Optimal Diet Decision Using Linear Programming

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Abstract *This paper demonstrates use of linear integer programming for a human diet decision problem undertaken by dietician in health care. Specifically, it investigate problem of deciding diet of human of age 40-45 years which is more intricate taking into consideration expenditure constraint. It details the constraint of problem, specifies objective, structure mathematical model and applies operation research tool integer programming to decide patient diet with minimum expenditure. The paper illustrates effectiveness of linear integer programming in diet decision.*

Keywords
Operation research, Linear programming, integer programming, diet decision, heath care, minimization,

1. INTRODUCTION

Operations Research is a science designed to provide quantitative tools to decision-making processes. It comprises a set of mathematical optimization and simulation methods and models, such as Linear Programming, Non-linear Programming, Theory of Queues, Dynamic Programming, Theory of Decisions, etc. Today, implementing optimized solutions by linear programming has reduced costs by hundreds or even thousands dollars in many middle to large sized companies in several industrialized countries. Linear programming has demonstrated to be an alternative solution to plan brachytherapy, replacing the traditional solutions based on trial and error. Linear programming has been used to formulate balanced diets at minimum cost and complying with a set of nutritional restrictions. The main objective of this case self study is to present and spread the linear programming method, in order to attain optimized solutions of healthcare problems involving Economics and Nutrition. It present the formulation of a diet at minimum cost using seven nutritional restrictions aiming at making investigators in the field of healthcare more familiar with the terms and potentialities of the method reported

2. LITERATURE REVIEW

Linear programming is mathematical model used to improve management decision and capable for production planning, resource allocation, inventory control and advertising. Method considers objective function as which is optimization element and decision variable as constraint.[1]. The method was extended to minimize transportation cost with 3 plants and 14 depot across India. Vogal approximation method, Big M Method, Two phase method and Dual simplex method of linear programming were used to get optimal cost comparison. [2]. The method was also used to maximize profit of cola manufacturing company considering production constraint of different products [3]. Further operation research tools were used to optimal utilization of rooms and scheduling to maximize patient satisfaction and minimize total operating cost in health care unit. [4]. Problem of nurse shifts and nurse allocation on day basis was considered and solved using linear programming to get optimal allocation that minimizes cost in health unit[5]. The literature review signifies the vide application of linear programming in service and also manufacturing domain.

3. MODEL DESCRIPTION

Proper diet is exceptionally essential for human being so to keep fit and healthy. Consuming dry or junk food is reason for early ageing and falling immune system of human being. Deciding balanced diet is multi dimensional problem as it constitutes numerous ingredients which are in turn necessary for growth of different body. The decision becomes more complex if it is appended by cost constraint. Model considers only important justified nutritional ingredient required by human body at age of 40-45 years. The ingredients considered are Calcium, Iron, Protein, Vitamin A, Vitamin B1, Vitamin C and Vitamin E. The readily available food considered includes orange, beans, wheat, milk, egg, soya beans, cauliflower, tomato and patato. We know that the nutritional requirements will be expressed in milligrams. Table 1 summarizes the quantity of each nutrient available in foods and their daily requirement for good health conditions of an individual, as well as the unitary cost of these foods. The objective is to minimize the total diet cost and comply with nutritional restrictions.

Table 1. Nutritional Requirement

Nutrient	Food Items								Daily Requirement
	Orange 1	Cup of beans	100gms Wheat	1 Glass Milk	2 Eggs	100gms Soya Beans	1 cup of Cauliflower	Tomato/Potato	
Calcium	52	112	32	276	87	138	10	12	800mg
Iron	0.13	1.91	4.56	0.07	1.46	3.9	0.2	0.33	15mg
Protein	1.23	12.48	11.31	7.69	13.53	35.22	1.14	1.08	50mg
Vitamin A	295	0	9	395	642	0	7	1025	8000IU
Vitamin B1	0.114	0.23	0.387	0.112	0.063	0.1	0.26	0.046	1.2mg
Vitamin C	69.7	2.1	0	0	0.2	2.2	0.26	15.6	60mg
Vitamin E	0.24	0	1.01	0.17	1.33	0	0.04	0.66	0.25mg
Cost in Rs.	4.5	5	2.5	7.5	8	8	6	2	Minimization

3.1 Objective function

To minimize the total diet cost and is defined by the food and unit cost respectively. The cost function (Z) is linear function of cost of one orange (X_1), Cost of cup of bean (X_2), cost of 100gms of wheat (X_3), cost of one glass of milk (X_4), cost of two eggs (X_5), cost of 100gms of soya (X_6), cost of one cup of cauliflower (X_7), cost of one tomato or patato (X_8).

3.2 Constraint

The total quantity of calcium in this diet should be equal or greater than 800mg. Iron content should be greater than 15gms, Protein 50gms, Vitamin A 8000IU, Vitamin B1 1.2gms, Vitamin C 60gms, Vitamin E 0.25gms

3.3 Total formulation of problem

$$Min\ Z = X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8$$

Subject to,

$$52*X_1 + 112*X_2 + 32*X_3 + 276*X_4 + 87*X_5 + 138*X_6 + 10*X_7 + 12*X_8 \quad >= 800;$$

$$0.13*X_1 + 1.91*X_2 + 4.56*X_3 + 0.07*X_4 + 1.46*X_5 + 3.9*X_6 + 0.2*X_7 + 0.33*X_8 \quad >= 15;$$

$$1.23*X_1 + 12.48*X_2 + 11.31*X_3 + 7.69*X_4 + 13.53*X_5 + 35.22*X_6 + 1.14*X_7 + 1.08*X_8 \quad >= 50;$$

$$295*X_1 + 9*X_3 + 395*X_4 + 642*X_5 + 7*X_7 + 1025*X_8 \quad >= 8000;$$

$$0.114*X_1 + 0.23*X_2 + 0.387*X_3 + 0.112*X_4 + 0.063*X_5 + 0.1*X_6 + 0.26*X_7 + 0.046*X_8 \quad >= 1.2;$$

$$69.7*X_1 + 2.1*X_2 + 0.2*X_5 + 2.2*X_6 + 0.26*X_7 + 15.6*X_8 \quad >= 60;$$

$$0.24*X_1 + 1.01*X_3 + 0.17*X_4 + 1.33*X_5 + 0.04*X_7 + 0.66*X_8 >= 0.25;$$

3.4 Model solving

Since this model has 8 variables LiPS solver is used to get solution. Solving problem using integer case gives feasible solution as Min Z = Rs. 43.5 and balanced diet comprised of

1. One cup of beans per day

2. 300gms of wheat per day

3. 2 glass of milk per day

4. Tomato or potato 8 per day

4. DISCUSSION AND CONCLUSION

The demand for efficient decisions in healthcare delivery gives opportunity to application of optimization techniques in problems related to resource allocation, which could be a complementary tool to economic evaluation models. Potential applications of optimization methods may include assessment of economic impact of several therapies by means of diseases and evaluation of product prices. For instance, optimized prices of product components could be assessed considering some restrictions, such as expenses with research and development, cost of alternative treatments, marketing strategies and estimates for sales projection. Mathematical modeling using linear programming may be applied to problems related to optimized resource allocation in healthcare.

The type of algebraic modeling presented in this self study known as linear programming could be considered a useful tool to support decision-making processes in healthcare. In a world with increasingly scarce resources and every day more competitive, the search of optimized solutions to replace traditional methods based on common sense and trial and error may become an issue of survival for many organizations.

5. SCOPE FOR FUTURE

In present day scenario, with increase in inflation rate daily expenditure is to be minimized. The expenditure can also be minimized by controlling spending on food and along with maintaining healthy diet. The finding of paper enables the optimum diet expenditure per day considering readily available food. The paper helped to understand the major human body requirement at age of 40-45 years and application of linear programming to get optimal diet. The further it can extended to the all age groups and also all season foods. The methodology can also be implemented to patient groups including diabetic, cardiac for those where diet control is important issue.

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