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Application of TOPSIS in the Diagnosis of Vector Borne Diseases

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Abstract: *"Intuitionistic Fuzzy Set" (IFS) is used to manage nebulousness and indecision. In current investigation, another intuitionistic fuzzy TOPSIS method is proposed for decision making by utilizing entropy weight. Current model permits estimating the degree of membership and non-membership of various alternatives assessed over a criterion set. A case study has been carried out to diagnosis of vector borne disease. Criteria's have been selected according to relevant disease and weight has been assigned to them by medical expert's committee. It has been established that TOPSIS method can diagnose the VBD diseases using specific symptoms as criteria and VBDs as alternatives. The suggested methodology can help in correct and timely diagnosis of VBDs and provides doctors an innovative diagnostic tool (WHO, 2004; WHO, 2014). The result is validated by applying fuzzy VIKOR method.*

Keywords: *Entropy, IFS, MCDM, TOPSIS, SIFWA operator.*

Nomenclature

W	Weight vector
CC	Closeness coefficient
IFDM	Intuitionistic fuzzy decision matrix
IF	Intuitionistic fuzzy
DOD	Degree of divergence
MCDM	Multiple criteria decision making
WFDM	weighted fuzzy decision matrix

I. INTRODUCTION

Mosquito also known as vectors has an ability to produce serious diseases in human or animal populations as they can spread pathogens and parasites. With respect to south-east Asia region, common vector-borne diseases (VBD) types are chikungunya, dengue, and malaria etc. Chikungunya resembles to dengue along with symptoms of severe joint pain also known as arthritis accompanied by high fever, rash, joint swelling, headache, muscle pain, nausea, and fatigue etc. It establishes itself in 9-14 days after the mosquito bite and its symptoms are high fever, headache, nausea, vomiting, and muscles pain. Symptoms of dengue are high fever, pain behind the eyes, head ache, body aches and joint pain, and skin rash. Symptoms of Malaria are high fever, headache, nausea, vomiting, and muscles pain.

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Figure 1 shows the rising cases of chikungunya, dengue, and malaria in Delhi and an indication of severity of the problem.To control these VBD, WHO recommended some instructions such as to provide moral and technical support as well as new tools and innovative diagnosis should be developed to further fortify this effort.

In the world, one sixth of illness and disability endured is because of VBD, with more than half of population right now evaluated to be in danger of these infections. VBD are transmitted by mosquitoes, black flies, ticks, snails, and lice etc. The difficulty in accurate and timely diagnosis of VBD can delay the relative treatment procedure especially in remote regions where doctors as well as hospitals are in scarce number. MCDM methodologies have been useful to engineering, management, economics, and so forth. Hwang and Yoon (1981) first developed the traditional MCDM approach like TOPSIS, this method has benefits like simple, rationally comprehensible concept, computational efficiency is good, capability of measuring the relative performance for every alternative (Yeh, 2002).

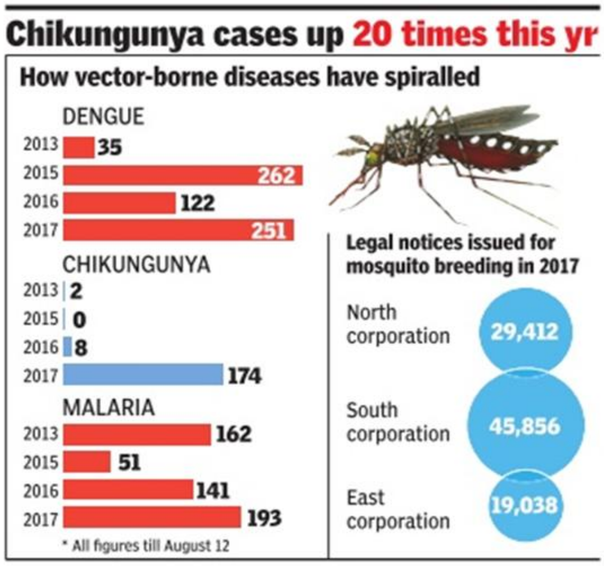

Figure 1 Spiralling Chikungunya and Malaria cases in Delhi
(Source: The Times of India August 15, 2017)

Zadeh (1965) introduced the fuzzy sets theory in year 1965, which can assign a single membership value to each element amongst zero and one, then Gau and Buechrer (1993) proposed vague set concept.

Bustince and Burillo (1996) shown that vague set coincides with IFSs. Kakushadze *et al*. (2017) assessed the savings in treatment cost from early diagnosis of cancer and found that annual savings was in 11 digits for U.S. nationals. Hung and Chen (2009) suggested a new fuzzy TOPSIS model by utilizing entropy weights. Balioti *et al*. (2018) used MCDM and TOPSIS in the selection of spillway for a dam in Greece. In another study, Vahdani *et al*. (2011) proposed fuzzy modified TOPSIS for manufacturing decisions regarding the selection of robot and rapid prototyping process.

II. PRELIMINARIES

2.1. IFS theory

Statement 1 (Atanassov, 1986).
An IFS B is subset of an universe of discourse X can be expressed as: $B = \{< x, \mu_B(x), \nu_B(x) >\}$, $\mu_B : X \to [0,1]$, $\nu_B: X \to [0,1]$ such that $0 \le \mu_B(x) + \nu_B(x) \le 1$, $\forall x$ with this property $\nu_B(x) = 1 - \mu_B(x)$
Where $\mu_B(x)$ and $\nu_B(x)$ represents the member and non-member ship function of X to B correspondingly. If B is a crisp set then either
$\mu_B(x) = 1, \nu_B(x) = 0$ 0r $\mu_B(x) = 0, \nu_B(x) = 1, \forall\, x \in X$
If B is an IF set in X then
$$\pi_B(x) = 1 - \mu_B(x) - \nu_B(x), 0 \le \mu_B(x) + \nu_B(x) \le 1, \forall\, x \in X \quad (1)$$
where $\pi_B(x)$ is hesitancy degree of X to B.

Statement 2 (De *et al*., 2000)
For each $B \in X$, *where B is IFS* with respect to positive real number σ the IFS $\sigma B$is expressed as:
$$\sigma B = \{\langle x, 1 - (1 - \mu_B(x))^{\sigma}, (\nu_B(x))^{\sigma} \rangle | x \in X\} \quad (2)$$

2.2. Entropy of IFS

Shannon (1948) suggested entropy function in the year 1948, $H(p_1, p_2, \ldots, p_n) = -\sum_{i=1}^{n} p_i \log(p_i)$ as a measure of uncertainty in discrete distribution on the basis of Boltzmann entropy in which probabilities $p_i (i = 1,2, \ldots, n)$ of random variable are calculated by probability mass function (P). Then De Luca and Termini (1972), created a formula of non-probabilistic entropy of a fuzzy set. Szmidt and Kacprzyk (2001) extended the entropy measure on IFSs (X). Vlachos *et al*. (2007) gave the measure of IF entropy as shown under":

$$E_{VS}^{IFS} = \left[\frac{1}{n\sqrt{e-1}} \sum_i^m \left(\frac{\mu_B(x_i)+1-\nu_B(x_i)}{2} \right) e^{\left(\frac{\nu_B(x_i)+1-\mu_B(x_i)}{2} \right)} + \left(\frac{\nu_B(x_i)+1-\mu_B(x_i)}{2} \right) e^{\left(\frac{\nu_B(x_i)+1-\mu_B(x_i)}{2} \right)} \right] \quad (3)$$

Noted that E_{VS}^{IFS} is comprised of hesitancy and fuzziness degree of IFS 'B'.

1.3. Properties of entropy

Suppose X is the universal set and let P, Q ∈ IFS (X) can be expressed by:
$P = \{\langle \tau_t, \mu_s(\tau_t), \nu_s(\tau_t) | \tau_t \in X \rangle\}$ and
$$Q = \{\langle \tau_t, \mu_t(\tau_t), \nu_t(\tau_t) | \tau_t \in X \rangle\} \quad (4)$$

Let E is an entropy, which is a real valued function such that IFS(X)→ [0,1] can satisfy these property (Szmidt and Kacprzyk, 2002):

(1) E(P) = 1 if $\mu_p(x_i) = \nu_p(x_i)$ for $\forall\, x \in X$. (5)

(2) E(P) = 0 if p is crisp set, i.e. $\mu_p(x_i) = 0, \nu_p(x_i) = 1$ or $\mu_p(x_i) = 1, \nu_p(x_i) = 0, \forall\, x_i \in X$. (6)

(3) E (P) ≤ E (Q) if P ⊆ Q. (7)

(4) E (P)= E (Q) (8)

III. PROPOSED FUZZY TOPSIS DECISION MAKING MODEL

For this method, calculation procedure has been discussed in the stages as shown below:

Step 1. Construct an IFDM. In order to get collective opinion, find the average of individual opinion of medical expert. In the disease choosing process, the medical expert's individual opinions should be aggregated into gathering assessment ascertain a collective IFDM. Suppose $r_{ij}^k = (\mu_{ij}^k, \nu_{ij}^k)$ be the IFN specified by DM_k on evaluation of F_i regarding S_i. Now the aggregated IF rating (r_{ij}) of diseases regarding each symptom can be evaluated with the help of SIFWA operator as:

$$r_{ij} = SIFWA(r_{ij}^1, r_{ij}^2, \ldots, r_{ij}^l) = \sum_{k=1}^{l} \eta_k r_{ij}^k = \left(\frac{\prod_{k=1}^{l} (\mu_{ij}^k)^{\eta_k}}{\prod_{k=1}^{l} (\mu_{ij}^k)^{\eta_k} + \prod_{k=1}^{l} (1-\mu_{ij}^k)^{\eta_k}}, \frac{\prod_{k=1}^{l} (\nu_{ij}^k)^{\eta_k}}{\prod_{k=1}^{l} (\nu_{ij}^k)^{\eta_k} + (1-\nu_{ij}^k)^{\eta_k}} \right) \quad (9)$$

The MCDM in the form of matrix:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ x_{m1} & x_{m2} & x_{mn} \end{bmatrix} \end{array} \quad (10)$$

$$W = (w_1, w_2, \ldots, w_n)$$

Assume $A = \{A_1, A_2, \ldots, A_m\}$ is an alternatives' set that comprises of m non-inferior decision-making options. Every alternative is measured on n criteria. Therefore, criteria set can be expressed as $C = \{C_1, C_2, \ldots, C_n\}$. Assume $W = \{w_1, w_2, \ldots, w_m\}$ is a criteria's weighting vector, i.e. $w_j \ge 0$ and $\sum_{j=1}^{n} w_j = 1$. In present study, the characteristics of alternatives A_i have been described by the IFS as:
$$A_i = \{\langle C_j, \mu_{A_i}(C_j), \nu_{A_i}(C_j) \rangle | C_j \in C\},\ i = 1, 2, \ldots, m \quad (11)$$
The IF $\pi_{A_i}(C_j) = 1 - \mu_{A_i}(C_j) - \nu_{A_i}(C_j)$ is such that the larger $\pi_{A_i}(C_j)$ the higher a hesitation margin of the DM about the alternative A_i regarding the criterion C_j.

Step 2. Entropy-based method can be utilized in order to assess the CWs.

As indicated by the decision matrix $\tilde{D}=\left[\tilde{x}_{ij}\right]_{m\times n}$, $i=1,\dots,m, j=1,\dots,n$, $\tilde{L}=[\tilde{x}_{ij}], i=1,2,3,4,\dots\dots,m$ and $j=1,2,3,\dots\dots,n$ under IF condition, the expected data substance produced from each criterion C_j can be estimated by the entropy value, meant as w

$$E_{VS}^{IFS}(C_j)=-\frac{1}{nln2}\sum_i^n[\mu_A(x_i)+v_A(x_i)lnv_A(x_i)-1-\pi Axi-\pi Axiln2 \quad (12)$$

Where $1/_{nln2}$ and $j=1,2,3,4\dots.n$ is a constant that ensures $0\le E_{VS}^{IFS}(C_j)\le 1$

In this way, degree of divergence is (d_j) of average intrinsic data that has been given by the relating performance rating on criterion C_j can be characterized as:

$$d_j=1-E_{VS}^{IFS}(c_j), j=1,2,3\dots\dots,n \quad (13)$$

Now j^{th} criterion's entropy weight is given by: $w_j=d_j/\sum_{j=1}^n d_j$ (14)

Step 3. Create the weighted IFDM.

A weighted IFDM ($\tilde{R}$) can be attained by aggregating W and IFDM ($\tilde{L}$) can be described as:

$$R=\widetilde{W^Q}\otimes\tilde{L}=W_Q\otimes[\tilde{x}_{ij}]_{m\times n}=[\tilde{x}_{ij}]_{m\times n}, \text{when} W=(w_{1,},w_2,w_3\dots\dots\dots w_j,\dots w_n)$$

$$\hat{x}_{ij}=\langle\hat{\mu}_{ij},\hat{v}_{ij}\rangle=\langle 1-(\mu_{ij}))^{w_j}, v_{ij}{}^{w_j}, \; w_j>0 \quad (15)$$

Step 4. Determine. IFPIS, A^+(positive ideal) and IFNIS, A^- (negative ideal), respectively.

Generally, evaluation of criteria may be classified into two parts, benefit and cost. Let G and B are collection of benefit & cost criteria, correspondingly. The IFPIS & IFNIS are expressed as:

$$A^+=\left\{\left\langle C_j,\left(\left(\max_i \mu_{ij}(C_j)\middle| j\in G\right),\left(\min_i \mu_{ij}(C_j)\middle| j\in B\right)\right),\left(\left(\min_i v_{ij}(C_j)\middle| j\in G\right),\left(\max_i v_{ij}(C_j)\middle| j\in B\right)\right)\right\rangle\middle| i\in m\right\}$$

$$A^-=\left\{\left\langle C_j,\left(\left(\min_i \mu_{ij}(C_j)\middle| j\in G\right),\left(\max_i \mu_{ij}(C_j)\middle| j\in B\right)\right),\left(\left(\max_i v_{ij}(C_j)\middle| j\in G\right),\left(\min_i v_{ij}(C_j)\middle| j\in B\right)\right)\right\rangle\middle| i\in m\right\}$$

(16)

Step 5. The distance measures of each alternative A_i from IFPIS and IFNIS.

By using (refer to Szmidt and Kacprzyk, 2001; 2002)

$$d_{IFS}(A_i,A^+)=\sqrt{\sum_{j=1}^n\left[\left(\mu_{A_i}(C_j)-\mu_{A^+}(C_j)\right)^2+\left(v_{A_i}(C_j)-v_{A^+}(C_j)\right)^2+\left(\pi_{A_i}(C_j)-\pi_{A^+}(C_j)\right)^2\right]}$$

$$d_{IFS}(A_i,A^+)=\sqrt{\sum_{j=1}^n\left[\left(\mu_{A_i}(C_j)-\mu_{A^-}(C_j)\right)^2+\left(v_{A_i}(C_j)-v_{A^-}(C_j)\right)^2+\left(\pi_{A_i}(C_j)-\pi_{A^-}(C_j)\right)^2\right]}$$

(17)

Step 6. Determine CC_i and rank the all alternatives' preference order.

The CC_i of each alternative regarding IF ideal solution may be computed by:

$CC_i=d_{IFS}(A_i,A^-)/(d_{IFS}(A_i,A^+)+d_{IFS}(A_i,A^-))$, where $0\le CC_i\le 1, i=1,2,\dots\dots,m$ (18)

The most favoured alternative is one with the highest value of CC_i.

IV. CASE STUDY: DIAGNOSIS OF DIFFERENT TYPE OF DISEASE

Let there is a patient (α^1) in a hospital at Delhi who is suffering from different type of fever due to mosquito's bite. Doctors need to diagnosis the disease. Let us consider disease ξ^C(Chikungunya), ξ^D(Dengue), ξ^M(Malaria) as alternatives with seven criteria, which include S_1 (Fever), S_2 (Joint Pain), S_3 (Chills and Rigors), S_4 Body Rash), S_5 (Retroorbital Head Ache), S_6 (Muscle Pain/ Body Pain), S_7 (vomiting/nausea) for further assignment. For evaluation of appropriate disease, three doctors such as ω^1, ω^2 and ω^3 are approached for getting their opinion.

The committee of medical experts has given their opinion in the form of linguistic term as listed in Table 1(c). Criteria weights for all three disease are presented in Table 1(b) and weightage according to the symptoms of particular patient diagnosed by doctors as shown in Table 1(c). In selection procedure of disease, accompanying weights are allocated to three medicinal specialists: λ_1 = 0.20, λ_2 = 0.35, and λ_3 = 0.45 on the basis of distinctive domain knowledge, background, & expertise.

Step 1. The decision matrix (individual opinion of medical experts)

Now construct an IFDM (collective opinion of experts) using SIFWA operator

Step 2. Determine the CWs Using Eq. (12), the entropy values for criteria S_1, S_2, S_3, S_4, S_5, S_6, S_7 correspondingly are:

E_1 (S_1) =.6993, E_2 (S_2) =.6366, E_3 (S_3) =.7554, E_4 (S_4) =.6756, E_5 (S_5) =.6390, E_6 (S_6) =.6285, E_7 (S_7) =.6803. The degree of divergence $d_j=1-E_{VS}^{IFS}(C_j)$.

Step 3. Obtain 'R' by Eq. (15), the weighted IFDM

Step 4. In present case, criteria S_1, S_2, S_3, S_4, S_5, S_6 fit to benefit and S_7 fit to cost criterion. Using Eq.(16), each alternative's IFPIS (ξ^+) and IFNIS (ξ^-) regarding criteria can be computed as:

ξ^+ = (0.9742, 0.7285), (0.9763, 0.6551), (0.9066, 0.9181), (0.9852, 0.6536), (0.9342, 0.8131), (0.9644, 0.6878), (0.7140, 0.9775)

ξ^- = (0.7920, 0.9662), (0.7544, 0.9593), (0.7728, 0.9828), (0.7105, 0.8929), (0.6230, 0.9835), (0.6145, 0.9830), (0.9693, 0.7246)

Step 5. The distance with alternatives and IF ideal solutions (IFPIS and IFNIS) using Eq. (17)

Step 6. The greater CC_i specifies that an alternative is nearer to IFPIS and beyond from IFNIS concurrently. Thus, ranking order of all alternatives can be calculated according to the descending order of CC_i and most favoured alternative is one with the highest value of CC_i. Using Eq. (18) the CC_i can be obtained.

Table 1(a). Verbal (Linguistic) terms for alternative's and criteria's rating

Poor (P)	(0.05, 0.90)
Fair (F)	(0.50, 0.50)
Strong (S)	(0.80, 0.10)
Very Strong (VS)	(0.90, 0.05)

Table:1(b) Symptom's weight by three experts for each disease

Symptoms	Dengue			Chikungunya			Malaria		
	δ^1	δ^2	δ^3	δ^1	δ^2	δ^3	δ^1	δ^2	δ^3
S_1	VS	VS	VS	S	S	S	S	S	S
S_2	S	S	S	VS	VS	VS	P	P	P
S_3	P	P	P	P	P	P	VS	VS	VS
S_4	S	S	S	S	F	S	P	P	P
S_5	VS	VS	VS	P	P	P	P	P	P
S_6	S	S	S	P	P	P	F	P	F
S_7	P	P	P	P	P	F	P	F	S

Table 1(c). The individual opinion in the decision matrix form on three disease

Symptoms	Doctors	Diseases		
		ξ^C	ξ^D	ξ^M
S_1	δ^1	VG	F	P
	δ^2	S	F	P
	δ^3	S	S	F
S_2	δ^1	VG	F	S
	δ^2	VS	F	S
	δ^3	F	S	F
S_3	δ^1	S	F	P
	δ^2	S	F	S
	δ^3	S	S	F
S_4	δ^1	VS	F	P
	δ^2	VS	F	P
	δ^3	VS	S	P
S_5	δ^1	P	F	P
	δ^2	P	F	F
	δ^3	P	S	P
S_6	δ^1	S	F	P
	δ^2	S	F	P
	δ^3	S	F	F
S_7	δ^1	F	S	P
	δ^2	F	S	P
	δ^3	F	S	P

Table 2. The DOD and CWs

d_1 = .3007	d_2 = .3634	d_3 = .2446	d_4 = .324	d_5 = .3610	d_6 = .3715	d_7 = .3197
W_1 = .1316	W_2 = .1590	W_3 = .1070	W_4 = .1419	W_5 = .1580	W_6 = .1626	W_7 = .1399

Table 3. Weighted IFDM (R)

	S_1	S_2	S3	S_4	S_5	S_6	S_7
P1	(.9742, 0.7285)	(.9763, 0.6551)	(.7728, 0.9828)	(.9852, 0.6536)	(.6230, 0.9835)	(.9644,0.6878)	(.9076,0.9076)
P2	(.9449, 0.8417)	(.7802, 0.9512)	(.8462, 0.9669)	(.9407, 0.8304)	(.9342,0.8131)	(.8934,0.8934)	(.9693,0.7246)
P3	(.7920,0.9662)	(.7544,0.9593)	(.9066,0.9181)	(.7105,0.8929)	(.7558,0.9596)	(.6145,0.9830)	(.7140,0.9775)

Table 4. The distance measure, Closeness coefficient CC_i and rank

Alternatives	$d_{IFS}(\xi_i, \xi^+)$	$d_{IFS}(\xi_i, \xi^-)$	CC_i	*Rank*
ξ^C	2.7062	2.8364	0.5118	1
ξ^D	2.6868	2.5871	0.4905	2
ξ^M	3.0708	2.7969	0.4767	3

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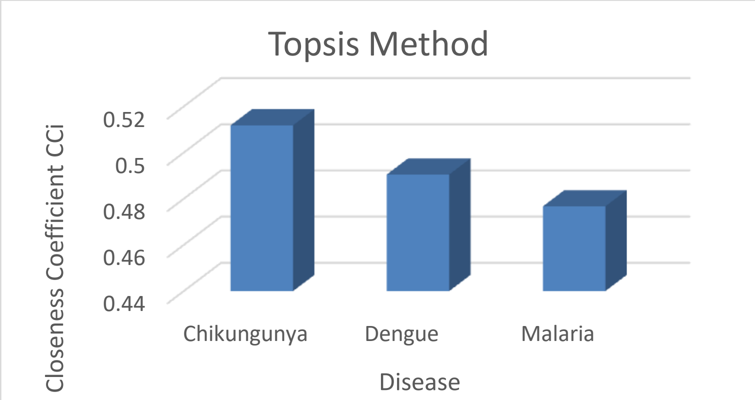

Figure 2: Prediction of diseases using TOPSIS

Table 5. Ranking and disease diagonosis in the patients as below:

Patients	Ranking of disease by TOPSIS	Disease diagnosed
α^1	$\xi^C > \xi^D > \xi^M$	Chikungunya
α^2	$\xi^D > \xi^C > \xi^M$	Dengue
α^3	$\xi^M > \xi^C > \xi^D$	Malaria
α^4	$\xi^C > \xi^D > \xi^M$	Chikungunya

Table 6 (a). SWs of disease and aggregated IFDM

Diseases	S_1	S_2	S_3	S_4	S_5	S_6	S_7
ξ^C	(.82,.09)	(.86,.07)	(.09,.85)	(.90,.05)	(.05,.90)	(.80,.10)	(.50,.50)
ξ^D	(.65,.27)	(.21,.73)	(.21,.73)	(.65,.27)	(.65,.27)	(.50,.50)	(.80,.10)
ξ^M	(.17,.77)	(.17,.77)	(.40,.45)	(.09,.85)	(.17,.77)	(.05,.90)	(.09,.85)
ω_j	(.80,.10)	(.90,.05)	(0.05,0.9)	(.711,.193)	(.05,.649)	(.05,.4709)	(.165,.770)

Table 6(b). Normalized SWs of criteria and NIFDs

Diseases	S_1	S_2	S_3	S_4	S_5	S_6	S_7
ξ^C	0	0	1	0	1	0	.5338
ξ^D	.2639	.9427	.6821	.3008	0	.4762	1
ξ^M	1	1	0	1	.7952	1	0
ω_j^S	.2944	.3138	0.0174	.2604	.0237	.0318	.0585

Table 6(c). OWs of diseases and evaluated IFE values

Weights	S_1	S_2	S_3	S_4	S_5	S_6	S_7
E_j	.6993	.6366	.7554	.5680	.6390	.6285	.6803
ω_j^0	.1257	.1519	.1022	.1805	.1509	.1552	.1336

Table 7(a) S, R and Q values for three diseases

Indexes	ξ^C	ξ^D	ξ^M
S	.1984	.5225	.8262
R	.0873	.2195	.2328
Q	0	.7123	1

Table 7(b) Ranking of three alternatives by S, R and Q

Indexes	ξ^C	ξ^D	ξ^M
S	1	2	3
R	1	2	3
Q	1	2	3

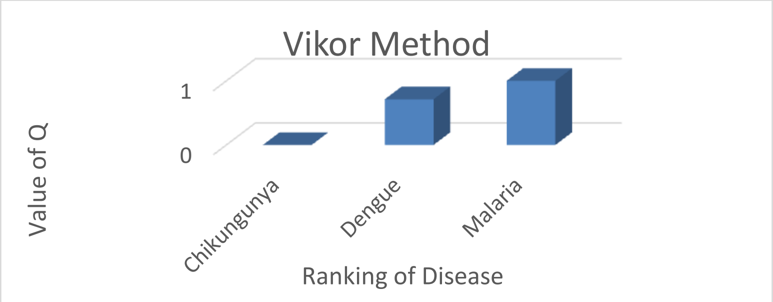

Figure3: Detection of the diseases using VIKOR

Table 7(c). Ranking and disease diagonosis in the patients as below:

Patient	Ranking by VIKOR	Disease
α^1	$\xi^C > \xi^D > \xi^M$	Chikungunya
α^2	$\xi^C > \xi^D > \xi^M$	Dengue
α^3	$\xi^C > \xi^D > \xi^M$	Malaria
α^4	$\xi^C > \xi^D > \xi^M$	Chikungunya

Validation of study

After evaluating the rank of disease by using TOPSIS, the by Opricovic, 1998 and Zhao *et al*. 2017 are used for validating the result. Thus, this technique can be recommended to give solution of disease selection and computational procedure has been discussed as under:

Step 1: We create consolidated IFDM by exploiting SIFWA operator by using 1(a) and 1(b). Relative outcomes have been revealed in Table 6(a)

Step 2: compute collective weightage of each criteria for relevant disease. Then, normalized SWs of criteria have been acquired as showed in Table 6(b).

Step 3: Each criterion's IFE value has been attained based on the OW method and the criteria's OWs have been computed which is presented in Table 6(c).

Step 4: Then S_1 to S_6 are chosen as benefit criteria whereas S_7 is considered as cost criterion. In this manner, we decide the IF positive and negative ideal solution of all criteria ratings as observed beneath.

$\xi^+ =$ (.17, .77), (.17,.77), (.09,.85), (.09,.45), (.05,.90), (.05,.90), (.80,.10)

$\xi^- =$ (.82,.09), (.86,.07), (.40,.45), (.90,.05), (.65,.27), (.80,.10), (.09,.85)

Step 5: we can calculate the NIFDs as shown in Table 6(b)

Step 6: Now S, R and Q values are computed for 3 alternatives, which have been displayed in Table 7(a).

Stage 7: Rankings of three alternatives by S, R and Q values in the ascending order have been presented in Table 7(a).

Step 8: On the basis of Table 7(b) the ranking of the three alternatives is in accordance with the Q value. The lowest Q value will be the most favored alternative while the highest value of Q will be the least favored alternative, or the alternatives can be calculated according to the ascending order of Q. Consequently, ξ^C i.e., Chikungunya is the most likely disease among the other diseases. Table 7(a) shows S, R, and Q values for three diseases. The three alternatives are ranked as a $\xi^C > \xi^D > \xi^M$ and finally patient α^1 has been diagnosed with chikungunya. This proves the confirmation of our suggested technique. As per Table 7(b), ranking of three diseases based on the value of Q. Likewise, for the other three patients, same process has been applied and evaluated, the results are summarized in Table 7(c). From Table 7c it is found by VIKOR method that patients α^1 and α^4 are suffering from chikungunya, whereas, α^2 and α^3 are facing dengue and malaria, respectively.

V. RESULT AND ANALYSIS

By using TOPSIS, the disease like chikungunya has occupied rank 1 among all the diseases and other patients were diagnosed with Dengue, Malaria and Chikungunya respectively. These results are also validated by using fuzzy VIKOR method, where same rank is obtained by the patients with the application of TOPSIS. Therefore, it is validated that the diseases can be better diagnosed with TOPSIS.

VI. CONCLUSION

The distance CC_j of three diseases are useful in providing order of rating among the alternatives. The only difference with respect to classical TOPSIS is that it is associates with objective entropy weight under IF environment. It provides relief to the doctors and also provides benefits to patients in a way that more precise and quickest diagnosis of concerned disease could be possible whereas, the current study has been applied only to four patients. Further, this method can be applied to large database of patients suffering with several types of VBDs to facilitate early diagnosis and immediate treatment. As a large number of people every year get affected with VBD, it becomes necessary to diagnose correct disease in the initial stage itself. So that patients shall get proper and timely treatments, and thus their life and resources may be saved from these types of diseases.

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