COVID-19 vaccine choice using the multi-criteria decision making method under uncertainty

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Abstract

COVID-19, a coronavirus pandemic unlike any seen before, is in a state of flux over the planet. Since the COVID-19 pandemic now poses a serious danger to all nations, it is critical that policymakers find the most effective response possible. The coronavirus is difficult to eradicate, however the COVID-19 vaccination may help with that. Everyone is wondering which vaccination would be best for them. Multi-criteria decision-making (MCDM) is an excellent method for assessing this maze. As a result, we have suggested a cutting-edge MCDM method for choosing COVID-19 vaccinations. The primary objective of this work is to deliver a technique for MCDM. In this investigation, we present a unique hybrid model that combines the strengths of the neutrosophic Analytic Hierarchy Process (N-AHP) and the neutrosophic VIKOR technique. Using the N-AHP, we can quantify the importance of the criterion, and using the N-VIKOR method, we can prioritize our options for interventions.

Keywords: MCDM; Neutrosophic Sets; Uncertainty; Single Valued Neutrosophic Sets;

1. Introduction

Because of its sudden appearance, the WHO officially classified COVID-19 as an epidemic in March of 2020. The global economy is in danger as a result of the COVID-19 pandemic. Thousands of individuals have misplaced their jobs, the value of enterprises has dropped, and several cable companies have been forced to close down. Numerous effective measures, including as lockdowns, travel restrictions, and school and business closures, were put into place at this time since effective remedies were not readily available. Public fitness procedures, like wearing medical masks, laundry hands, and disinfecting counters, were also strongly encouraged[1]–[3].

The rapidity with which coronavirus spreads in other nations is largely attributable to their greater population densities. The five most important things you can do to protect yourself and others from getting the coronavirus are (1) using a facial mask, (2) maintaining an appropriate distance from those other people if you're outside, (3) washing your hands with an antiseptic, (4) not touching your face, and (5) getting vaccinated against COVID-19. You should also follow three crucial rules to protect yourself from the COVID-19 virus: I get tested when you see symptoms, (ii) monitor your progress, and (iii) be vaccinated[4]–[7].

In light of the spare situation caused by the COVID-19 epidemic, the government granted permission for the use of the three vaccinations (Covishield, Covaxin, and Sputnik V). Since protection from the coronavirus may be attained by vaccination. Vaccination is also an important factor in preventing the transmission of COVID-19[8]–[11].

There has been a significant uptake of MCDM techniques in many diverse industries. However, these methods are seldom used to assess government actions taken to combat COVID-19[12]–[15]. The difficulties of MCDM are hampered by the lack of accuracy and the unknowns they introduce. The

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fuzzy MCDM makes use of fuzzy numbers in order to manage and quantify uncertainty and imprecision. Since people make decisions based on their gut feelings, there are no hard and fast rules for navigating complex real-world dilemmas. Numerous methods and ideas have been created to address ambiguity in situations that arise in the actual world. There are a number of competing factors to consider when assessing government interventions[16]–[19].

Atanassov created the intuitionistic fuzzy set (IFS) because just including fuzziness into DM issues is insufficient to address the hesitance experienced by those tasked with making important decisions. Each element's degree of non-membership is signified by a number among zero and one. When dealing with DM issues, IFSs have been widely applied.

In order to represent the indeterminacy clearly, Smarandache proposed the neutrosophic set (NS), an enlarged and generic variant of the classical fuzzy set and the intuitionistic fuzzy set. The neutrosophic set consists primarily of the elements truth memberships T, indeterminacy memberships I, and falsity memberships F.

In 2004, a research paper by Serafim Opricovic and Tzeng established the VIKOR approach as a viable tool for resolving MCDM matters. Seeing all of the viable choices, a middle ground is found that greatest approaches the best consequence [20]–[22]. When applied to the option choice issue, neutrosophic numbers and the VIKOR approach will fill this gap in the literature and provide more reliable outcomes. So, this paper proposed the MCDM methodology from the AHP[23]–[25] and VIKOR methods. The AHP used to compute the weights of factors. The VIKOR technique is performed to order the alternatives under the single valued neutrosophic numbers.

2. Neutrosophic Sets

Let X be a universal, then the A SVN sets is:

$A = \{< x, d_A(x), e_A(x), f_A(x) >: x \in X\}$

Definition 1:

Let $Q_1 = (d_1, e_1, f_1) and\ Q_2 = (d_2, e_2, f_2) be\ two\ SVNSs\ then$

$Q_1 \oplus Q_2 = (d_1 + d_2 - d_1 d_2, e_1 e_2, f_1 f_2)$

Definition 2:

Let $Q_1 = (d_1, e_1, f_1) and\ Q_2 = (d_2, e_2, f_2) be\ two\ SVNS\ then$

$Q_1 \otimes Q_2 = (d_1 d_2, e_1 + e_2, f_1 + f_2 - f_1 f_2)$

Definition 3:

Let $Q = (d, e, f)\ be\ a\ SVN\ number, then$

$\lambda Q = \left(1 - (1-d)^{\lambda}, e^{\lambda}, f^{\lambda}\right), \lambda > 0$

Definition 4:

Let $Q = (d, e, f)\ be\ SVN\ number, then\ the\ complement\ is$

$d_Q^c(x) = f_Q(x)$

$e_Q^c(x) = 1 - e_Q(x)$

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$$f_Q^c(x) = e_Q(x)$$

$$Q^c = \{< x, f_Q(x), 1 - e_Q(x), d_Q(x) >\}$$

Definition 5:

Let $\{Q_1, Q_2, Q_3, Q_4, Q_5, \dots Q_n\}$, *then the weighted average operator is*

$$\sum_{b=1}^{y} \lambda_b Q_b = \left(1 - \prod_{b=1}^{y}(1 - d_b)_b^{\lambda}, \left(\prod_{b=1}^{y}(e_b)_b^{\lambda}, \prod_{b=1}^{y}(f)_b^{\lambda}\right)\right)$$

Definition 6:

Let $Q = (d, e, f)$ *be a single valued neutrosophic number, then* score function is

$$S(Q) = \frac{d + (1 - e) + (1 - f)}{3}$$

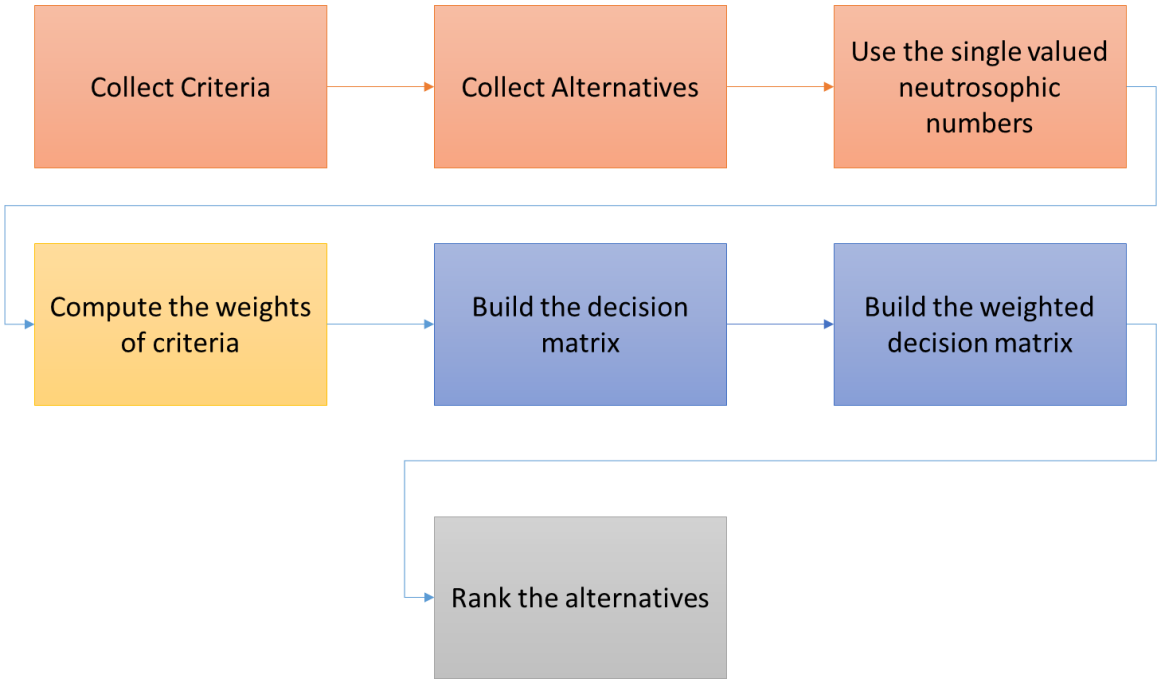

Figure 1: The stages of the AHP and VIKOR technique.

3. The AHP and VIKOR Technique

The AHP method is performed to calculate the weights of factors. In 2004, Opricovic and Tzeng were the first to distribute on the VIKOR approach. The technique's foundation is on a ranking of potential solutions using mutually exclusive criteria in order to determine the best course of action. The approach's ultimate goalmouth is to reach at a equally agreeable compromise throughout the vetting stage.

Step 1: Compute the weights of factors by the AHP technique
First build the comparison matrix between criteria by the opinions of experts. The experts are used the single valued neutrosophic numbers. Figure 1 demonstrations the stages of the suggested practise.

Step 2: Build the judgement background
This matrix is built by the criteria and alternatives.

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Step 3: Normalize the judgement background

After the judgement background is built then, normalize the judgement background

Step 4: Compute the weighted judgement background

Step 5: obtain the optimistic and bad factors

The beneficial criteria is classified as a positive criteria and cost criteria are classified as negative criteria.

Step 6: Calculate the values of S and R

$$S = \sum_{j=1}^{n} \frac{W_j^+ - W_{ij}}{W_j^+ - W_j^-}$$

$$R = \max_j W_j \frac{W_j^+ - W_{ij}}{W_j^+ - W_j^-}$$

Where W_j^+ is the positive factors.

W_j^- is the negative criteria.

N refers the number of criteria.

i mentions to the criteria

j mentions to the alternatives.

S and R refers the utility measure

Step 7: Compute the Q value

$$Q_i = \lambda \left[\frac{s_i - s^+}{s^- - s^+}\right] + (1 - \lambda) \left[\frac{s_i - s^+}{s^- - s^+}\right]$$

Step 8: Order the substitutions

The substitutions are ranked according to the lowest value to the uppermost value.

4. The Results

In this section, the outcomes of the neutrosophic AHP and VIKOR methods are illustrated.

Step 1: Calculate the weights of factors by the AHP technique

This paper used the single valued neutrosophic numbers to evaluate the standards and substitutions by the experts. The criteria of this paper are Vaccine effectiveness, the vaccination works quite well, consequences of the vaccination, and timing and dosage considerations. There are three alternatives like Covishield, Covaxin, Sputnik V. After the criteria are evaluated by the criteria, then used the score function from previous section to compute the crisp value. Then normalize the pairwise comparison as in Table 1. Then compute the weights of criteria as in Figure 2. The criterion 4 is the highest weight and criterion 1 is the lowest weight.

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Table 1: The normalization of pairwise comparison matrix.

	COVIDC1	COVIDC2	COVIDC3	COVIDC4
COVIDC1	0.07936	0.094335	0.175159	0.056075
COVIDC2	0.144291	0.171518	0.203083	0.154206
COVIDC3	0.115015	0.214397	0.253854	0.32243
COVIDC4	0.661334	0.519751	0.367904	0.46729

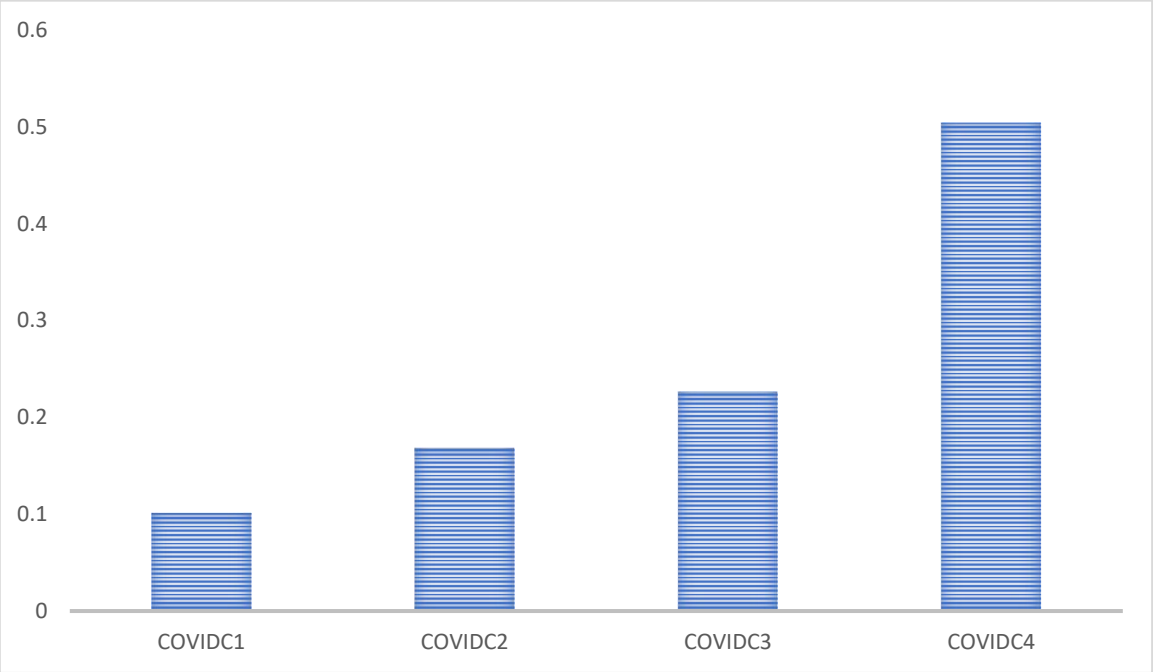

Figure 2: The weights of criteria.

Step 2: Build the judgement background

Table 2. shows the judgement background.

Table 2: The judgement background.

	COVIDC1	COVIDC2	COVIDC3	COVIDC4
COVIDA1	0.77	0.26	0.63	0.45
COVIDA2	0.59	0.6	0.77	0.92
COVIDA3	0.36	0.12	0.6	0.63

Step 3: Normalize the judgement background

Then normalize the judgement background

Step 4: Compute the weighted judgement background

Table 3 shows the weighted decision matrix.

Table 3: The weighted judgement background.

	COVIDC1	COVIDC2	COVIDC3	COVIDC4
COVIDA1	0	0.113333	0.08862	0.22
COVIDA2	0.043902	0	0	0
COVIDA3	0.1	0.16	0.10761	0.135745

Step 5: obtain the optimistic and bad criteria

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The all criteria are optimistic and non-beneficial standards.

Step 6: Calculate the values of S and R

The values of the S and R are computed

Step 7: Calculate the Q value

The value of Q is computed

Step 8: Order the options

Finally rank the options according to the lowest value of Q as shown in figure 3. The greatest alternative is option 2 and the nastiest option is alternative 1.

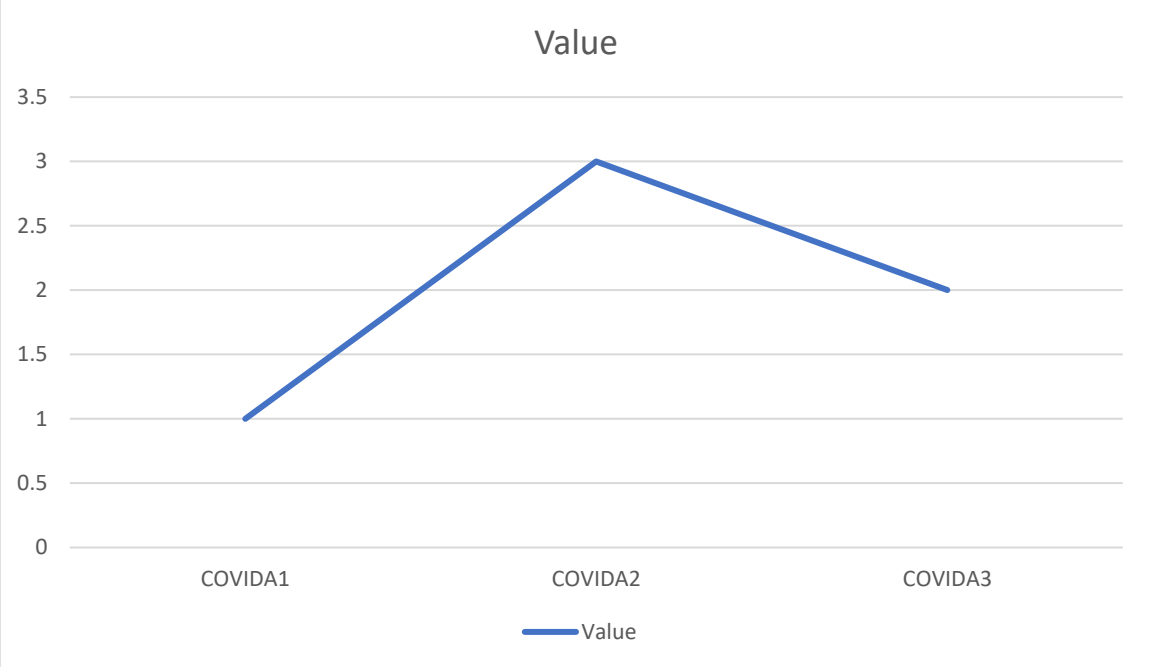

Figure 3: The rank of alternatives.

4. Conclusion

Coronavirus virus illness, or COVID-19, was major perceived in December 2019. In terms of speed, COVID-19 is second to none. Taking precautions like washing your hands often and remaining indoors are crucial in the ongoing battle against the COVID-19 outbreak. The coronavirus has no specific, FDA-approved antiviral treatment.

We have made some suggestions for the optimal vaccination based on four criteria in this research.

We've created a unique MCDM method for selecting the optimal vaccination from among three available options. The suggested rank interpreter approach is used to build this MCDM strategy.

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