Assessing the construct validity of five nutrient profiling systems using diet modeling with linear programming
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Nutrient profiling classifies individual food products according to their nutrient content. According to the WHO (World Health Organization), validation is a key step in the development of a nutrient profiling system. The aim was to assess the construct validity of five European nutrient profiling systems (Choices, Keyhole, AFSSA, European Commission (EC) system and FoodProfiler). Construct validity was assessed for each of the five-selected nutrient profiling systems by testing whether healthy foods (that is, identified as eligible by the system) make healthy diets, and unhealthy foods (that is, non-eligible) make unhealthy diets, using diet modeling. The AFSSA, EC and FoodProfiler systems were identified as valid, but differences in their levels of permissiveness suggested some misclassified food products. The two other systems failed the construct validity assessment. Among these three systems, the EC system is the less demanding in terms of nutritional information, it would, therefore, be the easiest to implement for regulating nutrition and health claims in Europe.

Using a previously described diet modeling approach, the feasibility of designing healthy or unhealthy diets with eligible foods only, or with non-eligible foods only, was tested for each nutrient profiling system. Healthy diets were defined by the fulfillment of a set of forty nutrient constraints, and unhealthy diets by the nonfulfillment of the same set of nutrient constraints. To ensure realism to the modeled diets, constraints on foods and food groups were included and the possibility to design a 2000-kcal diet was tested. Four feasibility tests were used to assess the construct validity of each system. Tests A, eating healthily with eligible foods only, and D, eating unhealthily with non-eligible foods only, were used to assess whether the systems respected the nutritional common sense. Tests B, eating unhealthily with eligible foods only, and C, eating healthily with non-eligible foods only, assessed more finely the level of permissiveness. The following terminology is used: ‘Strict unfeasibility’ means that no mathematical solution can be found at all. When solutions can be found, the range between the minimum and the maximum energy achievable is called the ‘energy range’. When the energy range includes 2000 kcal, the model is considered feasible. When the energy range excludes 2000 kcal, the model is considered unfeasible. A system is considered as valid when tests A and D are feasible, and tests B and C are unfeasible.

The percentage of eligible foods varied between systems: Choices: 31.8%; Green Keyhole: 35.6%; AFSSA: 35.8%; EC system: 46.5%; and FoodProfiler: 49.5%.

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Figure 1 shows that all tested systems allowed 2000 kcal healthy diets with eligible foods (test A), and 2000 kcal unhealthy diets with non-eligible foods (test D). Regarding test B, all tested systems exclude 2000 kcal from their energy range and were, therefore, considered as unfeasible: strict unfeasibility was observed for Choices and Green Keyhole systems. Unfeasibility was observed also for the FoodProfiler and EC systems, the maximum energy achievable being 1772 kcal and
1801 kcal, respectively, and for the AFSSA system, with a narrow and unrealistic energy range (587–907 kcal).

Regarding test C, strict unfeasibility was observed for FoodProfiler only. Test C was feasible for Choices and Green Keyhole (2000 kcal healthy diets allowed with non-eligible foods) and it was unfeasible for AFSSA and EC systems (the energy range for test C excluded 2000 kcal but the minimum energy achievable was close to 2000 kcal: 2018 kcal and 2162 kcal, respectively).

**DISCUSSION**

One important result is that, with all tested systems, it was possible to design healthy diets with eligible products and unhealthy diets with non-eligible products (tests A&D), demonstrating that all systems satisfied the nutritional common sense. In line with the latter results, Choices was previously presented as valid based on its beneficial impact on dietary quality in modeling studies simulating the replacement of foods not complying with the Choices criteria by existing Choices-compliant products.10 Nevertheless, Choices and Green Keyhole allowed to design 2000 kcal healthy diets with non-eligible products, and were, therefore, identified as invalid according to this construct validity assessment. In contrast, FoodProfiler, AFSSA and EC systems were identified as valid because they answered as expected to the four tests.

The three valid systems showed differences in their level of permissiveness. With the AFSSA system, it was almost feasible to design a 2000-kcal healthy diet with non-eligible foods (it is expected to be unfeasible). Test C assesses whether it is feasible to design healthy diets with non-eligible foods (it is expected to be unfeasible). 'Strictly unfeasible' means that no mathematical solution can be found at all. When the energy range includes 2000 kcal, the model is considered feasible. When the energy range excludes 2000 kcal, the model is considered unfeasible.

![Energy range, in kcal, to design healthy/unhealthy diets with eligible/non-eligible foods. Test A assesses whether it is feasible to design healthy diets with eligible foods (it is expected to be feasible). Test B assesses whether it is feasible to design unhealthy diets with eligible foods (it is expected to be unfeasible). Test C assesses whether it is feasible to design healthy diets with non-eligible foods (it is expected to be unfeasible). Test D assesses whether it is feasible to design unhealthy diets with non-eligible foods (it is expected to be feasible).](image)

**Figure 1.** Energy range, in kcal, to design healthy/unhealthy diets with eligible/non-eligible foods. Test A assesses whether it is feasible to design healthy diets with eligible foods (it is expected to be feasible). Test B assesses whether it is feasible to design unhealthy diets with eligible foods (it is expected to be unfeasible). Test C assesses whether it is feasible to design healthy diets with non-eligible foods (it is expected to be unfeasible). Test D assesses whether it is feasible to design unhealthy diets with non-eligible foods (it is expected to be feasible). 'Strictly unfeasible' means that no mathematical solution can be found at all. When the energy range includes 2000 kcal, the model is considered feasible. When the energy range excludes 2000 kcal, the model is considered unfeasible.
these tests could help identify the misclassified foods, and then fine-tune the systems.

The validation method used in the present study is perfectible, for instance by improving the realism of diets using more sophisticated diet modeling techniques. Nevertheless, this study revealed that some nutrient profiling systems, among those currently used, show weaknesses by failing this construct validity assessment.

Among the three systems identified as valid in the present study, the EC system is the less demanding in terms of nutritional information, it would, therefore, be the easiest to implement for regulating nutrition and health claims in Europe.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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