FUZZY DELPHI HIERARCHY PROCESS AND ITS APPLICATION TO IMPROVE INDIAN TELEMEDICAL SERVICES

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ABSTRACT

Telemedicine promises to be one of several possible solutions to some of the medical dilemmas facing India and other developing countries. The use of communication technology in the practice of medicine may change the face of health care in India by improving access to dispersed expert medical information, diagnostic tools, and consultations. Increasing demand on practitioners' time and the increasing complexity of patients' education and management has created a demand for creative solutions. Telemedicine incorporates telecardiology, teleradiology, telepathology, tele-ophthalmology, teledermatology, telesurgery. The selection of different mitigating or preventive alternatives often involve competing and conflicting criteria, which requires sophisticated multi-criteria decision making methods. However the nature of the real world problems often relates to fuzziness and ambiguousness which initiates by the unprecedented environment conditions, human factors, incomplete information, etc. In order to model this kind of uncertainty in human preference, fuzzy sets could be incorporated with pair wise comparison as an extension of AHP.

This paper presents Fuzzy Delphi Hierarchy Process (FDHP), a new Futuristic Multi Criteria Decision Making Methodology for solving unstructured futuristic decision problems with multi-criteria. The Methodology aggregates criteria, sub-criteria, etc. into unique hierarchical level and applies a total integral method for comparing futuristic decision alternatives. The proposed Methodology is also applied for computing the Global Futuristic Judgment Weights, $W_i^{J_L}$, for improving Telemedicine Services in India. Telemedicine will help in improving the inadequate quality health services of the rural and remote population of India.

Keywords: Telemedicine Services, Fuzzy Logic, Multi Criteria Decision Making, Future Scan

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Introduction

Decision making problem is the process of finding the best option from the entire feasible alternatives. In almost all such problems the multiplicity of criteria for judging the alternatives is pervasive. That is, for many such problems, the decision maker wants to solve a multiple criteria decision making problem. Analytic hierarchy process (AHP) has proved to be one of the most widely applied multiple criteria decision making methods, which has been applied for solving unstructured problems in areas of engineering (Chang et al. 2007), economics (Ghodsypour and Brien 1998; Badri 2000), medical (Huang et al. 2006), industrial (Udo 2000), military (Haapa 2003), etc. The AHP requires the decision maker furnish with complete information and ample knowledge of all aspects of the problem statements during their judgments under a pre-defined semantic scale. However the nature of the real world problems often relates to fuzziness and ambiguousness which initiates by the unprecedented environment conditions, human factors, incomplete information, etc. In order to model this kind of uncertainty in human preference, fuzzy sets could be incorporated with pairwise comparison as an extension of AHP. The fuzzy AHP approach allows a more accurate description of the decision making process.

FAHP was used to discuss the concept of risk attitude and associated confidence of a decision maker on the estimates of pair-wise comparison (Tesfamariam and Sadiq 2006). FAHP was applied to construct the multi-criteria decision making problem and determine criteria weights to select evaluation outcomes and evaluate the precision of optimal performing machines (Chang et al. 2006). Fuzzy set theory was also applied to evaluate the service quality of airline and described important aspects for the assessment of service quality of airline (Tsaur et al. 2002). A modified Fuzzy TOPSIS proposed for multiple criteria decision making problem when there was a group of decision maker (Saghafian and Hejari 2005). A fuzzy multiple criteria decision making method was discussed, which reflected both subjective judgment and objective information in real life situations (Kuo et al. 2006). A methodology for solving common robot selection problems using a modification of the conventional AHP by incorporating fuzzy linguistic variables were also presented (Kapoor and Tak 2005). Fuzzy multi-attribute axiomatic design approach and selection of the best company under determined criteria such as cost, time, damage/loss, flexibility and documentation ability using both multi-attribute Axiomatic Design and AHP were discussed (Kulak and Kahraman 2005). The key factors that affect success in e-commerce using Fuzzy AHP, and an evaluation method for e-commerce in order to help researchers and managers to determine the drawbacks and opportunities were determined (Kong and Liu 2005). A supplied selection analysis model considering both by AHP method and integration method of analysis results were proposed (Hwang et al. 2005). A 3 step restaurant planning based on service level, multi-criteria decision analysis, and stochastic set covering method and optimal decision of restaurant types of AHP and Fuzzy AHP were determined (Hwang and Ko 2003). An AHP based on fuzzy scales to determine the importance weights of customer requirements was proposed (Kwong and Bai 2002). A structured model for evaluating vendor selection using the AHP and Fuzzy AHP was proposed. The model was developed using evidence from an empirical study (Haq and Kannan 2006).

It is very essential for a decision maker to peep into short term future as well as long term future to make planning more effective and realistic. Future-scan is a powerful management tool that gives one vital clues how the decision one makes today will affect ones life in the coming year. (Taylor et al. 2008), (Custer et al. 1999), (Mehmood et al. 2003), (Li and Liu 2004), (Abbas and Bell 1994), (Haghani et al. 2003) have used various future-scan techniques like Delphi, System Dynamics, etc for various real-life socio-economic decision problems.

The primary objective of this paper is to present a new futuristic methodology for guiding decision making under vagueness type uncertainty. This task is achieved by proposing a Fuzzy Delphi Hierarchy Process (FDHP) Method. In the next section, basics of fuzzy theory are presented. This will be followed by a step-by-step procedure on the development of FDHP Methodology in aiding futuristic decision making process. Finally, a case study is also presented by applying the Methodology.

Overview of Fuzzy Theory

Vagueness type uncertainties can be handled using the fuzzy set theory. Fuzzy based techniques are a generalized form of interval analysis used to address uncertain and/or vague information. Following are some important definitions in order to understand and apply fuzzy set theory:

1. A fuzzy set $\widetilde{A}$ in a universe of discourse *U* is characterized by a membership function $\mu_{\widetilde{A}}(x)$ that takes values in the interval [0, 1]. $\mu_{\widetilde{A}}(x)$ is assigned to express the membership of *x* to $\widetilde{A}$.
2. The height of a fuzzy set is the largest membership value attained by any point. If the height of a fuzzy set equal to one, i.e. $\mu_{\widetilde{A}}(x)$ =1, it is called a normal fuzzy set.
3. An α-cut of a fuzzy set $\widetilde{A}$ is a crisp set $\widetilde{A}_\alpha$ that contains all the elements in *U* that have membership values in $\widetilde{A}$ greater that or equal to α, that is, $\widetilde{A}_\alpha = \{x \in U \mid \mu_{\widetilde{A}}(x) \geq \alpha\}$.
4. When the universe of discourse *U* is the n-dimensional Euclidean space R^n, a fuzzy set $\widetilde{A}$ is said to be convex if and only if its α-cut is a $\widetilde{A}_\alpha$ convex set for any α in the interval (0, 1]. This description can be expressed a formulation as below:

   A fuzzy set in is convex if and only if

   $$\mu_{\widetilde{A}}[\lambda x_1 + (1-\lambda)x_2] \geq \min[\mu_{\widetilde{A}}(x_1), \mu_{\widetilde{A}}(x_2)] \text{ for all } x_1, x_2 \in R^n \text{ and all } \lambda \in [0,1]$$

Fuzzy sets qualify as fuzzy numbers if they are normal, convex, and bounded. Different shapes of fuzzy numbers are possible (e.g. bell, triangular, trapezoidal, Gaussian, etc.). In order to simplify the implementation Triangular Fuzzy Numbers are used in this paper.

A Triangular Fuzzy Number $\widetilde{A}$ is a special class of fuzzy numbers expressed as $\widetilde{A} = (\beta, \rho, \delta)$, where β, ρ and δ are three real numbers satisfying $\beta = 0$ and $\beta \leq \rho \leq \delta$. Any real number in interval $[\beta, \delta]$ is characterized with a grade of membership between 0 and 1. Its membership function $\mu_{\widetilde{A}}(x)$ is piecewise continuous and linear *(Figure 1)* and satisfies the following conditions:

_ $\mu_{\widetilde{A}}(x)$ = 0, for all $x \in (-\infty, \beta] \cup [\delta, \infty)$;
_ $\mu_{\widetilde{A}}(x)$ is strictly increasing on $[\beta, \rho]$;
_ $\mu_{\widetilde{A}}(x)$ = 1, for $x = \rho$;
_ $\mu_{\widetilde{A}}(x)$ is strictly decreasing on $[\rho, \delta]$;

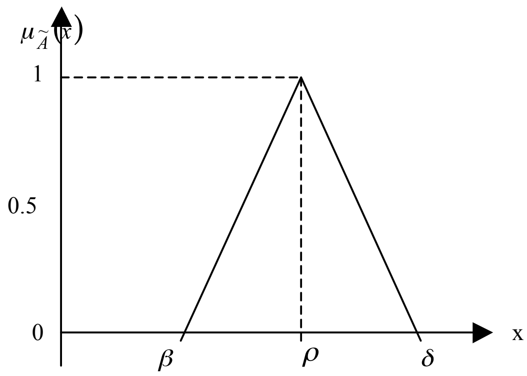

Figure 1

The membership of $\widetilde{A}$ can be defined as:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x}{\rho-\beta} - \frac{\beta}{\rho-\beta}, & x \in [\beta, \rho] \\ \frac{x}{\rho-\delta} - \frac{\delta}{\rho-\delta}, & x \in [\rho, \delta] \\ 0, & otherwise \end{cases}$$

The lower and upper bounds β and δ respectively support the modal value ρ and they illustrate its degree of fuzziness. The greater δ - β is, the fuzzier the degree is. When δ - β =0, the value ρ is not a fuzzy number and if δ - $\rho = \rho$ - δ , the triangular fuzzy number $\tilde{A}$ is symmetrical. The support of $\tilde{A}$ is the set of elements $\{x \in R \mid \beta < x < \delta\}$. When $\beta = \rho = \delta$, it is a non-fuzzy number by convention.

The fuzzy operations on two fuzzy numbers $\tilde{A}_1 = (\beta_1, \rho_1, \delta_1)$ and $\tilde{A}_2 = (\beta_2, \rho_2, \delta_2)$ can be defined as given in *Table 1*:

Operators	Formulae	Results
Summation	$\tilde{A}_1 \oplus \tilde{A}_2$	$(\beta_1 + \beta_2, \rho_1 + \rho_2, \delta_1 + \delta_2)$
Subtraction	$\tilde{A}_1 \ominus \tilde{A}_2$	$(\beta_1 - \beta_2, \rho_1 - \rho_2, \delta_1 - \delta_2)$
Multiplication	$\tilde{A}_1 \otimes \tilde{A}_2$	$(\beta_1 \times \beta_2, \rho_1 \times \rho_2, \delta_1 \times \delta_2)$
Division	$\tilde{A}_1 / \tilde{A}_2$	$(\beta_1 / \beta_2, \rho_1 / \rho_2, \delta_1 / \delta_2)$
Scalar Product	$k \cdot \tilde{A}_1$	$(k \cdot \beta_1, k \cdot \rho_1, k \cdot \delta_1)$

Table 1: Fuzzy Operations

Fuzzy Pairwise Comparison

The triangular fuzzy numbers $\tilde{1}$ *to* $\tilde{9}$ are utilized to improve the conventional nine-point scaling scheme. In order to take the imprecision of human qualitative assessments into consideration, the five triangular fuzzy numbers are defined with the corresponding membership functions as shown in *Figure 2*.

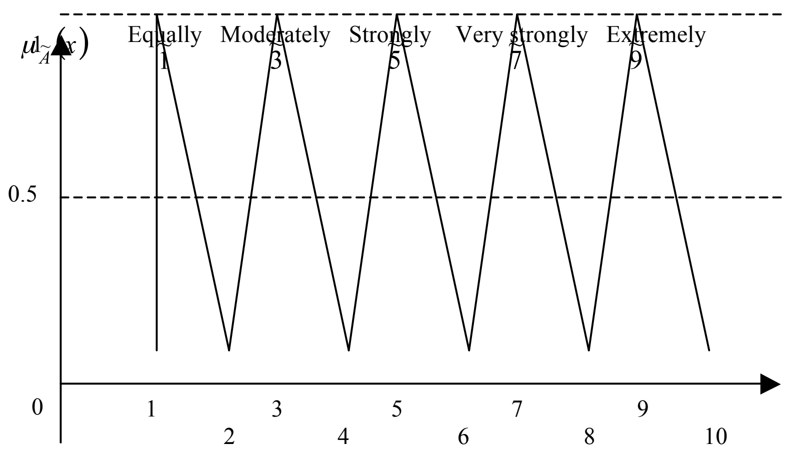

Figure 2: The membership function of triangular fuzzy numbers

The FDHP Methodology

The problem that arises is that traditional multi-criteria methods are not robust when dealing with limited experimental data, human judgments and the various metrics of decision variables. The main difficulties appear when quantitative measures are combined with linguistic expressions and the decision makers attitudes toward risk need to be modeled appropriately.

The Fuzzy Delphi Hierarchy Process (FDHP) Methodology is a quantitative forecasting method that involves the systematic solicitation and collation of experts and general users on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses. It deals with imprecision and subjectiveness in the pairwise comparison process. Considering the fuzziness in the decision data and futuristic decision making process strengthens the comprehensiveness and reasonableness of the futuristic decision making process. The methodology uses a range of value to incorporate decision maker's uncertainty. From this range decision maker can select the values that reflects his confidence and also can specify his attitude like optimistic, pessimistic or moderate. The stepwise procedure of the methodology is as follows:

Step 1: Cluster formation of Current Decision Plan

This Methodology revolves around three Groups- Judgment Making Group (JM), Interdisciplinary Respondent Group (IR) and Expert Group (EP). The JM Members are mainly responsible to select a problem, formulate goal, selects the IR Group and the EP Group, and compute Global Futuristic Judgment Weights $\left(W_i^{J_L}\right)$. Expert Group generates the Multi Futuristic Decision Parameters and forms Fuzzy Pairwise Comparison Matrices and IR Group rates and ranks the MFDPs. To meet the Goal, the Current Decision Plan is generated using Inside-Out and Outside-In Approach. This Current Decision Plan is clustered in to a responsible set of mutually exclusive and encompassing "i" Multi Futuristic Decision Parameters (MFDPs) by JM.

Step 2: Rating and ranking the Multi Futuristic Decision Parameters

A Modified Delphi Questionnaire (MDQ) is developed and designed to rate and rank the Multi Futuristic Decision Parameters. This allows the panel to immediately focus on the study issues. The rating and ranking is done by IR Group using a 9-Point Fuzzy Scale, where $\tilde{9}$ is for most important and $\tilde{1}$ is for least important MFDP.

Step 3: Establishing Triangular Fuzzy Decision Numbers (TFDNs)

The TFDNs for each level is established using:

$$\tilde{f}_i^L = (\theta_i, \beta_i, \gamma_i) \qquad \theta_i \leq \beta_i \leq \gamma_i \tag{1}$$

where
$$\theta_i = \min\left(P_{ijk}\right)$$
$$\beta_i = \sqrt[n]{\sum_{j=1}^{n} P_{ijk}}$$
$$\gamma_i = \max\left(P_{ijk}\right)$$

Here θ denotes the minimum numerical value for a consensus among the Experts, γ denotes the maximum numerical value and β is the Geometric Mean. L represents the level of the hierarchy and P_{ijk} represents judgment of IR Group Member k.

Step 4: Computation of Fuzzy Weights $\left(\tilde{w}_i^{f_L}\right)$

Given $\tilde{f}_i^L$ from (1), the corresponding Fuzzy Weights $\left(\tilde{w}_i^{f_L}\right)$ are calculated using (2):

$$\tilde{w}_i^{f_L} = \tilde{F}_i^L \otimes \left(\tilde{F}_1^L \oplus \tilde{F}_2^L \oplus \ldots\ldots \oplus \tilde{F}_n^L\right)^{-1} \tag{2}$$

where $\widetilde{F}_i^L = \left(\widetilde{f}_{i1}^L \otimes \widetilde{f}_{i2}^L \otimes \ldots\ldots \widetilde{f}_{in}^L\right)^{1/n}$

Sum of most likely values of Fuzzy Weights $\left(\widetilde{w}_i^{f_L}\right)$ (i= 1,…, n) is equal to 1, which is the basic axiom of AHP. Therefore, crisp AHP is a special case of Fuzzy-AHP when fuzzification factor reduces to zero. The difference between sum of minimum values and maximum values represents a range of uncertainty or fuzziness in the computed weight, and can be viewed as belief and plausibility, respectively.

Step 5: Computation of Fuzzy Pair wise Comparison Matrix $\left(\widetilde{P}^L\right)$

A Fuzzy Pair-wise Comparison Questionnaire (FPCQ) was developed. This questionnaire is rated and ranked by EP Group using a Fuzzy Evaluation Scale *(Table 2)* to generate Fuzzy Pair-wise Comparison Matrix $\left(\widetilde{P}^L\right)$ for each level.

Rank	Fuzzy Scale[b]	Definition[a]	Description
$\widetilde{1}$	(1, 1, 1) if diagonal else (1, 1, 3)	Equal importance	Two criteria contribute equally to objective
$\widetilde{2}$ $\widetilde{4}$ $\widetilde{6}$ $\widetilde{8}$	(1, 2, 2 + Δ[c]) (4 – Δ, 4, 4 + Δ) (6 – Δ, 6, 6 + Δ) (8 – Δ, 8, 8 + Δ)	Intermediate values between two adjacent judgments	When compromise is needed
$\widetilde{3}$	(3 – Δ, 3, 3 + Δ)	Weak importance	Experience and judgment slightly favor one criteria over another
$\widetilde{5}$	(5 – Δ, 5, 5 + Δ)	Essential or strong importance	Experience and judgment strongly favor one criteria over another
$\widetilde{7}$	(7 – Δ, 7, 7 + Δ)	Demonstrated importance	One criteria is strongly favored and demonstrated in practice
$\widetilde{9}$	(9 – Δ, 9, 9 + Δ)	Absolute importance	The evidence favoring one criterion over another is of the highest possible order of affirmation
$1/\widetilde{x}$ [d]	$\left(1/\widetilde{x} + \Delta,\ 1/\widetilde{x},\ 1/\widetilde{x} - \Delta\right)$	If criteria *i* has one of the above assigned to it when compared with criteria *j*, then *j* has the reciprocal value when compared with *i*	

[a] the intensity of importance definition is in accordance with the description proposed by Saaty
[b] minimum, most likely and maximum values
[c] Δ is the fuzzification factor and 0.5 ≤ Δ ≤ 2
[d] $\widetilde{x}$ = 2, …, 9

Table 2: Fuzzy Evaluation Scale

Step 6: Computation of Fuzzy Importance Weights $\left(\widetilde{W}_i^{I_L}\right)$

Using the Matrices $\left(\widetilde{P}^L\right)$, Fuzzy Aggregate Matrix, $\widetilde{A}^L$, are calculated using (3)

$$\widetilde{A}^L = \left[\widetilde{a}_{ij}^L\right] = \left[\frac{\sum \eta_{ij}}{m}, \frac{\sum \xi_{ij}}{m}, \frac{\sum \sigma_{ij}}{m}\right] \quad (3)$$

where m is the number of matrices rated by Expert Group. Here η denotes the minimum value, ξ is the Modal value and σ denotes the maximum numerical value.

The Fuzzy Performance Weights $\left(\tilde{w}_i^{P_L}\right)$ of each of the MFDPs with respect to all criteria of all levels are calculated using (4)

$$\tilde{w}_i^{P_L} = \sum_{j=1}^{m} a_j \otimes \left[\sum_{i=1}^{m}\sum_{i=1}^{m} a_{ij}\right]^{-1} \tag{4}$$

Now, the Fuzzy Importance Weights $\left(\tilde{W}_i^{I_L}\right)$ are computed using eq. (5):

$$\tilde{W}_i^{I_L} = \tilde{w}_i^{f_L} \otimes \tilde{w}_i^{p_L} \tag{5}$$

$$= \begin{bmatrix} W_{1\eta}^{I_L} & W_{1\xi}^{I_L} & W_{1\sigma}^{I_L} \\ \vdots & & \\ W_{m\eta}^{I_L} & W_{m\xi}^{I_L} & W_{m\sigma}^{I_L} \end{bmatrix}$$

Step 8: Calculation of the crisp interval $\left(\tilde{C}_i^{\alpha_L}\right)$

The α -cut based method is applied to the $\tilde{W}_i^{I_L}$ weights for each MFDP to obtain the Crisp Interval $\left(\tilde{C}_i^{\alpha_L}\right)$ of the form $\tilde{C}_i^{\alpha_L} = \left[\tilde{C}_i^{left}, \tilde{C}_i^{right}\right]$ using eq (6). Here C_i^{left} and C_i^{right} respectively denote the left point and the right point of the range of the triangle after using the α -cut α ranges between 0 and 1. When α = 1, the decision maker is very sure about his judgment and when α = 0, the uncertainty is maximum.

$$\tilde{C}_i^{\alpha_L} = \begin{bmatrix} C_1^{left}, C_1^{right} \\ | \\ | \\ C_n^{left}, C_n^{right} \end{bmatrix} \tag{6}$$

where
$$C_i^{left} = \left(W_{i\xi}^{I_L} - W_{i\eta}^{I_L}\right)\alpha + W_{i\eta}^{I_L}$$
$$C_i^{right} = \left(W_{i\sigma}^{I_L} - W_{i\xi}^{I_L}\right)\alpha + W_{i\sigma}^{I_L}$$

Step 9: Computation of Normalized Decision Weights $\left(D_i^{N_L}\right)$

The Decision Weights $\left(D_i^L\right)$ are calculated using (7):

$$D_i^L = \lambda C_i^{left} + (1-\lambda) C_i^{right} \qquad \lambda \in [0,1] \tag{7}$$

Where λ is the risk index. The risk index λ = 0, 0.5 or 1 indicates the decision-maker's optimistic, moderate or pessimistic view point about characteristics. The larger value of the index λ indicates the higher degree of optimism. These D_i^L are then normalized to get the Normalized Decision Weights $\left(D_i^{N_L}\right)$.

Step10: Computation of Global Futuristic Judgment Weights $\left(W_i^{J_L}\right)$ for all levels

Finally, using the $D_i^{N_L}$ the Global Futuristic Judgment Weights $\left(W_i^{J_L}\right)$ are calculated for all levels to determine the prioritized MFDPs.

The application of FDHP Methodology

With the growing cost of healthcare becoming a major headache for governments across the world, telemedicine could provide a solution to India and other countries grappling with the problem. Telemedicine makes healthcare delivery more efficient and effective and copes with some of the challenges that lie ahead, such as an ageing population, the rise in chronic conditions, the shortage of healthcare professionals, and the healthcare budgets. Development and implementation of telemedicine and e-health tools require good coordination and mutual understanding between all parties involved (patients/citizens, care providers, government, health insurers, industry, research), so that the tools can be implemented and used in the most optimal way.

Telemedicine in India provides insight into the growing telemedicine market in India. With a rural population nearing 700 million, India will benefit enormously from digital data transmission related to healthcare. Both public and private entities are aggressively pursuing the use of telemedicine to hasten diagnostics and treatment of a variety of diseases. The Ministry of Communications and Information Technology, Government of India, has classified "Telemedicine" as one of the thrust areas for development in the country. Availability of necessary telecommunication infrastructure, crucial for success of telemedicine program, is drawing special attention in India.

Multi criteria decision making problems often involve a complex decision process in which multiple requirements and fuzzy conditions have to be taken into consideration simultaneously. The selection of best alternative for the effective transportation system for the public is a multi criteria decision making problem. For telemedicine to be successful there must be an ability to clearly transmit a clinical situation, including clinical information of diagnostic quality, to a clinician located far from the point of need, and the ability for that clinician to effectively communicate concerns, additional requirements needed for diagnosis, or the provision of a diagnosis back to the point of need. There remain several challenges to the implementation of telemedicine on a large scale. In this section the FDHP Methodology has been applied to improve the Telemedical services in India.

Step 1: 5 members of Judgment Making Group selected 114 members of Interdisciplinary Respondent Group and 24 Experts. The Goal of this research study was ***to compute Global Futuristic Judgment Weights*** $\left(W_i^{J_L}\right)$ ***for improving the Telemedical services in India***. To meet the Research Study Goal total 12 Multi Futuristic Decision Parameters (MFDP) were generated and were clustered into a hierarchy of 2 levels. A Modified Delphi Questionnaire was developed to generate MFDPs.

Step 2: The generated MFDPs were rated and ranked by IR Group.

Step 3: Triangular Fuzzy Decision Numbers (TFDN) were established for the MFDPs for all the levels. The 1st level TFDN are:

$$\tilde{f}_i^1 = \begin{matrix} \left(\tilde{5},\tilde{7},\tilde{8}\right) \\ \left(\tilde{8},\tilde{9},\tilde{9}\right) \\ \left(\tilde{6},\tilde{8},\tilde{9}\right) \\ \left(\tilde{8},\tilde{8},\tilde{9}\right) \\ \left(\tilde{3},\tilde{4},\tilde{6}\right) \\ \left(\tilde{1},\tilde{1},\tilde{2}\right) \end{matrix} \qquad i = 1, \dots, 6$$

Step 4: Using the above $\tilde{f}_i^L$ corresponding $\tilde{w}_i^{f_L}$ were calculated using (2). $\tilde{w}_i^{f_L}$ for 1st level are:

$$\tilde{w}_1^{f_1} = (5.5178,\ 6.5421,\ 7.5595) \otimes \left(\frac{1}{42.0288}, \frac{1}{36.608}, \frac{1}{31.1374}\right)$$
$$= (0.1313,\ 0.1787,\ 0.2428)$$

Similarly,

$$\tilde{w}_i^{f_L} = \begin{matrix} (0.1821,0.2364,0.2890) \\ (0.1557,0.2065,0.302) \\ (0.1741,0.2273,0.2890) \\ (0.0739,0.1167,0.1668) \\ (0.0238,0.0344,0.0963) \end{matrix} \qquad i = 2, \dots, 6$$

Step 5: A Fuzzy Pair-wise Comparison Questionnaire was developed and rated and ranked by Expert Group using the Fuzzy Evaluation Scale to generate the Fuzzy Pair-wise Comparison Matrix.

Step 6: The Fuzzy Aggregated Pair-wise Matrix $\tilde{A}^L$ was then calculated using eq.(3). $\tilde{A}^L$ for level 1 is as follows:

$$\tilde{A}^1 = \begin{bmatrix} \tilde{1} & (0.22,0.22,0.25) & (0.24,0.27,0.31) & (0.37,0.45,0.58) & (0.37,0.45,0.58) & (1.00,2.00,3.00) \\ & \tilde{1} & (8.00,9.00,9.00) & (7.50,8.50,9.00) & (4.50,5.50,6.50) & (1.00,2.00,3.00) \\ & & \tilde{1} & (3.50,4.50,5.50) & (3.50,4.00,5.50) & (1.00,2.00,3.00) \\ & & & \tilde{1} & (7.00,8.00,9.00) & (1.00,2.00,3.00) \\ & & & & \tilde{1} & (1.00,2.00,3.00) \\ & & & & & \tilde{1} \end{bmatrix}$$

Step 7: $\tilde{w}_i^{P_L}$ were determined using eq (4) and $\tilde{W}_i^{I_L}$ were computed using eq. (5). $\tilde{W}_i^{I_L}$ for level 1 are:

$$\tilde{W}_i^{I_1} = \begin{bmatrix} 0.0048 & 0.0107 & 0.0234 \\ 0.0541 & 0.0988 & 0.1609 \\ 0.0219 & 0.0433 & 0.0864 \\ 0.1219 & 0.0422 & 0.0785 \\ 0.0035 & 0.0092 & 0.0199 \\ 0.0007 & 0.0016 & 0.0097 \end{bmatrix}$$

Step 8: The crisp interval, $\tilde{C}_i^{\alpha_1}$, were calculated using (6). $\tilde{C}_i^{\alpha_1}$ for 1st level are:

$$\tilde{C}_i^{\alpha_1} = \begin{matrix} [0.0078, 0.0141] \\ [0.0765, 0.1299] \\ [0.0326, 0.0639] \\ [0.0321, 0.0604] \\ [0.0064, 0.0146] \\ [0.0012, 0.0057] \end{matrix} \qquad i = 1, \ldots, 6$$

Step 9: The D_i were computed using (7) and were normalized to get $D_i^{N_L}$.

Step10:Finally the Global Futuristic Judgment Weights $W_i^{J_L}$ were calculated. $W_i^{J_L}$ for level 1 are:

$$W_i^{J_1} = \begin{matrix} 0.0489 \\ 0.4638 \\ 0.2171 \\ 0.2081 \\ 0.0472 \\ 0.0148 \end{matrix} \qquad i = 1, \ldots, 6$$

5. RESULTS AND CONCLUSION

The generated MFDPs and their $W_i^{J_L}$ are given in *Table 3*. The results indicate that there was an urgent need to increase the expenditure on healthcare in rural areas, remove the asymmetries in information in the doctor patient relationship and improve the infrastructure of rural health centers for achieving the goal.

	MFDP	$W_i^{J_L}$ **Weights**
A	Expenditure on healthcare in rural areas.	0.4638
B	Asymmetries in information in the doctor patient relationship	0.2171
C	Infrastructure of rural health centers	0.2081
D	Essential therapeutic drugs supply in most public health institutions	0.0489
E	Trained manpower	0.0472
F	Lack of advance technology	0.0148
A.1	Reduced cost of patient care	0.0295
A.2	Share resources optimally and increase efficiency and throughput	0.0671
A.3	Single referral hospital can handle multiple nodal centers simultaneously through telemedicine	0.1041
B.1	Faster access to patient records and reduced intervention time	0.1000
B.2	Capture and upload patient information, waveforms & images	0.1080
B.3	Real time transmitting of ECG and other vital sign data for expert opinion	0.0745
B.4	Providing instantaneous expert advice	0.0570
E.1	Awareness Programs	0.2600
E.2	Continuing Medical Education Programs for doctors in rural areas,	0.1031
E.3	Training of teachers for vision screening program	0.0322
F.1	Video conferencing equipment	0.0221
F.2	Live digital video and high-speed satellite connections enable specialists to evaluate and diagnose illnesses in real time	0.0423

Table 3: MFDP and their $W_i^{J_L}$ Weights

This paper proposes a FDHP Methodology for solving a multi-criteria futuristic decision making problems. The major advantages of the Methodology:

1. Can be used for both qualitative and quantitative criteria
2. Has the capability to be flexible and can be applied in different fields like medical, economic, engineering, social etc.
3. Can not only make trade-offs between both qualitative and quantitative factors but it also enables decision makers to deal with inconsistency judgments systematically.
4. Helps to identify future opportunities and judge in advance, the likely future threats. Identification of future events provide new ideas and alternative approaches for growth and socio-economic development and helps decision maker to avoid future threats and to realize new opportunities.

The proposed Methodology not only works equally effectively for crisp values and non-fuzzy situations but will also provide researchers with an effective tool for evaluating fuzzy representations for modeling subjective and ambiguous situation.

1. Essential therapeutic drugs are not supplied in most public health institutions
2. lack of trained manpower
3. lack of advance technology like video conferencing equipment

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