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Application of matrix for hospital dietary services

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Abstract

In this paper, we try to solve diet problem of patients in the hospital by considering that patients has some allergy with any ingredient of some particular food provided to them. The Mathematical model of the diet is developed in the form of matrix with the assumption that a particular patient is allergic to any particular food ingredient. The attempt has been made to study to advise patients that what kind of food they are supposed to take to avoid severe effects of allergies.

Keyword: diet scheduling, mathematical modeling, daily nutritional requirements.

Introduction

The healthy diet incorporates a balance range of food groups and all the necessary nutrients like carbohydrates, proteins, vitamins, minerals, fat and fibers to promote appropriate health to our body. Human nutritional diet is tremendously advanced and crucial for everybody to take care of physiological condition and body condition. A healthy diet might vary wide in line with a human genetic makeup, surroundings, and health. In fact, a well-planned diet is even a lot of vital for those that suffer from any kind of diseases.

Patients could typically have special dietary needs or restrictions whereas in hospital. It's vital that the food being brought in is appropriate and meets any restrictions. Often when somebody is indisposed or admitted in hospital, immune systems get weaker. This means that it's easier for harmful bacterium to penetrate in body and make patient more unwell. It could occur if patients' intake food is not safe and nutritional. The indication of illness will embrace nausea, vomiting, abdomen cramps, looseness of the bowels and fever. If patients puke out more and/or looseness of the bowels are severe then it will result in dehydration and that resulting illness can be life threatening in some cases. It is estimated that millions of patients in hospitals suffer from true food allergies. At this time, there is no proper cure for food allergic reactions. Prevention is the only way out to stop associate food sensitivity. Some foods cause food allergies to patients. Although patient could be allergic to any ingredient in any food such as vegetables, fruits, milk products, meats, nuts, etc., which causes allergic reactions on skin, eyes, respiratory tract like breathing problems and gastrointestinal tract such as abdominal pain cramps etc. Strict rejection is the only way to get rid of allergies from food. To maintain management over the hypersensitivity reaction on patients reading ingredient labels for all food is the key. In hospitals the fault is going to be on the hospital employees' members to spot and inform the acceptable network of people concerning their patients' food allergies and to produce safe food selections to those patients. Most significant, hospital employees members should be ready to quickly intervene just in case of any allergic reaction.

Polk, I.B. (2017) found a report that how food allergies in patients can be validated to stop any kind of food allergy in the hospitals. Sheng, L.Z., et.al. (2017) proposed a mathematical model to solve diet problem through linear programming and found the optimal solution for eczema diseased patients and how balanced diet charter has been prepared for controlling the diet. Mamat, M. et.al. (2012) described fuzzy linear programming for balancing diet in patients. They calculated nutrient contents in the food using fuzzy theory and found the requirements for patients body need in their daily diet to prevent an allergic reaction. HREŢCANU, C.E. et.al. (2010) conducted a mathematical model on diet program to get the nutrient from the food intake and by the usage of Solver in Microsoft Excel they showed how to provide a quick way to clear up this diet problem and to examine if the each day dietary necessities of someone are satisfied. Maillot, M. et .al. (2010) explained the dietary changes required to realize nutritional recommendations for every individual of a population. The results showed that nutrient wants may be consummated in many alternative ways that, betting on initial individual food patterns.

Mathematical Model of the Hospital Diet

We now consider a situation in a hospital where there are patients of *m* categories $P_1, P_2, P_3, ...P_m$ .Each category is allergic to some of the ingredients $I_1, I_2, I_3, ...I_n$, Kapur J. N. (1988). We define the matrix A by

$$A = \begin{array}{c} \\ P_1 \\ P_2 \\ . \\ . \\ . \\ P_m \end{array} \begin{array}{c} \begin{array}{cccccc} I_1 & I_2 & . & . & . & I_n \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & . & . & . & a_{1n} \\ a_{21} & a_{22} & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ a_{m1} & a_{m2} & . & . & . & a_{mn} \end{bmatrix} \end{array},$$

Where

$a_{ij} = 1$ *if category* P_i *is allergic to the ingredient* I_j

$= 0$ *if category* P_i *is not allergic to the ingredient* I_j.

Different types of food $M_1, M_2, M_3, ...M_{q,}$ are served in the hospital. Each of these contains some of the ingredients $I_1, I_2, I_3, ...I_n$ .These facts can be represented by the $q \times n$ *matrix* B :

$$B = \begin{array}{c} \\ M_1 \\ M_2 \\ . \\ . \\ . \\ M_q \end{array} \begin{array}{c} \begin{array}{cccccc} I_1 & I_2 & . & . & . & I_n \end{array} \\ \begin{bmatrix} b_{11} & b_{12} & . & . & . & b_{1n} \\ b_{21} & b_{22} & . & . & . & b_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ b_{q1} & b_{q2} & . & . & . & b_{qn} \end{bmatrix} \end{array},$$

where

$b_{kj} = 1 \quad if \;\; food \; M_i \; is \; contains \; ingredient \; I_j$

$= 0 \quad otherwise.$

Now we find the matrix product AB^T :

$$\left[AB^T\right]_{ik} = \sum_{j=1}^{n} a_{ij} b_{jk.} \cdots\cdots (3)$$

The summation (3) is zero if and only if each term is separately zero. There is at least one ingredient to which the patient is allergic and which is contained in the k-th food. The i-th category of patients should not therefore take the k-th food. Thus the choice of food must correspond to zeros in the AB^T matrix. If a row of the matrix does not contain any zero, no choice of food suitable for every category of patients. If a row has only one zero, the corresponding food has to be included. If a row contains two or more zeros, any one of the corresponding foods may be included. In general, we have to choose the minimum number of foods which can satisfy all categories of patients. This implies the choice of minimum number of columns in the matrix AB^T , which are such that there is a zero against every row in these columns.

Numerical Simulation:

Table: 1 (Matrix *A*) Ingredient contents of proposed foods [Hreţcanu, 2010]

	Nutrients(Ingredients)															
Food	Calories (kcal)(i1)	Protein (g) (i2)	Total fat (g) (i3)	Saturated fatty acids (g) (i4)	Cholesterol (mg) (i5)	Carbohydrate (g) (i6)	Total dietary fiber (g) (i7)	Calcium (mg)(i8)	Iron mg) (i9)	Potasium (mg) (i10)	Sodium (mg) (i11)	Vitamin A(RE)mg(i12)	Thiamin (mg) (i13)	Riboflavin (mg) (i14)	Niacin (mg) (i15)	Ascorbic acid(mg)(i16)
Apple juice, bottled (M1)	117	0.01	0.1	0	0	29	0.2	17	0.9	295	7	0	0.05	0.04	0.2	2

Boiled Potatoes (M2)	116	2	0.1	0	0	27	2.4	11	0.4	443	7	0	0.13	0.03	1.8	10
Bread of rye, reduced calorie (M3)	47	2	1	0.1	0	9	2.8	17	0.7	23	93	0	0.14	0.11	1.2	0
Bread of rye, untoasted(M4)	83	3	1	0.2	0	15	1.9	23	0.9	53	211	0.1	0.14	0.11	1.2	0
Breakfast cereals white (M5)	145	3	0.4	0.1	0	31	0.5	0	1.5	53	0	0	0.24	0.15	2	0
Cheese Feta(M6)	75	4	6	4.2	25	1	0	140	0.2	18	316	36	0.04	0.24	0.3	0
Chicken soup - home prepared (M7)	86	6	3	0.8	7	8	0	7	0.5	252	343	0	0.08	0.2	3.8	0
Coffee - espresso (M8)	5	0.1	0.2	0.1	0	1	0	1	0.1	69	8	0	0	0.11	3.1	0
Dry wine(M9)	130	0.1	0	0	0	4	0	8	0.2	95	9	0	0.02	0.02	0.2	0
Ice with milk and vanilla, in cone (M10)	164	4	6	3.5	28	24	0.1	153	0.2	169	92	52	0.05	0.26	0.3	1
Lemon juice (M11)	12	0.01	0	0	0	4	0.2	3	0	58	0	1	0.01	0	0	22
Salmon baked (M12)	184	23	9	1.6	78	0	0	6	0.5	319	56	54	0.18	0.15	5.7	0
Spaghetti in tomato sauce with cheese (M13)	192	6	2	0.7	8	39	0.7	40	2.8	305	963	58	0.35	0.28	4.5	10
Yogurt made with whole milk(M14)	139	8	7	4.8	29	11	8	274	0.1	351	105	68	0.07	0.32	0.2	1

Table: 2(Matrix *B*) Patients have allergy with food Ingredient

	Nutrients(Ingredients)															
Patients	Calories (kcal) (i1)	Protein (g) (i2)	Total fat (g) (i3)	Saturated fatty acids (g) (i4)	Cholesterol(mg) (i5)	Carbohydrate (g) (i6)	Total dietary fiber (g) (i7)	Calcium (mg) (i8)	Iron mg) (i9)	Potasium (mg)(i10)	Sodium (mg) (i11)	Vitamin A(RE)mg (i12)	Thiamin (mg) (i13)	Riboflavin (mg) (i14)	Niacin (mg) (i15)	Ascorbic acid(mg) (i16)
P1	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	0
P2	0	0	1	1	0	0	1	0	1	0	1	0	1	1	0	0
P3	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0
P4	0	0	0	1	0	1	0	0	1	0	1	0	1	0	0	0
P5	0	0	0	1	1	0	0	1	0	0	1	0	1	0	1	0
P6	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0
P7	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0
P8	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1
P9	0	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0
P10	0	0	0	0	0	1	1	0	1	0	1	0	1	0	0	0
P11	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0	0
P12	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
P13	0	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0
P14	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0

Table: 3 (Matrix $C=AB^T$) Results for the Hospital diet problem

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
Apple juice, bottled(M1)	325	8.29	302	37	24.3	1.11	17.3	297	37.2	37.2	7.35	29.1	37.2	1.1
Boiled Potatoes(M2)	472	10.1	454	34.5	19.9	4.8	13.5	455	38.8	36.9	9.63	27.1	36.9	2.8
Bread of rye, reduced calorie(M3)	33.9	97.9	120	103	111	5.5	19.9	25.9	108	106	96.9	10	107	3.6
Bread of rye, untoasted(M4)	70.2	215	267	227	236	5.9	25	55	232	229	214	16	230	3

Breakfast cereals white(M5)	87.5	2.89	55.5	32.8	2.34	5	0.74	53.7	36.2	33.2	1.14	31.4	33.4	2.1
Cheese Feta(M6)	55.5	327	334	321	486	40.2	140	18.2	321	317	347	32	323	4.4
Chicken soup - home prepared (M7)	264	348	599	352	362	6.5	7.08	252	358	352	353	18	355	1.3
Coffee - espresso(M8)	73.2	8.51	80.1	9.2	12.2	0.2	1	69.1	9.31	9.1	8.2	1.2	9.3	0.2
Dry wine(M9)	99.4	9.24	104	13.2	17.2	0.3	8.02	95	13.3	13.2	9.02	4	13.2	0.2
Ice with milk and vanilla, in cone(M10)	246	102	261	120	277	56.3	153	170	121	116	126	58	122	3.8
Lemon juice(M11)	63	0.21	58.2	4.01	3.01	1.21	3.21	80.2	4.21	4.21	0.21	4	4.2	0.2
Salmon baked(M12)	379	67.4	381	58.3	147	77.5	6.18	319	79.7	56.7	143	87	65.5	2.1
Spaghetti in tomato sauce with cheese(M13)	409	970	1273	1006	1017	67.5	41.1	316	1012	1006	974	49	1008	4.2
Yogurt made with whole milk(M14)	430	125	464	121	413	84.1	282	360	132	124	149	47	131	12.9

Table-1:(Matrix Form) represented the different foods items ($M_1, M_2,\ldots\ldots, M_{14}$) and its ingredients ($i_1, i_2, i_3\ldots\ldots i_{16}$) and Table-2: (Matrix Form) represented the patients ($P_1, P_2\ldots\ldots P_{14}$) have allergy with particular ingredients ($i_1, i_2, i_3\ldots\ldots i_{16}$). In Table-3: shows the particular patient have the allergy from which food and its level.

Result and Discussion:

The Mathematical model of the hospital diet is developed in the form of matrices having rows defining food/ patients and columns defining ingredients of the food. We have considered different types of food items $(M_1, M_2,\ldots\ldots, M_{14})$ with ingredients $(i1, i2, i3\ldots\ldots i16)$ in the form of matrix[Table-1] and a situation of fourteen patients $(P_1, P_2\ldots\ldots P_{14})$ those who are allergic to some ingredients ($i_1, i_2, i_3\ldots\ldots i_{16}$) of any particular food[Table-2].We have estimated the number of patients suffering from any kind of diseases for food ingredient allergic and non-allergic by considering the estimated value 1 or 0. By matrix multiplication of above matrices in MS-Excel we found an array of patients and food items [Table-3] and the value in the table is showing the allergy level of different types of food contents to one particular patient. It is concluded that the value is indicating that the higher the number more is the patient allergic to ingredient present in the food. Therefore the category of those patients should not therefore take that food. Patients are advised to take that much food which is having smaller number as that is indicating the low allergy reaction to them so that they can get the maximum nutritional ingredients and be safe from getting any kind of severe allergic reactions. This model can provide a fast way to solve the diet problem

and to decide the patient should not take the allergic food. It will help for hospital record for further study in future.

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