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Determining Limiting Nutrients by Linear Programming: A New Approach to Predict Insufficient Intakes From Complementary Foods

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▸ ARTICLE

Introduction

The WHO document on complementary feeding[1] suggests that zinc and iron might be "problem nutrients." The approach used relates the nutrient content of each available food to the energy density and takes into account the maximum quantity of each food a breastfed child is likely to eat. That univariate approach, however, does not explore all possible food combinations. It does not take into account either that other nutritional needs must be covered along with zinc and iron. Finally, the cost of different foods is not discussed, although this may determine which nutrients are deficient in poor communities.

In this work, we describe an approach based on cost minimization by linear programming to determine which nutrient may be below recommended intakes in poor families. This method examines the nutrient composition and the cost of available foods in the community and does not have the limitations of other methods. As an example, we used this approach to determine which nutrient intakes might be below the recommended levels in breastfed children in France 1 to 3 years old.

Methods

Linear programming gives the possibility of minimizing any linear function of a set of variables, when complying with a multiple set of constraints. It can be used to determine what type of food combination should be used to get the cheapest nutritionally balanced diet.[2] Linear programming is available on many standard software. This analysis was made by using an Excel (Microsoft) function.

In this study, minimum cost of a daily ration which complied with a pre-established list of nutritional

constraints (Table 1) was determined. Food prices were taken in local stores. Nutritional constraints were based on the European Population Reference Intakes (PRI) for the age group 1 to 3 years.[3] To examine problems associated with complementary feeding, the program was asked to design diets meeting all previous constraints assuming the child would receive 600 mL of breast milk in addition to selected foods. Upper limit for the energy derived from protein comes from the French recommended dietary intakes.[4] To avoid designing a diet that would be incompatible with usual food consumption patterns, constraints were added on the quantity of individual foods present in a ration: the 90th, 75th, and 50th centiles of intake for each food observed in a previous survey in the age group 1 to 3 years[5] were successively used as upper acceptable limits for each food. At the lowest cost level for which all nutritional constraints were met, nutrients set by the program at the lowest accepted level were regarded as problem nutrients.

TABLE 1

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List of Nutritional Constraints to Be Respected by the Program When Designing a Ration

The food composition table used for this analysis was a database adapted to the French context used in a previous survey.[5] Human milk composition was derived from Souci et al,[6] assuming a zinc content of human milk after 6 months of lactation of 1 mg/L.[7]

Results

Two food combinations determined by linear programming which were nutritionally acceptable and were respectively below or equal to the observed 90th and 75th centiles of the observed food intake of French children are given Table 2. The price of the foods was 0.47 Euros at the 90th centile and 0.55 Euros at the 75th centile limit (1 Euro = approximately 0.85 US dollars). It was impossible to find a combination of foods within the 50th centile limit that complied with all nutritional constraints. In all these food combinations, some highly nutritious foods reached the imposed upper limit, such as potatoes, carrots, and liver. In the cheapest food combination limited by the 75th centile, energy intake was slightly above the imposed limit of 1000 kcal, although it was possible to limit the energy to 1000 kcal by a slightly more expensive combination.

TABLE 2

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Low-Cost Food Combinations

Zinc was a problem nutrient in the combination with the 90th centile as upper limit of food intake, along with vitamins B1 and B6. Iron also became a problem nutrient when maximum levels of food intake were lowered to the 75th centile (Table 3).

TABLE 3

View this table: Nutrients Levels in Low-Cost Food Combinations
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Discussion

This analysis suggests that given the nutritional value of the most commonly consumed foods, there are tight limits on intakes of some nutrients for young French children. Furthermore, this analysis suggests that in families with a limited budget, insufficient intake of a few nutrients, including zinc and iron, is bound to occur even more frequently. The suggestion that zinc intakes may be lower than recommended in young children in France, has been shown independently by a survey in younger age group (10 months old).[8] A previous survey also showed that iron deficiency might be a problem in young children in France not given fortified foods.[9] The consistency between our theoretical results and observed intakes and deficiencies in France gives some validity to our approach.

In theory, this approach could be used to estimate which nutrients are most likely to be below recommended intakes in the low-income groups given the price and nutrient content of foods commonly given to children. Yet, before recommending the use of this method in different settings, the maximum amount of different foods a child is able to eat should be determined. Moreover, this analysis should be validated by comparison with results of classical food consumption surveys. Additional nutritional constraints may be needed in some settings such as introducing an upper limit to phytate intake, or to the phytate:zinc ratio may be needed before using this method in low-income countries.[10] An upper limit to the fiber intake may be needed.

Research Issues

There is a need

1. to determine in each community the maximum amount of highly nutritious foods children of different age groups are able to eat.
2. to validate in different countries, by comparison with classical dietary surveys, the use of linear programming techniques to determine which nutrients are most likely to be deficient in low-income groups.

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