Diet Recommendation for Hypertension Patient on basis of Nutrient using AHP and Entropy

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Abstract—**Hypertension is named as silent killer. It is considered as one of alarming factor for chronic kidney disease, heart failure, impaired vision, Ischemic heart disease, Stroke etc. Hypertension is divided into systolic and diastolic blood pressure. According to studies 90-95% cause of hypertension is change in lifestyle therefore Diet plays essential role to hypertension patient. According to WHO studies, Death due to chronic disease in increased by 18% in India. However high blood pressure had affected 1.13 billion people across the world. The observed systolic blood pressure measurement is >140 mmHg and diastolic blood pressure measurement is > 90mmHg in 2015. The paper shows the finest diet plan for hypertension patient using Analytic Hierarchy process. The technique used in this paper for representing diet plan is unique and haven't been shown earlier. The Diet plan considers all the meals needed to be consumed by hypertension patient in breakfast, lunch and dinner. The results are validated using Entropy method. The results evaluated during validation are same as obtained using AHP.**

Keywords—Hypertension, Diet, Analytic Hierarchy Approach (AHP), Entropy, Nutrients

I. INTRODUCTION

Hypertension is a general term known as high blood pressure. Many people are not able to identify its symptoms at early stages and untreated hypertension in long term can increase the risk of heart disease, dementia, and blindness. The hypertension is classified into primary and secondary stage. Several environmental factors affect at primary stage of hypertension such as excessive intake of salt due to deficiency of zinc, obesity, smoking, excessive alcohol etc. The proper diet is recommended in order to prevent and cure from hypertension. The secondary stage of hypertension increases the risk of heart myocardial infarction, chronic kidney disease (CDK), vision loss [1]. According to WHO research, it is observed that 40% of adults suffer from high blood pressure in developed and developing countries. Worldwide, 51% cerebrovascular disease and 45% of coronary heart disease deaths are attributable to high systolic blood pressure [2]. The diet chart consists of important minerals and vitamins required to intake by hypertension patient. Nutrition plays vital role in improving the health and standard of adequate balanced diet [3]. A consultation system has developed in order to recommend the diet to the patient suffering from chronic kidney diseases. It considers the amount of nutrition taken by patient by the food consumed. The system for evaluation is developed using web ontology language data model and semantic rules [4]. The personalized diet chart is constructed using the information regarding physical activity of person, the nutrition consumed and the seasonal activity of food items. The system considers the personal preference and appropriate dietary plan using technique fuzzy Ontology [5]. The increase in blood pressure is relatable to more amount of sodium intake whereas less amount of potassium and magnesium intake in dietary plan [6]. Kovasznai proposed an expert system for recommendation of diet sing case based reasoning and ripple down rule approach. The objective of system is to get deployed in health record management application [7]. The research has shown that DASH (Dietary approaches) is efficient way of reducing blood pressure. The DASH diet involves consumption of whole grain products, fruits, green vegetables etc. and restriction on usage of high fatty products, sugar, red meat, excessive sodium [8]. The DASH diet trail is conducted among men and women and it is observed that by reducing the sodium intake the lowered the systolic blood pressure by 2.1mmHg in controlled diet [9]. Approximately 60% elder people undergoing through pain of three chronic disease which are high cholesterol, diabetes and hypertension in Taiwan. These diseases are manageable through proper diet intake. The rational diet is constructed using Fuzzy rules and knapsack method [10]. Fuzzy expert system is developed in relevance to diet recommendation for jaundice patient which determines the details of nutrition that is to be consumed by patient in recent work [11]. Cancer is the most fatal disease. The cancer patient requires the different diet for recovery as well for treatment. The personalized diet recommendation chart is developed containing necessary nutrition using data mining technique, Genetic algorithm in one of the paper. The paper describes the amount of nutrition intake and suggesting dishes and food accordingly [12]. The nutrition plays indispensable part in recommendation of diet so we have

presented its importance using technique known as Analytic hierarchy process (AHP). The method has significant advantage over the conventional used method for diet recommendation. The minerals and vitamins considered in diet are beneficial for hypertension patient. By using AHP a proper rational diet chart is developed which provides the well-maintained balance of nutrition in the body. AHP considers the consistency of data with the help of consistency ratio. Singh and Dubey [13] proposed the diet recommendation for anemia patient using AHP in which validation is performed using fuzzy TOPSIS approach. The AHP evaluates on the basis of critical factors thus provides precise assessment of considered data [14]. The objective of proposed paper is to provide the finest diet plan for hypertension patient using Analytic Hierarchy process.

In the proposed paper the validation of results is achieved through the usage of entropy method. The expert doctor, practitioner recommended the nutrition diet for hypertension patient which is authenticated and verified. The meal consists of breakfast, lunch, dinner among which good alternative can be selected. It provides the concrete and precise diet plan that is not developed in traditional method. The hypertension patient can refer the diet chart so that high blood pressure can be cured at early stage of disease. The paper is organized in following structure. The section 2 describes about the proposed methodology which determines the various steps to obtain the result. In section 3, the experimental work is shown using Analytic hierarchy process (AHP). In section 4, the results are compared and presented. In section 5, the conclusion of work performed is shown along with its future scope.

II. PROPOSED METHODOLOGY

MCDM stands for multi criteria decision making. It is used as significant tool for analyzing the outcome dependent upon certain criteria and effect of those criteria on decision making process. Analytic hierarchy process is MCDM approach constructed by Thomas L. Saaty in 1980. In this approach order of preferences are considered to solve real complex problem. The best alternative available is chosen for the process based on priority. It incorporates the judgement of expert, practitioner, researchers in decision making. It arranges the complex problem in hierarchal and structure form. It makes use of sample comparison matrices. The Eigen values, Consistency ratio, Eigen vector and consistency index plays crucial role in determining the results.

TABLE 1. COMPARISON MATRIX

X	Zi	Zj	Zn
Zi	1	Zij	Zin
Zj	1/Zij	1	Zjn
Zn	1/Zin	1/Zjn	1

A. STEPS FOR EVALUATION USING AHP

a) Consider the critical factors and the desirable alternative.
b) Determine the pairwise comparison matrix with the help of Saaty's fundamental scale.
c) Evaluate the nth root of the product and their respective sum.
d) Obtaining the assigned weights by normalizing the nth root of products evaluated.
e) Computation of consistency index (C.I) using Saaty's random consistency index table

$$C.I = (\lambda max - n) / (n - 1) \qquad (1)$$

Here λmax is Eigen value.

f) Computation of consistency ratio which should be less than 10%. If C.R is less than 10% than decision made is satisfactory using eq 2.

$$C.R = C.I / R.I \qquad (2)$$

Here R.I represents Reliability index.

TABLE 2. SAATY'S FUNDAMENTAL GRADING

Grading	Significance
1	Equally significant
3	Moderately significant
5	Highly significant
7	Extremely significant
9	Strongly significant
2,4, 6,8	Intermediate values

TABLE 3. RANDOM CONSISTENCY INDEX TABLE

n	1	2	3	4	5	6
C.N	0.0	0.0	0.58	0.90	1.12	1.24

B. ENTROPY METHOD

The Entropy method is introduced by Shannon. In the proposed work it is used to determine the weights for the coordinates used in Multi criteria decision making. It is used for validation of results in this paper. The results obtained from AHP and entropy method are compared.

STEPS FOR EVALUATION USING ENTROPY

a) Computation of Eigen vector.
b) Calculate the constant.

$$(\mu) = 1/\ln(n) \qquad (3)$$

where n represents number of Diet.

c) Evaluate the vector using eq 4

$$V_j = \mu \sum (l_{ij} * \ln (l_{ij})) \qquad (4)$$

d) Calculate Eigen Vector and weights.

$$E_i = (1 - V_i) \tag{5}$$

$$W_j = E_j / \sum E_j \ (j=1) \tag{6}$$

e) Calculate probability vector and place the ranking accordingly.

$$R^3 I_i = \sum (l_{ij} * W_j) \tag{7}$$

III . EXPERIMENT RESULTS

Based on survey these critical factors are considered. Table 4 shows the elements and their importance level to high blood pressure patient diet.

TABLE 4. FACTORS AND ITS IMPORTANCE IN DIET

POTASSIUM	The American heart association stated that potassium plays important role for managing the HBP. Potassium in the correct amount if included in diet it controls HBP as it reduces the sodium intake. It includes fruits, legumes, raisin, spinach etc. in diet. The suggested potassium intake for adult is 4700 mm per day. However too much quantity of potassium intake can affect kidney patients.
MAGNESIUM	Dr. Mercola determined that magnesium helps in maintain the proper blood pressure level. Magnesium [17] supplements have shown significant reduction in HBP. Low fat dairy product, bananas, potatoes etc. comes in diet of Mg alternatives.
CALCIUM	It is the abundant mineral present in human body needed for blood vessel contraction and expansion, secretion of enzymes, hormonal secretion. The product included in calcium are yogurt, leafy green vegetable, nuts etc.
COENZYMEQ10	CoenzymeQ10 helps in lowering of systolic and diastolic blood pressure. It acts as antioxidant. The journal of human hypertension concluded from their research that it has power to reduce blood pressure. Fruits, vegetables, fish, nuts are the moderate sources of CoenzymeQ10.

On the basis of critical factor, the diet plan is constructed by consulting to dietitian. The diet plan consists of meals that includes breakfast, lunch and dinner. The diet is developed keeping the above factors into concentration.

TABLE 5. DIET PLAN

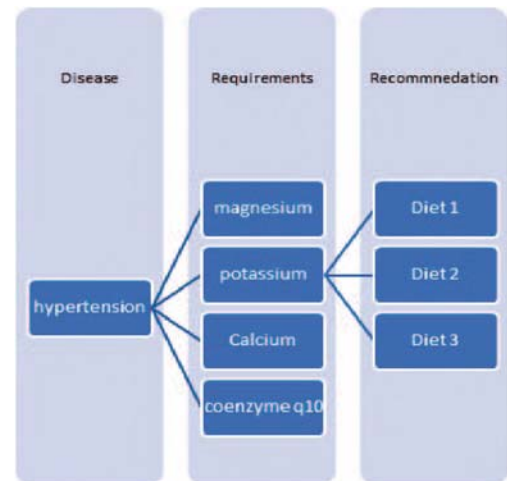| DIET SEQUENCE	ELEMENTS REQUIRED IN DIET
DIET 1	Breakfast – Milk, Almonds, Banana
	Lunch – Salad, Leafy green Vegetables
	Dinner – Legumes, Brown, wheat
DIET 2	Breakfast – Oats, oranges, nuts
	Lunch – Roasted potato, brown bread, seeds
	Dinner – Brown rice, barley
DIET 3	Breakfast – spinach, broccoli veg, sweet potato
	Lunch – Mix grain cereals, Yogurt
	Dinner – Fish, brown wheat chapatti

Fig 1. AHP Model

The Table is developed for elements potassium, Magnesium, Calcium, Coenzymeq10 and Eigen vector is calculated.

TABLE 6. POTASSIUM WITH RESPECT TO D1, D2, D3

Potassium	Diet 1	Diet 2	Diet 3	Eigen vector
Diet 1	1	0.33	5	0.2784
Diet 2	3	1	7	0.6500
Diet 3	0.2	0.14	1	0.0715

λavg(max) = 3.0537, C.I. = 0.0268, C.R. = 0.0463

TABLE 7. MAGNESIUM WITH RESPECT TO D1, D2, D3

Magnesium	Diet 1	Diet 2	Diet 3	Eigen vector
Diet 1	1	6	3	0.6361
Diet 2	0.16	1	0.2	0.0771
Diet 3	0.33	5	1	0.2868

λavg(max) = 3.0733, C.I. = 0.0367, C.R. = 0.0632

TABLE 8. CALCIUM WITH RESPECT TO D1, D2, D3

Calcium	Diet 1	Diet 2	Diet 3	Eigen vector
Diet 1	1	0.33	4	0.2702
Diet 2	3	1	6	0.6456
Diet 3	0.25	0.16	1	0.0842

λavg(max)= 3.0340, C.I. = 0.0170, C.R. = 0.0293

TABLE 9. COENZYME WITH RESPECT TO D1, D2, D3

CoenzymeQ10	Diet 1	Diet 2	Diet 3	Eigen vector
Diet 1	1	5	8	0.7420
Diet 2	0.2	1	3	0.1830
Diet 3	0.125	0.33	1	0.0750

λavg(max)= 3.0414, C.I. = 0.0207, C.R. = 0.0357

TABLE 10. ELEMENTS ACCORDING TO ITS IMPORTANCE

Elements	Pot	Mag	Cal	Coenzyme Q10	Eigen vector
Potassium	1	0.16	0.2	0.143	0.0450
Magnesium	6	1	6	2	0.5039
Calcium	5	0.165	1	0.25	0.1166
Coenzyme Q10	7	0.5	4	1	0.3346

λavg(max)= 4.2685, C.I. = 0.0895, C.R. = 0.0994

3.1 Ranking

TABLE 11. RANKING

Validation	Diet 1	Diet 2	Diet 3	E
Potassium	0.2784	0.6500	0.0715	0.249
Magnesium	0.6361	0.0771	0.2868	0.232
Calcium	0.2702	0.6456	0.0842	0.231
CoenzymeQ10	0.7420	0.1830	0.0750	0.331
Priority	0.50496	0.37207	0.12298	
Rank	1	2	3	

3.2 Validation

In Table 12, the priority and rank are shown using entropy method.

TABLE 12. VALIDATION PERFORMED USING ENTROPY

Rank	Pot	Mag	Cal	Coenz	Priority	Rank
Diet 1	0.2784	0.6361	0.2702	0.7420	0.6128	1
Diet 2	0.6500	0.0771	0.6456	0.1830	0.2046	2
Diet 3	0.0715	0.2868	0.0842	0.0750	0.1826	3

IV. Matching Results

After generating the values from AHP and Entropy method, the comparison is made between their results and it is predicted that the order of preferences are same.

TABLE 13. COMPARED RESULT

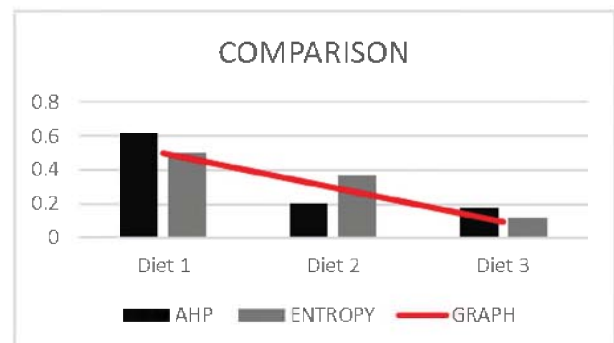| SEQUENCE	AHP	ENTROPY	RANK
Diet 1	0.6128	0.50496	1
Diet 2	0.2046	0.37207	2
Diet 3	0.1826	0.12298	3

Fig 2. Matching result

V. Conclusions

Hypertension can be reduced by taking proper rational diet. In the proposed paper we consider the diet plan containing meal having necessary nutrition for hypertension patient. The technique AHP is used to determine the best among three alternative diet suggested by dietitian. It is founded that recommended diet 1 priority is 0.612, diet 2 is 0.2046 and diet 3 is 0.1826. The work is validated using Entropy decision making approach to check the consistency of proposed model and reduce the linguistic errors The system can help medical practitioners for considering the diet chart for patients. The future research work includes more alternative nutritional diet which can be converted into mobile based application upon more reliable finding of work.

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