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Food designing for Covid-19 patients with the help of applied mathematical optimization technique in LINDO Software

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Summary

Objective: Due to the alarming rise in COVID-19 cases every day in India, numerous academics are already developing a variety of math-based estimation models to forecast the pandemic future course. This paper makes use of publicly available data to anticipate certain COVID-19 trajectories in India. **Methods:** We used the Auto-Regressive Integrated Moving Average Model, a time series model, to anticipate the number of COVID-19 infected cases every day soon. People need to consume nutritious food that is well-balanced and contains the right number of calories, nutrients, as well as vitamins for strong development, bearing in mind that sustaining and repairing bodily tissues is the goal while preventing unfavorable illnesses and disease. **Results:** Recent studies have shown that healthy eating can help lower the possibilities of developing cancer, cardiovascular disease and for COVID patients. Therefore, an optimization strategy and LINDO software was used to solve the model. This study offers an exhaustive daily meal plan created especially for hospital patients, acting as a helpful resource for school administrators. With six different food choices, the diet plan makes sure that you get all the nutrients you need each day at a reasonable price. **Conclusions:** The model is solved

using LINDO software in the study, which shows how effective it is when compared to other heuristic techniques like biological algorithms. It is determined through thorough investigation that the chosen meals are both financially and nutritionally feasible to serve in ho spital settings. Hospital patients make up the study's participants, and each day's total cost comes to Rs109.34. This cost makes it possible to deliver meals that are minimally more costly but of higher quality, improving the patients' overall nutritional value.

Keywords: Menu planning, integer linear programming, optimization, mathematical modelling, decision-making.

Resumen

Diseño de alimentos para pacientes de Covid-19 con la ayuda de la técnica de optimización matemática aplicada del software LINDO

Objetivo: Debido al alarmante aumento de casos de COVID-19 cada día en la India, numerosos académicos ya están desarrollando una variedad de modelos de estimación basados en matemáticas para pronosticar el curso futuro de la pandemia. Este documento utiliza datos disponibles públicamente para anticipar ciertas trayectorias de COVID-19 en la India. **Métodos:** Utilizamos el modelo de media móvil integrada autorregresiva, un modelo de series temporales, para anticipar el número de casos de infección por COVID-19 todos los días en el corto plazo. Las personas necesitan consumir alimentos nutritivos, bien equilibrados y que contengan la cantidad adecuada de calorías, nutrientes y vitaminas para un desarrollo fuerte, teniendo en cuenta que el objetivo es mantener y reparar los tejidos corporales y, al mismo tiempo, prevenir enfermedades y dolencias desfavorables. **Resultados:** Estudios recientes han demostrado que una alimentación saludable puede ayudar a reducir las posibilidades de desarrollar cáncer, enfermedades cardiovasculares y en pacientes con COVID. Por lo tanto, se utilizó una estrategia de optimización y el software LINDO para resolver el modelo. Este estudio ofrece un plan de alimentación diario exhaustivo creado especialmente para pacientes hospitalarios, que actúa como un recurso útil para los administradores escolares. Con seis opciones de alimentos diferentes, el plan de dieta garantiza que obtenga todos los nutrientes que necesita cada día a un precio razonable. **Conclusiones:** El modelo se resuelve utilizando el software LINDO en el estudio, lo que muestra su efectividad en comparación con otras técnicas heurísticas como los algoritmos biológicos. A través de una investigación exhaustiva se determina que las comidas elegidas son viables desde el punto de

vista financiero y nutricional para servir en entornos hospitalarios. Los pacientes del hospital constituyen los participantes del estudio y el costo total de cada día asciende a 109,34 rupias. Este costo permite entregar comidas mínimamente más costosas pero de mayor calidad, mejorando el valor nutricional general de los pacientes.

Palabras clave: Planificación de menús, programación lineal entera, optimización, modelado matemático, toma de decisiones.

Resumo

Design de alimentos para pacientes com Covid-19 com ajuda de técnica de otimização matemática aplicada no software LINDO

Objectivo: Devido ao aumento alarmante de casos diários de COVID-19 na Índia, vários académicos já estão a desenvolver uma variedade de modelos de estimativa baseados em matemática para prever o curso futuro da pandemia. Este artigo utiliza dados disponíveis publicamente para antecipar certas trajetórias da COVID-19 na Índia. **Métodos:** Usamos o modelo de média móvel integrada auto-regressiva, um modelo de série temporal, para antecipar o número de casos infectados por COVID-19 todos os dias em breve. As pessoas precisam consumir alimentos nutritivos, bem balanceados e que contenham a quantidade certa de calorias, nutrientes e vitaminas para um forte desenvolvimento, tendo em mente que o objetivo é sustentar e reparar os tecidos corporais, ao mesmo tempo que se previnem doenças e enfermidades desfavoráveis. **Resultados:** Estudos recentes demonstraram que uma alimentação saudável pode ajudar a diminuir as possibilidades de desenvolvimento de cancro, doenças cardiovasculares e para pacientes com COVID. Portanto, uma estratégia de otimização e o software LINDO foram utilizados para resolver o modelo. Este estudo oferece um plano alimentar diário exaustivo criado especialmente para pacientes hospitalares, atuando como um recurso útil para administradores escolares. Com seis opções alimentares diferentes, o plano de dieta garante que você obtenha todos os nutrientes necessários todos os dias a um preço razoável. **Conclusões:** O modelo é resolvido utilizando o software LINDO no estudo, o que mostra sua eficácia quando comparado a outras técnicas heurísticas como algoritmos biológicos. Através de investigação minuciosa é determinado que as refeições escolhidas são financeiramente e nutricionalmente viáveis para serem servidas em ambientes hospitalares. Os pacientes do hospital constituem os participantes do estudo e o

custo total de cada dia chega a Rs109,34. Esse custo permite entregar refeições minimamente mais caras, mas de maior qualidade, melhorando o valor nutricional geral dos pacientes.

Palavras-chave: Planejamento de cardápio, programação linear inteira, otimização, modelagem matemática, tomada de decisão.

Introduction

Nutrition is very important in this lifestyle. Numerous socioeconomic and environmental factors have an impact on nutrition. Even if the world's diet crisis was acute during World War II, the task of supplying food for everyone in a sustainable and nutritious way will only get worse. Between 1950 and 1960, the initial analysis incorporating LP into diets was released. Jerry Cornfield developed "The Diet Problem for the Army during World War II (1941–1955) in an effort to find a cheap diet that would satisfy a soldier's nutritional requirements". This was the beginning of the hunt for diet solutions. The COVID-19 pandemic, which started rapidly and extensively spreading in late 2019, had a significant impact on food security and nutrition.

Therefore, utilize operational research and judgement to create a mathematical model to study menu planning. The issue was solved using LINDO and LP Solve programming language. LP problem can be addressed using a variety of techniques, including the graphical and simplex methods. These techniques take a long time to manually solve the LP model. The LP model is solved using the LINDO programmer in this paper's application to calculate the patient minimum meal cost. By using computer assisted menu planning and data control, for institutional feeding programmers, a multiple-phase system was created to lower the price of food. Assembling meal items for a series of days that meet the necessary structural, nutritional, compatibility requirements, and variety restrictions at fewer prices was the basis for the formulation of food management objectives, a problem that is commonly encountered by each individual and volume feeding agency. The answer was found by solving big integer programs sequentially using a newly created truncated block enumeration technique [1, 2].

The correlation in both palatable meals and satisfying nutrients is mathematically modelled and analyzed. The standard minimal-cost dietary issue is inappropriate for many uses in the pursuit of the least financial cost that leads to meals that are undesirable to individuals as well as to groups of people. This research presents a unique thought that utilizes a goal value dependent on each person food preferences. Based on this research, a computational technique for using linear programming to create individu-

ally appropriate diets is described [3-5]. Scientific proof is still required to determine which foods constitute a healthy diet in terms of the primary prevention of serious chronic diseases.

Therefore, sought to provide a thorough review of foods associated with health based on the eight years data from the EPIC-Potsdam research [6, 7]. Every patient was getting supportive treatment at the outset, such as anti-inflammatory and antiviral medications, and all patients were receiving oxygen assistance. "Nine patients experienced at least a 1-point improvement on the clinical scale by day 7 post- transfusion with convalescent plasma, and seven of those patients were discharged. On day 14 following the transfusion, 11 patients were released, and 19 (76%) patients had at least a 1-point improvement in their clinical state". No unfavorable effects of the plasma transfusion were noted. There was no association between strain genotype and disease severity found in the whole genome sequencing data [8, 9].

It is generally known that poor nutrition has an adverse effect on critically ill patients, contributing to higher mortality, longer stays in intensive care units (ICUs), impairment and general morbidity following hospitalization. Guidelines for nutritional therapy for people with SARS-CoV-2 infection were just released by "European Society for Clinical Nutrition and Metabolism (ESPEN)", and they include suggestions for patients being treated in the intensive care unit (ICU). The main goal of these suggestions is to use promotility drugs to promote gastric emptying, initiating proximal nutrition (PN) if enteral food (EN) is not tolerated, providing early EN where feasible, and utilizing EN Post Extubation if oral feeding is not tolerated [10].

The article addresses how students choose their diets, consuming certain foods to meet their daily nutritional requirements. The goal of the current investigation was to reduce the daily [11, 12]. According to the World Health Organization, as of November 14, 2020, there were more than 54 million COVID-19 cases globally, and more than 1,323,196 individuals died as a result. As a result, several countries had to declare an illness or impose a period of isolation, which had a negative effect on society, the economy, and public health in addition to slowing the COVID-19 pandemic progress. Therefore, "we provide a mathematical model for the dynamics of COVID-19 disease transmission as well as a mathematical model for the dynamics of diabetes before emphasizing the detrimental effects of quarantine on the health of diabetics [9]. One Chinese meta-analysis of 1,527 patients revealed that diabetes (9.7%, 95% CI 6.9–12.5%) and cardio-cerebrovascular disease (16.4%, 95% CI 6.6–26.1%) were the two most common cardiovascular metabolic comorbidities with COVID-19". According to this study, patients with diabetes or high blood pressure had a 2-fold increased chance of developing a serious illness or needing admission to an intensive care unit

(ICU), but patients with cardio-cerebrovascular disease had a 3-fold increased risk. In a subset of 355 COVID-19 patients in Italy who passed away, the mean number of underlying diseases was 2.7, and only 3 people were co morbidity-free [13].

At the time of corona-virus incidents, the condition damaged many people. When someone tests positive for corona-virus, they should adhere to the nutrition to boost their immunity. Therefore, the Health Department oversees creating patient diets that take food prices into account. Hospital caterers who provide the whole day food according to the given menu lists. Patients are not given the option to select their favorite dishes from the non-selective menu that is offered. This research paper main goal is to create a framework that might enable the construction of the whole day meal. We tried to meet the needs of COVID-19 patients while keeping government funding to a minimum. Additionally, we aimed to maximize variety and satisfy consumer preferences.

Therefore, it is imperative to conduct investigation into meal preparation using computational frameworks that incorporate logistic study and scientific decision-making approaches to help caterers serve healthy meals for extended periods of time while adhering to financial restrictions. A healthy diet helps ensure that the body is in the best condition to fight the infection. Researchers have discovered that there is no source of viral transmission via food or food packaging, so that to stop the virus from spreading, the system for managing food safety needs to provide staff and food safety officials with appropriate respiratory protection. However, adopting safe food practices is always advised to reduce the possibility of getting infected.

Mathematical model: This model represents an effort to investigate a portion of the real-life problem mathematically. Mathematical transformation of a physical situation under certain conditions.

Linear programming: the method of optimizing a problem that is subject to restrictions is known as linear programming. It denotes the process of maximizing or minimizing linear functions under limits imposed by linear inequality. The easiest problem to solve is the one using linear programmers.

LINDO Software: system creates software tools for modelling and optimization. Quickly and simply solve linear, nonlinear, and integer problems. LINDO Systems has committed itself to offering robust, cutting-edge optimization tools that are both adaptable and user-friendly. In 1988, LINGO, the company's first product with a full-featured modelling capability, was released. Users were able to use summations and subscripted variables to succinctly express models using the modelling language. A large-scale nonlinear solver was implemented in LINGO in 1993. The user did not have to specify which solver to use, making it special. Following a model analysis,

LINGO would automatically select the best linear or nonlinear solver. The ability to support both general and binary integer limitations was another feature exclusive to LINGO's nonlinear solver.

Data interpretation

A menu-displaying model requires different types of information. The institutionalized cost is included in the Recommended Daily Allowance (RDA), which includes the recommended daily requirement of nutritional diet for hospitalized individuals and the national budget for nutrition suppliers for each menu item. Total six supplements were taken into consideration, as indicated in Table 1, carbs, protein, fat, calories, fiber, and iron. Also, fourteen different types of meals, Egg, papaya, lentils, idly, cardamom, banana, milk, ragi porridge, fresh dates, dosa, almond, cottage cheese, curd and muskmelon were all taken into consideration in this study.

Table 1. Everyday Consumption of Food Ingredient

Food Ingredient	Everyday Consumption
Carbohydrates	185
Protein	60
Fats	50
Calories	1800
Fibber	35
Iron	20

Table 1, six supplements were taken into consideration, these are carbs, protein, fat, calories, fiber, and iron. These six supplements are making a complete diet for a human in a day. The consumption of all these supplements in different valued that is carbohydrates in a day a human can takes 185, protein 60, fats 50, calories 1800, fibber 35 and iron 20.

So that based on above table, forms a mathematical model as follows: -

Minimization $Y = d_1q_1 + d_2q_2 + d_3q_3 + \ldots + d_nq_n$

Subject to constraints:

$$p_{11}\ q_1 + p_{12}\ q_2 + p_{13}\ q_3 + \cdots + p_{1n}\ q_n \geq 185$$

$$p_{21}\ q_1 + p_{22}\ q_2 + p_{23}\ q_3 + \cdots + p_{2n}\ q_n \geq 60$$

$$p_{31}\,q_1 + p_{32}\,q_2 + p_{33}\,q_3 + \cdots + p_{3n}\,q_n \geq 50$$

$$p_{41}\,q_1 + p_{42}\,q_2 + p_{43}\,q_3 + \cdots + p_{4n}\,q_n \geq 1800$$

$$p_{51}\,q_1 + p_{52}\,q_2 + p_{53}\,q_3 + \cdots + p_{5n}\,q_n \geq 35$$

$$p_{61}\,q_1 + p_{62}\,q_2 + p_{63}\,q_3 + \cdots + p_{6n}\,q_n \geq 20$$

$$q_1 + q_2 + q_3 + \cdots + q_n \geq 1$$

Since the information is reliant on the menu supplied by the hospital administration, the LP model will be configured in accordance with the meal prices determined by the management. Here are some examples of foods for COVID sufferers that are nutrient rich.

As summarized in Table 2, there are fourteen different types of meals, that is, Egg, papaya, lentils, idly, cardamom, banana, milk, ragi porridge, fresh dates, dosa, almond, cottage cheese, curd and muskmelon were all taken into consideration in this study. The cost is also considering all the fourteen meals that is, Egg is 7 rupees, papaya is 10 rupees, lentils is 10 rupees, idly is 5 rupees, cardamom is 4 rupees, banana is 3 rupees, milk is 20 rupees, ragi porridge is 15 rupees, fresh dates is 20 rupees, dosa is 10 rupees, almond is 20 rupees, cottage cheese is 25 rupees, curd is 10 rupees and muskmelon is 15 rupees.

Table 2. Different types of foods

Code	Food item	Cost
$x1$	Cottage cheese	25
$x2$	Curd	10
$x3$	Papaya	10
$x4$	Egg	7
$x5$	Idly	5
$x6$	Milk	20
$x7$	Cardamom, banana	7
$x8$	Ragi Porridge	15
$x9$	Almond	20
$x10$	Lentils	10
$x11$	Spinach Soup	10
$x12$	Dosa	10
$x13$	Fresh Dates	20
$x14$	Muskmelon	15

Formulation of the equation

Minimize Y = 25$x1$ + 10$x2$ + 10$x3$ + 7$x4$ + 5$x5$ + 20$x6$ + 7$x7$ + 15$x8$ + 20$x9$ + 10$x10$ + 10$x11$ + 10$x12$ + 20$x13$ + 15$x14$

Table 3 summarizes that there are six supplements taken into consideration, these are carbs, protein, fat, calories, fiber, and iron. These six supplements are making a complete diet for a human in a day. Also, Table 1 is told about the consumption of all these six supplements. Table 2, is about fourteen different types of meals, that is, Egg, papaya, lentils, idly, cardamom, banana, milk, ragi porridge, fresh dates, dosa, almond, cottage cheese, curd and muskmelon were all taken into consideration in this study. Table 2 is also told about the cost of all the fourteen meals. Table 3 is the combination of Table 1 and Table 2.

Table 3. Menu contained the nutrients or the patients

Variable	$x1$	$x2$	$x3$	$x4$	$x5$	$x6$	$x7$	$x8$	$x9$	$x10$	$x11$	$x12$	$x13$	$x14$
Carbohydrates	6	4.7	30	1.1	12	12	18	32	6.1	8	7.1	15.6	5.33	8
Protein	18.3	3.5	2	13	3	8.14	1	13	6	25	7.2	2	0.17	0.8
Fat	27	3.3	0.5	11	0.1	8	0	1	14.2	1.2	2.4	5.1	0.03	0.2
Calories	265	4.7	119	72	58	122	105	354	164	147	37	133	20	34
Fiber	0	0	5	0	0.3	0	3.07	3	3.5	12	2	0.8	0.6	0.9
Iron	216	0.1	0.2	1.89	5	0	0.1	0.1	10	7.57	2.7	0	0.07	0.1

Subject to constrains:

6$x1$ + 4.7$x2$ + 30$x3$ + 1.1$x4$+ 12$x5$ + 12$x6$ + 18$x7$ + 32$x8$ + 6.1$x9$ + 8$x10$ + 7.1$x11$ + 15.6$x12$ + 5.33$x13$ + 8$x14$ ≥ 185

18.3$x1$ + 3.5$x2$+ 2$x3$ + 13$x4$ + 3$x5$ + 8.14$x6$ + $x7$ + 13$x8$ + 6$x9$ + 25$x10$ + 7.$x2x11$ + 2$x12$ + 0.17$x13$ + 0.8$x14$ ≥ 60

27$x1$ + 3.3$x2$ + 0.5$x3$ + 11$x4$ + 0.1$x5$ + 8$x6$ + $x8$ + 14.2$x9$ + 1.2$x10$ + 2.4$x11$ + 5.1$x12$ + 0.03$x13$ + 0.2$x14$ ≥ 50

$265x1 + 4.7x2 + 119x3 + 72x4 + 58x5 + 122x6 + 105x7 + 354x8 + 164x9 + 147x10 + 37x11 + 133x12 + 20x13 + 34x14 \geq 1800$

$5x3 + 0.3x5 + 3.07x7 + 3x8 + 3.5x9 + 12x10 + 2x11 + 0.8x12 + 0.6x13 + 0.9x14 \geq 35$

$216x1 + 0.1x2 + 0.2x3 + 1.89x4 + 5x5 + 0.1x7 + 0.1x8 + 10x9 + 7.57x10 + 2.7x11 + 0.07x13 + 0.1x14 \geq 20$

$q_1, q_2, q_3, \ldots, q_n$ & $x_1, x_2, x_3, \ldots, x_n$ represents same elements

As a visual help, Fig. 1 represents the process of working LINDO Software.

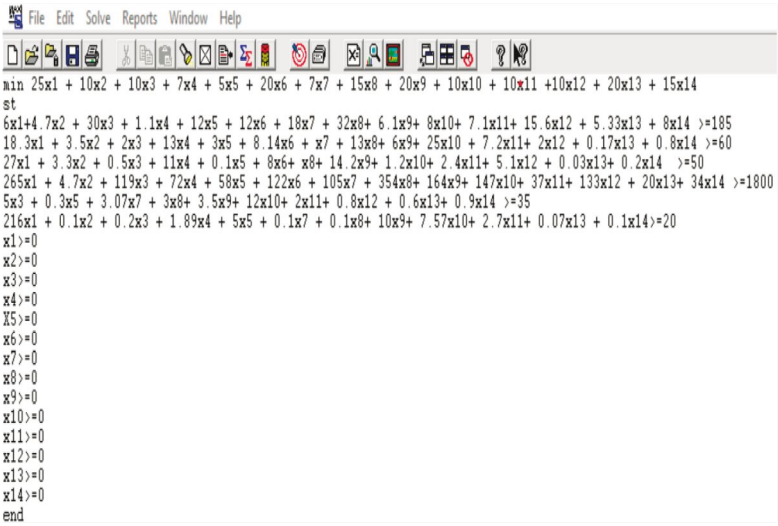

Figure 1. Process of working LINDO software

A single serving of each dish was allowed per day. The decision variables, restrictions, and parameters used in this investigation were numerous. This program was created in LINDO using LP Solve, and it took just one second to find the best solution for a one-day menu. Comparing this to alternative methods that would have required more than 4 hours or even a day, this is incredibly quick. Investigations carried out in the past have illustrated the effectiveness of the strategies in resolving this menu planning issue. These are a few sample problems that is resolved using the LINDO Software.

Lindo formulation

LINGO solution

Global optimal solution

Objective value: 109.3363

Infeasibilities: 0.000000

Total solver iteration: 6

Model class: LP

Total variable: 14

Nonlinear variable: 0

Total constraints: 20

Total variables: 14

Nonlinear variables: 0

Total constraints: 20

As a visual help Fig. 2 represents the optimum solution by using LINDO Software.

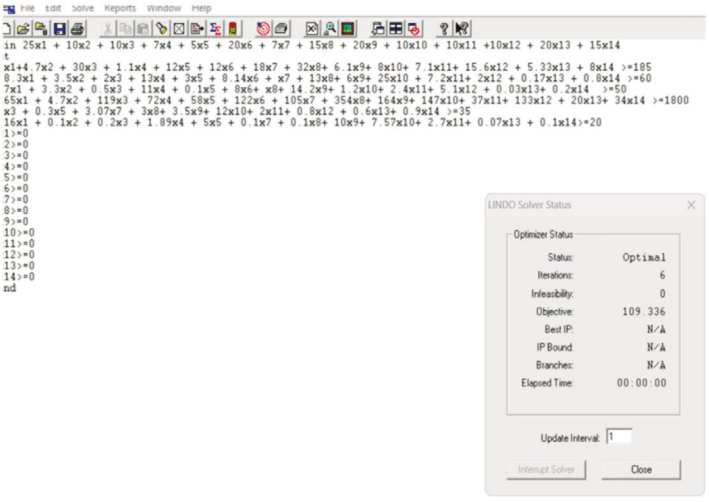

Figure 2. Optimum solution by using LINDO Software.

Using LINGO, an application of LINDO Software. Here are find a solution the problem of a diet plan of a person of a day. That is the objective value is 109.3363, Infeasibilities are 0.000000, Total solver iteration are 6, Model class is LP, Total variable is 14, Nonlinear variable is 0, Total constraints are 20, Total variables are 14, Nonlinear variables is 0 and the Total constraints are 20.

Figure 3 is an example of finding exact solution.

LP OPTIMUM FOUND AT STEP 6

OBJECTIVE FUNCTION VALUE

1) 109.3363

VARIABLE	VALUE	REDUCED COST
X1	0.015202	0.000000
X2	0.000000	7.525709
X3	2.600355	0.000000
X4	4.003656	0.000000
X5	0.000000	1.347327
X6	0.000000	11.460486
X7	0.000000	0.372815
X8	2.927621	0.000000
X9	0.000000	7.047612
X10	1.101280	0.000000
X11	0.000000	5.985193
X12	0.000000	1.648369
X13	0.000000	18.386141
X14	0.000000	12.417277

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	0.000000	-0.173712
3)	63.117512	0.000000
4)	0.000000	-0.470173
5)	0.000000	-0.022079
6)	0.000000	-0.384239
7)	0.000000	-0.025057
8)	0.015202	0.000000
9)	0.000000	0.000000
10)	2.600355	0.000000
11)	4.003656	0.000000
12)	0.000000	0.000000
13)	0.000000	0.000000
14)	0.000000	0.000000
15)	2.927621	0.000000
16)	0.000000	0.000000
17)	1.101280	0.000000
18)	0.000000	0.000000
19)	0.000000	0.000000
20)	0.000000	0.000000
21)	0.000000	0.000000

NO. ITERATIONS= 6

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES

VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
X1	25.000000	47.881336	5.293648
X2	10.000000	INFINITY	7.525709
X3	10.000000	0.844178	3.661041
X4	7.000000	2.175130	4.989720
X5	5.000000	INFINITY	1.347327
X6	20.000000	INFINITY	11.460486
X7	7.000000	INFINITY	0.372815
X8	15.000000	2.650131	5.460338
X9	20.000000	INFINITY	7.047612
X10	10.000000	9.904737	4.535483
X11	10.000000	INFINITY	5.985193
X12	10.000000	INFINITY	1.648369
X13	20.000000	INFINITY	18.386141
X14	15.000000	INFINITY	12.417277

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	185.000000	62.793018	26.102392
3	60.000000	63.117512	INFINITY
4	50.000000	21.836929	42.488907
5	1800.000000	567.394531	724.040222
6	35.000000	5.107429	12.999310
7	20.000000	347.551483	3.211621
8	0.000000	0.015202	INFINITY
9	0.000000	0.000000	INFINITY
10	0.000000	2.600355	INFINITY
11	0.000000	4.003656	INFINITY
12	0.000000	0.000000	INFINITY
13	0.000000	0.000000	INFINITY
14	0.000000	0.000000	INFINITY
15	0.000000	2.927621	INFINITY
16	0.000000	0.000000	INFINITY
17	0.000000	1.101280	INFINITY
18	0.000000	0.000000	INFINITY
19	0.000000	0.000000	INFINITY
20	0.000000	0.000000	INFINITY
21	0.000000	0.000000	INFINITY

Figure 3. Finding exact solution.

Result

the findings are shown in Table 4 It lists the meals that the hospital administration will give the patients each day. Table 4 shows a variety of beverages and foods given in various forms for a single day, which covers six different meals. All of these provide hospital patients with the daily nutrition they need at a low cost. Therefore, it can be said that every meal picked is healthy and is suggested to be given to the patients. The whole cost is less than the management's allocated budget. Therefore, the hospital's administration will only pay around 200 rupees each day.

Table 4. Menu of per day

Food	Time
Papaya, milk and idly	Breakfast
Muskmelon	Morning tea
Egg, curd, lentils and ragi	Lunch
Spinach soup, almond	Evening tea
Dosa, cottage cheese	Dinner
Cardamom, banana, fresh dates	Supper

A complete and healthy diet is most important for every human on the earth, Table 4, is about menu of a day, according to this table, in breakfast, can be take, papaya, milk and idly. In morning tea, muskmelon can be taken, in lunch time, egg, curd, lentils and ragi can be eat. In evening tea, spinach soup, and almond can be taken. In dinner, can be eat dosa and cottage cheese and in super can be eat cardamom, banana, and fresh dates.

Conclusion

This article includes a useful per day diet that can serve as a manual for school administration. The foods provided in diverse way for six separate meals in a single day. These all affordably supply hospital patients with the daily nutrients they require. Consequently, it can be concluded that each meal chosen is healthful and should be served to the patients. The entire expenditure is less than the budget that the management set aside. LINDO software was used to solve the model. When compared to other methods of heuristics like biological algorithms, it yields a better result and satisfies all the study limitations. The participants in this study were hospital patients. Rs109.34 is the total cost for the day. As a result, we can provide the patients with slightly more expensive and higher-quality meals.

Declaration

Conflict of Interest: The authors report that there is no conflict of interest.

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References

1. J.L. Balintfy, A mathematical programming system for food management applications, *Interfaces,* **6**(1-part-2), 13-31 (1975). Doi: https://doi.org/10.1287/inte.6.1pt2.13

2. N.G. Khiêm, Q.M. Tuấn, L.N. An, T.T.T. Trà, Building a personalized diet proposal algorithm for Covid 19 patients' treatment at home with linear programming planning method, *VNU-HCM Journal of Engineering and Technology*, **5**(SI1), 56-61 (2022). Doi: https://doi.org/10.32508/stdjet.v5iSI1.991

3. N. Arkin, K. Krishnan, M.G. Chang, E.A. Bittner, Nutrition in critically ill patients with COVID-19: Challenges and special considerations, *Clinical Nutrition*, **39**(7), 2327-2328 (2020). Doi: https://doi.org/10.1016/j.clnu.2020.05.007

4. E.L. Ferguson, N. Darmon, A. Briend, I.M. Premachandra, Food-based dietary guidelines can be developed and tested using linear programming analysis, *The Journal of Nutrition*, **134**(4), 951-957 (2004). Doi: https://doi.org/10.1093/jn/134.4.951

5. J. Foytik, Devising and using a computerized diet: An exploratory study, *The Journal of Consumer Affairs*, **15**(1), 158-169 (1981). Doi: https://doi.org/10.1111/j.1745-6606.1981.tb00699.x

6. A. Hussain, B. Bhowmik, N.C. do Vale-Moreira, COVID-19 and diabetes: Knowledge in progress, *Diabetes Research and Clinical Practice*, **162**, 108142 (2020). Doi: https://doi.org/10.1016/j.diabres.2020.108142

7. M. Maillot, A. Drewnowski, A conflict between nutritionally adequate diets and meeting the 2010 dietary guidelines for sodium, *American Journal of Preventive Medicine*, **42**(2), 174-179 (2012). Doi: https://doi.org/10.1016/j.amepre.2011.10.009

8. H. Laarabi, A. Abta, K. Hattaf, Optimal control of a delayed SIRS epidemic model with vaccination and treatment, *Acta Biotheoretica*, **63**(2), 87-97 (2015). Doi: https://doi.org/10.1007/s10441-015-9244-1

9. R. Yadav, M. Sahu, Diet planning problems for diabetic patients by using mathematical modeling technique, *AIP Conference Proceedings*, **2800**, 020189 (2023). Doi: https://doi.org/10.1063/5.0169434

10. V.E. Smith, Linear programming models for the determination of palatable human diets, *American Journal of Agricultural Economics*, **41**(2), 272-283 (1959). URL: https://onlinelibrary.wiley.com/doi/10.2307/1235154

11. D. Sklan, I. Dariel, Diet planning for humans using mixed- integer linear programming, *British Journal of Nutrition*, **70**(1), 27-35 (1993). Doi: https://doi.org/10.1079/BJN19930102

12. R. Yadav, M. Sahu, Food intake pattern to achieve nutritional goals for Indian adults by linear programming optimization techniques, *International Journal of Health Sciences*, **16**(S2), 7346- 7352 (2022). Doi: https://doi.org/10.53730/ijhs.v6nS2.6858

13. R. Yadav, S. Wadia, Generalizing the effect of Indian populace with the help of mathematical modeling, *Journal of Physics: Conference Series*, **1531**, 012079 (2020). URL: https://iopscience.iop.org/article/10.1088/1742-6596/1531/1/012079/pdf

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