Nutrition Security and Optimal Dietary Intake in Taiwan

Ching-Cheng Chang\textsuperscript{1,2}, Yi-Ting Liu\textsuperscript{1}, Chia-Sheng Hsu\textsuperscript{2}, Shih-Hsun Hsu\textsuperscript{1}

\textsuperscript{1}Department of Agricultural Economics, National Taiwan University

\textsuperscript{2}Institute of Economics, Academic Sinica, Taiwan.

Contributed paper prepared for presentation at the 63\textsuperscript{rd} AARES Annual Conference, Melbourne, Vic 12-15 February 2019

Copyright 2018 by Authors names. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.
Nutrition Security and Optimal Dietary Intake in Taiwan

Ching-Cheng Chang¹,², Yi-Ting Liu¹, Chia-Sheng Hsu², Shih-Hsun Hsu¹

¹Department of Agricultural Economics, National Taiwan University
²Institute of Economics, Academic Sinica, Taiwan.

Abstract

The rapid urbanization and income growth have led to changes in the global food systems and nutrition transition in many developing countries. The prevalence of obesity and dietary-related diseases has become an urgent issue in developing national health policies. Taiwan is a rapidly aging society and its highest prevalence of obesity is observed in adults above 65 years old. This paper aims to find the optimal age-specific dietary intake pattern for both sexes based on the data from Nutrition and Health Surveys in Taiwan (NAHSIT). Goal programming approach is adopted to minimize the gap between observed diet and the dietary recommendation intakes (DRIs) from the public health authorities. Food consumption constraints is added to prevent diet plans from including unreasonable pattern and to minimize impacts on household food expenditures. Our result suggests that lack of calcium intake is a common problem for all age groups and both sexes in Taiwan and a shift from meat and oil products to more fish, nuts and vegetables is required. The age- and gender-specific results also show how goal programming modelling can be used to translate the DRIs into economically acceptable food plans.

Keywords

Goal programming, optimization, food intake pattern, Nutrition and Health Survey in Taiwan (NAHSIT)

Introduction

In recent years, rapid urbanization and income growth in many developing countries have led to changes in food systems resulting in a global nutrition transition. Nutrition transition refers to recent global shifts in dietary patterns towards higher intakes of saturated fats, sugars and refined foods, and lower intakes of high-fiber foods, driven by technological advances that have made energy dense, nutrient-poor foods cheaply available on global food markets (Ghattas, 2014). Popkin and Gordon-Larsen (2004) indicated that modern societies
seem to be converging on a diet high in saturated fats, sugar, and refined foods but low in fiber, which is called food westernization.

Westernization of Asian diet has changed the food production and consumption in an irreversible pattern (Pingali, 2006). Taiwan was among the fastest food westernization countries in Asia. Using household survey data, Peng et al. (2015a), Misra and Khurana (2008), and Pan et al. (2011) found that Taiwanese consumed more meat, sweetened beverage, and oil but less vegetable and fruit leading to persistently rising obesity prevalence rate. In 2016, the Health Promotion Administration (HPA) announced that Taiwan had the highest obesity and overweight ratio (44% of adults) in all Asian countries. In addition, the diseases related with obesity such as cardiovascular diseases and diabetes had become the 2nd and 5th of the ten leading causes of death in Taiwan.

Furthermore, Taiwan will enter an “aged society” as its proportion of elderly reached 14 percent in 2018. The statistics of Ministry of the Interior indicate that its dependency ratio has exceeded 100% in 2017, meaning elder generation is more than younger one. Chang et al. (2011) found that the physical and mental health significantly led to inadequate nutrient intakes of the elderly in Taiwan, and they suggested that not only younger generation but elderly have problems for malnutrition. Therefore, the paper aims to study the optimal dietary intake pattern for Taiwan taking into account the compounding effect of age and gender. A mathematical goal programming model and the Nutrition and Health Survey in Taiwan (NASHIT) data representing the dietary habits of adults over 19 years old in Taiwan are adopted in our empirical results.

Linear programming model has been widely used to find optimal diets (Soden & Fletcher, 1992, Briend et al., 2003, Darmon et al. 2006). Masset et al. (2009) and Okubo et al. (2015) used goal programming to find the optimal dietary pattern for Americans and Japanese. Masset et al. (2009) focused on preventing serious cancer problem and Okubo et al. (2015) focused on the adjustment of dietary culture to prevent chronic disease for Japanese. We follow the similar approach and divide the NASHIT data into eight sub-groups by age and sex to provide suitable dietary recommendations for each age and sex group. The optimal results will be used to show how programming models can be used to develop practical dietary guidelines for men and women across different age groups by translating the DRIs into economically acceptable food plans.

Methods

In 1957, Charnes and Cooper were first to mention goal programming and this tool first applied in management (Feng et al. 1989). Anderson and Earle (1983) indicated that goal programming is presented as a method of achieving nutritional balance in selected diets. In recent years, many experts used goal programming to design optimal dietary intake (Ferguson et al., 2006; Masset et al., 2009; Okubo et al., 2015). According to previous studies (Ferguson et al., 2006; Okubo et al., 2015; Masset et al., 2009), the objective function minimizes the
deviation in food intake between the observed and optimized food intake patterns met the nutritional recommendations with a little change as possible from the reported food intake.

In this study, we follow the approach suggested by Ferguson et al. (2006), Masset et al. (2009) and Okubo et al. (2015) and define the objective function as follows:

\[
\text{Minimize } Y = \sum_{j=1}^{16} \left( \frac{X_{j}^{opt} - X_{j}^{obs}}{X_{j}^{obs}} \right),
\]

where \( Y \) denotes the objective function to minimize, \( X_{j}^{opt} \) denotes the serving of food subgroup \( j \) in optimized food subgroup intake pattern, and \( X_{j}^{obs} \) denotes the mean serving of food subgroup in the observed food intake pattern across the whole population. Therefore, we try to minimize the summation of all deviation from dietary intake to optimal intake, \( Y \), hence we define new decision variable to be non-negative and representing positive and negative deviation from the observed food per serving, and the definitions are as the following:

If \( X_{j}^{opt} < X_{j}^{obs} \), then \( d_{j}^{-} = \frac{(X_{j}^{obs} - X_{j}^{opt})}{X_{j}^{obs}} \) and \( d_{j}^{+} = 0 \),

(2)

If \( X_{j}^{opt} > X_{j}^{obs} \), then \( d_{j}^{-} = 0 \) and \( d_{j}^{+} = \frac{(X_{j}^{opt} - X_{j}^{obs})}{X_{j}^{obs}} \),

(3)

If \( X_{j}^{opt} = X_{j}^{obs} \), then \( d_{j}^{-} = 0 \) and \( d_{j}^{+} = 0 \),

(4)

Subject to: \( d_{j}^{+} - d_{j}^{-} = \frac{(X_{j}^{opt} - X_{j}^{obs})}{X_{j}^{obs}} \)

(5)

Equation (2), (3), and (4) are summarized in equation (5). Because the decision variable is redefined, therefore the new linear function \( Y' \) is expressed as the summation of the deviational variables and the objective function is rewritten as the following.

\[
\text{Minimize } Y' = \sum_{j=1}^{16} d_{j}^{+} + d_{j}^{-}
\]

(6)

Data set of this study mainly sources from two databases, including the data of NAHSIT survey in Taiwan 2005-2008 and food and nutrient database (FDA, 2015). The NAHSIT data is 24 hours dietary recall data obtained through face-to-face interviews in each survey. In 2005-2008, Taiwan’s government conducted the third NAHSIT survey targeting children aged 0-6 years (including 1,443 children) and adults aged over 19 years (included 3,116 adults aged 19-
64 years and 1,545 elderly aged 65 years and over), which had 6,104 total participants. The raw data of NASHIT survey shows all food items ate by one participant during 24 hours. Before data processing, the total number of food item for all participants are 172,337, and the total number of food item for above 19 age of participants are 138,025. Considering that children dietary intake of children is simple and the obesity rate of adult is getting higher year by year, so this study aims to analyse the dietary intake of people who are above 19 years old. Finally, the total effective subjects above 19 years old are 2,908 which is constructed by 1,446 females and 1,462 males. Subsequently, we use food categories (see Appendix Table 1) to divide data into 12 food groups and 48 subgroups. In order to compare dietary habit with dietary recommendation intakes (DRIs), we separate data into 8 sub-groups by 4 age region (9-30 years old, 31-50 years old, 51-70 years old and over 71 age) and sex. Although NAHSIT survey also includes nutrient information, however, it doesn’t show uniform criteria of each nutrient. Therefore, we employ the uniform criteria defined by food and nutrient database to cooperate with NAHSIT data, hence we can transfer food form into nutrient form.

Food and Nutrient database provides uniform criteria which shows how much nutrients are contained for each kind of food per 100 grams (see Appendix Table 2 and Appendix Table 3). Food and Nutrient database contains 1,333 kinds of food and 23 nutrients but we only choose 11 nutrients in order to in accordance with the nutrients of FBS (food balance sheet). Therefore, we compare the food name of food and nutrient database with the food name of NASHIT data, and sort the food name of NASHIT data by the food name of food and nutrient database, hence we can transfer the food consumption of NAHSIT data into nutrient form by uniform criteria of Food and Nutrient database. Finally, we represent the nutrient profile of NAHSIT data (hereafter nutrient profile) with 6 food groups and 16 subgroups which is the same with the categories of food and nutrient database. Therefore, we get 8 nutrient profiles for each sub-group which respectively contains the consumption pattern of energy and 11 nutrients. We simply describe the processing of data with Figure 1.

Figure 1. The diagram of data processing
The process of establishing nutrient profile is mainly constructing of the following steps. For modelling purposes, we collapsed food into 16 sub-groups based on similarity of nutrient composition firstly (Gao et al. 2006). However, some food items of NASHIT data usually are not consumed by people, and to avoid those affecting the final result of data processing, we eliminate the food item which the frequency of occurrences is less than 1% of total food item numbers from NASHIT data.

Second, through mapping the representative food item from NAHSIT survey and Food and Nutrient database in Taiwan, we transfer food item into the form of nutrients. Therefore, we assign respectively a weight to every nutrient from each representative food item that corresponded to the percentage consumption of its sub-group, and then we use a bottom-up method to category into 16 sub-groups (Marcoe et al., 2006).

Finally, nutrient profiles are represented by nutrient content of one serving of food from each food subgroup. They are calculated separately for each sex and age group and are used as input data for our diet model. Table 1 reports the average dietary intake per day of each sub-group. According to Taiwan food guides (FDA, 2012), suggesting that every Taiwanese should eat Fruit 2-4 serving, vegetable 3-5 serving, cereal/roots 6-15 serving, soybean/fish/meat/egg 3-8 serving, dairy 1.5-2 serving, oil/nuts 4-8 serving per day. However, we can see that Table 1 shows people who are in the range of 19-30 years old in both sex and greater than or equal to 71 years old has a low vegetable intake. Furthermore, males of both 19-30 and 31-50 age groups are over the soybean/fish/meat/egg intake suggested by DRIs. On the other hand, Huang et al. (2003) indicated that the prevalence rate of lactose intolerance is 95% in Asia due to Asian do not have persistent dairy intakes. Therefore, Table 1 also shows that all sub-groups are insufficient dietary intake of dairy which is consistent with the characteristic of dietary intake in Asia.

Results

According to Nutrition Information (2017), cereal and oil/nut are the main source of energy for Taiwanese. Nuts are rich in nutrients such as vitamin B group, vitamin E, mineral, fiber and unsaturated fat. These nutrients are helpful to prevent cardiovascular diseases and metabolic diseases. However, oil is rich in fat which could cause cardiovascular diseases, especially saturated fat. Therefore, we should eat more nuts and less oil intake for a healthy fat intake. Dairy is not only rich in calcium but also helpful to digest and absorb protein, carbohydrate, fat, a variety of vitamins (especially vitamin B2), minerals, but it lacks vitamin C and iron. However, the prevalence rate of lactose intolerance is 95% in Asia because we don’t have persistent dairy intake (Huang et al. 2003). Therefore, vegetable is another choice to be the source of calcium, and is rich in vitamins, minerals, fiber, and phytochemicals. Especially,
the dark vegetable has high amounts of calcium nutrient and can be supplement with calcium nutrients for us. Fruit is also rich in vitamin A, vitamin C, mineral and fiber, therefore we can have more fruits to meet the demand of those nutrients in daily life. Finally, soy/fish/meat/egg are the source of protein, soybean is the source of vegetable protein, and fish/meat/egg are the source of animal protein. Furthermore, the average fat content of fish is lower than meat and the proportion of fatty acids is healthier. Food of meat contains a considerable number of saturated fatty acids or processed seasoning made of frozen food, both would be adverse health of cardiovascular disease, that is, choosing lean and fresh meat should be more appropriate. In addition, egg has the best quality of protein among all foods.

In summary, our optimized food intake pattern is reasonable, and we believe it will make contributions for suggestions of healthier dietary intake. We find out that Taiwanese should increase intake of carbohydrate nutrient mainly sourced from rice. Also, the optimized intake of Soy/fish/meat/egg indicates that we should take the healthier protein from fish and soybean to replace meat. Furthermore, dairy is the best source of calcium, and elderly are easy to get osteoporosis caused by lacking calcium (Lin et al. 2013). Therefore, the optimized dairy intake pattern also suggests that elderly in Taiwan should increase dairy intake, and it would be the benefit of improving osteoporosis. On the other hand, increasing of the optimized vegetable intake will replenish the lacking calcium of Asian caused by lactose intolerance.

Discussion

In summary, we provide some policy implications for food system both on demand and supply side. Firstly, from the side of food supply, we find out that Taiwan’s food system provide too much food of less nutrient-density, such as oil and red meat. Although these are necessary for daily life, we still can eat less of these and use healthier food such as fish and vegetable to replace them. Therefore, Taiwan government should introduce some rules of health food supply to provide more health food for Taiwanese.

Secondly, from the side of food demand, empirical results found that people eat more red meat and oil caused them absorb too much fat. Also, calcium insufficient because Taiwan population drink less dairy. Therefore, government should promote eat less fat density food in order to prevent rise obesity prevalence rate. It is a linchpin that Taiwan's government needs to encourage people to eat more vegetables which are good calcium sources for their sufficient calcium intakes.
References


