CDS512 BUSINESS INTELLIGENCE & DECISION ANALYTICS

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Project

Group-01

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1.0 Project Identification

1.1 Project Motivation and Relevance

The healthcare industry consists of health activities that provide related goods and services to treat patients with curative, preventive, rehabilitative and palliative care.[1] Among these, preventive healthcare consists of measures taken for disease prevention such as preventing obesity, thrombosis, and sexually transmitted infections. Obesity is a major risk factor for diseases including cardiovascular diseases, hypertension, certain cancers, and type 2 diabetes.[1] Evidence suggests that dietary restrictions, and increased physical activities are preventive healthcare approach and can significantly reduce obesity. [2] However, in Malaysia recently, MCO has caused some citizens gained weight due to lack of physical movement. In this environment, a company called Herbalife is providing a diet subscription plan for anyone who wishes to live a healthier life by controlling their weight and nutrition intake. The company collaborated with dining shops (such as Day to Day Café) and subscribers will have their meals at those collaborating dining shops after the payment done beforehand. We would like to propose the similar business idea to healthcare organization like Gleneagles Hospital Penang by providing diet plan solutions as a preventive healthcare of obesity (as another value-added income source). It is expected that the hospital can attract customers for signing up due to higher credibility and issue of rising of number of overweight citizens. To propose the idea, real-world dataset namely "Subjects with Overweight Issue" and "Food Nutrition Information" have been used in the research. Hospital side will determine how they target their customer and how the food reached customers, such as collaborate with food delivery service for the customers who want their food to be delivered within the period of diet plan.

1.2 Problem Statements

Key Points Summarized	**Proposed Solutions**
• Overweight Citizen is growing during MCO. • Difficult to fulfill all daily needs nutrition. • Physical restriction for a preventive plan from obesity.	• Preventive Healthcare Plan • LP modelling • Meal-delivery

Malaysia being called as the fattest country in Asia for the first time in 2014. [3] Half of the adults in Malaysia is suffering from overweight issue or obesity. [4] A rapid change in dietary trends coupled with a worsening obesity crisis has been observed in the nation. [5] As mentioned earlier, obesity rate is climbing in Malaysia since establishment of MCO, which contribute deleterious effect to the existing problem. In another aspect, hospital as a formal healthcare organization has higher trustworthiness can solve the obesity issue by promoting diet subscription plan to public. Generally, hospitals generate income from diseased patient but not ordinary public, so it is an opportunity for the hospital to generate extra income.

Moreover, it is difficult to ensure all nutrients intake are met objectively, including nutrients such as Iron, Vitamin, Fiber etc., without a sophisticated program to monitor the intake. If we do only ourselves, normally we will make assumption of what should be eaten and avoid in order to slim down healthy without the facts. Eventually we might end up in spending unnecessary amount of money and ignore some aspect of nutrition values to meet the weight goal. Hence, the project able

to provide a healthcare solution using linear programming to optimize the diet plan while minimizing the meal cost for the hospital to solve the rising obesity rate problem while expand the hospital income sources. We would also like to study how feasible the LP model built are able to encounter the problem stated, and its constraints` flexibility to explore further possibilities to different possible problem scenario in our what-if analysis.

For those individuals who like to reduce weight by a preventive plan, it is difficult to implement due to physical restriction brought by the national MCO. Preventive healthcare normally requires customers to have a face-to-face visti in order to have the service. However, environment has changed and it is an opportunity to ride the new wave. We will deliver the service without even see the customers by delivering the diets to customers' hand. Thus, customers can enjoy hassle-free meals while satisfying calories and nutrients goals.

2.0 Analysis

2.1 Problem Modelling

In this project, optimization problem is introduced as designing daily meal plan on behalf of hospital according to dieting customer biometrics measurement with lowest cost under daily nutrient intake constraint. There will be three meal plans proposed without repetition of food type. Proportion of Meal 1 is equal to 0.4 while Meal 2 and Meal 3 is equal to 0.3. List of dieting customer is generated from dataset of 18 individuals in Mexico who has level II overweight issue. [6]

Cost per meal, also known as objective function, Z of this project will be the product of the proportion of food intake, x_j, and cost of food per serving, c_j. Minimization of Z is subjected to nutrient intake constraints, b_{ik}. More specifically, the nutrient intake constraints included both upper and lower limit. To lose weight by food control, the amount of daily nutrient intake is restricted by certain range of value. The nutrition included carbohydrates, fat, protein, saturated fat, cholesterol, sodium, potassium, fibre, sugar, vitamin A, vitamin C, calcium, and iron. Nutrition intake per meal is the product of proportion of food with their respective nutrition per serving, a_{ij}. [7]

In this project, the upper limit value of daily nutrient intake is computed by MyFitnessPal, a meal tracking application as shown in Figure 7.4. The daily nutrition intake is determined according to customer's biometric such as age, gender, height, current weight, target weight, daily active level and weight to lose per week as shown in Figure 7.5. [8] On the other hand, lower limit of daily nutrient intake which is also the minimum daily nutrient required is set based on Report of Recommended Nutrient Intakes for Malaysia by Ministry of Health Malaysia. [9] Furthermore, another constraint on top of this is the repetitive of type of food is restricted as mentioned before.

In Section 7.1, the modelling of problem is formulated in mathematical expression for a better perspective.

2.2 Model Formulation

Customer 269 from dataset is taken as example. This male customer is 38 years-old with height of 1.7m and weight of 78kg. Based on median of normal BMI which is 21.7, target or goal weight of

this customer will be 62.7kg. To lose 0.5kg per week, the restriction of daily nutrient intake is shown in Figure 7.1 in dark orange table. From Figure 7.1, the allowable range of nutrient intake of Meal 1 for Customer 269 is shown in light orange table. As mentioned earlier, Meal 1 proportion is 0.4 of daily nutrient intake value. Proportions of food intake, which are the decision variables are shown as light green cells while dark green cell is the total cost of Meal 1. Food used in Meal 1 will be assigned with value "1" for Meal 2 plan modelling to restrict repetition of food used in Meal 1.

After modelling Meal 1 plan, daily remaining nutrient intake is shown in dark orange section from Figure 7.2. The daily remaining nutrient (for Meal 2 and 3) is computed by deducting Meal 1 LHS value from daily nutrient intake. Meal 2 proportion is 0.3 of daily proportion which is 0.5 of daily remaining nutrient intake. In Meal 2, Constraint 27 is added to prevent repetition of food from Meal 1 which is shown as yellow section in Figure 7.2. Food that used in Meal 1 will be assigned with "1" and sum of product of a_{ij} and x_j is restricted so that it is not more than 0.

Allowable range of Meal 3 nutrient intake is computed by deducting Meal 1 LHS and Meal 2 LHS value from daily nutrient intake. Once again, yellow row as shown in Figure 7.3 is assigning 1 on used food in Meal 1 and 2 to prevent the model selecting repetitive food type.

3.0 Application

3.1 Technique and Algorithm Applied

Linear programming is the standard tool to solve general problem of optimization under constraint. [6] As mentioned above, this project objective is to design meal plan on behalf of hospital for dieting customer with lowest cost under daily nutrient intake constraint. Therefore, Simplex method of Linear Programming is implemented to solve the problem stated.

3.2 Results and Discussion

For this section, result from the example which is Customer 269 will be analysed and discussed. Table 7.5 shows the amount of nutrient intake by each meal, total nutrient intake according to meal plan and recommended daily nutrient intake (also known as allowable range of nutrient intake). From the table, total nutrient intake for each nutrition type is within the allowable range where nutrient intake constraint is fulfilled with total daily meal cost of RM16.77. In addition, from Table 7.6, types of food used in three meals are not repeating.

For this project optimization problem, recommended daily nutrient intake of dieting customer is the primary factor that contributing on food proportion decision. Meal plan design must satisfy minimum healthy nutrient intake constraint and help customer to reduce weight at the same time. Daily nutrition intake constraint is not the only factor that contribute to the optimization problem, nutrient contained in available food choices is another key factor that affect the decision of food proportion in each meal. In particular, Meal 3 always having higher cost than Meal 1 as the highly nutritious food with low cost is used in Meal 1 and the food chose are not allowed to be repeated. This caused the solver to select other food with higher cost and increase the proportion to achieve the daily recommended nutrient intake constraint.

In general, daily meal plans of majority of customer in dataset are designed with lowest cost while achieving constraints set by using LP model generated above. However, exception occurred on female customer cases. Minimum iron intake of female is higher than male and this caused some nutrition constraints cannot be satisfied given that repetition of food such as clams or oysters are restricted. From optimized solution, there were at least five different types of food selected in single meal. Therefore, the relaxation of constraint for food repetition across different meal is reasonable.

Thus, the plan is considered able to generalize on overweight customer with normal health condition given that biometric measures of customer are provided. Hospital as healthcare organization can promote the meal plan solution to their target customers while knowing the cost of the plan. This help hospital to decide on price of meal plan after considering cost from aspects such as cost of food, labour cost, partnership cost and the list goes on.

Furthermore, based on sensitivity analysis, reduced price of each type of food can be reference of hospital while planning resource purchasing or food purchasing. Concretely, if any wholesaler or retailer offer grapefruit price with RM 5.28 per kilogram which is RM 0.813 per serving, the cost of Meal 2 for Customer 269 will be reduced, and grapefruit will be selected as one of the food intakes in Meal 2.

Another finding from optimized solution included the frequency of food being selected. From this hospital can have better food resource planning. For instance, ingredients such as green cabbage, potato, clams and oysters have higher frequency being selected, thus these ingredients should be prevented from scarcity. Besides that, frequent intake food can be purchased from wholesaler for lower cost and further reduce the cost for each meal plan.

3.3 What-If Analysis

In sections above, LP models are design for customers who do not have any specific requirement and normal in health condition. In following sub-sections, customer subjected to different constraints is modelled and discussed. Customer 269 is applied under what-if analysis to observe the changes of the model under different conditions. Table 3.1 summarized the optimized cost and constraints adjusted for Customer 269 subjected to different What-if situation. Optimized solutions of "Minimal Activity" and "Osteoporosis" what-if situations are included in this report in Table 7.7, Table 7.8 and Table 7.9, Table 7.10 respectively to show situation with food repetition and without. Remaining situation results will be presented in Excel file model.

Table 3.1: Overview of Comparison of Meal Plan Cost and Constraints between Ordinary and What-if Situation.

	Conditions	**Optimized Cost (RM)**	**Constraint(s) Adjusted**
What-If	Normal	16.77	Meal ratio: 0.4/0.3/0.3; standard normal range
	Minimal Activity (Level)	12.96	Myfitnesspal activity setting adjusted from sedentary to lightly active
	Fixed Ingredient Requested (Lobster)	23.96	Minimum 0.1 portion of lobster
	Food Proportion Adjustment	12.64	Meal ratio: 0.6/0.35/0.15

	Diabetes	18.34	Meal ratio: 0.33/0.33/0.33; Fibre minimum intake as 0.35mg
	Osteoporosis	27.09	Calcium minimum intake 1g

3.3.1 Minimal Level of Activity

The minimal activity is set by assuming the customer spend a good part of the day on their feet. Hence, the activity setting in the MyFitnessPal is adjusted from sedentary to lightly active. The generated nutrient goal is used as the upper limit for the nutrient intake in the LP model. From Table 7.7, it is observed that most of the nutrients have a higher upper limit value compared to the example. From the result, we can observe that the model for minimal activity produced a lower daily meal cost of RM12.96 compared to the example.

3.3.2 Fixed Ingredient Requested

For a special customer who demanded lobster ingredient in his every meal, which is our most expensive ingredient that seldom will be used in normal serving. We want to use LP to calculate the minimum cost of ingredient to have an 8.4 gram (i.e., 0.1 portion) of lobster in the customer meal. The minimum cost of 1-day ingredient cost (sum of three of the meal) is RM23.96.

3.3.3 Food Proportion Adjustment

Customer might have request that the meal proportion proposed in model before is not matching his or her lifestyle. If the customer is soliciting for meal proportion of 0.6, 0.35 and 0.15 for Meal 3, Meal 2 and Meal 1 respectively, the nutrition intake RHS value will be changed according to proportion requested. The optimized solution shows that the total daily meal cost is RM12.64 and is lower as compared to the ordinary Customer 269.

3.3.4 Diabetes

For patients with diabetes illness, careful meal planning is needed control the glucose level of the body to maintain it within the allowable intake range. Carbohydrates were the main source of food as well as the sugar glucose coming have be tuned down while glucose intake for all three meals is best to maintain the same rough amount to avoid spikes and fall in blood sugar. Therefore, for this we tune the constraint with meal plan equally distributed or ratio of 33% for meal 1, meal 2 and meal 3. Following the studies, the optimal combination of macronutrients, the best mix are carbohydrate 45%, fat 35% and protein 20%. [10] For micronutrients we will emphasize on nutrient-dense carbohydrate sources which are high in fibre such as vegetables and fruits, we fixed the lower limit to 35mg. The cost of observed subject ordinary customer 269 and what-if customer 269 suffering diabetes, the latter has higher cost.

3.3.5 Osteoporosis

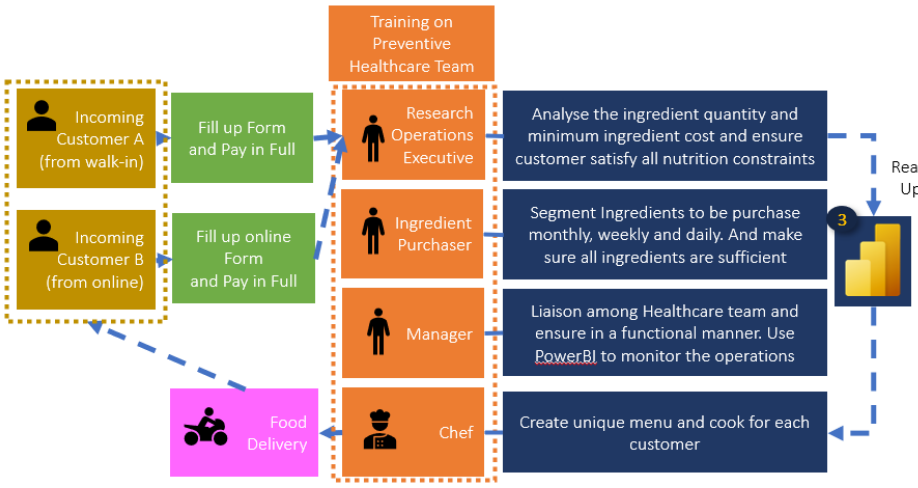
For adults who suffered from osteoporosis, recommended daily intake of calcium is 1000mg considering diet and supplement as source of calcium. [11] Thus, calcium intake constraint is changed to way that the lower limit which is the minimum intake per day is increased from ordinary requirement to 1000mg. From Table 7.9, minimum calcium intake is adjusted to 1000 mg and total nutrient intake fell between the range of recommended nutrient intake value. By comparing cost

between ordinary Customer 269 and what-if Customer 269 suffering osteoporosis, the latter has higher cost with cost of RM27.09.

4.0 Organization of Business Idea

4.1 Business Formulation

The business formulation below is from hospital point of view as illustrated in Figure 4.1. The preventive healthcare business is in a monthly subscription-based business model that can receive an expected incremental revenue. There are 2 source of customers that will engage with the business, which are from walk-in and online (customer who converted from an online advertisement). The business is in a functional form of structure that require at least 5 employees (Research Operations, Ingredient Purchaser, Manager, Chef and Food Delivery Executive). It will be organized in decentralised form in order to augment the focus of R&D and make a faster decision in the uncertain environment. The role of the preventive healthcare team has illustrated in Figure 4.1 as below. The food will be delivered to customers hand twice a day at 10 am in the morning for breakfast and lunch meals; and 6 pm in the evening for the dinner. For every extra 15 customers will employ 1 additional food delivery staff; an extra 30 customers will hire a new chef; an extra 50 customers will hire a new purchaser and research operation executive. The sample image of food packaging is as shown in Figure 7.6.



Organisational Structure	
Characteristic	**Functional Form of structure**
Specialisation	Yes
Formalisation	Informal
Centralisation	Decentralised
Reporting Relationship	Dynamic Relationship
Focus	R&D and Marketing

Figure 4.1: Business Formulation

4.2 Competitiveness Analysis

The competitiveness of the preventive healthcare business is considered competitive as analyzed by V.R.I.O as in Table 4.1 below. It is valuable as it is providing solutions in an environment of growing overweight citizens. It is moderately rare business model as it can provide customized service in a relative low price. And the organizational is dynamic as it is operating in a decentralized functional form. However, the caution we need to inform the aspect hospital to take care of is the intellectual property of the Linear Programming Model as it is imitable by using Excel Solver.

Table 4.1: Competitiveness Analysis by using V.R.I.O

	Valuable	Rarity	Imitability	Organizational
Explanation	A growing number of overweight citizens demanding nutritious diet in hassle-free manner.	Fulfilling all nutritious criteria meal normally comes with high price.	The linear programming model can be imitated.	Dynamic structure allows a flexible and fast decision-making process.
Result	Highly Valuable	Moderately Rare	Medium to High Imitability	Dynamic

4.3 Feasibility Analysis

Apart from the V.R.I.O analysis, feasibility analysis is also conducted to examine practicability in a pandemic environment in Table 4.2. It is a feasible service due to it provided food-delivery service from door-to-door. It is a feasible target market to serve the customers who is overweight and demanded to slim down in a physically restrictive environment. Besides, the supplier of resources is sufficient as the food ingredients supplies are not restricted from movement control order. The initial outlay is not expensive in extending a new business model, which is calculated in Table 4.4. Therefore, it is a feasible preventive healthcare business model.

Table 4.2: Feasibility Analysis

	Service	Target Market	Organizational	Financial
Explanation	High desirability and demands from overweight target customers with food delivery service	Attractive healthcare industry due to low entry cost and low bargaining power of customers.	Sufficient resource, which mostly come from ingredient and intangible resource of LP model.	Total start up cash is not expensive in proportion to the new values-added service.
Results	Feasible	Feasible	Feasible	Feasible

4.4 Different Level of Strategies

COVID-19 pandemic has imposed high uncertainty in the business environment. Many of the traditional industry including healthcare is looking to diversify their business to sustain further growth. With our proposed solutions, it can allow the hospital and other health-care firms to have a new business model to serve a particular segment of customers. Thus, the diversification of business allows the hospital to earn am extra revenue and reduce corporate risk at the same time. The LP model can allow to have cost leadership and differentiation on the service at the same time, which means that it can have an attractive pricing to customers and customized to each of the customers' meal, which is rare in the business environment [12]. Besides, we also allow that the healthcare firm to use the purchased LP model as an extra opportunity to expand their business overseas by using licensing and complementary strategic alliance. You may question is it practicle to expand the

business globally through the strategy mentioned. To explain, take Herbalife for example, there are, in fact, several F&B companies using complementary strategies to buy the ingredients from Herbalife and make it as a meal subscription plan to customers. In this case, Herbalife can get more revenue by having more pipelines to purchase their products, and the F&B companies can generate passive income from Herbalife. The different level of strategies is summarized in Table 4.3.

Table 4.3: Different Level of Strategies

Business Level Strategies	Corporate Level Strategies	Global Level Strategies
•Integrated Cost Leadership and Differentiation •Deliver Service value •Meet minimum ingredient cost while differentiate each customer meal without a time-consuming process	•Allow moderate to high level of diversification (related-constrained-diversification) to reduce corporate risk •Share resource with business unit and to serve new segment of customers, who has no health conditions to visit a hospital	•The linear programming model allow the healthcare company to export the license or Complementary Strategic Alliance with another firm from different country •Tool to start an International Business

4.5 Financial Projection

The financial projection is summarised in Table 4.4 below. The total initial outlay for the preventive healthcare business model is RM23,000 and is expected to reach breakeven in the fourth month of operation. As mentioned, the business model is a subscription manner by building a loyal customers base so is expected to have continuous subscription. To describe the marketing budget, a competitive digital marketer will be outsourced that can achieve cost per click of advertisement at RM2 and below at social media platform. In lower boundary, every 50 clicks will convert 1 customer to subscribe the meal plan. And it can make a profit of RM 3,176 after all the cost. If the hospital has grown to having a number 100 customers to subscribe for a year, the expected annual profit will be grown to RM328,000.

Table 4.4: Financial Projection.

Initial Outlay		**Cash Flow**	
-RM10,000	Linear Programming Model and Business Plan	RM36,000	Incremental Revenue (30 Customers)
-RM10,000	Investment in Working Capital	-RM10,800	Ingredient Cost (RM12*30 Customers*30 Days)
-RM3,000	Training Cost	-RM4,000	Food Shipping Cost (2*2000)
-RM23,000	Net Initial Outlay	-RM8,800	Operating Cost (4 *RM2200)
		RM12,400	Incremental Earning Before Tax
		RM3,224	Tax on Increment (26%)
		RM9,176	Incremental Earning After Tax
		-RM2,000	Additional Capital Spending
		RM7,176	Monthly Free Cash Flow
		RM86,112	Annual Free Cash Flow

Marketing Budget	
-RM1,000	Outsourcing Digital MarketIng Agent for specific task
-RM100	Expected Each Coversion per 50 clicks (RM2*50)
-RM3,000	Total Cost to Subscribed by 30 Customer
-RM4,000	Total Marketing Cost for 30 Customers
RM7,176	Total Profit by Marketing by acquiring 30 Customers.
RM3,176	Total Monthly Profit after Marketing

5.0 SWOT Analysis

5.1 Strengths

- **Easy and fast implementation and expansion.** The model able to fit into any meal preparation and selling business. With our researched food nutrition and human recommended daily intake information directory, we only need the potential business owner provide us their food or recipe ingredient, our model will process accordingly with minimal computation and human intervention, where the best optimum with the careful calculated nutrition meal result will be output.
- **Customizable and tailored to different customer need or budget**. Potential business partner can utilize our model which can tailored their meal preparation with different concern not only patients with obesity problem but other illness as well whether recovery, diabetes, or osteoporosis meals.
- **Low capital cost requirement.** With our simple LP model, there only minimal computation cost needed while provide best optimum solution not only for our services but also for business partner side where they can prevent food wastage and efficient and proper food procurement and inventory

(storage). We can introduce subscription fee-based services to try our model and different payment plan from monthly, yearly or lifetime to suit each individual need.

- **Leverage and expand existing hospital`s well-being services.** Gleneagles Hospital is well-established and reputable which offer wide range of medical services over 16 years. They offer customized health screening programme to help patients stay healthy and designed to assess how each patient coping with stress, investigate any signs of disease or illness and offer advice on lifestyle and diet changes that can be incorporated to maintain their general well-being. With their human capital and customer`s confident, they easily gain additional revenue stream to their business and even much better cost saving with their current hospital size capacity in bulk food ordering.

5.2 Weaknesses

- **Limited of food variety**. With current food nutrition list, there are only fruit, vegetable, and seafood ingredient, we looking to expand the list while we are going towards the progression plan. This easy achievable when our potential business partner feed in their food recipe and ingredient as input to our model. Looking forward to saving more meat choices and small snacks to be collect.
- **Food ingredient price vary through different time**. It will be our best interest to have few foods price surveyor to join and update the model from time to time to serve the best interest of our customer and mark to market accurate food price result.
- **The model may easy replicable**. Our tools which based on Microsoft excel solver add-in tool is easily replicable especially for those professional persons with related knowledge exposure. However, we will compliment it with the best nutrition resources information inventory and potentially food market analysis with fast pace growth at first to grab the market share.
- **Lack of trusted and reliable business partner**. For a start-up, to convince and put faith for ease expansion, we may partner with more well reputable business partner to ascertain our model is work and fit in the market. We may roll out some trial plan, collect some feedback and improve the model further, which in future might become our potential big customer at the same time build up our model brand name. In addition, we may work with or hire more nutritionist to certify and guarantee and safeguard our model.

5.3 Opportunities

- **High quality of life mindset and staying home during Covid-19.** With the current Covid-19 situation, where lock down is a norm, and everyone have to stay home to work while struggling to eat healthy. Even before, we can see trend people working out in gym and sharing healthy food across social network. We able to help them with our nutrition meal get to deliver to their doorsteps, when they may face inconvenience or too busy to prepare their own food while not all food delivery is guarantee with proper nutrition. Worst case for those who work on recovery plan or diabetes patients where proper meal nutrition is very crucial to their health.
- **Penang as the Centre of Medical Tourism.** There is undoubtful in customer segmentation, high number medical tourist signalling a huge market opportunity in medical tourism especially after covid-19 easing out. We can gather all nearby hospital in the island and co-partner and promote with each other to roll out nutritional while fusing with local delicacies dishes in carefully selecting the food ingredient during preparation.

- **Expansion the LP model to other industry.** We can the ride on healthy lifestyle train and promote our business model not only in hospital, but also partnering with fitness gym, canteen in school, university campus, sport and recreation centre but also other potential business partner which want to modify or market their recipe in a healthy manner.

5.4 Threats

- **Existing and new entrant competitor tries to grab market share**. Since the LP model is easy replicable, we may face competition especially their numerous website which promoting and sharing healthy recipe with detail nutrition value or fitness app like 'MyFitnessPal' which display the nutrition value you needed daily. However, none of them bring up both nutrition value meal plan which target on different individual need and prepare then get to delivered to them. There is existing competitor on the market, Herbalife's weight loss subscription mentioned beginning in the report is nothing but feeding you with different flavour of shake and tied to its own food products throughout the day, even though comprised with low calorie and supplement meal replacement at the bottom line. However, it lacks long-term success studied and expensive, and customer more likely want to eat actual dishes with variety option which is our model trying to fill.
- **Food price hike.** Food prices are influenced by demand and supply which may in turn may incurred extra cost and affecting our revenue model as we unable to easily change the menu pricing. For this, we need carefully study those food ingredients which price tends to be more volatile.

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7.0 Appendices

7.1 Standard Form of Problem Modelling

Table 7.1: Table Summarizing Decision Variables (Portion of Food per Meal, x_j).

Asparagus	Bell Pepper	Broccoli	$Food_4$, $Food_5$, …, $Food_{56}$	Tuna
x_1	x_2	x_3	$x_4 , \dots , x_{56}$	x_{57}
$j = 1,2,3, \dots ,57$ (57 types of food)				

Table 7.2: Table Summarizing Objective Coefficient (Cost per Serving of Food, c_j).

Food	Asparagus	Bell Pepper	Broccoli	$Food_4$, $Food_5$, …, $Food_{56}$	Tuna
Price per Serving (RM)	4.1	1.18252	3.29	$c_4 , \dots , c_{56}$	0.8307
$j = 1,2,3, \dots ,57$ (57 types of food)					

Table 7.3: Table Summarizing Constraint Coefficient of Decision Variable (Nutrition per Serving of Food, $a_{i\ j}$).

Food	Asparagus	Bell Pepper	Broccoli	$Food_4$, $Food_5$, …, $Food_{56}$	Tuna
a_1, Calories	4	6	8	$a_{1\ 4,\dots,56}$	0
a_2, Carbohydrate (g)	0	0	0.5	$a_{2\ 4,\dots,56}$	1.5
a_3, Fat (g)	2	1	4	$a_{3\ 4,\dots,56}$	26
a_4 ⋮ a_{13}	$a_{4\ 1}$ ⋮ $a_{13\ 1}$	$a_{4\ 2}$ ⋮ $a_{13\ 2}$	$a_{4\ 3}$ ⋮ $a_{13\ 3}$	$a_{4\ 4,\dots,56}$ ⋮ $a_{13\ 4,\dots,56}$	$a_{4\ 57}$ ⋮ $a_{13\ 57}$
a_{14}, Iron (mg)	0.36	0.72	1.08	$a_{13\ 4,\dots,56}$	0
$i = 1,2,3, \dots ,14$ (14 nutrition types considered) $j = 1,2,3, \dots ,57$ (57 types of food)					

Table 7.4: Example Constraint Values of One of the Customer, ($Range\ of\ Nutrition\ Intake, b_{i\ k}$).

Nutrition	Lower Limit Constraint, $b_{i\ k=1}$	Upper Limit Constraint, $b_{i\ k=2}$
Calories	340	608
Carbohydrate(g)	20	76
Fat(g)	0	20.4
Protein(g)	24.4	30.4
Saturated fat (g)	0	6.8
Cholesterol (mg)	0	120
Sodium(mg)	140	920
Potassium(mg)	0	1400
Fibre(g)	8	15.2
Sugar(g)	0	22.8
Vitamin A (mg)	0.24	1.2
Vitamin C (mg)	28	800
Calcium (mg)	280	1000
Iron (mg)	3.6	18
$i = 1,2,3, \dots ,14$ (14 nutrition types considered) $k = 1,2$ (2 limit which are upper and lower limit)		

$$Minimize\ Cost\ per\ meal, Z = 4.1x_1 + 1.18252x_2 + 3.29x_3 + c_4x_4 + \cdots + c_{56}x_{56} + 0.8307x_{57}$$

Subjected to constraints below:

Constraint 1 (Carbohydrate Upper Limit):

$$4x_1 + 6x_2 + 8x_3 + a_{1\,3}x_4 + a_{1\,3}x_5 + \cdots + a_{1\,56}x_{56} + 0x_{57} \leq b_{11}$$

Constraint 2 (Carbohydrate Lower Limit):

$$4x_1 + 6x_2 + 8x_3 + a_{1\,3}x_4 + a_{1\,3}x_5 + \cdots + a_{1\,56}x_{56} + 0x_{57} \geq b_{12}$$

Constraint 3 (Fat Upper Limit):

$$0x_1 + 0x_2 + 0.5x_3 + a_{3\,4}x_4 + a_{3\,5}x_5 + \cdots + a_{3\,56}x_{56} + 1.5x_{57} \leq b_{21}$$

⋮

Constraint 28 (Iron Lower Limit):

$$0.36x_1 + 0.72x_2 + 1.08x_3 + a_{13\,3}x_4 + a_{13\,3}x_5 + \cdots + a_{13\,56}x_{56} + 0x_{57} \geq b_{12}$$

Constraint 29 and 30 (Food Repetition Restriction on Meal 2 and Meal 3):

$$a_{14\,1}x_1 + a_{14\,2}x_2 + a_{14\,3}x_3 + a_{14\,4}x_4 + a_{14\,5}x_5 + \cdots + a_{14\,56}x_{56} + a_{14\,57}x_{57} \leq 0$$

$$a_{14\,j} = 1\ when\ x_j > 0\ in\ Meal\ 1\ and\ Meal\ 2$$

	A	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN
1																	
2	**Food and Serving**	Rainbow Trout (	Salmon, Atlan	Salmon, Chum	Scallops, a	Shrimp (84g)	Swordfish (84g)	Tilapia (84g)	Tuna (84g)			**Total Cost**					
3	**Price/serve**	4.704	2.93916	3.78	4.7572	2.18316	0.71568	0.038315225	0.83076			3.861845579					
4	**Serving**	0	0	0	0	0	0	0	0								
5																	
6																	
7																	
8	Customer																
9	269																
10																	
11																	
12												Meal 1 Nutrient Intake RHS			Daily Remaining Nutrient Intake		
13	**Nutrient/serving**									LHS	between	Lower Limit RNI/meal	Upper Limit RNI/meal		Lower Limit RNI/day	Upper Limit RNI/day	
14	Calories	140	200	130	140	100	120	110	130	400		400	608		1000	1520	
15	Carbohydrate(g)	0	0	0	5	0	0	0	0	47.69949342		20	76		50	190	
16	Fat(g)	6	10	4	1	1.5	6	2.5	1.5	8.639683938		0	20.4		0	51	
17	Protein(g)	20	24	22	27	21	16	22	26	30.4		24.4	30.4		61	76	
18	Saturated fat (g)	10	10	5	0	0	8	5	0	6.8		0	6.8		0	17	
19	Cholesterol (mg)	18	23	23	22	57	13	25	17	36.72364759		0	120		0	300	
20	Sodium(mg)	35	55	65	310	240	100	30	40	178.6266429		140	920		350	2300	
21	Potassium(mg)	370	430	420	430	220	310	360	480	1400		0	1400		0	3500	
22	Fibre(g)	0	0	0	0	0	0	0	0	8.8581326		8	15.2		20	38	
23	Sugar(g)	0	0	0	0	0	0	0	0	22.8		0	22.8		0	57	
24	Vitamin A (mg)	0.036	0	0.018	0	0	0	0	0	0.749802412		0.24	1.2		0.6	3	
25	Vitamin C (mg)	3.6	1.8	1.8	0	0	0	0	0	172.7584821		28	800		70	2000	
26	Calcium (mg)	78	0	26	0	0	0	0	0	280		280	1000		700	2500	
27	Iron (mg)	1.8	0.36	0.72	0	0	0	0	0	6.546805625		3.6	18		9	45	
28																	
29	Ingredient used Meal 1	0	0	0	0	0	0	0	0								

Figure 7.1: Meal 1 Plan Model for Customer 269

	A	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM
2	**Food and Serving**	Pollock (8	Rainbow Trout	Salmon, Atlan	Salmon, Chum	Scallops, (	Shrimp (8	Swordfish (8	Tilapia (84g)	Tuna (84g)			**Total Cost**				
3	**Price/serve**	1.4	4.704	2.93916	3.78	4.7572	2.18316	0.71568	0.038315225	0.83076			3.792996126				
4	**Serving**	0	0	0	0	0	0	0	0	0							
8	Customer																
9	269																
12													Meal 2 Nutrient Intake RHS			Daily Remaining Nutrient Intake	
13	**Nutrient/serving**										LHS	between	Lower Limit RNI/meal	Upper Limit RNI/meal		Lower Limit RNI/day	Upper Limit RNI/day
14	Calories	90	140	200	130	140	100	120	110	130	300		300	560		600	1120
15	Carbohydrate(g)	0	0	0	0	5	0	0	0	0	41.17222189		1.150253289	71.15025329		2.300506577	142.3005066
16	Fat(g)	1	6	10	4	1	1.5	6	2.5	1.5	5.576582376		0	21.18015803		0	42.36031606
17	Protein(g)	20	20	24	22	27	21	16	22	26	22.8		15.3	22.8		30.6	45.6
18	Saturated fat (g)	0	10	10	5	0	0	8	5	0	5.1		0	5.1		0	10.2
19	Chlolesterol (mg)	27	18	23	23	22	57	13	25	17	35.38909469		0	131.6381762		0	263.2763524
20	Sodium(mg)	110	35	55	65	310	240	100	30	40	387.9533723		85.68667857	1060.686679		171.3733571	2121.373357
21	Potassium(mg)	370	370	430	420	430	220	310	360	480	1050		0	1050		0	2100
22	Fibre(g)	0	0	0	0	0	0	0	0	0	8.378799278		5.5709337	14.5709337		11.1418674	29.1418674
23	Sugar(g)	0	0	0	0	0	0	0	0	0	17.1		0	17.1		0	34.2
24	Vitamin A (mg)	0.018	0.036	0	0.018	0	0	0	0	0	0.006065936		0	1.125098794		0	2.250197588
25	Vitamin C (mg)	0	3.6	1.8	1.8	0	0	0	0	0	140.8280672		0	913.620759		0	1827.241518
26	Calcium (mg)	0	78	0	26	0	0	0	0	0	210		210	1110		420	2220
27	Iron (mg)	0.36	1.8	0.36	0.72	0	0	0	0	0	9.237384858		1.226597188	19.22659719		2.453194375	38.45319438
28	Ingredient Used Constraint	0	0	0	0	0	0	0	0	0	0			0			
29																	
30	Ingredient used Meal 1	0	0	0	0	0	0	0	0	0							

Figure 7.2: Meal 2 Plan Model for Customer 269

	A	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO
2	Food and Serving	Salmon, Atlan	Salmon, Chum	Scallops, (	Shrimp (8	Swordfish (8	Tilapia (84g)	Tuna (84g)			**Total Cost**				**Total 3 Meals Cost**		
3	Price/serve	2.93916	3.78	4.7572	2.18316	0.71568	0.038315225	0.83076			9.123744478				16.77858618		
4	Serving	0.253336825	0	0	0.020403	0.10723727	0	0									
8	Customer																
9	269																
12											Meal 3 Nutrient Intake RHS					Daily Nutrient Intake	
13	**Nutrient/serving**								LHS	between	Lower Limit RNI/meal	Upper Limit RNI/meal			Optimized	Lower Limit RNI/day	Upper Limit RNI/day
14	Calories	200	130	140	100	120	110	130	300		300	820			1000	1000	1520
15	Carbohydrate(g)	0	0	5	0	0	0	0	49.76066505		1.150253289	101.1282847			138.6323804	50	190
16	Fat(g)	10	4	1	1.5	6	2.5	1.5	4.346552446		0	36.78373369			18.56281876	0	51
17	Protein(g)	24	22	27	21	16	22	26	22.8		15.3	22.8			76	61	76
18	Saturated fat (g)	10	5	0	0	8	5	0	5.1		0	5.1			17	0	17
19	Chlolesterol (mg)	23	23	22	57	13	25	17	16.92748368		0	227.8872577			89.04022596	0	300
20	Sodium(mg)	55	65	310	240	100	30	40	85.68667857		85.68667857	1733.419985			652.2666938	350	2300
21	Potassium(mg)	430	420	430	220	310	360	480	1050		0	1050			3500	0	3500
22	Fibre(g)	0	0	0	0	0	0	0	13.75843904		5.5709337	20.76306812			30.99537092	20	38
23	Sugar(g)	0	0	0	0	0	0	0	17.1		0	17.1			57	0	57
24	Vitamin A (mg)	0	0.018	0	0	0	0	0	0.359771237		0	2.244131652			1.115639585	0.6	3
25	Vitamin C (mg)	1.8	1.8	0	0	0	0	0	218.9827944		0	1686.413451			532.5693437	70	2000
26	Calcium (mg)	0	26	0	0	0	0	0	210		210	2010			700	700	2500
27	Iron (mg)	0.36	0.72	0	0	0	0	0	1.226597188		1.226597188	29.21580952			17.01078767	9	45
28	Ingredient Used Constraint	0	0	0	0	0	0	0	0			0					
29																	
30	Ingredient used Meal 1+2	0	0	0	0	0	0	0									

Figure 7.3: Meal 3 Plan Model for Customer 269

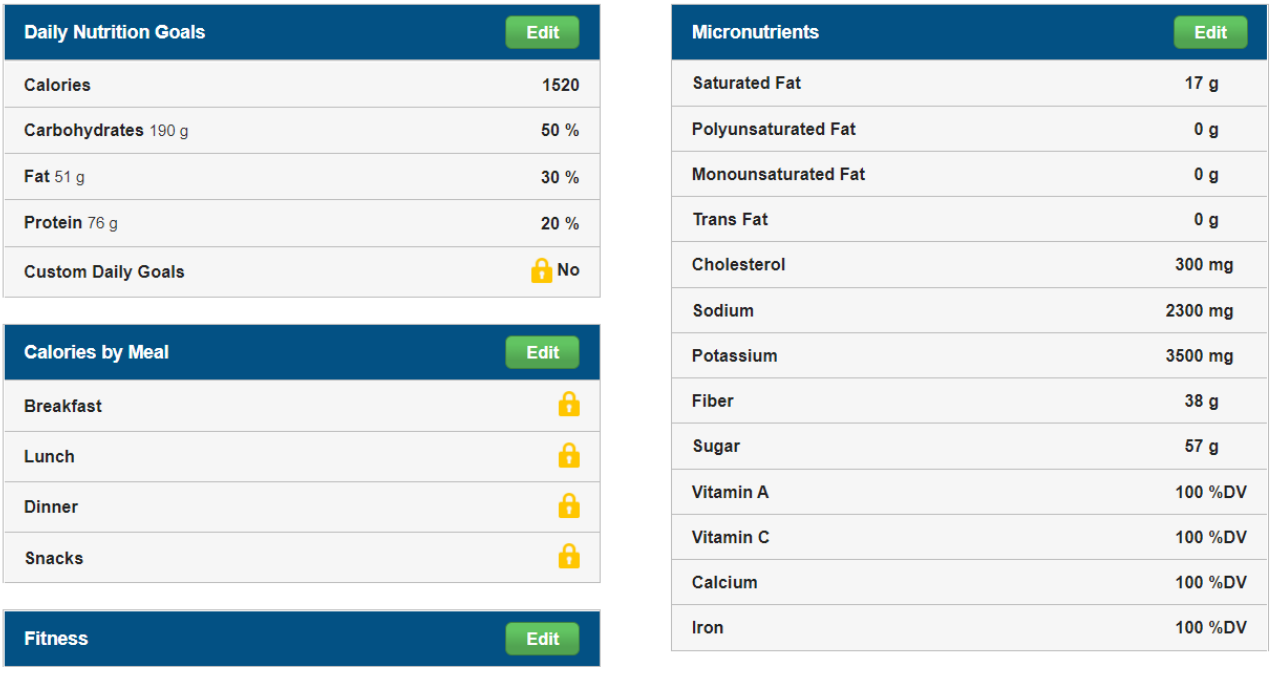

Figure 7.4: Daily Nutrient Intake Upper Limit Constraint Set by MyFitnessPal

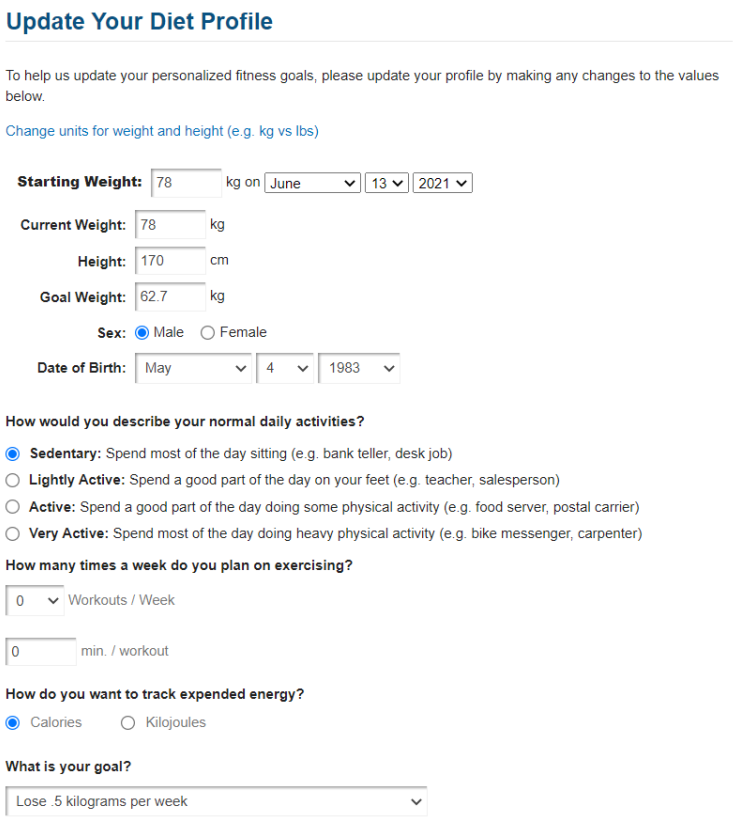

Figure 7.5: Setting Up of Customer 269 Profile

7.2 Optimized Solution with Respective Results

Table 7.5: Comparison between Total Nutrient Intake and Recommended Daily Nutrient Intake for Customer 269.

Nutrition Type	Meal 1 Nutrient Intake	Meal 2 Nutrient Intake	Meal 3 Nutrient Intake	Total Nutrient Intake	Recommended Daily Nutrient Intake	
					Lower Limit	Upper Limit
Calories	400	300	300	1000	1000	1520
Carbohydrate (g)	47.699493	41.17222	49.760665	138.63238	50	190
Fat (g)	8.639683	5.5765824	4.3465524	18.56282	0	51
Protein (g)	30.4	22.8	22.8	76	61	76
Saturated fat (g)	6.8	5.1	5.1	17	0	17
Cholesterol (mg)	36.723648	35.389095	16.927484	89.040226	0	300
Sodium (mg)	178.62664	387.9533723	85.68668	652.26669	350	2300
Potassium (mg)	1400	1050	1050	3500	0	3500
Fibre (g)	8.8581326	8.378799	13.758439	30.99537	20	38
Sugar (g)	22.8	17.1	17.1	57	0	57
Vitamin A (mg)	0.7498024	0.0060659	0.3597712	1.1156396	0.6	3
Vitamin C (mg)	172.75848	140.8281	218.98279	532.56934	70	2000
Calcium (mg)	280	210	210	700	700	2500
Iron (mg)	6.5468056	9.23738	1.226597	17.010788	9	45
Cost (RM)	**3.86**	**3.79**	**9.12**	**16.77**		

Table 7.6: Food Used in Each Meal Plan Designed.

Meal 1						
Selected Food	Green Onion	Sweet Potato	Avocado	Orange	Catfish	Clams
Proportion, x_j	2.388917	0.557124	0.702601	1.179372	0.68	0.931987
Meal 2						
Selected Food	Green Cabbage	Potato	Sweet Corn	Pear	Flounder	Oyster
Proportion, x_j	0.52282639	0.15168	0.336996	0.594453	0.436061	1.02
Meal 3						
Selected Food	Green Bean	Onion	Grapefruit	Lime	Ocean Perch	Salmon	Shrimp	Swordfish
Proportion, x_j	1.20562	0.40455	1.00435	3.45962	0.56958	0.25334	0.0204	0.10724

Table 7.7: Comparison between Total Nutrient Intake and Recommended Daily Nutrient Intake for Customer 269 (What-if Case 1: Minimal Activity)

Nutrition Type	Meal 1 Nutrient Intake	Meal 2 Nutrient Intake	Meal 3 Nutrient Intake	Total Nutrient Intake	Recommended Daily Nutrient Intake	
					Lower Limit	Upper Limit
Calories	400	300	300	1000	1000	1770

Carbohydrate (g)	48.352897	36.772371	29.5936423	114.71891	50	221
Fat (g)	5.7676178	5.4895979	9.5732788	20.830495	0	59
Protein (g)	35.6	25.354341	25.309543	86.2638837	61	89
Saturated fat (g)	8	6	6	20	0	20
Cholesterol (mg)	42.451934	33.03295	21.295441	96.780327	0	300
Sodium (mg)	166.59587	345.38717	91.702063	603.68511	350	2300
Potassium (mg)	1400	1050	1050	3500	0	3500
Fibre (g)	8.5343817	9.42538636	10.036426	27.996194	20	38
Sugar (g)	26.4	19.8	19.8	66	0	66
Vitamin A (mg)	0.6467458	0	0.0398167	0.6865625	0.6	3
Vitamin C (mg)	203.26985	155.18787	49.783698	408.2414	70	2000
Calcium (mg)	280	210	210	700	700	2500
Iron (mg)	5.4082068	6.6436772	2.5687313	14.62061	9	45
Cost (RM)	**3.27**	**3.40**	**6.29**	**12.96**		

Table 7.8: Food Used in Each Meal Plan Designed for Customer 269 (What-if Case 1: Minimal Activity)

Meal 1						
Selected Food	Green Onion	Sweet Potato	Orange	Catfish	Clams	Tilapia
Proportion, x_j	2.16113	0.47168	1.49551	0.57579	0.79455	0.44842
Meal 2						
Selected Food	Green Cabbage	Pear	Flounder	Oysters	Swordfish	
Proportion, x_j	2.28615584	0.80885	0.53997	0.7186	0.30087492	
Meal 3						
Selected Food	Green Beans	Onion	Avocado	Ocean Perch	Salmon	Shrimp
Proportion, x_j	1.106018	1.954218	0.855717	0.39129	0.48261298	0.075895

Table 7.9: Comparison between Total Nutrient Intake and Recommended Daily Nutrient Intake for Customer 269 (What-if Case 5: Osteoporosis)

Nutrition Type	**Meal 1 Nutrient Intake**	**Meal 2 Nutrient Intake**	**Meal 3 Nutrient Intake**	**Total Nutrient Intake**	**Recommended Daily Nutrient Intake**	
					Lower Limit	**Upper Limit**
Calories	400	300	300	1000	1000	1520
Carbohydrate (g)	48.1552479	49.3708589	45.76161	143.28772	50	190
Fat (g)	8.3703918	4.5829939	3.037192	15.990578	0	51
Protein (g)	30.4	22.8	22.8	76	61	76
Saturated fat (g)	6.8	5.1	3.9494218	15.84942	0	17

Cholesterol (mg)	58.072184	26.7630835	16.4727296	101.308	0	300
Sodium (mg)	495.78009	273.2761	157.80087	926.8571	350	2300
Potassium (mg)	1400	1050	1050	3500	0	3500
Fibre (g)	8.6807714	13.1895450	14.811739	36.682055	20	38
Sugar (g)	22.8	17.1	17.1	57	0	57
Vitamin A (mg)	0.24	0.18	0.18	0.6	0.6	3
Vitamin C (mg)	191.85934	286.803209	123.45578	602.11833	70	2000
Calcium (mg)	400	300	300	1000	**1000**	2500
Iron (mg)	16.2899042	6.09290022	2.990151	25.3729552	9	45
Cost (RM)	**5.98**	**11.08**	**10.03**	**27.09**		

Table 7.10: Food Used in Each Meal Plan Designed for Customer 269 (What-if Case 5: Osteoporosis)

Yellow highlighted is repeated food intake.

Meal 1							
Selected Food	Green Onion	Sweet Potato	Avocado	Orange	Clams	Catfish	Oyster
Proportion, x_j	4.158011	0.056561	0.386646	1.30329	0.895676	0.076515	1.20697
Meal 2							
Selected Food	Green Cabbage	Sweet Corn	Grapefruit	Lemon	Lime	Ocean Perch	Oyster
Proportion, x_j	1.1153860	0.304786	0.554012	3.067888	1.5527	0.64743	0.631542
Meal 3							
Selected Food	Green Onion	Leaf Lettuce	Lime	Pear	Ocean Perch	Salmon	
Proportion, x_j	6.244694	0.057774	2.230098	0.674846	0.91223	0.121273306	

Figure 7.6: Sample Food Packing

8.0 Reflection

8.1 Soh Hong Say

Mistakes/Problems Encountered

In a nutshell, a linear programming model for optimizing the diet meal plan while minimizing the ingredient cost and fulfil the nutrient constraints is introduced.

Although the linear programming model is deployable, we encountered some problems when working with different customers. One of the problems we faced is the solution could not cope with some of the constraints (e.g., calories), hence no optimal solution produced. This situation usually occurs on certain customers, such as Customer 371 when it comes to Meal 2 or Meal 3 or both as the model has less low pricing food ingredients to choose from. Hence, it produced a minimum solution with higher pricing and not fitting to certain constraints. We developed a solution where we allowed some ingredients to be repeated. This is because various food ingredients would be selected for the meals. So, a small portion of repetition is acceptable, and it is up to the chef's creativity for creating the meals based on the food ingredients provided.

Besides that, another mistake we made is the limitation of the food ingredients. There are lots of ingredients to choose from in the real world, such as meats, rice, flour, etc. However, our current model only focuses on vegetables, fruits and seafood which restricts the model to generate an optimal solution from the limited food ingredients. Not every customer can consume all ingredients on the list, especially those with allergies or certain food restriction such as vegetarian. It is advisable to expand the food ingredients list in the future so that more combinations could be produced through the model.

Knowledge & Experience Gained

Private hospitals currently facing a major impact on revenues due to the decreasing demand for non-essential treatments during the COVID-19 pandemic.[13] IHH Healthcare, a healthcare group that owned Gleneagles Hospital, experiencing declined revenue in the 4th quarter of the financial year 2020 due to postponement of elective and non-urgent treatment.[14] Besides increasing operational efficiency and lower down finance cost, a company needs to continuously seek business growth by exploring new opportunities and new source of income.

Through the project implementation, we can deploy a linear programming model into a real-life business application. What-if analysis is introduced in the project to test out the model's ability in handling different situations and constraints. This helps us learn to merge the business model with the usage of the linear programming model in cost control. Moreover, the project helps us to learn the implementation of business venture that fits the current pandemic situation. With the help of current technologies and the development of online business, this business could be rapidly deployed and deliver the meal with minimal face-to-face contact between customers and business.

To ensure the LP model works well with real-world scenarios, an operational research (OR) team is needed. Further LP model development and supervision by expertise from various professional fields, including nutritionist, dietician, chef, procurement and management are required to ensure the LP model deployed is fit to both customers and company benefit.

8.2 Cheong Xian Yao

Proposed at first the transportation LP model of a chipset manufacturing shipping optimization with a defined constraints available however due to it overwhelming complexity and instances which is not worth the efforts to continue focusing on and as claimed there already solution, but the implementation into excel solver is a pain. Therefore, with risk and reward evaluated, we switched to this diet plan optimization.

Food ingredient prices. There is no single source of price reference list to obtain from with so many varieties. We use Tesco Online pricing as our input pricing and careful input according to the amount and portion from the original food list we obtained from FDA website. While there are seafood types which is normal at oversea but rare in Malaysia, we are using import pricing from Malaysia local vendor marketed at their website.

Setting the constraint. Depend on the subject we studied, some objects tend behave quite abnormal to the real-world constraint, where the LP solver unable to solve especially due to limited food ingredient list to optimize with. Using 'MyFitnessPal' app, most upper limit is calculated and available for us to use but not lower limit. With this tuning the constraint lower while keeping it reasonable slight below recommended level or reliving some constraint but not the extreme limit point to survive. Apart from three main dishes a day, the patients may eat other small snacks between the meal to add on into that.

Conducted SWOT analysis targeted lean towards the Gleneagles hospital rather than the LP model itself. Rather than focusing on how Gleneagles hospital, which is our target hospital to work with, we focus on the strength of the hospital, which is well staffed and resourcefully sufficient, but we try to market our business solution which is the simple and basic LP model and how flexible the model able to adapt to different business requirement need.

Experience and knowledge from the project in short, giving the best with what you have. Relieving some constraint indicate the model weakness and tweaking it for now not guarantee the best result but temporary best feasible solution or quick patch and improve it over time. For diabetes what-if conditions, we do a quick fix patch by allowing repetitive food ingredients as we cannot meet the lower limit of calories constraint, food while those food with the high calories does not guarantee other nutrition values. Feeding the model with more food ingredients will lower the possibility of repetitive optimum food ingredients.

8.3 Khoo Hui Xian

1. Mistakes Done

a. Recommended daily nutrient intake values are based on a general guideline of nutrient intake by MOH Malaysia and MyFitnessPal application. However, the recommended nutrient intake values are dependent on health condition, lifestyle, biometric measures and even country of a human.

b. There are 57 types of food available for the LP model of this project which is based on the ready dataset as nutrition information of the food is contained. This caused the model has limited choice of food in designing meal plan under recommended nutrient intake constraint.

2. Solution Proposed with Respect to Mistakes Done

a. In real world application, it is more appropriate to generate the recommended daily nutrient intake values from professional such as doctor or nutritionist.

b. Food should be provided for the model to generate optimized solution with lower cost and satisfy constraints in better or more efficient way.

3. Knowledge and Experience Gained

a. During topic identification stage, I learnt about the complexity of real-world problem is much higher than what illustrated from reference book. Our first topic suggested was transportation problem which is has a larger dataset that contain 10000 of instances while constraints are dependent witch each other. Hence, the current meal plan design problem is proposed.

b. Initially, the current meal plan design plan was targeting customer instead of hospital which is inappropriate based on the project requirement. Objective of the project is changed to promoting the meal plan design service to hospital for them to expand their market to non-diseased people.

c. While solving the problem using Excel Solver, I noticed that constraint relaxation is so much crucial in real world problem. During solving female customers and what-if customers problems, the “optimized” solution given by Excel Solver is not satisfying nutrition intake constraint if food repetition is not allowed. For these cases, the problem is solvable whole solution is optimized when clams or oysters are allowed to be repeated used in Meal 2 or Meal 3.

8.4 Lee Kah Win

1. Mistakes and Solutions

a. During the proposal, I have not thinking carefully that the industry we were doing is it in healthcare industry or just a F&B industry. Realising that, our team have switching the gear and pointing a clear direction into healthcare industry by specifically to help hospital to monetize on preventive healthcare segment.

b. I have proposed equality constraints for the model of nutrition value and calories in the beginning of the project, which needs to be exactly equal. But eventually find out that due it is difficult to satisfy with all the constraints particulars for different meal combinations. So, after listening into other teammates opinion, a range of values with lower limit and upper limit with credible references will be more feasible, which is implemented in this project.

c. I have mistakenly put underweight constraints for subjects who have underweight issue. After getting clear with our project objective which is to target overweight and obese customers as a preventive healthcare solution, I have changed that into solely model for overweight constraints.

2. Knowledge and Experience Gained

a. I have gain knowledge on how to optimize a diet plan with LP model without having to pay an expensive amount of money to seek for a doctor or purchase an app to know what portion of food I should eat to fulfill all my nutrition's daily requirement.

b. To be honest, it is a tiring process to find a dataset that is qualified for a LP problem. Majority of the dataset does not fulfill the criteria to be put into LP problem. We have faced issues such as the data set is too large to be analyzed by using Excel Solver or the dataset has already been solved for the LP model by previous scholar. I have gain knowledge and experience on how to find a dataset that can be formulated into a LP problem and from the LP problem to transform it into a LP model that can solve real world optimization problem.

c. Besides, I also have gain experience in develop a workable business plan in a COVID-19 environment from our proposed LP model. I have learnt the business analysis such as competitive analysis of V.R.I.O, feasibility analysis and setting up a financial projection of initial outlay, marketing budget and cash flow to operate the business.

8.5 Sumanthiran A/L R Subramaniam

The nutrition-based dataset consists of a complex data and needs to be aware of each value propositions with cost involved. The nutrition data using LP model helped us to determine the cost effectiveness of nutrition for the needy customer.

With regular meetings and discussions in our group, we were able to help each other for arriving at a better understanding of the project subject in order to arrive at the desired model for this project.

During the What-If analysis, we tried with a customer who was having allergy to seafoods and who consumes vegetables and fruits only. However, such constraints are unsolvable due to customer unable to meet their nutrition level only with vegetables and fruits consumption from the given dataset.

The nutrition table helped us to choose the appropriate food to be recommended for the customer. Also, the customer themselves can determine for preparing choice of food based on the recommended chart to match with their preferred goal. Though it will be helpful to the individual customers, the same will be detrimental to our project goal.

The nutritional fact table was able to reveal the nutritional aspects of various foods which is also helpful to us in the real-world day to day problems. The dataset from the nutrition table was informative for determining the percentage of nutrition available in the food sold in the world market. From this data, the actual market cost for the value of the nutrition could be known.

Through this LP model I have also gained knowledge on various aspects which will be helpful in recommending the model to solve my current Institution real world problems.