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Selecting Medical Service Scheme: a Novel Method based on Prospect Theory

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Abstract. With the frequent incidents of domestic medical disputes, the doctor-patient relationship has been strained, and government and medical institution have gradually been focusing on doctor-patient communication. The service medical model based on patients' psychological expectation allows patients taking the initiatives in the medical decision-making, and plays an important role in improving the doctor-patient relationship. The costs of medical services schemes for different patients vary from the different expectations existed. In this paper, we presented a method for selection of medical services schemes based on prospect theory. First, based on the calculation of total similarity among all characteristic attributes, we built a possibility distribution for a set of medical service schemes; then, according to the patient's expectations, we calculated the values of all medical service schemes on necessary-type index treatment effects and the values of charismatic-type indexes of curing time and costs based on prospect theory, respectively. We further determined the weight of necessary-type indexes and charismatic-type indexes; on this basis, we calculated the comprehensive prospect values of all medical service schemes, and selected the medical service schemes in accordance with the comprehensive prospect values; finally, we verified the feasibility and effectiveness of this method by case analysis.

1. Introduction

With the gradual strengthening of the socio-economic development and people's awareness of health self-management awareness and legal awareness, patients have a more clear understanding of their status and rights in the process of accepting the medical services. Patients involved in the treatment process to reduce the medical costs and achieve the medical goals had been focused by both doctors and patients. Medical services had also gradually been transforming the decision-making model from the traditional doctor-sole-agent-patient model to patient-centered new model, making the patients enjoy more quality

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medical services based on the patients' psychological expectations. Patients involved in medical decision-making could improve the patients' autonomy and compliance of involving in disease treatment and enhance the disease treatment effects [1].

Some studies have been conducted to deal with the selection problem of medical service scheme. Van et al. [2] proposed a decision making method to obtain the therapeutic schedulein acquired equinovarus deformity based on Analytic Hierarchy Process (AHP) Yun et al. [3] developed a method combined with the General Data Envelopment Analysis (GDEA) and Genetic Algorithm (GA) to select the Pareto optimal solutions considering the decision maker's aspiration level. Tuinman et al. [4] believed that the patients' families as the undertakers for medical treatment, physical, psychological consequences and medical costs are the important subjects for medical decisions-making. Because the decision-makers cannot be completely rational. Lahdelma and Salminen [5] proposed the stochastic multi-criteria acceptability analysis (SMAA) method for to analyze the incomplete rationality from the aspect of decision makers' psychology. Corrente et al. [6] developed the SMAA-PROMETHEE methods to solve the real world decision making problems with the expectations of decision makers. Nowak [7] considered a discrete stochastic multiple criteria decision making problem and proposed an interactive method based on stochastic domination and expectation level. Jin et al. [8] extended a TOPSIS method in interval-valued intuitionistic fuzzy environment in which the preference provided by decisionmakers was presented as interval-valued intuitionistic fuzzy decision matricesand the information about attribute weights were partially known. Zhou et al. [9] presented a novel continuous ordered weighted distance (COWD) measure by using the continuous ordered weighted averaging (COWA) operator in the interval distance to solve the group decision making problems. However, some studies seldom considered the psychological behavior characteristics such as with reference to the dependence, loss aversion and probability judgment distortions, etc [10–13]. It should be noted that, the prospect theory proposed by Kahneman and Tversky [10, 11], was a result of behavior scientific study to explain the decision-making behavior in an uncertain environment, which can be better described the behaviors of decision-maker such as with reference to the dependence, loss avoid distortion behavior and probability judgment distortions, etc. On this basis, a method for selection of medical service scheme based on prospect theory was proposed in this paper.

2. Problem Description

Considering the selection of multi-attribute medical service scheme with the decision-makers' expectations, $X = \{X_1, X_2, \cdots, X_m\}$ was recorded as a set of schemes, in which X_i represented the i kind of medical service scheme of diseases, $i = 1, 2, \cdots, m$; $Q = \{Q_1, Q_2, \cdots, Q_n\}$ represented the characteristic attribute set is characterized by the disease, which represented the characteristic attribute of disease; in which Q_j represented the j characteristic attribute of the disease. $j = 1, 2, \cdots, n$; $W = (w_1, w_2, \cdots, w_n)^T$represented the characteristic attribute weight vector, in which w_j represented the weight of characteristic attribute Q_j, $0 \le w_j \le 1$, and met $\sum\limits_{j=1}^{n} w_j = 1$; $y = (y_1, y_2, \cdots, y_n)^T$ represented the characteristic attribute value vector relative to characteristic attribute Q, in which y_j represented the detailed characteristic attribute value of characteristic attribute Q_j after the onset of disease Y. Because of the complexity and uncertainty of disease information, in this paper, we introduced the concept of intervals to describe the imprecise attribute of cases. $y_j = \left[y_j^L, y_j^U\right]$ represented the characteristic attribute values in interval form given by characteristic attribute Q_j corresponds to incident Y, in which $0 \le y_j^L < y_j^U$; $y_j = y_j^R$ represented the characteristic attribute values in real form given by characteristic attribute Q_j corresponds to disease.

$\tilde{E} = (\tilde{e}_1, \tilde{e}_2, \cdots, \tilde{e}_m)$ represented the vector of treatment effects, in which $\tilde{e}_i$ represented the treatment effects achieved in case of medical service scheme X_i. Considering the disease relapse rate and other factors, so the final treatment effects were uncertain. In this paper, we considered $\tilde{e}_i$ in interval information form, namely $\tilde{e}_i = \left[\tilde{e}_i^L, \tilde{e}_i^U\right], 0 \le \tilde{e}_i^L \le \tilde{e}_i^U, i = 1, 2, \cdots, m$; $\tilde{T} = (\tilde{t}_1, \tilde{t}_2, \cdots, \tilde{t}_m)$ represented the curing time vector, in which $\tilde{t}_i$ represented the treatment time needed in case of medical service scheme X_i. Similarly, considering that $\tilde{t}_i$ also was represented in interval information form herein, namely $\tilde{t}_i = \left[\tilde{t}_i^L, \tilde{t}_i^U\right], 0 \le \tilde{t}_i^L \le \tilde{t}_i^U, i = 1, 2, \cdots, m$;

$C = (c_1, c_2, \cdots, c_m)$ represented a curing cost vector, in which c_i represented a total investment cost of medical services scheme X_i; e^R, t^R, c^R represented the psychological expectations of decision-makers on the treatment effects, curing time and curing costs, respectively. In this paper, we considered the psychological expectations of decision-makers as reference points; $\theta = (\theta_1, \theta_2)$ represented the weight vector for the curing costs and curing time, in which θ_1 represented the degree of importance of curing costs, θ_2 represented the degree of importance of curing time, and $\theta_1 + \theta_2 = 1, 0 \leq \theta_1, \theta_2 \leq 1$ usually represented that the decision-making vector was directly given by decision-makers.

In this paper, the issue to be solved was to judge the probability of a patient with a disease based on calculating the similarity. According to $\tilde{E}$, $\tilde{T}$, C, e^R, t^R, c^R and θ decision-making related information responded to the diagnosis, we considered with reference to the psychological behavior characteristics such as independence, loss aversion, probability judgment distortions, etc. , and ranked the medical service scheme by scientific decision analysis.

3. Principle and Method

3.1. Similarity calculation

For the complexity of disease information and incompleteness of information that the patients grasp, we can introduce the concept of intervals to describe the uncertain attributes of cases and achieve the adaptability to uncertain information in an uncertain environment. In the study of reference [14, 15], Slonim, represented as a scholar, proposed numerical algorithm of interval similarity, and performed a algorithm study on the similarity between two intervals within a specific range. The results of this study could give two quantitative results on the similarity between intervals. Based on the reference [14, 15], we could get the following conclusions:

(1) The similarity between two exact values within a specific interval range was calculated as follows:

$$sim_j\left(y_{1j}^R, y_{2j}^R\right) = 1 - \frac{y_{2j}^R - y_{1j}^R}{\beta - \alpha}, \quad y_{1j}^R, y_{2j}^R \in [\alpha, \beta] \quad j = 1, 2, \cdots, n \tag{1}$$

In the formula, α, β represented the lower and upper bounds of the intervals, respectively.

(2) The exact values within a specific interval range and the similarity between the intervals were calculated as follows:

$$sim_j\left(y_{1j}^R, [y_{2j}^L, y_{2j}^U]\right) = \begin{cases} 1 - \dfrac{\left(y_{2j}^U + y_{2j}^L - 2y_{1j}^R\right)}{1\left(\beta - \alpha\right)}, & y_{1j}^R \leq y_{2j}^L \\ 1 - \dfrac{\left(y_{2j}^U - y_{1j}^R\right)^2 + \left(y_{2j}^L - y_{1j}^R\right)^2}{2\left(\beta - \alpha\right)\left(y_{2j}^U - y_{2j}^L\right)}, & y_{2j}^L < y_{1j}^R < y_{2j}^U \\ 1 + \dfrac{\left(y_{2j}^U + y_{2j}^L - 2y_{1j}^R\right)}{2\left(\beta - \alpha\right)}, & y_{1j}^R \geq y_{2j}^U \end{cases} \tag{2}$$

(3) The similarity between two intervals within a specific interval range was calculated as follows:

$$sim_j\left(\left(y_{1j}^L, y_{1j}^U\right), [y_{2j}^L, y_{2j}^U]\right) = \begin{cases} 1 - \dfrac{\left(y_{2j}^U + y_{2j}^L - y_{1j}^U - y_{1j}^L\right)}{2(\beta-\alpha)}, & y_{1j}^U \le y_{2j}^L \\ 1 - \dfrac{3\left(y_{2j}^U - y_{2j}^L\right)\left(y_{2j}^L - y_{1j}^L\right)\left(y_{2j}^U - y_{1j}^L\right)}{6(\beta-\alpha)\left(y_{1j}^U - y_{1j}^L\right)\left(y_{2j}^U - y_{2j}^L\right)} + \\ \quad \dfrac{\left(y_{1j}^U - y_{2j}^L\right)^3 + \left(y_{1j}^U - y_{2j}^U\right)^3 + \left(y_{2j}^L - y_{1j}^L\right)^3}{6(\beta-\alpha)\left(y_{1j}^U - y_{1j}^L\right)\left(y_{2j}^U - y_{2j}^L\right)}, & y_{2j}^L < y_{1j}^U \le y_{2j}^U \\ 1 - \dfrac{\left(y_{2j}^U\right)^2 + \left(y_{2j}^L\right)^2 + y_{2j}^L y_{2j}^U}{3\left(y_{1j}^U - y_{1j}^L\right)(\beta-\alpha)} - \\ \quad \dfrac{\left(y_{1j}^U\right)^2 + \left(y_{1j}^L\right)^2 - \left(y_{1j}^U + y_{1j}^L\right)\left(y_{2j}^U + y_{2j}^L\right)}{3\left(y_{1j}^U - y_{1j}^L\right)(\beta-\alpha)}, & y_{2j}^U < y_{1j}^U \end{cases} \tag{3}$$

By combining with the adjacent method, we could calculate the total similarity between the diseases and diagnosed disease in disease spectrum, the specific calculation was shown as follows:

$$SIM = \sum_{j-1}^{n} w_j sim_j,\ j = 1, 2, \cdots, n \tag{4}$$

3.2. Calculation of Charismatic-type index comprehensive value

First, based on behavioral characteristics of decision-makers with reference to independence that decision-makers considered the results as gains or losses relative to the reference points, we calculated using gains and losses from the curing costs c_i of medical scheme X_i relative to the reference point c^R, namely

$$a_{1i} = c_i - c^R, i = 1, 2, \cdots, m \tag{5}$$

If $a_{1i} > 0$, then the curing costs invested into the medical services scheme in decision-makers' subjective psychological perceptions represented as "losses"; If $a_{1i} < 0$, the curing costs invested into the medical services scheme in decision-makers' subjective psychological perceptions represented as "gains", the cost value of such scheme X_i was equal to:

$$v_{1i} = \begin{cases} (-a_{1i})^{\alpha_1}, & a_{1i} < 0 \\ -\lambda_1 (a_{1i})^{\beta_1}, & a_{1i} \ge 0 \end{cases} \qquad i = 1, 2, \cdots, m \tag{6}$$

In the formula, α_1 and β_1 represented the concave and convex extents of value function of gains and losses from curing costs invested, respectively, and $0 \le \alpha_1, \beta_1 \le 1$. The greater α_1 and β_1 were, representing that the greater the sensitivity of decision-makers to invest the costs would be decreased progressively and the greater the risks would be inclined. λ_1 represented the coefficient of loss aversion, on behalf of the degree of risk aversion. The greater λ_1 was, the greater the degree of loss aversion on curing costs. Based on the reference [11–14], we usually took $\alpha_1 = 0.88, \beta_1 = 0.92, \lambda_1 = 2.25$.

Then, we calculated the gains and losses from the curing time $\tilde{t}_i$ using medical scheme X_i relative to the reference point t^R, namely

$$\tilde{a}_{2i} = \tilde{t}_i - t^R = [t_i^L - t^R, t_i^U - t_i^R] = [a_{2i}^L, a_{2i}^U], \qquad i = 1, 2, \cdots, m \tag{7}$$

Assuming a_{2i} as a stochastic variable within the interval $[a_{2i}^L, a_{2i}^U]$, and $f_{2i}(a_{2i})$ as the probability density function, we usually consider $f_{2i}(a_{2i})$ as uniform distribution or normal distribution. On this basis, the curing time value was calculated:

$$v_{2i} = \begin{cases} \int_{a_{2i}^L}^{a_{2i}^U} v_2^-(a_{2i}) f_{2i}(a_{2i}) d_{a_{2i}}, & a_{2i}^L > 0 \\ \int_{a_{2i}^0}^{L} v_2^+(a_{2i}) f_{2i}(a_{2i}) d_{a_{2i}} + \int_0^{a_{2i}^U} v_2^-(a_{2i}) f_{2i}(a_{2i}) d_{a_{2i}}, & a_{2i}^L \le 0 \le a_{2i}^U, \quad i = 1, 2, \cdots m \\ \int_{a_{2i}^U}^{a_{2i}^L} v_2^+(a_{2i}) f_{2i}(a_{2i}) d_{a_{2i}}, & a_{2i}^U < 0 \end{cases} \tag{8}$$

In which, $v_2^-(a_{2i})$ represented as $a_{2i} \ge 0$, then the curing time in the decision-makers' subjective psychological perceptions represented as "gains" of positive values. Based on the idea of prospect theory, the formulas for $v_2^+(a_{2i})$ and $v_2^-(a_{2i})$ were shown as follows:

$$v_2^+(a_{2i}) = (-a_{2i})^{\alpha_2}, \qquad a_{2i} \le 0, i = 1, 2, \cdots, m \tag{8a}$$

$$v_2^-(a_{2i}) = -\lambda_2 (a_{2i})^{\beta_2}, \qquad a_{2i} \ge 0, i = 1, 2, \cdots, m \tag{8b}$$

In the formula, α_2 and β_2 represented the concave and convex extents of value function of gains and losses from curing time, respectively, and $0 \le \alpha_2, \beta_2 \le 1$. And the greater α_2 and β_2 were, representing that the greater the sensitivity of decision-makers to invest the costs would be decreased progressively and the greater the risks would be inclined. λ_2 represented the coefficient of loss aversion, on behalf of the degree of risk aversion. The greater λ_2 was, the greater the degree of loss aversion on curing costs. Based on references [10–13], we usually took $\alpha_2 = 0.88, \beta_2 = 0.92, \lambda_2 = 2.25$.

Furthermore, in order to eliminate the impacts of different dimensions on the results, we standardized the curing cost value v_{1i} and curing time value v_{2i} of charismatic-type indexes, its formula was standardized as:

$$\bar{v}_{ki} = \frac{v_{ki}}{|v_k|_{\max}}, i = 1, 2, \cdots, m, k = 1, 2 \tag{9}$$

In which, $|v_k|_{\max} = \max\{|v_{k1}|, |v_{k2}|, \cdots, |v_{km}|\}, k = 1, 2$, calculated based on the above formula as $0 \le |\bar{v}_{ki}| \le 1$, $i = 1, 2, \cdots, m, k = 1, 2$

On this basis, considering that the curing time and curing costs were related with the decision-makers' psychological perceptions, the comprehensive values of charismatic-type indexes were calculated, namely:

$$v_i = \theta_1 \bar{v}_{1i} + \theta_2 \bar{v}_{2i} + \mu_i \bar{v}_{1i} \bar{v}_{2i}, \qquad i = 1, 2, \cdots, m \tag{10}$$

In which, μ_i represented the parameter related to curing time and curing costs on scheme X_i, which represented the mutual impact degree of curing time and curing costs in decision-makers' psychological perceptions. Based on the characteristics of medical services schemes, and the value range μ_i for different $\bar{v}_{1i}$ and $\bar{v}_{2i}$ value was as shown in Table 1.

Table 1: Value Range of μ_i

Value of $\bar{v}_{1i}$ and $\bar{v}_{2i}$	Value Range of μ_i	Description of Value Range
$\bar{v}_{1i}, \bar{v}_{2i} \geq 0$	$0 \leq \mu_i \leq 1$	Curing costs and curing time had some positive impacts on psychological perception of decision-makers
$\theta_1\bar{v}_{1i} + \theta_2\bar{v}_{2i} \geq 0, \bar{v}_{1i}\bar{v}_{2i} < 0$	$-1 \leq \mu_i \leq 0$	Same as above
$\theta_1\bar{v}_{1i} + \theta_2\bar{v}_{2i} \leq 0, \bar{v}_{1i}\bar{v}_{2i} < 0$	$0 \leq \mu_i \leq 1$	Curing costs and curing time had some negtive impacts on psychological perception of decision-makers.
$\bar{v}_{1i}, \bar{v}_{2i} \leq 0$	$-1 \leq \mu_i \leq 0$	Same as above

3.3. Calculation of necessary-type index value

We calculated the value of necessary-type index treatment effect $\tilde{e}_i$ using medical service scheme X_i, similarly as the calculation of curing time $\tilde{t}_i$:

$$v_{3i} = \begin{cases} \int_{a_{3i}^U}^{a_{3i}^L} v_3^-(a_{3i}) f_{3i}(a_{3i}) d_{a_{3i}}, & a_{3i}^L < 0 \\ \int_0^{a_{3i}^L} v_3^-(a_{3i}) f_{3i}(a_{3i}) d_{a_{3i}} + \int_0^{a_{3i}^U} v_3^+(a_{3i}) f_{3i}(a_{3i}) d_{a_{3i}}, & a_{3i}^L \leq 0 \leq a_{3i}^U \quad i = 1, 2, \cdots, m \\ \int_{a_{3i}^L}^{a_{3i}^U} v_3^+(a_{3i}) f_{3i}(a_{3i}) d_{a_{3i}}, & a_{3i}^U > 0 \end{cases} \tag{11}$$

In which,

$$\tilde{a}_{3i} = \tilde{e}_i - e^R = [e_i^L - e^R, e_i^U - e_i^R] = [a_{3i}^L, a_{3i}^U], \qquad i = 1, 2, \cdots, m \tag{11a}$$

$$v_3^+(a_{3i}) = (a_{3i})^{\alpha_3}, a_{3i} \geq 0, \qquad i = 1, 2, \cdots, m \tag{11b}$$

$$v_3^-(a_{3i}) = -\lambda_3(-a_{3i})^{\beta_3}, a_{3i} \leq 0, \qquad i = 1, 2, \cdots, m \tag{11c}$$

In the formula (11), $f_{3i}(a_{3i})$ represented the probability density function for necessary-type index treatment effect $\tilde{e}_i$, α_3 and β_3 represented the concave and convex extents of value function of gains and losses from curing time, respectively, and $0 \leq \alpha_2, \beta_2 \leq 1$. And the greater α_3 and β_3 were, representing that the greater the sensitivity of decision-makers to invest the costs would be decreased progressively and the greater the risks would be inclined. λ_3 represented the coefficient of loss aversion, on behalf of the degree of risk aversion. The greater λ_3 was, the greater the degree of loss aversion on curing costs.

3.4. Calculation of probability weight

Based on prospect theory [10–13], the method for calculation of probability weight was given as:
In case of gains

$$w^+(p) = \frac{p^\gamma}{p^\gamma + (1-p)^{1/\gamma}} \tag{12}$$

In case of losses

$$w^-(p) = \frac{p^\delta}{p^\delta + (1-p)^{1/\delta}} \tag{13}$$

In which, we usually took the model parameters γ and δ as $\gamma = 0.61$ and $\delta = 0.69$[10–13]. Assuming that a function relation existed between the similarity and the disease probability was determined, disease probability could be calculated as probability p.

3.5. Calculation of comprehensive prospect value of medical service schemes medical scheme

First, we calculated the charismatic-type index expected prospect value DV_i and the necessary-type index expected prospect value V_i^C as follows:

$$DV_i = v_i \pi_i, \qquad i = 1, 2, \cdots, m \tag{14}$$

$$V_i^C = v_{3i} \pi_i, \qquad i = 1, 2, \cdots, m \tag{15}$$

In which, in case of gains, $\pi_i = w^+(p)$; in case of losses, $\pi_i = w^-(p)$.

Furthermore, in order to eliminate the impacts of different dimensions on the results, we standardized the curing cost value v_{1i} its formula was standardized as:

$$\overline{DV}_i = \frac{DV_i}{|DV_i|_{\max}}, \qquad i = 1, 2, \cdots, m \tag{16}$$

$$\overline{V_i^C} = \frac{V_i^C}{\left|V_i^C\right|_{\max}}, \qquad i = 1, 2, \cdots, m \tag{17}$$

In which,

$|DV_i|_{\max} = \max\{|DV_1|, |DV_2|, \cdots, |DV_m|\}$, and $0 \le \left|\overline{DV}_i\right| \le 1, \qquad i = 1, 2, \cdots, m$

$\left|V_i^C\right|_{\max} = \max\left\{\left|V_1^C\right|, \left|V_2^C\right|, \cdots, \left|V_m^C\right|\right\}$, and $0 \le \left|\overline{V_i^C}\right| \le 1, \qquad i = 1, 2, \cdots, m$

On this basis, the comprehensive prospect values of medical services scheme X_i were calculated, namely:

$$FV_i = \kappa_1 \overline{DV}_i + \kappa_2 \overline{V_i^C}, \qquad i = 1, 2, \cdots, m \tag{18}$$

In which, κ_1 and κ_2 represented the degrees of importance of charismatic-type index value and the necessary type index value. κ_1 and κ_2 were usually given by decision-makers and met $0 \le \kappa_1, \kappa_2 \le 1, \kappa_1 + \kappa_2 = 1$. The greater V_i was, representing that more optimal the medical service scheme X_i would be. Therefore, the schemes could be ranked based on the size of V_i, selecting the most optimal medical scheme.

4. Case Analysis

Table 2 is a simplified clinical classification of stones in ureter, Y_1 on behalf of Class I stones, Y_2 on behalf of Class II stones, Y_3 on behalf of Class III stones, and Y_4 on behalf of the disease to be diagnosed. Hydronephrosis statuses could be divided into Level 0, Level 1 and Level 2 based on without hydronephrosis, mild hydrocephalus and severe hydrocephalus, respectively.

Table 2: Simplified Clinic Classification of Stones in Ureter

Characteristic Attribute	Y_1	Y_2	Y_3	Y_4	Weight	α	β
Q_1: Max dia. of stone/mm	[0, 0.6]	[0.6, 1.2]	[1.2, 3.0]	[2.1, 2.3]	0.40	0	3.0
Q_2: Time for stones located in ureter/week	[0, 4]	[4, 52]	[52, 156]	[50, 53]	0.15	0	156
Q_3: Hydronephrosis status	0	1	2	2	0.45	0	2

Note: α represented the minimum value of characteristic attribute, β represented the maximum value of characteristic attribute.

Similarity among the disease to be diagnosed and "max dia. of stone/mm" and "time for stones located in ureter/week " in attributes of Class I stones was calculated based on Formula(3).

$$sim_{Q_1}([0, 0.6], [2.1, 2.3]) = 0.85$$
$$sim_{Q_2}([0, 4], [50, 53]) = 0.68$$

Similarity between the disease to be diagnosed and "hydronephrosis statuses" in characteristic attributes of Class I stones was calculated based on Formula (1).

$$sim_{Q_3}(0,2) = 0$$

Total similarity between the disease to be diagnosed and Class I stones was calculated based on Formula (4).

$$\begin{aligned} SIM_1 &= 0.4 \times 0.85 + 0.15 \times 0.68 + 0.45 \times 0 \\ &= 0.116 \end{aligned}$$

Similarly, calculated as:

$$\begin{aligned} SIM_2 &= 0.578 \\ SIM_3 &= 0.889 \end{aligned}$$

Finally, calculated as: $SIM_3 > SIM_2 > SIM_1$

Assuming that a function relation existed between the similarity and the disease probability was determined, the disease to be diagnosed was considered with Class III stones and probability value was calculated.

The main treatment for Class III stones currently included minimally invasive percutaneous nephrolithotomy lithotripsy (MPCNL) and ureteroscopic lithotomy (URL). [16, 17] In this case, the fragmented stone clearance rate was up to 95%. The required number of days was deemed as the curing time. Hospitalization costs were deemed as the curing costs. Complementation of probability of postoperative complications that might occur was deemed as the treatment effect. The curing time, curing costs, and treatment effects were as shown in Table 3.

Table 3: Therapy scheme of Class III stone

Treatment schedule	Healing Time/Day	Healing Costs (in ten thousands)	Treatment Effects
X_1(MPCNL)	[3, 5]	2.6	[0.70, 0.80]
X_2(URL)	[30, 40]	1.4	[0.84, 0.94]

Assuming that the reference point given by decision-makers represented $c^R = 30000$ Yuan, $t^R = 10$ days, $e^R = 0.95$, the weight vectors of curing time and curing were given as $\theta = (0.8, 0.2)$.

First, based on Formula (5) and Formula (7), we calculated the gains and losses from curing costs c_i and curing time $\tilde{t}_i$ relative to the reference point c^R. Then, we considered the characteristics of the probability density function in compliance with the uniform distribution. We calculated the value function based on Formula (6) and Formula (8). Finally, we standardized the value function based on Formula (9) and calculated as: $\bar{v}_{ki} = \frac{v_{ki}}{|v_k|_{\max}}$, $i = 1, 2, k = 1, 2$, Calculated results were as shown in Table 4.

Table 4: Values of a_{ki}, v_{ki} and $\bar{v}_{ki}$

	X_1	X_2
a_{1i}	0.6	−0.6
$\tilde{a}_{2i}$	[−7, −5]	[20, 30]
v_{1i}	0.4424	1.5194
v_{2i}	4.8368	−43.4583
$\bar{v}_{1i}$	0.2912	1
$\bar{v}_{2i}$	0.1113	−1

In this case, we took $\mu_1 = \mu_2 = 0.2$, and calculated all charismatic-type index values of medical service schemes based on Formula (10) as:

$$v_1 = 0.1538, v_2 = -0.8$$

Similarly, we calculated v_{31} and v_{32} of necessary-type index treatment effect of medical service scheme X_1, X_2 based on Formula (11) as:

$$v_{31} = -0.5114, \quad v_{32} = -0.1675$$

Secondly, we calculated the probability weight based on Formula (12) and Formula (13):

$$w^+ (p) = 0.9761$$

Thirdly, we calculated the charismatic-type index expected prospect value and the necessary type index expected prospect value V_i^C based on Formula (14) and Formula (15). After normalization, finally, we calculated all compressive prospect values of all medical service schemes based on Formula (18) as $FV_i, i = 1, 2$: In this case, we took $\kappa_1 = 0.9, \kappa_2 = 0.1$ The detailed calculated results were shown in Table 5.

Table 5: Values of DV_i, V_i^C and FV_i

	X_1	X_2
DV_i	0.1501	−0.7706
V_i^C	−0.4926	−0.1613
FV_i	0.0753	−0.9327

As we could see from Table 5, $FV_1 > FV_2$ in case that a patient was considered with Class III stones, he should select the treatment of minimally invasive percutaneous nephrolithotomy(MPCNL).

5. Conclusions

In this paper, we proposed a method for medical decision-making based on prospect theory in the case of different preferences existed in different medical service schemes.

In this method, we obtained the probability distribution based on the calculation of similarity. On this basis, we used the value function and weight function in prospect theory to replace the utility function and probability in expected utility theory. We also divided the indexes into necessary-type indexes and charismatic-type indexes, which helped the patients play their positive initiatives from based on decision-makers' psychological behavior characteristics such as with reference to the dependence and sensitivity decreasing and based on their actual demands, enabling the final medical service scheme obtained more complying with the patients' subjective perception. This has important theoretical and practical value had an important theory theoretical significance and practical value to improve the patients' autonomy and compliance of involving in disease treatment, as well as enhance the disease treatment effects, and improve the doctor-patient relationship.

It should be noted that in this study, a simple comparison to determine the possibility with a disease simply based on similarity makes certainly scientific and rational to the general disease with characteristic attributes significant and easy to distinguish. However, but in case of the disease with more characteristic attributes and the diagnosed results caused by small differences of an attribute, the method was not applicable. In case that the reasonable and scientific result diagnosed of a disease was given, the patients could select the relative medical service schemes based on their own psychological expectations, so as for us to provide better quality medical services for patients and improve patient satisfaction. Therefore, the scope of application for improving the disease diagnosis would be an study direction to be extended.

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