Nutrition Economics: How to Eat Better for Less

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Summary Food prices and diet costs contribute to socioeconomic disparities in diet quality and health. Lower-cost diets provide ample calories but lack essential nutrients. Nutrition economics can remedy health disparities by helping to identify food patterns that are nutrient-rich, affordable, and appealing. First, nutrient profiling models—such as the Nutrient Rich Food (NRF) family of indices—are able to separate foods that are energy-dense from those that are nutrient-rich. Whereas energy-dense foods contain more calories than nutrients, nutrient-rich foods contain more nutrients than calories. Second, new value metrics have identified affordable healthy foods, based on nutrients per unit cost. Third, these methods have now been applied to the analyses of individual foods and beverages, meals, menus, and the total diet. The Healthy Eating Index (HEI), based on compliance with dietary guidelines, was the principal measure of total diet quality. Although healthier diets did generally cost more, some population subgroups managed to obtain nutrient-dense diets at a lower cost. Being able to create affordable, healthy food patterns on limited budgets is an example of nutrition resilience.

Key Words nutrient density, food prices, diet cost, diet quality

Most foods provide both nutrients and calories. Nutrient profiling models separate energy-dense foods that contain more calories than nutrients from nutrient-rich foods that contain more nutrients than calories (1, 2). Foods that contain substantial amounts of essential nutrients, including vitamins and minerals, but relatively few calories are described as nutrient-rich (1, 2). The concept of nutrient density has now been applied to new affordability metrics that assess the cost of meeting nutrient requirements from foods (3–5). These nutrient value metrics can be applied to individual foods, to composite meals, to menus, or to total diets. Novel sustainability metrics have also explored nutrient density of foods in relation to their environmental footprint (6), measured as greenhouse gas emissions (GHGEs). These new methods help identify those foods and population-level food patterns that are nutrient-rich, affordable, sustainable, and appealing.

What Is Nutrient Profiling

Nutrient profiling models calculate the content of key nutrients in a given food or beverage per reference amount, which can be 100 g, 100 kcal, or a serving (7, 8). Among the beneficial nutrients and food ingredients are protein, fiber, and a variety of vitamins and minerals. The selection of vitamins and minerals for nutrient profiling models needs to be guided by the nutritional needs of the population (1). Based on shortfall nutrients in the US diet, the Nutrient Rich Food (NRF) index was based on the food’s content of fiber, calcium, iron, potassium, and magnesium as well as on vitamin A, vitamin C, and vitamin E (2). Even though protein was not a shortfall nutrient in the US, it was included in the NRF, given that the provision of high quality protein in the diet is needed for optimum health. Bioavailability was another concern. Populations with predominantly vegetarian diets may be at risk for low intakes of bioavailable calcium and iron, and vitamin D.

Nutrient profile models need to take into account the positive nutrients, including multiple vitamins, as well as the so-called nutrients of public health concern (2). The World Health Organization and other expert bodies have expressed concerns that the global diet is overly high in fats, added sugars, and sodium, suggesting that those nutrients be more restricted in the global food supply. Nutrient profile models, developed in different countries, have used different approaches. Some were based on the beneficial nutrients only, whereas others were largely based on nutrients of public health concern.

The concept of nutrient density can be illustrated by dairy products. Nutrient density can be measured using the percent daily value (%DV) of different beneficial nutrients per serving, always in relation to calories. Thus, a 6-ounce serving of plain skimmed-milk yogurt supplied less than 5% DV of daily calories but supplied >10% DV of calcium, >25% DV of phosphorus, >10% DV of potassium and zinc, and >5% DV of magnesium. Similarly, a fruit-flavored low-fat yogurt provided less than 10% of dietary energy but >25% DV of calcium, >20% DV of phosphorous, close to 15% DV of protein, and >10% DV of potassium. Based on these favorable metrics and the ratio of nutrients to calories, milk and yogurt can be classified as nutrient-rich foods.

For nutrient profiling to remain a science, it needs to follow scientific rules (1, 2). Nutrient profile models need to be transparent, preferably based on publicly accessible nutrient composition data, and need to be validated against independent measures of a healthy diet. These...
The NRF models balanced nutrients to encourage against nutrients of public health concern (1, 2). Alternative algorithms were repeatedly tested. The final NRF9.3 index was based on 9 beneficial nutrients (protein; fiber; vitamins A, C, and E; calcium; iron; potassium; and magnesium) and on 3 nutrients to limit (saturated fat, added sugar, and sodium). Models based on 100 kcal and serving sizes performed better than those based on 100 g. Formulas based on sums and means performed better than those based on ratios. The performance of alternative NRF indices was tested against the Healthy Eating Index (HEI), an independent measure of a healthy diet. Higher NRF9.3 index scores were associated with healthier diets of lower energy density and higher nutrient content.

Nutrient profiling models can rate foods along a continuum or assign them into categories based on their overall nutritional value. The French SAIN, LIM score classified individual foods into 4 groups based on their nutrient content. The SAIN, LIM score was based on five positive nutrients (protein, fiber, calcium, iron and vitamin C) and on four optional nutrients (vitamin D, vitamin E, linolenic acid and monounsaturated fatty acids). The 3 nutrients to limit were saturated fatty acids, added sugars and sodium, comparable to the NRF9.3 index scores.

Illustrating the global appeal of nutrient density concept, the SAIN, LIM system has been adopted by ANSES, the French regulatory agency, as the scientific basis for regulating food labeling and marketing in France. The choice of an optimal nutrient profiling tool in the European Union is still under discussion by the European Commission. Efforts at harmonizing nutrient profiling initiatives in Asia have been led by the International Life Sciences Institute (ILSI) in collaboration with Asian regulators from multiple countries. Being able to identify nutrient-rich foods has implications for public health policy.

It is important to note that the NRF never made a distinction between “good” and “bad” foods. Rather, rigorous scientific standards were applied to the development of the Nutrient-Rich Foods (NRF) family of nutrient profile models.

The concept of nutrient density is critical to a better understanding of the relation between diet quality and its cost. In general, while empty calories were cheap, the more nutrient-dense foods and higher-quality diets tended to be more expensive on a per calorie basis. The relation between per calorie diet cost and HEI 2005 scores is shown in Fig. 2. Based on a representative sample of the US population, diets that were more consistent with the dietary guidelines were also more expensive (11). In other studies, low dietary energy density and high nutrient density were each independently associated with higher per calorie diet cost.

However, there were exceptions. The new metrics of nutrients per calorie and nutrient per unit cost have identified milk and milk products as the most affordable sources of calcium and low cost sources of good quality protein. In the US and in France, dairy products including milk and yogurt have provided an important source of affordable nutrition. Higher proportion of dairy in the diet was not linked to higher diet cost. Similar claims can be made for diets containing citrus fruit, nuts, beans, and cereals.

**Health Disparities and Nutrition**

The lower-cost diets of lower-income groups in devel-
Developed countries tend to be energy-dense but nutrient-poor. Studies on nutrition economics have addressed nutritional deficiencies and hidden hunger among selected population groups, especially the elderly and other populations at risk.

In poor countries, it is the rich who are obese; in rich countries it is the poor. In US-based studies, empty calories of minimal nutritional value were cheaper as compared to many healthier options and were more likely to be purchased by lower-income families. In the US and in the European Union, lower diet quality and higher obesity rates were linked to lower education and incomes. This social gradient in diet quality, body weights, and health may be explained—in part—by food prices and by diet cost. Long thought to be a paradox, obesity and hidden hunger can co-exist, since the lowest-cost diets can provide ample calories but lack essential nutrients.

These advances in nutrition economics allow us to ask whether people can eat better for less. Being able to create affordable, healthy food patterns on limited budgets is an example of nutrition resilience in the face of adversity. Nutrition economics can halt obesity by helping us identify foods and food patterns that are nutrient-rich, affordable, and appealing. The concept of nutrient density of foods, paired with a comprehensive program of consumer education, can become the foundation of dietary recommendations and guidelines.

REFERENCES

1) Drewnowski A. 2005. Concept of a nutritious food: toward a nutrient density score. *Am J Clin Nutr* **82**: 721–732.

2) Fulgoni VL 3rd, Keast DR, Drewnowski A. 2009. Development and validation of the Nutrient-Rich Foods Index: A tool to measure nutritional quality of foods. *J Nutr* **139**: 1549–1554.

3) Darmon N, Darmon M, Maillot M, Drewnowski A. 2005. A nutrient density standard for vegetables and fruits: nutrients per calorie and nutrients per unit cost. *J Am Diet Assoc* **105**: 1881–1887.

4) Maillot M, Ferguson EL, Drewnowski A, Darmon N. 2008. Nutrient profiling can help identify foods of good nutritional quality for their price: a validation study with linear programming. *J Nutr* **138**: 1107–1113.

5) Maillot M, Darmon N, Darmon M, Lafay L, Drewnowski A. 2007. Nutrient-dense food groups have high energy costs: An econometric approach to nutrient profiling. *J Nutr* **137**: 1815–1820.

6) Drewnowski A, Rehm CD, Martin A, Verger EO, Voinnesson M, Imbert P. 2015. Energy and nutrient density of foods in relation to their carbon footprint. *Am J Clin Nutr* 2014 [Epub ahead of print].

7) Drewnowski A, Maillot M, Darmon N. 2008. Should nutrient profiles be based on 100 g, 100 kcal or serving size? *Eur J Clin Nutr* **63**: 898–904.

8) Drewnowski A, Maillot M, Darmon N. 2009. Testing nutrient profile models in relation to energy density and energy cost. *Eur J Clin Nutr* **63**: 674–683.

9) Drewnowski A, Rehm CD. 2013. Vegetable cost metrics show that potatoes and beans provide most nutrients per penny. *PLoS One* **8**: e63277.

10) Drewnowski A. 2013. New metrics of affordable nutrition: which vegetables provide most nutrients for least cost. *J Acad Nutr Dietetics* **113**: 1182–1187.

11) Rehm CD, Monsivais P, Drewnowski A. 2011. The quality and monetary value of diets consumed by adults in the United States. *Am J Clin Nutr* **94**: 1333–1339.