The Application of Fuzzy Collaborative Intelligence to Detect COVID-19 Minor Symptoms

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Abstract

Coronavirus Illness 2019 (COVID-19), a rare disease carried by a coronavirus known as a novel coronavirus, is now posing a danger to the whole planet. Despite the rising number of cases, there is no commercially available vaccination for COVID-19. The moderate symptoms of COVID-19 illness, on the other hand, may be treated with a variety of antiviral treatments. Even yet, selecting the optimum antiviral medication to manage the moderate symptom of COVID-19 is a difficult and ambiguous option. Selecting a drug might be challenging. Fuzzy collaborative intelligence (FCI) was presented in this research as a solution to solve the difficulty of evaluating the appropriateness of a drug selection. In the FCI method, the fuzzy inverse of column sum, partial consensus fuzzy intersection, and fuzzy procedure for order preference by similarity to the ideal solution. To show the practicality and usefulness of the created approach in real-world applications, a case study of medication choice for COVID-19 illness is being investigated.

Keywords: Fuzzy Collaborative Intelligence; TOPSIS; Drug; COVID-19;

1. Introduction

In December 2019, Wuhan, China, experienced a significant danger, which warped public health and caused worldwide pandemonium. COVID-19, SARS-CoV-2, or 2019-nCoV is the name given to a new beta coronavirus that caused pneumonia cases in the United States. Wuhan's traffic flow was deliberately channelled to limit transmission of the COVID-19 outbreak because of its unpredictable speed of dissemination [1]. Brazil, the USA, France, Russia, and India are the 5 nations with the most verified COVID-19 cases. An epidemic is expected to start in March 2020, according to the WHO. Some countries and areas have implemented strict social segregation measures to stop the spread of the virus so far. Over 62,570,316 persons have been infected by the COVID-19 thus far (as of November 29, 2020) [2]. The virus that causes COVID-19 is likely transferred by droplets formed when an infected person coughed, sneezed, or exhaled. Coronavirus is more dangerous for those with weakened immune systems, the elderly, diabetics, and other medical conditions, especially those affecting the lungs[3]–[6]. Factors such as weather and density of population might influence the propagation of the virus [7].

Many distinct forms of illnesses may be induced by coronaviruses, a broad genus of viruses. SARS (Severe Acute Respiratory Syndrome), MERS (Middle East Respiratory Syndrome), and the common cold are the most prevalent respiratory tract infections in people[8]–[10]. Man & bat SARS-like coronaviruses have been linked to the COVID-19

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strain by genomic and techniques [11], [12]. Speculation has claimed that the COVID-19 evolved from bats into more complex living forms[13]–[15]. When COVID-19 was first detected, it was found linked to Haman fisheries and live-animal stores. No vertebrate origin has yet been identified, and the ripple effects may yet occur. If COVID-19 is transmitted by bats, it is critical to identify a mediator species to prevent the epidemic from expanding worldwide.

Given the lack of information and medical technology, such as clinical studies, the COVID-19 was only recognized in December 2019. Before the advent of new mathematical tools, it was very difficult to apply known illness data directly to existing mathematical models and determine how effective the current medical therapy is. Doctors, specialists, or medical departments should conduct tests, devise tactics, or choose an ideal plan to prevent the crisis from worsening further throughout the therapy procedure.

The section in charge of strategizing must be able to make choices quickly and effectively. People tend to make conclusions in this scenario logically rather than rationally. The need of developing Decision-Making (DM) systems that take into account the behaviors of people to provide them with appropriate responses to crises cannot be overstated. It has always been challenging to work with data that is both ambiguous and unpredictable in a real-world environment. Fuzzy Sets (FSs) and their generalization are useful tools for dealing with the complexity and ambiguity of everyday life operations.

Inside this research, a fuzzy collaboration Intelligence (FCI) technique was used to select the best drug. A very well cognitive modeling tool, FCI is also a biological reasoning method that models human uncertainty[16]–[18]. The FCI method evaluates current and future mobile and smart technologies to address the first issue. [19]The second difficulty may be solved by drawing on the judgments of several people to eliminate personal bias. For the third challenge, it is important to take into account both the needs of those who will be served and the surrounding environment[20].

Partially-consensus fuzzy intersection (PCFI) and the fuzzy method Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) comprise the three components of the FCI approach. Mobile and smart technology applications are evaluated for their appropriateness for healthy aging by using FICSM to examine the relative importance of the factors used to assess the app's appropriateness. The PCFI approach provided by Chen is then used to aggregate the fuzzy priorities resulting from the results. Finally, fuzzy TOPSIS was used to select the best drug. The centre-of-gravity (COG) approach may defuzzify the evaluation data to make ranking alternatives easier. Results from this study might be useful in providing a welcoming and healthy environment for older people to live in, we believe.

The following is a breakdown of the paper's content. Section 2 is devoted to a literature evaluation of the planned research. Section 3 introduces fuzzy TOPSIS in its most basic form. Section 4 focuses on a research study to demonstrate the model's superiority. Section 5 concludes the paper by summarising the findings and making suggestions for further work.

2. Related Work

People infected are the primary source of the CODIV-19's rapid spread, making it even more difficult to contain[21]–[23]. A wide range of measures, such as social distance, must be addressed internationally to reduce the transmission of illness in this situation. However, the only way to halt the COVID-19 epidemic is to find an effective vaccination. Contact with an infected individual to the onset of symptoms is the COVID-19 incubation period. COVID-19 often causes symptoms such as fever, cough, nausea, & difficulty breathing [24].

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The symptoms of COVID-19 are similar to those of many other viral chest infections, such as H1N1 (Glycoprotein Type 1 and Monoclonal Type 1) and H5N1 (Glycoprotein Type 5 and Monoclonal Type 1).
Polymerase (PCR), a test, or a chest CT scan are the most often utilized diagnostic methods for COVID-19. The PCR approach may directly identify viral nucleic acids, while the CT scan method is used to quantify the amount of illness on both lobes of the lung[25].
The creation of a vaccine might represent a turning point in this pandemic. WHO, on the other hand, predicts it will take at least 18 months[26]. Until far, the virus has only been treated with symptomatic medications. Till a vaccine is created, social isolation and knowledge are the best ways to limit the spread of the disease. It's still dangerous to treat and manage COVID-19 infections without proper infection systems measures. When used for routine clinical applications, the CNN architecture-based model developed by Nour et al.[27] 142 countries were tested against the COVID-19 epidemic using an Aydin and Yurdakul [28] three-phase model built using machine learning processes and data envelopment analysis. Using CNNs, Marques et al. [29] suggested a medical decision-making framework for COVID-19.
Using a model developed by Mohammed et al.[30], health care organizations might be helped in their decision to use the COVID-19 diagnostic tool. Hazarika and Gupta [31] used Wavelet Combined Randomized Vector Functional Link Network (WCRVFL) to model and estimate the transmission of COVID-19 in the five most important badly countries (Brazil, India, Peru, Russia, as well as the United States) according to reports on July 10, 2020.

The topic of COVID-19 spread has recently received a lot of interest from academics and practitioners alike. Using Sameni's[32] Susceptible–Infected–Recovered (SIR) methodology, researchers were able to identify COVID-19 epidemic patterns. The COVID-19 epidemic was examined by Ahmadi et al. [33]using geographic and climatological variables. According to Zhu and Chen[34], a statistical disease model was used to evaluate the epidemic in China's early days. The danger of COVID- 19 epidemics in nations from outside China was recently assessed using a new integrated approach developed by Boldog et al. [35]Using a mathematical model, Yang and Wang [36]were able to examine the numerous transmission paths for the COVID-19 pandemic in Wuhan, China. The methodology proposed by Chen et al. evaluated the possible risk of transmitting from reservoir to person and individual to individual of SARS-CoV-2. Several academic publications [37] have already been reported in the literature to investigate the dissemination of COVID-19.

Since the year 2020, the COVID-19 virus has been growing rapidly around the globe and has had a significant influence on people's daily lives. Researchers have developed studies and viable methods to identify COVID-19 and lessen its impact. By assessing the regressive finite difference method, Abdo et al. described the COVID-19 thorough technique. When Melin et al. used fuzzy sets (FSs) to boost the predictability of the COVID-19 time series, they were successful. At Rio, Crokidakis used a SIQR method to assess the effectiveness of isolation and loneliness in dealing with the COVID-19 pandemic, which is a measure of susceptibility, infectiousness, quarantine, and recovery (SIQR). Globally, Melin et al. investigated the distribution of COVID-19 from a geographical perspective. The SEIRA (Susceptible–Exposed–Infected–Recovered–Asymptomatic) tool was acknowledged by Contreras et al. as a useful resource for those involved in establishing treatment plans. According to Boccaletti et al, the pandemic's negative effect may be reduced by merging applied mathematics with other disciplines, like virology and machine learning. Adopting a model that included the pathogenic set, the Best–Worst Method (BWM), and TOPSIS

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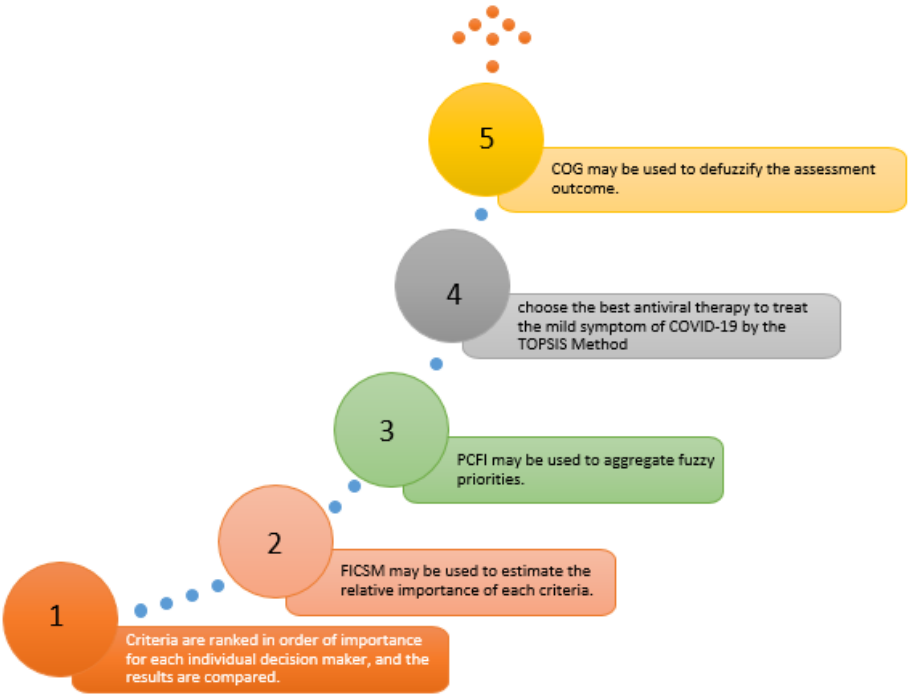

Figure 1: The Steps of the paper.

3. Fuzzy TOPSIS Method

FICSM, PCFI, and fuzzy TOPSIS were the three main components of the study's FCI technique.
The following are the stages involved in implementing the FCI strategy: A selection drug is evaluated by each decision maker by determining the relative importance of the criteria used to evaluate it.
For each decision-maker, FICSM is used to estimate the fuzzy priority of each criterion.
The fuzzy priorities of decision-makers are aggregated using PCFI in this step.
Fuzzy TOPSIS is used to evaluate whether the drug is appropriate for older adults who want to remain active and healthy as they age.
Defuzzifying the assessment result is the last step of COG.
This technique is shown in the flowchart seen in Figure 1. There is no loss of generality since all fuzzy variables and factors are supplied in or estimated using triangular fuzzy numbers in the suggested technique (TFNs).
The performance of a selection of a drug aging in all aspects is aggregated using Fuzzy TOPSIS. To get fuzzy weighted scores, multiply the normalized performance by the fuzzy precedence of every criterion. However, the PCFI result's complicated structure makes it difficult to integrate into fuzzy TOPSIS.
We can compute the normalization value as:

$$N = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} {x_{ij}}^2}} \quad (1)$$

Compute the weighted normalized matrix by multiplying the weights of criteria by the normalization matrix.
Two points of contact, a fuzzy ideal point A^- the anti-ideal pointA^-

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$$d_q^+ = \sqrt{\sum_{i=1}^{n} (A_i^+(-)s_{qi})^2} \quad (2)$$

$$d_q^- = \sqrt{\sum_{i=1}^{n} (A_i^-(-)s_{qi})^2} \quad (3)$$

$$d_q^{+L}(\alpha) \sqrt{\sum_{i=1}^{n} (max A_i^{+L}(\alpha) - s_q^R(\alpha), 0)^2} \quad (4)$$

$$d_q^{+R}(\alpha) \sqrt{\sum_{i=1}^{n} \left(A_i^{+R}(\alpha) - s_q^L(\alpha)\right)^2} \quad (5)$$

$$d_q^{-L}(\alpha) \sqrt{\sum_{i=1}^{n} (min A_i^{-R}(\alpha) - s_q^L(\alpha), 0)^2} \quad (6)$$

$$d_q^{-R}(\alpha) \sqrt{\sum_{i=1}^{n} \left(A_i^{+L}(\alpha) - s_q^R(\alpha)\right)^2} \quad (7)$$

$$A_i^+ = \max_q s_{qi} \quad (8)$$

$$A_i^- = \min_q s_{qi} \quad (9)$$

$$A_i^{+L}(\alpha) = \max_q s_{qi}^L(\alpha) \quad (10)$$

$$A_i^{+R}(\alpha) = \max_q s_{qi}^R(\alpha) \quad (11)$$

$$A_i^{-L}(\alpha) = \min_q s_{qi}^L(\alpha) \quad (12)$$

$$A_i^{-R}(\alpha) = \min_q s_{qi}^R(\alpha) \quad (13)$$

Lastly, fuzzy closeness is calculated by taking into account all distances:

$$CLo = \frac{d^-}{d^+ + d^-} \quad (14)$$

$$C_q^L(\alpha) = \min\left(\frac{d_q^{-R}(\alpha)}{d_q^{+R}(\alpha) + d_q^{-R}(\alpha)}, \frac{d_q^{-L}(\alpha)}{d_q^{+R}(\alpha) + d_q^{-L}(\alpha)}\right. \quad (15)$$

$$C_q^R(\alpha) = \min\left(\frac{d_q^{-R}(\alpha)}{d_q^{+L}(\alpha) + d_q^{-R}(\alpha)}, \frac{d_q^{-L}(\alpha)}{d_q^{+L}(\alpha) + d_q^{-L}(\alpha)}\right. \quad (16)$$

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Fuzzy closeness may be defuzzifed utilizing COG in the following way to produce an objective ranking:

$$COG(C_q)\frac{\sum_{\alpha}\left(\alpha\left(\frac{C_q^L(\alpha)+C_q^R(\alpha)}{2}\right)\right)}{\sum_{\alpha}\alpha} \quad (17)$$

As a consequence of the vast range of C_q, their discriminative strength is limited. To solve this issue, the following equations may be used to defuzzify C_q:

$$COG(C_q)\frac{\sum_{\alpha}\left(\alpha\left(\frac{d_q^{-L}(\alpha)+d_q^{-R}(\alpha)}{d_q^{-L}(\alpha)+d_q^{+R}(\alpha)+d_q^{-L}(\alpha)+d_q^{-R}(\alpha)}\right)\right)}{\sum_{\alpha}\alpha} \quad (18)$$

4. Case Study

The newly discovered COVID-19 strain has been formally dubbed COVID-19 by the Centers for Disease Control and Prevention. The term "corona" refers to the virus's throne peaks on the outside of the cell [38]. SARS-CoV and MERS-CoV are closely linked to this virus, which has some clinical symptoms [39]. The moderate manifestations of COVID-19 infection may be prevented by many currently available antiviral medications [40]. Antiviral medicines, on the other hand, have yet to be developed.
In Japan, an antiviral drug called favipiravir is used to treat influenza.
Viral genetic material is selectively inhibited by it.
Two antiretroviral drugs (LPV/RTV) are used in the treatment of HIV/AIDS. However, it may recover clinical consequences or avoid infections for COVID-19, MERS, and SARS confirmation. COVID-19 patients are expected to gain from the investigation.

Finally, we put up a list of physicians and patients who meet the requirements; these physicians have treated the patients and have experienced COVID-19. Virologists are trained to study and comprehend the human body's viral behaviour. Medical council training and 7 to 10 years of professional experience were also assets to these practitioners when it came to treating patients with COVID-19 symptoms.

Forging a consensus or gaining a better knowledge of the topic by distributing surveys among physicians and patients. Patients were handed questionnaire-style data sheets, and the goal of the data collection was explained in detail to each clinician. The questionnaire was reworked, and the linguistic data obtained was standardised in order to preserve anonymity. There are three doctors provide the data in tables 1,2,3. This paper used seven criteria and five alternatives:

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Criteria	Alternatives
Anorexia GCC1	GCA1 GCA2 GCA3 GCA4 GCA5
Cough GCC2	
Fatigue GCC3	
Fever GCC4	
Myalgia GCC5	
Shortness of breath GCC6	
Sputum production GCC7	

First compute the weights of criteria by the TOPSIS method in figure 2.

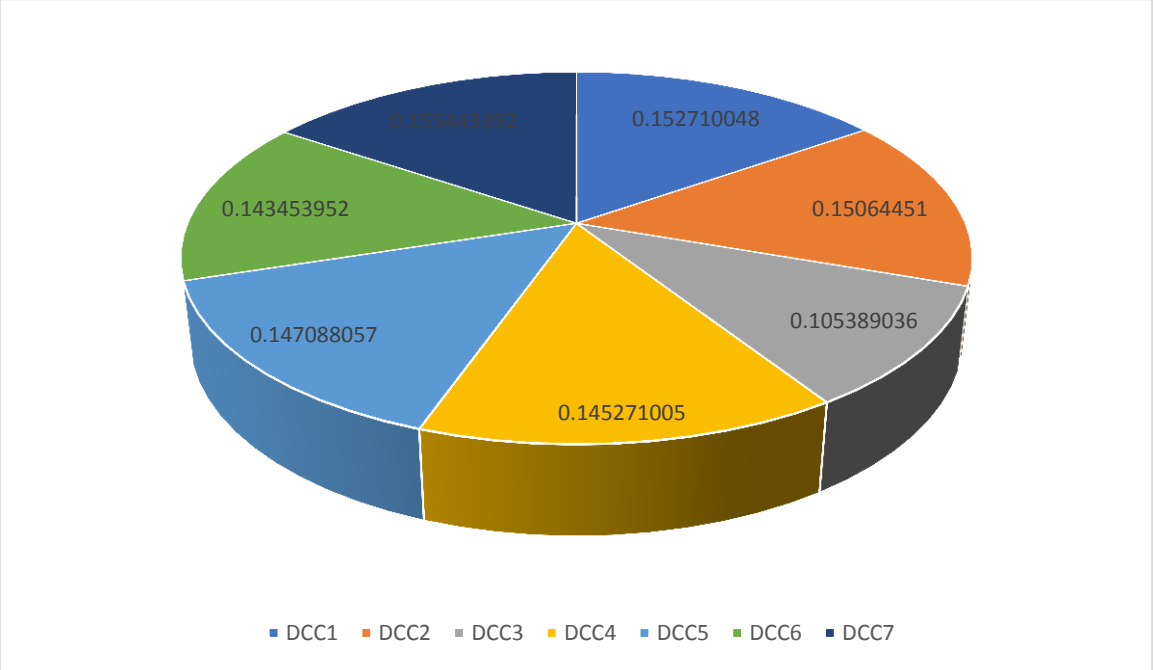

Figure 2: The weights of criteria.

Let three experts evaluate the criteria and alternatives in Tables 1-3. The study used the seven criteria and five alternatives. Then aggregate the decision matrix into one matrix by the average method in table 4.

Table 1: The decision matrix by the first expert

	DCC_1	DCC_2	DCC_3	DCC_4	DCC_5	DCC_6	DCC_7
DCA_1	0.3636	0.304	0.304	0.304	0.3636	0.3333	0.3043

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DCA_2	0.3043	0.3636	0.333	0.3333	0.3157	0.3636	0.3043
DCA_3	0.304	0.363	0.304	0.3157	0.304	0.3636	0.3333
DCA_4	0.3636	0.3157	0.304	0.3157	0.3157	0.3157	0.3636
DCA_5	0.3157	0.3157	0.304	0.304	0.304	0.333	0.3636

Table 2: The decision matrix by the second expert

	DCC_1	DCC_2	DCC_3	DCC_4	DCC_5	DCC_6	DCC_7
DCA_1	0.3636	0.3636	0.333	0.304	0.3333	0.3333	0.333
DCA_2	0.3333	0.3636	0.3636	0.3333	0.3636	0.3636	0.363
DCA_3	0.3636	0.3636	0.304	0.3157	0.304	0.3636	0.3333
DCA_4	0.3636	0.3636	0.304	0.3157	0.3636	0.3157	0.3636
DCA_5	0.3333	0.3157	0.3636	0.3333	0.304	0.333	0.333

Table 3: The decision matrix by the third expert

	DCC_1	DCC_2	DCC_3	DCC_4	DCC_5	DCC_6	DCC_7

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DCA_1	0.304	0.3157	0.304	0.3157	0.3636	0.3157	0.3157
DCA_2	0.3043	0.3157	0.3157	0.3157	0.3157	0.3636	0.3043
DCA_3	0.3157	0.3157	0.304	0.3157	0.304	0.3157	0.3157
DCA_4	0.3636	0.3157	0.3157	0.3157	0.3157	0.3157	0.3636
DCA_5	0.3157	0.304	0.304	0.304	0.304	0.333	0.304

Table 4: The aggregated decision matrix

	DCC_1	DCC_2	DCC_3	DCC_4	DCC_5	DCC_6	DCC_7
DCA_1	0.343733	0.327767	0.313667	0.3079	0.3535	0.327433	0.317667
DCA_2	0.313967	0.347633	0.337433	0.327433	0.331667	0.3636	0.323867
DCA_3	0.327767	0.347433	0.304	0.3157	0.304	0.347633	0.327433
DCA_4	0.3636	0.331667	0.3079	0.3157	0.331667	0.3157	0.3636
DCA_5	0.321567	0.3118	0.323867	0.313767	0.304	0.333	0.333533

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Compute the normalization matrix by the aggregated decision matrix in table 5. Then compute the weighted normalized decision matrix in table 6.

Table 5: The normalized aggregated decision matrix

	DCC_1	DCC_2	DCC_3	DCC_4	DCC_5	DCC_6	DCC_7
DCA_1	0.459428	0.439486	0.441672	0.435525	0.485661	0.433384	0.425847
DCA_2	0.419642	0.466124	0.475138	0.463154	0.455665	0.481253	0.434158
DCA_3	0.438087	0.465856	0.42806	0.446558	0.417655	0.46012	0.438939
DCA_4	0.485981	0.444715	0.433552	0.446558	0.455665	0.417854	0.487422
DCA_5	0.4298	0.418077	0.456034	0.443823	0.417655	0.440752	0.447117

Table 6: The weighted normalized decision matrix

	DCC_1	DCC_2	DCC_3	DCC_4	DCC_5	DCC_6	DCC_7
DCA_1	0.070159	0.066206	0.046547	0.063269	0.071435	0.062171	0.066195
DCA_2	0.064084	0.070219	0.050074	0.067283	0.067023	0.069038	0.067487
DCA_3	0.0669	0.070179	0.045113	0.064872	0.061432	0.066006	0.06823
DCA_4	0.074214	0.066994	0.045692	0.064872	0.067023	0.059943	0.075767

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DCA_5	0.06 5635	0.06 2981	0.04 8061	0.06 4475	0.06 1432	0.06 3228	0.06 9501

Compute the closeness value then rank alternatives in figure 3. From figure 3. The DCA_4 is the best alternatives and DCA_4 is the worst alternatives.

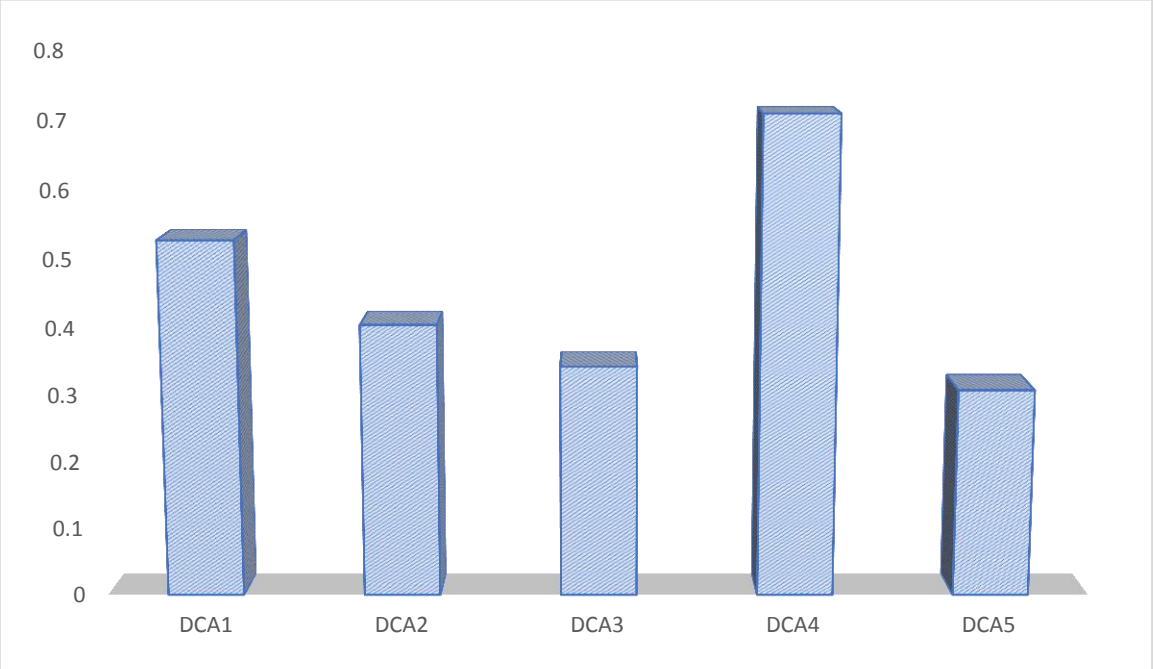

Figure 3: Rank the alternatives.

5. Conclusion

A novel paradigm for evaluating the treatment selection issue for moderate symptoms of COVID-19 illness on fuzzy TOPSIS is the goal of this research.

As a result, it was suggested that an FCI technique be used to find a viable application. An innovative mix of FICSM, PCFI, and fuzzy TOPSIS is used in the FCI technique. Using PCFI to combine the fuzzy objectives predicted by decision-makers using FCISM, the proposed FCI strategy is similar to current fuzzy collaborative forecasting approaches. Following the PCFI result, fuzzy TOPSIS was used to evaluate the drug.

The suggested technique yielded significantly different rankings from the ones currently in use. It was, however, difficult to determine the optimal strategy. However, only the FCI strategy took into account the agreement of the decision-makers in the process. As a consequence, all of the decision-makers were satisfied with the findings.

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