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# Single-valued neutrosophic TODIM method based on cumulative prospect theory for multi-attribute group decision making and its application to medical emergency management evaluation

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**ABSTRACT**

In recent years, emergent public health events happen from time to time, which puts forward new requirements for the establishment of a perfect medical emergency system. It is a new direction to evaluate the effectiveness of medical emergency systems from the perspective of multi-attribute group decision making (MAGDM) issues. In such article, we tend to resolve the MAGDM issues under single-valued neutrosophic sets (SVNSs) with TODIM method based on cumulative prospect theory (CPT). And the single-valued neutrosophic TODIM method based on CPT (CPT-SVN-TODIM) for MAGDM issues are developed. This new method not only inherits advantages of classical TODIM method, but also has further improvement in some aspects. For example, we set up the entropy to calculate attribute weights for ensuring the more objective decision-making process. Furthermore, it is also an extension of MAGDM method to utilize single-valued neutrosophic numbers (SVNNs) to depict decision makers' ideas. In addition, we introduce the application of CPT-SVN-TODIM method in the assessment of medical emergency management. And finally, the reliability of CPT-SVN-TODIM method is confirmed by comparing with some other methods.

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## 1. Introduction

The indistinct or indeterminate thing pervades the real world. In 1965, Zadeh (1965) created fuzzy sets which takes advantage of membership functions to present imprecise phenomena. After that, a variety of fuzzy sets become progressively more, such as intuitionistic fuzzy sets (Atanassov, 1986; Zhang, Gao, et al., 2021; Zhao, Wei, Chen, et al., 2021), bipolar fuzzy sets (Wen-Ran, 1994; Zhao, Wei, Guo, et al., 2021), neutrosophic sets (Wang et al., 2010), Pythagorean fuzzy sets (He et al., 2021; Yager,

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2014; Zhao, Wei, Wei, et al., 2021), and picture fuzzy sets (Cuong, 2014). The MADM or MAGDM refers to the decision-making issues of choosing the best alternative or alternative-ranking when considering multiple attributes (Wei, Wei, et al., 2021; Zanon et al., 2021; Zhao, Li, et al., 2021). In traditional MADM or MAGDM, the attribute value is expressed with crisp number (Agrebi & Abed, 2021; Guo et al., 2021; Huang et al., 2021). At present using fuzzy numbers to study MADM or MAGDM problems has been extended to many fields (Lei et al., 2021; Tehreem et al., 2021; Verma, 2021).

The basic concept of neutrosophic set (NS) was built by Smarandache (2002) in 2002. Wang et al. (2010) built the single-valued neutrosophic set (SVNS) for dealing with the difficulty of NS in practical application. Huang (2016) proposed distance formula & similarity formula of SVNSs. Ji et al. (2018) defined frank operations of SVNSs and presented Frank BM (SVNFBM) operator under SVNSs. Wu et al. (2018) investigated the entropy & similarity under SVNSs. Peng et al. (2019) also put forward some power Shapley Choquet average under SVNSs.

In order to study the issue of MADM/MAGDM in-depth, lots of methods were created, such as TODIM method (Gomes et al., 2009; Long et al., 2020), WASPAS method (Davoudabadi et al., 2020; Dorfeshan & Mousavi, 2020), MABAC method, Taxonomy method (Jurkowska, 2014), TOPSIS method (Xu, Ke, et al., 2020) and so on. The design idea of TODIM method is derived from the different attitudes of decision makers towards profit and loss, which makes the method have good applications. Moreover, many scholars combined TODIM method with different fuzzy sets. For example, Xu et al. (2017) developed TODIM method with SVNS information. Liang et al. (2019) built TODIM method under proportional hesitant fuzzy linguistic setting. Liu et al. (2019) focused on fermatean fuzzy linguistic information. Lin et al. (2020) established new TODIM method under hesitant fuzzy linguistic setting. Ji et al. (2020) selected the dual hesitant Pythagorean fuzzy setting to investigate TODIM method. Lu et al. (2020) utilized triangular fuzzy number to express the uncertain information. Sun et al. (2019) proposed a new SVNS distance and utilized it in establishing extended TODIM model and ELECTRE III model. Xu et al. (2019) constructed SVNS TODIM method as the tool for dealing with the decision making in venture capital. Long et al. (2020) also created new TODIM with SVNS and the determination method of weights. Xu, Wei, et al. (2020) chose to improve TODIM method and PROMETHEE method under single-valued neutrosophic environment.

Tian et al. (2019) built TODIM method based on CPT (CPT-TODIM). This method uses the concept of weight function to improve the traditional TODIM. In the traditional TODIM method, relative weights are used to deal with attribute weights, while CPT-TODIM takes advantage of weight functions to express the influence of decision-makers' different attitudes towards gains and losses on attribute weights. To a certain extent, increasing the risk weighting moderately is conducive to the enterprise's risk avoidance and conforms to the enterprise's decision-making requirements. Therefore, in my opinion, CPT-TODIM method has obvious advantages in dealing with multi-attribute decision problems. However, there are few studies using this method and few studies evaluating medical emergency response systems based on this method. Therefore, this paper aims to build the single-valued neutrosophic TODIM based on CPT (CPT-SVN-TODIM) method and discuss its application to evaluation of medical emergency system.

The structure of such paper is given as follows. In the section 2, we introduce the definition of NSs and SVNSs. In addition, we also introduce the CPT-TODIM method. In the section 3, we establish CPT-SVN-TODIM method and demonstrate its calculative procedure including determining attribute weights. In the section 4, we apply this CPT-SVN-TODIM method to evaluation of the medical emergency system. And through the fifth part of the comparative analysis concludes that the CPT-SVN-TODIM method proposed in such paper is with effectiveness.

## 2. Preliminary knowledge

In this section, we introduce the basic knowledge about SVNSs and the CPT-TODIM method.

### 2.1. NSS and SVNSs

**Definition 1** (Smarandache, 2002). A NS $Y$, which consists of truth-membership $\rho_Y(n)$, indeterminacy-membership $\sigma_Y(n)$ and falsity-membership $\lambda_Y(n)$, can be expressed as follows in a fix set $N$

$$Y = \{\langle n, \rho_Y(n), \sigma_Y(n), \lambda_Y(n) | n \in N \rangle\} \tag{1}$$

where $\rho_Y(n)$, $\sigma_Y(n)$, $\lambda_Y(n)$ are lying in $]0^-, 1^+[$ and $0^- \le \sup\rho_Y(n) + \sup\sigma_Y(n) + \sup\lambda_Y(n) \le 3^+$.

Neutrosophic set brings in a new function named as indeterminacy-membership function, but it is hard to apply in practice. Hence, the SVNS is exploited.

**Definition 2** (Wang et al., 2010). A SVNS $Y$ in a fix set $N$ can be expressed as the following form

$$Y = \{\langle n, \rho_Y(n), \sigma_Y(n), \lambda_Y(n) | n \in N \rangle\} \tag{2}$$

where truth-membership $\rho_Y(n)$, indeterminacy-membership $\sigma_Y(n)$ and falsity-membership $\lambda_Y(n)$ all belong to $[0, 1]$ and satisfy $0 \le \rho_Y(n) + \sigma_Y(n) + \lambda_Y(n) \le 3$.

For convenience, we usually use single-valued neutrosophic number (SVNN) $Y = (\rho_Y, \sigma_Y, \lambda_Y)$ in calculating. Moreover, the score and the accuracy function are created to describe relative precision.

**Definition 3** (Zhang et al, 2014). The score function of SVNN $Y = \langle \rho_Y, \sigma_Y, \lambda_Y \rangle$ is

$$S(Y) = \frac{1}{3}(2 + \rho_Y - \sigma_Y - \lambda_Y), \quad S(Y) \in [0, 1] \tag{3}$$

**Definition 4** (Zhang et al., 2014). The accuracy function of SVNN $Y = \langle \rho_Y, \sigma_Y, \lambda_Y \rangle$ is

$$A(Y) = \rho_Y - \lambda_Y, \quad A(Y) \in [-1, 1] \tag{4}$$

**Definition 5** (Zhang et al., 2014). Suppose two SVNNs $Y = \langle \rho_Y, \sigma_Y, \lambda_Y \rangle$ and $X = \langle \rho_X, \sigma_X, \lambda_X \rangle$, $S(Y) > S(X)$ means $Y > X$; if $S(Y) = S(X)$, when $A(Y) > A(X)$ then $Y > X$, and when $A(Y) = A(X)$ then $Y = X$.

**Definition 6** (Wang et al., 2010). Suppose two SVNNs $Y = \langle \rho_Y, \sigma_Y, \lambda_Y \rangle$ and $X = \langle \rho_X, \sigma_X, \lambda_X \rangle$, then the basic operations are given:

1. $Y^c = \langle \lambda_Y, 1 - \sigma_Y, \rho_Y \rangle$;
2. $\mu Y = \langle 1 - (1 - \rho_Y)^\mu, (\sigma_Y)^\mu, (\lambda_Y)^\mu \rangle, \mu > 0$;
3. $(Y)^\mu = \langle (\rho_Y)^\mu, (\sigma_Y)^\mu, 1 - (1 - \lambda_Y)^\mu \rangle, \mu > 0$;
4. $Y \oplus X = \langle \rho_Y + \rho_X - \rho_Y \rho_X, \sigma_Y \sigma_X, \lambda_Y \lambda_X \rangle$;
5. $Y \otimes X = \langle \rho_Y \rho_X, \sigma_Y + \sigma_X - \sigma_Y \sigma_X, \lambda_Y + \lambda_X - \lambda_Y \lambda_X \rangle$;

**Definition 7** (Sahin & Kucuk, 2014). Let $Y = \langle \rho_Y, \sigma_Y, \lambda_Y \rangle$ and $X = \langle \rho_X, \sigma_X, \lambda_X \rangle$ be two SVNNs respectively, the Hamming distance between two given SVNNs is defined by Eq. (5).

$$d(Y, X) = \frac{|\rho_Y - \rho_X| + |\sigma_Y - \sigma_X| + |\lambda_Y - \lambda_X|}{3} \tag{5}$$

**Definition 8** (Zhang et al., 2014). If there is a collection of SVNNs $Y_t = \langle \rho_{Y_t}, \sigma_{Y_t}, \lambda_{Y_t} \rangle$ $(t = 1, 2, ..., l)$ and the weighting vector of $Y_t$ $(t = 1, 2, ..., l)$ is $r = (r_1, r_2, ..., r_l)^T$ where $r_t \geq 0$ and $\sum_{t=1}^{l} r_t = 1$, then the single-valued neutrosophic weighted averaging (SVNWA) operator is:

$$\begin{aligned} \text{SVNWA}_r(Y_1, Y_2, ..., Y_l) &= \bigoplus_{t=1}^{l} (r_t Y_t) \\ &= \left( 1 - \prod_{t=1}^{l} (1 - \rho_{Y_t})^{r_t}, \prod_{t=1}^{l} (\sigma_{Y_t})^{r_t}, \prod_{t=1}^{l} (\lambda_{Y_t})^{r_t} \right) \end{aligned} \tag{6}$$

**Definition 9** (Zhang et al., 2014). If there is a group of SVNNs $Y_t = \langle \rho_{Y_t}, \sigma_{Y_t}, \lambda_{Y_t} \rangle$ $(t = 1, 2, ..., l)$ and the weighting of $Y_t$ $(t = 1, 2, ..., l)$ is $r = (r_1, r_2, ..., r_l)^T$ where $r_t \geq 0$ and $\sum_{t=1}^{l} r_t = 1$, then the single-valued neutrosophic weighted geometric (SVNWG) operator is:

$$\begin{aligned} \text{SVNWG}_r(Y_1, Y_2, ..., Y_l) &= \bigotimes_{t=1}^{l} (Y_t)^{r_t} \\ &= \left( \prod_{t=1}^{l} (\rho_{Y_t})^{r_t}, 1 - \prod_{t=1}^{l} (1 - \sigma_{Y_t})^{r_t}, 1 - \prod_{t=1}^{l} (1 - \lambda_{Y_t})^{r_t} \right) \end{aligned} \tag{7}$$

### 2.2. CPT-TODIM method

In this topic, we introduce the CPT-TODIM method (Tian et al., 2019). There are two collections including the set of alternatives $J = \{J_1, J_2, ..., J_p\}$ and the set of attributes $F = \{F_1, F_2, ..., F_s\}$. The vector of attribute weights is $o = (o_1, o_2, ..., o_s)^T (o_h \geq 0$ and $\sum_{h=1}^{s} o_h = 1)$. At the same time, establish a decision matrix $Q = (q_{mh})_{p \times s}$, in which represents the value of alternative $J_m$ $(m = 1, 2, ..., p)$ under attribute $F_h$ $(h = 1, 2, ..., s)$.

**Step 1.** Compute the modified weights $\delta^*_{mwh}(o_h)$ $(m, w = 1, 2, ..., p; h = 1, 2, ..., s)$ based on Eq. (8) and Eq. (9), where $\alpha$ and $\beta$ as parameters are used to express the curvature of weighting function.

$$\delta_{mwh}(o_h) = \begin{cases} (o_h)^\alpha / \left((o_h)^\alpha + (1 - o_h)^\alpha\right)^{\frac{1}{\alpha}}, & q_{mh} \geq q_{wh} \\ (o_h)^\beta / \left((o_h)^\beta + (1 - o_h)^\beta\right)^{\frac{1}{\beta}}, & q_{mh} < q_{wh} \end{cases} \tag{8}$$

$$\delta^*_{mwh}(o_h) = \frac{\delta_{mwh}(o_h)}{\max\{\delta_{mwb}(o_b) | b \in s\}} \qquad \forall m, w \in p; \;\; h = 1, 2, ..., s; \tag{9}$$

**Step 2.** Acquire the comprehensive predominance $\varsigma(J_m, J_w)$ $(m, w = 1, 2, ..., p)$ by taking advantage of Eq. (10) .

$$\varsigma(J_m, J_w) = \sum_{h=1}^{s} \theta_h(J_m, J_w) \qquad m, w = 1, 2, ..., p \tag{10}$$

where

$$\theta_h(J_m, J_w) = \begin{cases} \dfrac{\delta^*_{mwh}(o_h) \cdot (q_{mh} - q_{wh})^{\partial}}{\sum_{h=1}^{s} \delta^*_{mwh}(o_h)}, & \text{if} \quad q_{mh} > q_{wh} \\ 0 \qquad , & \text{if} \quad q_{mh} = q_{wh} \\ -\omega \cdot \dfrac{\left(\sum_{h=1}^{s} \delta^*_{mwh}(o_h)\right) \cdot (q_{mh} - q_{wh})^{\ell}}{\delta^*_{mwh}(o_h)}, & \text{if} \quad q_{mh} < q_{wh} \end{cases} \tag{11}$$

and $\partial$, $\ell$ and $\omega$ are the parameters.

**Step 3.** Calculate the overall predominance $\xi(J_m)$ $(m = 1, 2, ..., p)$ by applying Eq. (12).

$$\xi(J_m) = \frac{\sum_{w=1}^{p} \varsigma(J_m, J_w) - \min_m \left\{ \sum_{w=1}^{p} \varsigma(J_m, J_w) \right\}}{\max_m \left\{ \sum_{w=1}^{p} \varsigma(J_m, J_w) \right\} - \min_m \left\{ \sum_{w=1}^{p} \varsigma(J_m, J_w) \right\}} \qquad m = 1, 2, ..., p \tag{12}$$

**Step 4.** According to the overall predominance $\xi(J_m)$ $(m = 1, 2, ..., p)$, rank all alternatives and the most optimal alternative with the biggest value of overall predominance.

## 3. Single-valued neutrosophic TODIM method for MAGDM based on CPT

Based on the above TODIM method and SVNSs, we create the CPT-SVN-TODIM method which is expounded in this section for resolving the issue of MAGDM. There are three sets of information: the set of alternatives $J = \{J_1, J_2, ..., J_p\}$, the set of attributes $F = \{F_1, F_2, ..., F_s\}$ and the set of decision makers $D = \{D_1, D_2, ..., D_l\}$. About the decision maker $D_t$, $u_{mh}^{(t)}$ expresses the evaluation of the alternative $J_m$ about the attribute $F_h$. Gathering the assessment of decision maker $D_t$ for every alternative in every attribute, we can get single-valued neutrosophic decision matrix $U^{(t)} = (u_{mh}^{(t)})_{p\times s} = (\langle \rho_{mh}^{(t)}, \sigma_{mh}^{(t)}, \lambda_{mh}^{(t)} \rangle)_{p\times s}$, where $\rho_{mh}^{(t)}$, $\sigma_{mh}^{(t)}$ as well as $\lambda_{mh}^{(t)}$ respectively indicate truth-membership, indeterminacy-membership and falsity-membership and satisfy $\rho_{mh}^{(t)}, \sigma_{mh}^{(t)}, \lambda_{mh}^{(t)} \in [0, 1]$ and $0 \leq \rho_{mh}^{(t)} + \sigma_{mh}^{(t)} + \lambda_{mh}^{(t)} \leq 3(m = 1, 2, ..., p, h = 1, 2, ..., \ s, t = 1, 2, ..., l)$. Furthermore, the weighting values of DMs is $r = (r_1, r_2, ..., r_l)^T (r_t \geq 0$ and $\sum_{t=1}^{l} r_t = 1)$.

First of all, keep unification of attributes with different characters by using the Eq. (13) and make up the standardized single-valued neutrosophic decision matrix $\tilde{U}^{(t)} = (u_{mh}^{(t)})_{p\times s}$ $(m = 1, 2, ..., p; h = 1, 2, ..., s; t = 1, 2, ..., l)$.

$$\tilde{u}_{mh}^{(t)} = \langle \tilde{\rho}_{mh}^{(t)}, \tilde{\sigma}_{mh}^{(t)}, \tilde{\lambda}_{mh}^{(t)} \rangle = \begin{cases} u_{mh}^{(t)} = \langle \rho_{mh}^{(t)}, \sigma_{mh}^{(t)}, \lambda_{mh}^{(t)} \rangle & , \quad F_h \text{ is a positive attribute} \\ \left( \tilde{u}_{mh}^{(t)} \right)^c = \langle \lambda_{mh}^{(t)}, 1 - \sigma_{mh}^{(t)}, \rho_{mh}^{(t)} \rangle & , \quad F_h \text{ is a negative attribute} \end{cases} \tag{13}$$

The foundation of the follow-up work is to integrate all decision matrices from different decision makers into one group decision matrix $\tilde{Q} = (\tilde{q}_{mh})_{p\times s} (m = 1, 2, ..., p;$ $h = 1, 2, ..., s)$. The Eq. (14) can help us to finish it.

$$\begin{aligned} \tilde{q}_{mh} = \langle \tilde{a}_{mh}, \tilde{z}_{mh}, \tilde{b}_{mh} \rangle &= SVNWA_r(\tilde{u}_{mh}^{(1)}, \tilde{u}_{mh}^{(2)}, ..., \tilde{u}_{mh}^{(l)}) = \bigoplus_{t=1}^{l} \left( r_t \tilde{u}_{mh}^{(t)} \right) \\ &= \langle 1 - \prod_{t=1}^{l} \left( 1 - \tilde{\rho}_{mh}^{(t)} \right)^{r_t}, \prod_{t=1}^{l} \left( \tilde{\sigma}_{mh}^{(t)} \right)^{r_t}, \prod_{t=1}^{l} \left( \tilde{\lambda}_{mh}^{(t)} \right)^{r_t} \rangle \end{aligned} \tag{14}$$

Attribute weights is a prerequisite for guaranteeing more impersonal consequence. Therefore, we select the single-valued neutrosophic entropy (Wu et al., 2018) to analyze the information of group decision matrix $\tilde{Q} = (\tilde{q}_{mh})_{p\times s} (m = 1, 2, ..., p; \ h = 1, 2, ..., s)$ and achieve the initial weighting vector of attributes $o=(o_1,o_2,\ldots,o_s)^T(o_h\geq 0$ and $\sum_{h=1}^{s}o_h=1)$ which is figured out by Eqs. (15)–(17).

$$E_{mh}(\tilde{q}_{mh})=\frac{1}{3(\sqrt{2}-1)}\left[\begin{array}{c}\left(\sqrt{2}\cos\dfrac{\pi(2\tilde{a}_{mh}-1)}{4}-1\right)+\\ \left(\sqrt{2}\cos\dfrac{\pi(2\tilde{z}_{mh}-1)}{4}-1\right)+\\ \left(\sqrt{2}\cos\dfrac{\pi\left(2\tilde{b}_{mh}-1\right)}{4}-1\right)\end{array}\right] \tag{15}$$

$$\tilde{E}_h=\frac{1}{p}\sum_{m=1}^{p}E_{mh}(\tilde{q}_{mh}),\qquad h=1,2,\ldots,s \tag{16}$$

$$o_h=\frac{1-\tilde{E}_h}{\sum_{h=1}^{s}\left(1-\tilde{E}_h\right)},\qquad h=1,2,\ldots,s \tag{17}$$

The weighting function (18) and Eq. (19) are taking advantage of disposing the initial weighting vector of attributes $o=(o_1,o_2,\ldots,o_s)^T$ to obtain the modified weights $\delta^*_{mwh}(o_h)$ $(m,w=1,2,\ldots,p;\ h=1,2,\ldots,s)$.

$$\delta_{mwh}(o_h)=\begin{cases}(o_h)^{\alpha}/\left((o_h)^{\alpha}+(1-o_h)^{\alpha}\right)^{\frac{1}{\alpha}}, & \tilde{q}_{mh}\geq\tilde{q}_{wh}\\ (o_h)^{\beta}/\left((o_h)^{\beta}+(1-o_h)^{\beta}\right)^{\frac{1}{\beta}}, & \tilde{q}_{mh}<\tilde{q}_{wh}\end{cases} \tag{18}$$

$$\delta^*_{mwh}(o_h)=\frac{\delta_{mwh}(o_h)}{\max\left\{\delta_{mwb}(o_b)|b\in s\right\}}\qquad \forall m,w\in p;\ \ h=1,2,\ldots,s; \tag{19}$$

Then, based on the modified weights and the distance equation (Eq. (20)), we have ability to calculate the relative predominance $\theta_h(J_m,J_w)$ of alternative $J_m$ compared with $J_w$ underneath the attribute $F_h$.

$$d_h(J_m,J_w)=\frac{|\tilde{a}_{mh}-\tilde{a}_{wh}|+|\tilde{z}_{mh}-\tilde{z}_{wh}|+\left|\tilde{b}_{mh}-\tilde{b}_{wh}\right|}{3},\qquad m,w=1,2,\ldots,p \tag{20}$$

$$\theta_h(J_m,J_w)=\begin{cases}\dfrac{\delta^*_{mwh}(o_h)\cdot(d_h(J_m,J_w))^{\partial}}{\sum_{h=1}^{s}\delta^*_{mwh}(o_h)}, & \text{if}\ \ \tilde{q}_{mh}>\tilde{q}_{wh}\\ 0, & \text{if}\ \ \tilde{q}_{mh}=\tilde{q}_{wh}\\ -\omega\cdot\dfrac{\left(\sum_{h=1}^{s}\delta^*_{mwh}(o_h)\right)\cdot(d_h(J_m,J_w))^{\ell}}{\delta^*_{mwh}(o_h)}, & \text{if}\ \ \tilde{q}_{mh}<\tilde{q}_{wh}\end{cases} \tag{21}$$

where $\partial$, $\ell$ and $\omega$ are the parameters. And the relative predominance $\theta_h(J_m,J_w)$ can be gathered in the relative predominance matrix $\theta_h=(\theta_h(J_m,J_w))_{p\times p}$, just as:

$$\theta_h = (\theta_h(J_m, J_w))_{p\times p} = \begin{array}{c} \\ J_1 \\ J_2 \\ \vdots \\ J_p \end{array} \begin{array}{c} \begin{array}{cccc} J_1 & J_2 & \cdots & J_p \end{array} \\ \begin{pmatrix} 0 & \theta_h(J_1, J_2) & \cdots & \theta_h(J_1, J_p) \\ \theta_h(J_2, J_1) & 0 & \cdots & \theta_h(J_2, J_p) \\ \vdots & \vdots & \ddots & \vdots \\ \theta_h(J_p, J_1) & \theta_h(J_p, J_2) & \cdots & 0 \end{pmatrix} \end{array} \quad h = 1, 2, \ldots, s \tag{22}$$

The overall predominance matrix $\varsigma = (\varsigma(J_m, J_w))_{p\times p}(m, w = 1, 2, \ldots, p)$ is adding all relative predominance matrices together.

$$\varsigma = (\varsigma(J_m, J_w))_{p\times p} = \begin{array}{c} \\ J_1 \\ J_2 \\ \vdots \\ J_p \end{array} \begin{array}{c} \begin{array}{cccc} J_1 & J_2 & \cdots & J_p \end{array} \\ \begin{pmatrix} 0 & \varsigma(J_1, J_2) & \cdots & \varsigma(J_1, J_p) \\ \varsigma(J_2, J_1) & 0 & \cdots & \varsigma(J_2, J_p) \\ \vdots & \vdots & \ddots & \vdots \\ \varsigma(J_p, J_1) & \varsigma(J_p, J_2) & \cdots & 0 \end{pmatrix} \end{array} \quad h = 1, 2, \ldots, s \tag{23}$$

Except for the diagonal elements, each element of overall predominance matrix $\varsigma = (\varsigma(J_m, J_w))_{p\times p}$ is computing by Eq. (24).

$$\varsigma(J_m, J_w) = \sum_{h=1}^{s} \theta_h(J_m, J_w) \qquad m, w = 1, 2, \ldots, p \tag{24}$$

Finally, the standard overall predominance $\xi(J_m)$ $(m = 1, 2, \ldots, p)$ of the alternative $J_m$ over all others is determined according to Eq. (25).

$$\xi(J_m) = \frac{\sum_{w=1}^{p}\varsigma(J_m, J_w) - \min_m\left\{\sum_{w=1}^{p}\varsigma(J_m, J_w)\right\}}{\max_m\left\{\sum_{w=1}^{p}\varsigma(J_m, J_w)\right\} - \min_m\left\{\sum_{w=1}^{p}\varsigma(J_m, J_w)\right\}} \qquad m = 1, 2, \ldots, p \tag{25}$$

The standard overall predominance value of the optimal alternative is equivalent to 1.

To sum up, the CPT-SVN-TODIM method includes the following steps:

**Step 1.** Build the single-valued neutrosophic decision matrix $U^{(t)} = (u_{mh}^{(t)})_{p\times s} = (\langle \rho_{mh}^{(t)}, \sigma_{mh}^{(t)}, \lambda_{mh}^{(t)} \rangle)_{p\times s}$.
**Step 2.** Take advantage of the Eq. (13) to ensure the unification of all of attributes.
**Step 3.** Integrate all single-valued neutrosophic decision matrices into group decision matrix $\tilde{Q} = (\tilde{q}_{mh})_{p\times s}$ with respect to Eq. (14).
**Step 4.** Acquire the modified weights $\delta_{mwh}^{*}(o_h)$ on the basis of Eqs. (15)–(19).
**Step 5.** Figure out the relative predominance $\theta_h(J_m, J_w)$ according to Eqs. (20) and (21).
**Step 6.** Determine the overall predominance $\varsigma(J_m, J_w)$ in line with Eq. (24).
**Step 7.** Calculate the standard overall predominance $\xi(J_m)$ by using Eq. (25).

**Step 8.** Obtain the order of alternatives by means of sorting the standard overall predominance $\xi(J_m)$ in descending order.

## 4. Numerical instance

Earthquake, in view of its great destructive power, huge difficulty in forecasting and the consequent influence upon social order, needs us to be fully aware of the importance of medical aid in disaster rescue. With the development of society, human beings have put forward higher and higher demands on the need and ability to provide health security. Especially when life is threatened, they are eager to receive timely and efficient emergency assistance. Therefore, it is of great practical significance to reduce disasters and improve the efficiency of medical rescue at the beginning of the new century. In order to testify this new CPT-SVN-TODIM method, we apply this new proposed method to the assessment of medical emergency management. Now there are five regions' medical emergency systems $J_m(m = 1, 2, 3, 4, 5)$ awaiting evaluation. Five experts $D_t(t = 1, 2, 3, 4, 5)$ are invited to analyze six aspects of these systems. Additionally, the weighting vector of experts is $r = (r_1, r_2, r_3, r_4, r_5)^T = (0.17, 0.20, 0.18, 0.23, 0.22)^T$. And then the six attributes respectively are: (1) $F_1$ is the diagnostic testing capability; (2)$F_2$ is the awareness of risk information; (3)$F_3$ is the capability to process different sources of information; (4)$F_4$ is the immunity from interference in analyzing information; (5)$F_5$ is the capability of precision positioning; (6)$F_6$ is the heterogeneous team coordination ability. Each expert's assessment is shown in the Tables 1–5.

Based on the above information, by using Eqs. (13) and (15), the single-valued neutrosophic group decision matrix $\tilde{Q} = (\tilde{q}_{mh})_{5\times6}$ is obtained successfully, which is demonstrated in Table 6.

Because the weight information is completely unknown, we use the entropy weight method, Eqs. (15)–(17), analyzing the information of group decision matrix and working out the original attribute weights $o_1 = 0.2187, o_2 = 0.2272, o_3 = 0.2083, o_4 = 0.1245$, $o_5 = 0.1192, o_6 = 0.1020$. Then Eqs. (18) and (19) are used to compute the modified weights $\delta^*_{mwh}(o_h)(m, w = 1, 2, 3, 4, 5; h = 1, 2, 3, 4)$, as listed in Tables 7–11. ($\alpha = 0.61$, $\beta = 0.69$, based on the experiment of Tversky & Kahneman (1992))

Suppose $\partial = 0.88$, $\ell = 0.88$ and $\omega = 2.25$ (Tversky & Kahneman, 1992), according to distances shown in Table 12, as well as the modified weights, we can acquire

**Table 1.** Decision matrix $U^{(1)}$ given by the expert $D_1$.

| | $F_1$ | $F_2$ | $F_3$ |
|---|---|---|---|
| $J_1$ | $\langle 0.70, 0.25, 0.30 \rangle$ | $\langle 0.15, 0.65, 0.85 \rangle$ | $\langle 0.25, 0.65, 0.70 \rangle$ |
| $J_2$ | $\langle 0.65, 0.30, 0.35 \rangle$ | $\langle 0.55, 0.45, 0.50 \rangle$ | $\langle 0.75, 0.20, 0.15 \rangle$ |
| $J_3$ | $\langle 0.60, 0.45, 0.40 \rangle$ | $\langle 0.60, 0.40, 0.45 \rangle$ | $\langle 0.70, 0.25, 0.30 \rangle$ |
| $J_4$ | $\langle 0.45, 0.40, 0.55 \rangle$ | $\langle 0.35, 0.65, 0.70 \rangle$ | $\langle 0.55, 0.60, 0.65 \rangle$ |
| $J_5$ | $\langle 0.55, 0.60, 0.40 \rangle$ | $\langle 0.40, 0.55, 0.65 \rangle$ | $\langle 0.60, 0.50, 0.45 \rangle$ |
| | $F_4$ | $F_5$ | $F_6$ |
| $J_1$ | $\langle 0.65, 0.45, 0.50 \rangle$ | $\langle 0.65, 0.50, 0.45 \rangle$ | $\langle 0.70, 0.25, 0.35 \rangle$ |
| $J_2$ | $\langle 0.65, 0.40, 0.50 \rangle$ | $\langle 0.60, 0.55, 0.50 \rangle$ | $\langle 0.65, 0.40, 0.35 \rangle$ |
| $J_3$ | $\langle 0.60, 0.50, 0.55 \rangle$ | $\langle 0.70, 0.30, 0.35 \rangle$ | $\langle 0.60, 0.55, 0.45 \rangle$ |
| $J_4$ | $\langle 0.45, 0.65, 0.60 \rangle$ | $\langle 0.65, 0.50, 0.45 \rangle$ | $\langle 0.35, 0.60, 0.65 \rangle$ |
| $J_5$ | $\langle 0.70, 0.30, 0.35 \rangle$ | $\langle 0.45, 0.65, 0.60 \rangle$ | $\langle 0.55, 0.45, 0.40 \rangle$ |

Source: Ours.

**Table 2.** Decision matrix $U^{(2)}$ given by the expert $D_2$.

| | $F_1$ | $F_2$ | $F_3$ |
|---|---|---|---|
| $J_1$ | $\langle 0.65, 0.35, 0.40\rangle$ | $\langle 0.35, 0.65, 0.70\rangle$ | $\langle 0.35, 0.55, 0.65\rangle$ |
| $J_2$ | $\langle 0.70, 0.25, 0.20\rangle$ | $\langle 0.65, 0.40, 0.35\rangle$ | $\langle 0.80, 0.10, 0.15\rangle$ |
| $J_3$ | $\langle 0.65, 0.30, 0.35\rangle$ | $\langle 0.50, 0.55, 0.45\rangle$ | $\langle 0.70, 0.25, 0.30\rangle$ |
| $J_4$ | $\langle 0.50, 0.45, 0.45\rangle$ | $\langle 0.40, 0.65, 0.60\rangle$ | $\langle 0.60, 0.35, 0.40\rangle$ |
| $J_5$ | $\langle 0.60, 0.50, 0.45\rangle$ | $\langle 0.35, 0.70, 0.60\rangle$ | $\langle 0.55, 0.45, 0.65\rangle$ |
| | $F_4$ | $F_5$ | $F_6$ |
| $J_1$ | $\langle 0.60, 0.45, 0.50\rangle$ | $\langle 0.55, 0.40, 0.45\rangle$ | $\langle 0.70, 0.25, 0.35\rangle$ |
| $J_2$ | $\langle 0.60, 0.45, 0.50\rangle$ | $\langle 0.70, 0.25, 0.35\rangle$ | $\langle 0.65, 0.40, 0.35\rangle$ |
| $J_3$ | $\langle 0.45, 0.65, 0.60\rangle$ | $\langle 0.65, 0.50, 0.45\rangle$ | $\langle 0.60, 0.45, 0.40\rangle$ |
| $J_4$ | $\langle 0.50, 0.55, 0.60\rangle$ | $\langle 0.60, 0.55, 0.50\rangle$ | $\langle 0.45, 0.55, 0.50\rangle$ |
| $J_5$ | $\langle 0.75, 0.20, 0.25\rangle$ | $\langle 0.50, 0.45, 0.65\rangle$ | $\langle 0.50, 0.55, 0.60\rangle$ |

Source: Ours.

**Table 3.** Decision matrix $U^{(3)}$ given by the expert $D_3$.

| | $F_1$ | $F_2$ | $F_3$ |
|---|---|---|---|
| $J_1$ | $\langle 0.55, 0.60, 0.40\rangle$ | $\langle 0.20, 0.60, 0.80\rangle$ | $\langle 0.30, 0.65, 0.75\rangle$ |
| $J_2$ | $\langle 0.65, 0.30, 0.35\rangle$ | $\langle 0.65, 0.40, 0.35\rangle$ | $\langle 0.60, 0.45, 0.50\rangle$ |
| $J_3$ | $\langle 0.75, 0.20, 0.20\rangle$ | $\langle 0.60, 0.35, 0.40\rangle$ | $\langle 0.65, 0.35, 0.45\rangle$ |
| $J_4$ | $\langle 0.35, 0.65, 0.60\rangle$ | $\langle 0.35, 0.65, 0.70\rangle$ | $\langle 0.55, 0.50, 0.65\rangle$ |
| $J_5$ | $\langle 0.50, 0.45, 0.45\rangle$ | $\langle 0.30, 0.70, 0.65\rangle$ | $\langle 0.45, 0.65, 0.50\rangle$ |
| | $F_4$ | $F_5$ | $F_6$ |
| $J_1$ | $\langle 0.50, 0.60, 0.65\rangle$ | $\langle 0.60, 0.55, 0.50\rangle$ | $\langle 0.75, 0.20, 0.30\rangle$ |
| $J_2$ | $\langle 0.65, 0.35, 0.45\rangle$ | $\langle 0.65, 0.50, 0.45\rangle$ | $\langle 0.70, 0.25, 0.35\rangle$ |
| $J_3$ | $\langle 0.65, 0.35, 0.45\rangle$ | $\langle 0.60, 0.55, 0.50\rangle$ | $\langle 0.65, 0.40, 0.35\rangle$ |
| $J_4$ | $\langle 0.55, 0.45, 0.65\rangle$ | $\langle 0.45, 0.65, 0.60\rangle$ | $\langle 0.40, 0.60, 0.55\rangle$ |
| $J_5$ | $\langle 0.40, 0.55, 0.65\rangle$ | $\langle 0.35, 0.65, 0.70\rangle$ | $\langle 0.55, 0.45, 0.40\rangle$ |

Source: Ours.

**Table 4.** Decision matrix $U^{(4)}$ given by the expert $D_4$.

| | $F_1$ | $F_2$ | $F_3$ |
|---|---|---|---|
| $J_1$ | $\langle 0.65, 0.35, 0.40\rangle$ | $\langle 0.25, 0.60, 0.75\rangle$ | $\langle 0.40, 0.55, 0.65\rangle$ |
| $J_2$ | $\langle 0.80, 0.10, 0.15\rangle$ | $\langle 0.70, 0.20, 0.25\rangle$ | $\langle 0.75, 0.20, 0.15\rangle$ |
| $J_3$ | $\langle 0.65, 0.25, 0.35\rangle$ | $\langle 0.75, 0.20, 0.20\rangle$ | $\langle 0.65, 0.35, 0.40\rangle$ |
| $J_4$ | $\langle 0.70, 0.20, 0.30\rangle$ | $\langle 0.45, 0.50, 0.55\rangle$ | $\langle 0.45, 0.55, 0.60\rangle$ |
| $J_5$ | $\langle 0.60, 0.40, 0.50\rangle$ | $\langle 0.40, 0.55, 0.65\rangle$ | $\langle 0.35, 0.65, 0.70\rangle$ |
| | $F_4$ | $F_5$ | $F_6$ |
| $J_1$ | $\langle 0.60, 0.45, 0.55\rangle$ | $\langle 0.50, 0.55, 0.60\rangle$ | $\langle 0.70, 0.25, 0.35\rangle$ |
| $J_2$ | $\langle 0.50, 0.65, 0.60\rangle$ | $\langle 0.80, 0.15, 0.20\rangle$ | $\langle 0.60, 0.50, 0.45\rangle$ |
| $J_3$ | $\langle 0.65, 0.35, 0.45\rangle$ | $\langle 0.70, 0.25, 0.35\rangle$ | $\langle 0.65, 0.45, 0.40\rangle$ |
| $J_4$ | $\langle 0.65, 0.40, 0.50\rangle$ | $\langle 0.65, 0.45, 0.50\rangle$ | $\langle 0.50, 0.55, 0.60\rangle$ |
| $J_5$ | $\langle 0.70, 0.25, 0.35\rangle$ | $\langle 0.50, 0.55, 0.60\rangle$ | $\langle 0.45, 0.55, 0.50\rangle$ |

Source: Ours.

the relative predominance matrix $\theta_h = (\theta_h(J_m, J_w))_{5\times5}$ $(h = 1, 2, 3, 4, 5, 6)$ under different attributes for each of the two alternatives.

$$\theta_1 = (\theta_1(J_m, J_w))_{5\times5} = \begin{array}{c} \\ J_1 \\ J_2 \\ J_3 \\ J_4 \\ J_5 \end{array} \begin{array}{c} \begin{array}{ccccc} J_1 & J_2 & J_3 & J_4 & J_5 \end{array} \\ \begin{pmatrix} 0 & -2.1350 & -0.7683 & 0.0100 & 0.0856 \\ 0.0362 & 0 & -0.0260 & 0.0403 & 0.0540 \\ 0.0130 & -1.5314 & 0 & 0.0179 & 0.0327 \\ -0.5906 & -2.3718 & -1.0553 & 0 & 0.0180 \\ -1.3201 & -3.1853 & -1.9271 & -1.0591 & 0 \end{pmatrix} \end{array}$$

**Table 5.** Decision matrix $U^{(5)}$ given by the expert $D_5$.

| | $F_1$ | $F_2$ | $F_3$ |
|---|---|---|---|
| $J_1$ | $\langle 0.55, 0.35, 0.50\rangle$ | $\langle 0.35, 0.70, 0.60\rangle$ | $\langle 0.45, 0.65, 0.50\rangle$ |
| $J_2$ | $\langle 0.75, 0.15, 0.20\rangle$ | $\langle 0.70, 0.20, 0.25\rangle$ | $\langle 0.70, 0.25, 0.30\rangle$ |
| $J_3$ | $\langle 0.60, 0.40, 0.50\rangle$ | $\langle 0.60, 0.35, 0.40\rangle$ | $\langle 0.65, 0.45, 0.35\rangle$ |
| $J_4$ | $\langle 0.65, 0.25, 0.35\rangle$ | $\langle 0.25, 0.60, 0.75\rangle$ | $\langle 0.50, 0.70, 0.65\rangle$ |
| $J_5$ | $\langle 0.55, 0.50, 0.60\rangle$ | $\langle 0.20, 0.65, 0.75\rangle$ | $\langle 0.40, 0.60, 0.65\rangle$ |
| | $F_4$ | $F_5$ | $F_6$ |
| $J_1$ | $\langle 0.65, 0.35, 0.45\rangle$ | $\langle 0.70, 0.35, 0.25\rangle$ | $\langle 0.65, 0.40, 0.35\rangle$ |
| $J_2$ | $\langle 0.65, 0.45, 0.35\rangle$ | $\langle 0.75, 0.30, 0.25\rangle$ | $\langle 0.55, 0.45, 0.50\rangle$ |
| $J_3$ | $\langle 0.70, 0.25, 0.35\rangle$ | $\langle 0.65, 0.40, 0.35\rangle$ | $\langle 0.45, 0.55, 0.50\rangle$ |
| $J_4$ | $\langle 0.55, 0.45, 0.65\rangle$ | $\langle 0.50, 0.55, 0.60\rangle$ | $\langle 0.60, 0.50, 0.45\rangle$ |
| $J_5$ | $\langle 0.80, 0.10, 0.15\rangle$ | $\langle 0.60, 0.50, 0.45\rangle$ | $\langle 0.50, 0.55, 0.60\rangle$ |

Source: Ours.

**Table 6.** Group decision matrix $\tilde{Q}$.

| | $F_1$ | $F_2$ | $F_3$ |
|---|---|---|---|
| $J_1$ | $\langle 0.6230, 0.3642, 0.4001\rangle$ | $\langle 0.2701, 0.6394, 0.7278\rangle$ | $\langle 0.3613, 0.6049, 0.6375\rangle$ |
| $J_2$ | $\langle 0.7229, 0.1929, 0.2277\rangle$ | $\langle 0.6592, 0.2987, 0.3196\rangle$ | $\langle 0.7292, 0.2116, 0.2170\rangle$ |
| $J_3$ | $\langle 0.6530, 0.3052, 0.3502\rangle$ | $\langle 0.6246, 0.3446, 0.3562\rangle$ | $\langle 0.6694, 0.3266, 0.3567\rangle$ |
| $J_4$ | $\langle 0.5621, 0.3436, 0.4227\rangle$ | $\langle 0.3647, 0.6013, 0.6519\rangle$ | $\langle 0.5289, 0.5286, 0.5791\rangle$ |
| $J_5$ | $\langle 0.5640, 0.4807, 0.4814\rangle$ | $\langle 0.3322, 0.5971, 0.6601\rangle$ | $\langle 0.4698, 0.5675, 0.5925\rangle$ |
| | $F_4$ | $F_5$ | $F_6$ |
| $J_1$ | $\langle 0.6047, 0.4484, 0.5235\rangle$ | $\langle 0.6044, 0.4597, 0.4306\rangle$ | $\langle 0.6997, 0.2663, 0.3404\rangle$ |
| $J_2$ | $\langle 0.6098, 0.4588, 0.4730\rangle$ | $\langle 0.7165, 0.2997, 0.3177\rangle$ | $\langle 0.6290, 0.3971, 0.4011\rangle$ |
| $J_3$ | $\langle 0.6212, 0.3909, 0.4667\rangle$ | $\langle 0.6629, 0.3786, 0.3924\rangle$ | $\langle 0.5938, 0.4764, 0.4184\rangle$ |
| $J_4$ | $\langle 0.5512, 0.4853, 0.5941\rangle$ | $\langle 0.5782, 0.5325, 0.5283\rangle$ | $\langle 0.4757, 0.5552, 0.5419\rangle$ |
| $J_5$ | $\langle 0.7003, 0.2323, 0.3036\rangle$ | $\langle 0.4928, 0.5486, 0.5884\rangle$ | $\langle 0.5074, 0.5127, 0.4992\rangle$ |

Source: Ours.

**Table 7.** The modified weights $\delta^*_{1wh}(o_h)$.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ |
|---|---|---|---|---|---|---|
| $\delta^*_{12}$ | 0.9776 | 1.0000 | 0.9497 | 0.6998 | 0.6819 | 0.6785 |
| $\delta^*_{13}$ | 0.9776 | 1.0000 | 0.9497 | 0.6998 | 0.6819 | 0.6785 |
| $\delta^*_{14}$ | 0.9823 | 1.0000 | 0.9497 | 0.7479 | 0.7323 | 0.6785 |
| $\delta^*_{15}$ | 0.9823 | 1.0000 | 0.9497 | 0.6998 | 0.7323 | 0.6785 |

Source: Ours.

**Table 8.** The modified weights $\delta^*_{2wh}(o_h)$.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ |
|---|---|---|---|---|---|---|
| $\delta^*_{21}$ | 0.9816 | 1.0000 | 0.9586 | 0.7474 | 0.7318 | 0.6206 |
| $\delta^*_{23}$ | 0.9816 | 1.0000 | 0.9586 | 0.6993 | 0.7318 | 0.6781 |
| $\delta^*_{24}$ | 0.9816 | 1.0000 | 0.9586 | 0.7474 | 0.7318 | 0.6781 |
| $\delta^*_{25}$ | 0.9816 | 1.0000 | 0.9586 | 0.6993 | 0.7318 | 0.6781 |

Source: Ours.

**Table 9.** The modified weights $\delta^*_{3wh}(o_h)$.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ |
|---|---|---|---|---|---|---|
| $\delta^*_{31}$ | 0.9816 | 1.0000 | 0.9586 | 0.7474 | 0.7318 | 0.6206 |
| $\delta^*_{32}$ | 0.9776 | 1.0000 | 0.9497 | 0.7479 | 0.6819 | 0.6211 |
| $\delta^*_{34}$ | 0.9816 | 1.0000 | 0.9586 | 0.7474 | 0.7318 | 0.6781 |
| $\delta^*_{35}$ | 0.9816 | 1.0000 | 0.9586 | 0.6993 | 0.7318 | 0.6781 |

Source: Ours.

**Table 10.** The modified weights $\delta^*_{4wh}(o_h)$.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ |
|---|---|---|---|---|---|---|
| $\delta^*_{41}$ | 0.9769 | 1.0000 | 0.9586 | 0.6993 | 0.6815 | 0.6206 |
| $\delta^*_{42}$ | 0.9776 | 1.0000 | 0.9497 | 0.6998 | 0.6819 | 0.6211 |
| $\delta^*_{43}$ | 0.9776 | 1.0000 | 0.9497 | 0.6998 | 0.6819 | 0.6211 |
| $\delta^*_{45}$ | 0.9816 | 1.0000 | 0.9586 | 0.6993 | 0.7318 | 0.6206 |

Source: Ours.

**Table 11.** The modified weights $\delta^*_{5wh}(o_h)$.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ |
|---|---|---|---|---|---|---|
| $\delta^*_{51}$ | 0.9769 | 1.0000 | 0.9586 | 0.7474 | 0.6815 | 0.6206 |
| $\delta^*_{52}$ | 0.9776 | 1.0000 | 0.9497 | 0.7479 | 0.6819 | 0.6211 |
| $\delta^*_{53}$ | 0.9776 | 1.0000 | 0.9497 | 0.7479 | 0.6819 | 0.6211 |
| $\delta^*_{54}$ | 0.9776 | 1.0000 | 0.9497 | 0.7479 | 0.6819 | 0.6785 |

Source: Ours.

**Table 12.** Distance between each of the two alternatives.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ |
|---|---|---|---|---|---|---|
| $d_h(J_1, J_2)$ | 0.1479 | 0.3793 | 0.3939 | 0.0220 | 0.1283 | 0.0874 |
| $d_h(J_1, J_3)$ | 0.0463 | 0.3403 | 0.2891 | 0.0436 | 0.0592 | 0.1313 |
| $d_h(J_1, J_4)$ | 0.0347 | 0.0695 | 0.1008 | 0.0537 | 0.0656 | 0.2381 |
| $d_h(J_1, J_5)$ | 0.0856 | 0.0573 | 0.0637 | 0.1772 | 0.1194 | 0.1991 |
| $d_h(J_2, J_3)$ | 0.1016 | 0.0390 | 0.1048 | 0.0285 | 0.0691 | 0.0440 |
| $d_h(J_2, J_4)$ | 0.1689 | 0.3098 | 0.2931 | 0.0687 | 0.1939 | 0.1508 |
| $d_h(J_2, J_5)$ | 0.2335 | 0.3220 | 0.3302 | 0.1621 | 0.2478 | 0.1118 |
| $d_h(J_3, J_4)$ | 0.0673 | 0.2707 | 0.1883 | 0.0973 | 0.1248 | 0.1068 |
| $d_h(J_3, J_5)$ | 0.1319 | 0.2829 | 0.2254 | 0.1336 | 0.1787 | 0.0678 |
| $d_h(J_4, J_5)$ | 0.0659 | 0.0149 | 0.0371 | 0.2309 | 0.0539 | 0.0390 |

Source: Ours.

$$\theta_2 = (\theta_2(J_m, J_w))_{5\times5} = \begin{matrix} & J_1 & J_2 & J_3 & J_4 & J_5 \\ J_1 & 0 & -4.7816 & -4.3460 & -1.0967 & -0.9167 \\ J_2 & 0.0845 & 0 & 0.0114 & 0.0699 & 0.0731 \\ J_3 & 0.0768 & -0.6450 & 0 & 0.0621 & 0.0652 \\ J_4 & 0.0194 & -3.9550 & -3.5131 & 0 & 0.0050 \\ J_5 & 0.0162 & -4.1317 & -3.6877 & -0.2804 & 0 \end{matrix}$$

$$\theta_3 = (\theta_3(J_m, J_w))_{5\times5} = \begin{matrix} & J_1 & J_2 & J_3 & J_4 & J_5 \\ J_1 & 0 & -5.2053 & -3.9648 & -1.6013 & -1.0589 \\ J_2 & 0.0838 & 0 & 0.0261 & 0.0639 & 0.0716 \\ J_3 & 0.0638 & -1.6204 & 0 & 0.0433 & 0.0512 \\ J_4 & 0.0258 & -3.9667 & -2.6872 & 0 & 0.0106 \\ J_5 & 0.0170 & -4.4485 & -3.1790 & -0.6575 & 0 \end{matrix}$$

$$\theta_4 = (\theta_4(J_m, J_w))_{5\times5} = \begin{matrix} & J_1 & J_2 & J_3 & J_4 & J_5 \\ J_1 & 0 & -0.5572 & -1.0185 & 0.0112 & -3.5358 \\ J_2 & 0.0052 & 0 & -0.7105 & 0.0139 & -3.2764 \\ J_3 & 0.0094 & 0.0066 & 0 & 0.0189 & -2.7630 \\ J_4 & -1.2110 & -1.5026 & -2.0396 & 0 & -4.4211 \\ J_5 & 0.0327 & 0.0303 & 0.0256 & 0.0409 & 0 \end{matrix}$$

$$\theta_5 = (\theta_5(J_m, J_w))_{5\times 5} = \begin{matrix} & J_1 & J_2 & J_3 & J_4 & J_5 \\ J_1 & 0 & -2.7017 & -1.3686 & 0.0131 & 0.0224 \\ J_2 & 0.0238 & 0 & 0.0138 & 0.0339 & 0.0425 \\ J_3 & 0.0121 & -1.5635 & 0 & 0.0230 & 0.0318 \\ J_4 & -1.4824 & -3.8403 & -2.6065 & 0 & 0.0112 \\ J_5 & -2.5370 & -4.8114 & -3.6088 & -1.2707 & 0 \end{matrix}$$

$$\theta_6 = (\theta_6(J_m, J_w))_{5\times 5} = \begin{matrix} & J_1 & J_2 & J_3 & J_4 & J_5 \\ J_1 & 0 & 0.0159 & 0.0228 & 0.0377 & 0.0325 \\ J_2 & -2.1387 & 0 & 0.0086 & 0.0252 & 0.0195 \\ J_3 & -3.0614 & -1.1535 & 0 & 0.0186 & 0.0126 \\ J_4 & -5.0628 & -3.3790 & -2.4948 & 0 & -1.0411 \\ J_5 & -4.3681 & -2.6224 & -1.6894 & 0.0078 & 0 \end{matrix}$$

The overall predominance matrix $\varsigma = (\varsigma(J_m, J_w))_{5\times 5}$ is adding all relative predominance matrices together.

$$\varsigma = (\varsigma(J_m, J_w))_{5\times 5} = \begin{matrix} & J_1 & J_2 & J_3 & J_4 & J_5 \\ J_1 & 0 & -15.3648 & -11.4434 & -2.6261 & -5.3709 \\ J_2 & -1.9051 & 0 & -0.6246 & 0.2470 & -3.0157 \\ J_3 & -2.8862 & -6.5073 & 0 & 0.1838 & -2.5695 \\ J_4 & -8.3016 & -19.0154 & -14.3965 & 0 & -5.4174 \\ J_5 & -8.1592 & -19.1690 & -14.0665 & -3.2191 & 0 \end{matrix}$$

Finally, obtain the standard overall predominance $\xi(J_m)$ $(m = 1, 2, 3, 4, 5)$ by utilizing Eq. (25) and the outcomes are $\xi(J_1) = 0.2946$, $\xi(J_2) = 1$, $\xi(J_3) = 0.8451$, $\xi(J_4) = 0$, $\xi(J_5) = 0.0602$. Therefore, the ordering of alternatives is $J_2 > J_3 > J_1 > J_5 > J_4$, and the alternative $J_2$ is the most excellent one.

It is obvious that the value of parameters just as $\alpha, \beta, \omega, \partial, \ell$ can make a change in the above calculative outcome. And there is no doubt that we need to select the perfect parameters according to the problem we study. The responsibility of this paper isn't to analyze the parameters but to establish a brilliant single-valued neutrosophic MAGDM model.

## 5. Comparative analysis

It is necessary to bring in other methods for verifying this new proposed CPT-SVN-TODIM method. In this part, we select some methods including SVNWA operator (Zhang et al., 2014), SVNWG operator (Zhang et al., 2014), TODIM method (Xu et al., 2017), TOPSIS approach (Nancy & Garg, 2019; Selvachandran et al., 2018), Single valued neutrosophic cross-entropy (Ye, 2014) and MABAC method (Peng & Dai, 2018) to compare with the new method in this paper.

From Table 13, we can come to the same conclusion that the alternative $J_2$ is the greatest, although there are subtle differences. However, the superiority of CPT-SVN-TODIM method, in describing decision maker's psychological states about risk, reflects distinctiveness which keeps practicability of this new CPT-SVN-TODIM

**Table 13.** The sequence from different methods.

| Method | The sequence | The best alternative |
|---|---|---|
| SVNWA (Zhang et al., 2014) | $J_2 > J_3 > J_1 > J_5 > J_4$ | $J_2$ |
| SVNWG (Zhang et al., 2014) | $J_2 > J_3 > J_4 > J_5 > J_1$ | $J_2$ |
| Xu et al. (2017) | $J_2 > J_3 > J_1 > J_5 > J_4$ | $J_2$ |
| Nancy and Garg (2019) | $J_2 > J_3 > J_1 > J_5 > J_4$ | $J_2$ |
| Selvachandran et al. (2018) | $J_2 > J_3 > J_1 > J_4 > J_5$ | $J_2$ |
| Ye (2014) | $J_2 > J_3 > J_1 > J_5 > J_4$ | $J_2$ |
| Peng and Dai (2018) | $J_2 > J_3 > J_1 > J_5 > J_4$ | $J_2$ |
| CPT-SVN-TODIM | $J_2 > J_3 > J_1 > J_5 > J_4$ | $J_2$ |

Source: Ours.

method. In addition, CPT-SVN-TODIM method also takes a more scientific approach to solving attribute weights for preventing subjective assumptions from adversely affecting the outcome. Hence, the above evidences suggest that the new proposed CPT-SVN-TODIM method is reliable and valid.

## 6. Conclusions

The MAGDM issue is a very important in practical management decision-making all the time. With the continuous development of society, more and more situations can be classified as MAGDM. In such article, we tend to resolve the MAGDM issues with SVNSs and CPT-TODIM method and put forward the CPT-SVN-TODIM method. This new method not only inherits some advantages of classical TODIM method, but also has further improvement in some aspects. For example, we set up the entropy to calculate attribute weights for ensuring the more objective decision-making process. Furthermore, it is also an extension of MAGDM method to utilize SVNN to express decision makers' ideas. In addition, we introduce the application of CPT-SVN-TODIM method in the assessment of medical emergency management. Finally, the reliability of CPT-SVN-TODIM algorithm is checked by comparing with other existed methods. In the future, we shall continue to explore the application of this method in some other different fields (Fan et al., 2021; Lu et al., 2021; Wei, Wu, et al., 2021)and make continuous improvement to build more scientific and reasonable new methods to solve MAGDM issues (Jin et al., 2021; Kumar et al., 2021; Xu et al., 2021; Zhao, Wei, Guo, et al., 2021).

## Disclosure statement

No potential conflict of interest was reported by the authors.

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