpha_1 \alpha_2 >\} \quad (14)$$
$$\alpha s_1 \otimes \alpha s_1 == \cup_{< s_1, \alpha_1 > \in \alpha s_1, < s_2, \alpha_2 > \in \alpha s_2}\{< s_1 s_2, \alpha_1 \alpha_2 >\} \quad (15)$$

*2.3.5 Definition five*

The score function of PHFS can be defined as:

$$C(\alpha s(y)) = \sum_{i=1}^{\#s} \alpha_i s_i \quad (16)$$

Where, $\sum_{i=1}^{\#s} \alpha_i = 1$ (17)

### 2.4 The Suggested Complex Proportional Assessment (COPRAS) Method

The COPRAS technique, developed by Zavadskas et al., performs similarly to SAW. Regarding MCDM methods, SAW is the simplest and most widely implemented practice. SAW is commonly used as a benchmark when evaluating the efficacy of other MCDM methods. Abdullah and Adawiyah thoroughly introduced SAW techniques, highlighting their various composite material-related uses. For instance, a critic weights method–based MCDM technique for treatment strategy selection was presented for use during the COVID-19 pandemic. Whereas limiting criteria must be transformed into maximized variables before usage, SAW may focus just on improving quality [40-41]. The COPRAS method integrated with the crisp values of fuzzy set (by applying score function 16 and 17) is as follows:

Stage 1: Calculate the normalization of the decision matrix.

$$q_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \tag{18}$$

Stage 2: Calculate the weighted normalization decision matrix.

$$Wq_{ij} = w_j \times q_{ij} \tag{19}$$

Stage 3: Compute the weighted mean values for positive and negative factors.

$$F_{+i} = \sum_{j=1}^{n} Wq_{+ij} \quad \text{for positive factors} \tag{20}$$

$$F_{-i} = \sum_{j=1}^{n} Wq_{-ij} \text{ for negative factors} \tag{21}$$

Stage 4: Compute the value of $r_i$ to assess solutions.

$$r_i = F_{+i} + \frac{\sum_{i=1}^{m} F_{+i}}{F_{+i} \sum_{i=1}^{m} \frac{1}{F_{+i}}} \tag{22}$$

Stage 5: Compute the value of performance.

$$P_i = \frac{r_i}{r_{max}} \tag{23}$$

## 3. Results and Discussion

Physical and emotional suffering were inflicted upon the global population due to the COVID-19 pandemic. The number of people infected with COVID-19 increased steadily around the world. There was a plethora of adopted approaches to contain such a crisis. Examples include imposing a quarantine, tracking outsources, avoiding close relationships, etc. This paper used the PHFS with the COPRAS method to show the best way to treat COVID-19 according to various criteria, as shown in Figure 2. This paper also used ten criteria and three treatment ways. Several factors must be considered to determine the most effective COVID-19 treatment policy. The COVID-19 criteria to be considered when making policy choices on treatment include the following:

$COC_1$: Safeguarding patients against unwanted or dangerous consequences of their therapy should be a top priority for every treatment program. When considering safety, it is essential to evaluate possible adverse reactions, medication interactions, and contraindications.

$COC_2$: Occurrence: The incidence and severity of COVID-19 cases in the treated population should be considered. Indicators, such as infection rates, hospitalization rates, and fatality rates, may influence the severity and timeliness of therapeutic actions.

$COC_3$: The key to successful treatment of COVID-19 is the early and accurate diagnosis. Diagnostic procedures, such as polymerase chain reaction (PCR), or antigen testing, may help identify infected people and direct therapy.

$COC_4$: Accordingly, the treatment strategy should consider availability and reliability. Decisions on treatment policies should be based on evidenced efficacy of available treatments. Antiviral medicines, immunomodulatory therapies, and supportive care interventions, in addition to insights from clinical trials, research studies, and evidence-based recommendations may impact treatment policy.

$COC_5$: The cost of necessary medical care and treatment should be a significant factor in the decision-making process. Policymakers designing treatments need to prioritize efficient interventions that minimize cost for patients, insurers, and the healthcare system.

$COC_6$: Treatment policy choices should consider the accessibility of resources, including medications, medical devices, and trained medical personnel. Disruptions in the global supply chain, production limits, and the availability of workers may all have an impact on accessibility.

$COC_7$: Although monetary gain is seldom a top priority in public health policy, it may affect for-profit healthcare providers and pharmaceutical firms working on innovative treatments. However, public health authorities put population health before profits by concentrating on patient outcomes and fair access to care.

$COC_8$: Potential environmental issues impact decisions pertaining to use, production, and disposal of medical items like PPE and drugs, considering the possibility of adverse environmental effects. Ecological footprint reduction is possible through environmental sustainability and careful waste management.

$COC_9$: Leverage: Decisions on treatment policy may consider opportunities to pool resources and enhance treatment results by means of collaboration and partnership.

$COC_{10}$: To allow coordinated responses and information exchange, it is necessary to use research and development capabilities, public-private partnerships, in addition to global health networks.

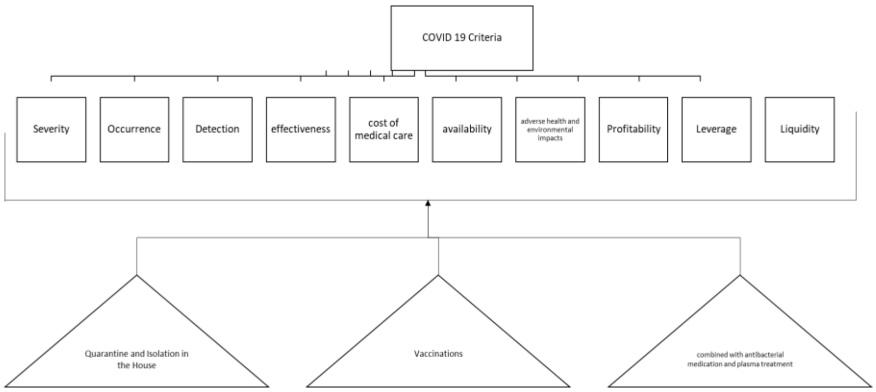


**Fig. 2.** COVID-19 criteria and alternatives.

Consideration should be given to the available funds and other resources needed to implement treatment policies. The availability of needed medical supplies, healthcare infrastructure, and labor capacity for successful treatment depends on adequate financing and resource allocation. Decisions on treatment policies should be determined by trained medical personnel, public health officials, and regulatory agencies after carefully considering relevant scientific data, clinical guidelines, and local conditions. To guarantee the best potential results for COVID-19 therapy, these criteria should be examined alongside rigorous scientific research, ethical concerns, and patient-centered methods. The criteria weights were computed by the average process, and the average value of each criterion was obtained via expert opinions. The outputs of the criteria are shown in Figure 3.

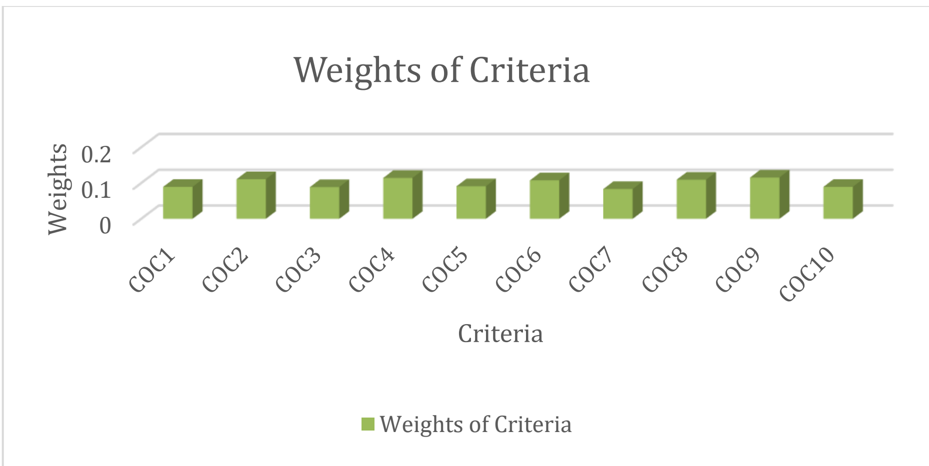


**Fig. 3.** Weights of criteria.

The decision-makers used the PHF numbers to evaluate the criteria and treatment ways, hence build the PHF matrix, as shown in Table 1. Data were collected through interviews with experts, as well as decision-makers with expertise in the medical field. Moreover, data were collected from the related work and questionnaires. In this study, three experts and decision-makers evaluate the criteria and alternatives by the linguistic terms of the fuzzy numbers. Then we replace these numbers with the crisp values by the score function. Then we aggregate these crisp numbers by the average method like (0.55+0.47+0.45)/3= 0.49. Then we built the aggregated decision matrix as shown in the last three rows in Table 2.
Afterwards, these numbers were replaced with the score fuzzy numbers, as shown in Table 2.

**Table 1**
Probabilistic Hesitant Fuzzy Set data with ten criteria and three alternatives

| **Expert 1** | **$COC_1$** | **$COC_2$** | **$COC_3$** | **$COC_4$** | **$COC_5$** | **$COC_6$** | **$COC_7$** | **$COC_8$** | **$COC_9$** | **$COC_{10}$** |
|---|---|---|---|---|---|---|---|---|---|---|
| **$COA_1$** | {<0.5,0.5>, <0.6,0.5>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.6>, <0.5,0.4>} | {<0.5,0.5>, <0.6,0.5>} | {<0.5,0.3>, <0.6,0.7>} | {<0.6,0.8>, <0.7,0.2>} | {<0.4,0.6>, <0.5,0.4>} | {<0.5,0.5>, <0.6,0.5>} | {<0.5,0.3>, <0.6,0.7>} | {<0.5,0.5>, <0.6,0.5>} |
| **$COA_2$** | {<0.4,0.6>, <0.5,0.4>} | {<0.5,0.3>, <0.6,0.7>} | {<0.8,0.4>, <0.9,0.6>} | {<0.5,0.3>, <0.6,0.7>} | {<0.8,0.4>, <0.9,0.6>} | {<0.6,0.8>, <0.7,0.2>} | {<0.5,0.3>, <0.6,0.7>} | {<0.6,0.8>, <0.7,0.2>} | {<0.6,0.8>, <0.7,0.2>} | {<0.4,0.6>, <0.5,0.4>} |
| **$COA_3$** | {<0.5,0.5>, <0.6,0.5>} | {<0.4,0.6>, <0.5,0.4>} | {<0.4,0.6>, <0.5,0.4>} | {<0.5,0.5>, <0.6,0.5>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.6>, <0.5,0.4>} | {<0.5,0.5>, <0.6,0.5>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.6>, <0.5,0.4>} | {<0.5,0.5>, <0.6,0.5>} |
| **Expert 2** | **$COC_1$** | **$COC_2$** | **$COC_3$** | **$COC_4$** | **$COC_5$** | **$COC_6$** | **$COC_7$** | **$COC_8$** | **$COC_9$** | **$COC_{10}$** |
| **$COA_1$** | {<0.4,0.3>, <0.5,0.7>} | {<0.5,0.3>, <0.6,0.7>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.3>, <0.5,0.7>} |
| **$COA_2$** | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.4,0.2>, <0.5,0.8>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.5,0.3>, <0.6,0.7>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.5,0.3>, <0.6,0.7>} |
| **$COA_3$** | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.5,0.3>, <0.6,0.7>} | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.4,0.3>, <0.5,0.7>} | {<0.4,0.2>, <0.5,0.8>} | {<0.4,0.3>, <0.5,0.7>} |
| **Expert 3** | **$COC_1$** | **$COC_2$** | **$COC_3$** | **$COC_4$** | **$COC_5$** | **$COC_6$** | **$COC_7$** | **$COC_8$** | **$COC_9$** | **$COC_{10}$** |
| **$COA_1$** | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.3,0.5>, <0.6,0.5>} | {<0.7,0.2>, <0.9,0.8>} | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.7,0.2>, <0.9,0.8>} | {<0.3,0.5>, <0.6,0.5>} |
| **$COA_2$** | {<0.7,0.2>, <0.9,0.8>} | {<0.6,0.2>, <0.7,0.8>} | {<0.6,0.2>, <0.7,0.8>} | {<0.7,0.2>, <0.9,0.8>} | {<0.6,0.2>, <0.7,0.8>} | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.7,0.2>, <0.9,0.8>} |
| **$COA_3$** | {<0.3,0.5>, <0.6,0.5>} | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.7,0.2>, <0.9,0.8>} | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.7,0.2>, <0.9,0.8>} | {<0.3,0.5>, <0.6,0.5>} | {<0.6,0.2>, <0.7,0.8>} | {<0.3,0.5>, <0.6,0.5>} |

**Table 2**
Score values of PHFSs with ten criteria and three alternatives.

| **Expert 1** | **$COC_1$** | **$COC_2$** | **$COC_3$** | **$COC_4$** | **$COC_5$** | **$COC_6$** | **$COC_7$** | **$COC_8$** | **$COC_9$** | **$COC_{10}$** |
|---|---|---|---|---|---|---|---|---|---|---|
| **$COA_1$** | 0.55 | 0.57 | 0.44 | 0.55 | 0.57 | 0.62 | 0.44 | 0.55 | 0.57 | 0.55 |
| **$COA_2$** | 0.44 | 0.57 | 0.86 | 0.57 | 0.86 | 0.62 | 0.57 | 0.62 | 0.62 | 0.44 |
| **$COA_3$** | 0.55 | 0.44 | 0.44 | 0.55 | 0.57 | 0.44 | 0.55 | 0.57 | 0.44 | 0.55 |
| **Expert 2** | **$COC_1$** | **$COC_2$** | **$COC_3$** | **$COC_4$** | **$COC_5$** | **$COC_6$** | **$COC_7$** | **$COC_8$** | **$COC_9$** | **$COC_{10}$** |
| **$COA_1$** | 0.47 | 0.57 | 0.57 | 0.47 | 0.48 | 0.47 | 0.48 | 0.57 | 0.47 | 0.47 |
| **$COA_2$** | 0.57 | 0.48 | 0.48 | 0.57 | 0.47 | 0.48 | 0.57 | 0.57 | 0.48 | 0.57 |
| **$COA_3$** | 0.47 | 0.48 | 0.57 | 0.47 | 0.48 | 0.47 | 0.48 | 0.47 | 0.48 | 0.47 |

| Expert 3 | $COC_1$ | $COC_2$ | $COC_3$ | $COC_4$ | $COC_5$ | $COC_6$ | $COC_7$ | $COC_8$ | $COC_9$ | $COC_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $COA_1$ | 0.45 | 0.68 | 0.45 | 0.86 | 0.45 | 0.68 | 0.45 | 0.68 | 0.86 | 0.45 |
| $COA_2$ | 0.86 | 0.68 | 0.68 | 0.86 | 0.68 | 0.45 | 0.68 | 0.45 | 0.68 | 0.86 |
| $COA_3$ | 0.45 | 0.45 | 0.68 | 0.86 | 0.45 | 0.68 | 0.86 | 0.45 | 0.68 | 0.45 |
| **Aggregation** | $COC_1$ | $COC_2$ | $COC_3$ | $COC_4$ | $COC_5$ | $COC_6$ | $COC_7$ | $COC_8$ | $COC_9$ | $COC_{10}$ |
| $COA_1$ | 0.49 | 0.60 | 0.48 | 0.62 | 0.5 | 0.59 | 0.45 | 0.6 | 0.63 | 0.49 |
| $COA_2$ | 0.62 | 0.57 | 0.67 | 0.66 | 0.67 | 0.51 | 0.60 | 0.54 | 0.59 | 0.62 |
| $COA_3$ | 0.49 | 0.45 | 0.56 | 0.62 | 0.5 | 0.53 | 0.63 | 0.49 | 0.53 | 0.49 |

Stage 1: Calculate the normalization of the decision matrix, Stage 2: Calculate the weighted normalization decision matrix.

Then, Equation (18) was used to compute the normalization matrix, and Equation (19) was used to compute the weighted normalization matrix.

Stage 3: Compute the weighted mean values for positive and negative factors.

The weighted mean values were added for positive and negative factors using Equations (20-21).

Stage 4: Compute the value of $r_i$ to assess solutions.

Then, the value of $r_i$ was computed using Equation (22) to assess the solutions.

Stage 5: Compute the value of performance.

Equation (23) was used to compute the performance value, as shown in Figure 4.

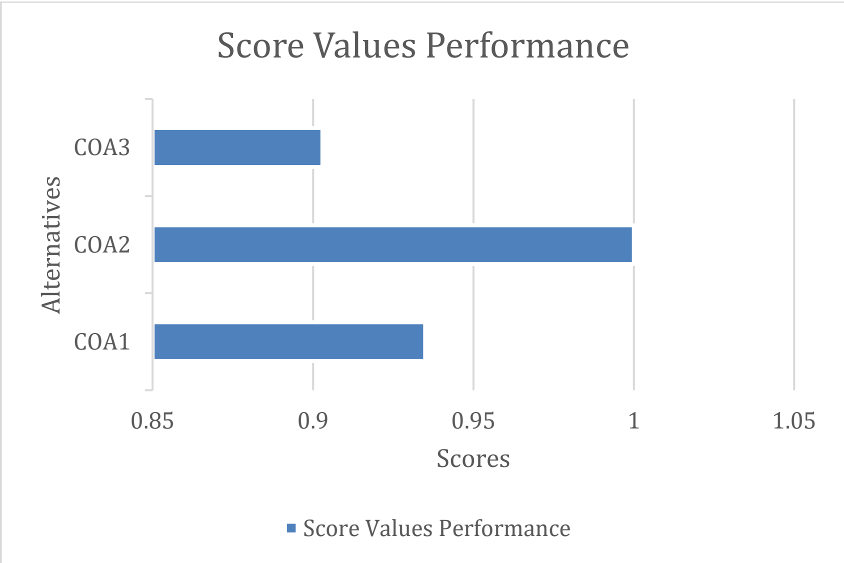


**Fig. 4.** Score values of performance

The second treatment way was the best, followed by the first treatment way, while the third treatment way had the lowest rank. Combinations of measures, such as quarantine and isolation, immunizations, antiviral drugs, and supportive care, were often the most effective means of treating COVID-19. A rundown of various parts of the treatment is discussed in the following section. The only way to stop the spread of COVID-19 was via strict quarantine and isolation procedures. Those who tested positive for COVID-19 or were exposed to the virus were often advised to stay in isolation at home or in special facilities until the virus was cleared from their system.

Vaccines against COVID-19 effectively reduced the likelihood of severe disease, hospitalization, and death. The use of vaccinations was critical to the plan to contain the infection. The severity of sickness and the likelihood of transmission may both be decreased by using a vaccine against SARS-

CoV-2. Hospitalized individuals with severe COVID-19 were approved to take some antiviral drugs, such as remdesivir. These drugs stopped the virus from reproducing, reducing sick time and symptom severity. However, certain patients could only use them under close medical care. Antibiotics, or drugs that kill germs, were ineffective against viruses like COVID-19. Antibiotics were only effective in treating bacterial infections that already spread to other body parts. Treatment with plasma obtained from persons who had recovered from COVID-19, and produced antibodies against the virus is known as convalescent plasma treatment. The goal of this treatment was to confer a kind of passive immunity on the patient. However, the efficacy of convalescent plasma therapy is still under study, and its use may be contingent on regional guidelines and existing data. The present study shows that quarantine and isolation procedures were the best treatment for COVID-19.

### 3.1 Sensitivity Analysis

A sensitivity analysis was conducted once the validation was finished. The purpose of this study is to determine how shifting the importance of one criterion affected the order in which solutions were presented [42-45]. Criteria weights were changed by the ten cases. One criterion was put with 0.5, while all the other criteria were equal. All criteria had 0.055556 weights. Then, the ten cases were applied in the COPRAS method to show the rank of alternatives, as shown in Figure 5.

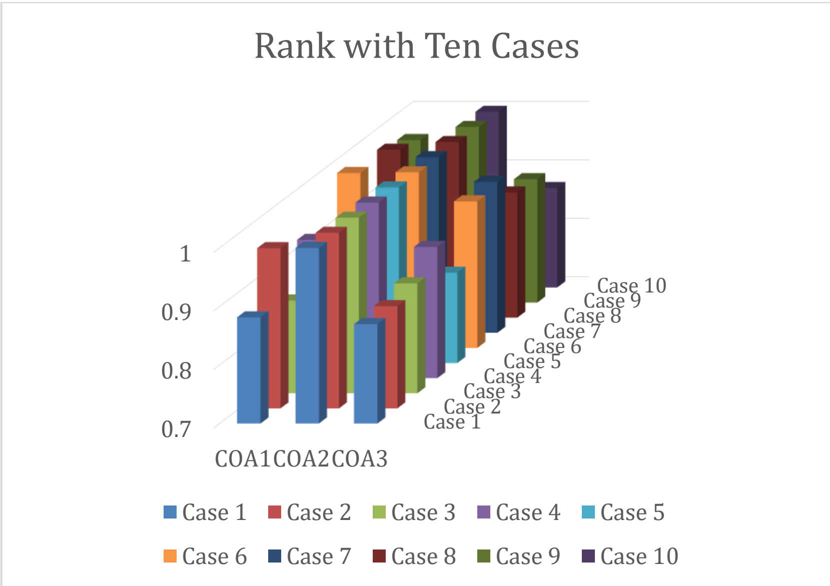


**Fig. 5**. Rank of alternatives via sensitivity analysis.

Cases three and seven were ranked identical, whereas alternative two was the best, followed by alternative three and alternative one. The remaining eight criteria had equal ranks, while alternative two was the best, followed by alternative one and alternative three. The ten cases agreed that alternative two was the best.

### *3.2 Comparative Analysis*

To show its robustness, the proposed method was compared to other MCDM methods, such as fuzzy CODAS [46] and LOPCCSA [47]. The comparison results in Figure 6 shows the alternative 2 is the best three methods. In the LOPCCSA method, the alternative 2 is the best followed by alternative 3 and the alternative 1 is the worst. In the CODAS method, the alternative 2 is the best followed by alternative 1 and the alternative 3 is the worst.

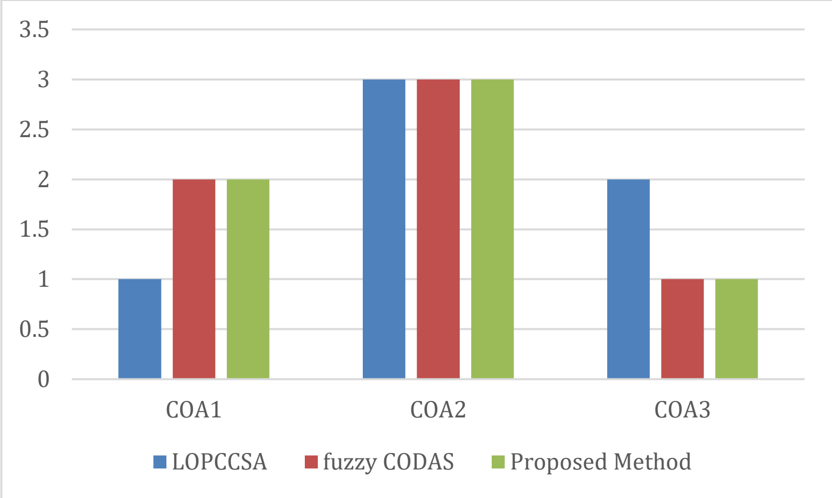


**Fig. 6.** Comparison between the proposed method and other MCDM methods.

## 4. Conclusion

The COVID-19 pandemic was a disaster on a scale not seen in centuries. Imposing lockdowns for extended periods was the first and most efficient technique to slow down the spread of infection during the initial phases of the pandemic. Therefore, this paper introduced the MCDM methodology under the PHF to select the best treatment way for COVID-19. An innovative MCDM method was created in a PHF setting. People infected with the COVID-19 virus during the pandemic had difficulty making rational treatment decisions and consequently experienced an increase in unpleasant emotions. Using the notion of probability in fuzzy, the right choice may be made quickly and readily. In this research, an MCDM technique was provided to make use of the COPRAS method in a fuzzy environment. The COVID-19 treatments in PHF settings were chosen in this way. There were potential drawbacks and risks with any COVID-19 therapy and medication. The decision-making process in the context of the present study outperforms other approaches. Ten criteria and three treatment ways for COVID-19 were used. Quarantine and in-house isolation proved to be the best treatment, followed by vaccinations, then combined with antibacterial medication and plasma treatment.

The suggested model and its findings were validated via a sensitivity analysis, proving the model's applicability. Results showed that the combined fuzzy approach introduced in this research effectively solved the mentioned types of decision-making issues. In addition, results revealed that a combination of fuzzy methods could be used for the same objective as well. This study compared the proposed method with various MCDM methods such as (LOPCCSA and CODAS methods). We found the two methods agreed the alternative 2 is the best alternative. In the LOPCCSA method, the alternative 2 is the best followed by alternative 3 and the alternative 1 is the worst. In the CODAS method, the alternative 2 is the best followed by alternative 1 and the alternative 3 is the worst.

Therefore, the contributions of the present study can be summed up as follows:

I. The combined technique proposed in this paper can be employed by experts and decision-makers in the medical field.
II. The proposed framework has the ability to deal with uncertain and vague data in the evaluation process.
III. There are various criteria related to COVID-19.
IV. The proposed method can be applied in various fields within the decision-making model.

The suggested integrated fuzzy approach is an innovative hybrid methodology that offers several benefits over conventional MCDM approaches. More realistic, practical, and accurate outcomes are possible because the enhanced COPRAS method incorporates fuzzy set theory. The number of criteria can be extended in future work, and the number of alternatives can be increased. The proposed method can be developed in future work with other uncertainty techniques, such as neutrosophic sets, among others. The proposed method can be applied to other decision-making problems, such as personnel selection, material selection, etc.

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### Conflicts of Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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