Title: Development of the Healthy Purchase Index (HPI): A scoring system to assess the nutritional quality of household food purchases

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Abstract

Objective: To develop an index to assess the nutritional quality of household food purchases based on food expenditures only.

Design: A database of monthly food purchases of a convenient sample of low-income households was used to develop the Healthy Purchase Index (HPI). The HPI is the sum of two subscores based on expenditure shares of food categories in total household food expenditure: the *purchase diversity subscore* and the *purchase quality subscore.* The first was adapted from an existing diversity score. The second integrated those food categories identified as the best predictors of the nutritional quality of purchases based on associations between expenditure shares of food categories and two nutritional quality indicators, namely the mean adequacy ratio (MAR) and the mean excess ratio (MER). Correlation between the HPI and a score assessing adherence to French dietary guidelines (PNNS-GSmod) was performed as a first validation.

Setting/Subjects: Food purchases of 112 households from deprived neighborhoods of Marseille (France), participating in the Opticourses and Jassur projects (2012–2015).

Results: The *purchase diversity subscore* reflects the presence in food purchases of five food categories, namely fruits, vegetables, starches, dairy products, and meat fish & eggs. The *purchase quality subscore* is based on expenditure shares for fruit & vegetables, added fats & seasonings, sweet snacks, cheese, sugary beverages, refined grains, and fish, as these were identified as predictors of the nutritional quality of purchases. The HPI was positively associated with the PNNS-GSmod ($r_s = 0.378$; $p<0.001$).

Conclusions: The HPI helps assess the healthiness of household food purchases.

Keywords: supermarket receipts; food supply; French household; economic barrier; food price; nutrition; low-income

Introduction

Studies have shown a positive association between diet quality and socio-economic status[(1)], mediated in part by diet cost[(2)]. Low-cost diets tend to have high energy density and low nutrient adequacy given that energy-dense foods are cheaper per calorie than recommended nutrient-dense foods[(3)]. Socially-disadvantaged people thus run up against more economic barriers hindering the adoption of healthier diet[(4)]. However, previous research has found that a healthier diet is not necessarily more expensive when households select foods with good nutritional quality for their price[(5)], making it important to develop decision-support tools to help consumers achieve nutritionally optimal choices at affordable cost.

Despite recent shifts in eating patterns favoring eating out, dietary energy intake in Europe mostly comes from food consumed at home[(6)], especially in France[(7)]. Food consumption is therefore driven mainly by household food purchases. Consumer purchasing behaviors have been investigated in both interventional and observational studies, based on analyses of sale data or till receipts. Studies exploring the impact on sales of in-store interventions targeting point-of-purchase food-product availability, access, incentives or information have found that modification of the retail store environment can drive consumers toward healthier food purchasing behavior[(8–10)]. Household till receipts provide unique in-depth information on food sources and food items as well as accurate information on expenditures and quantities purchased[(11,12)]. Till receipts have been used in observational studies to characterize household food consumption patterns, especially in relation to different socio-economic characteristics[(11,13–15)], as they can provide a good estimate of dietary quality and nutrient intakes[(12,16,17)]. Collecting supermarket and grocery receipts was found to provide relevant information on energy and fat intakes[(12)]. Moreover, in households with obese individuals, food purchase provided more reliable information than dietary recalls based on self-reported measures, which are subject to desirability bias and memory failure[(16)].

However, nutritional analysis of food purchases can prove tedious and time-consuming, typically restricting studies to a few hundred households[(5,11–18)]. Participants are asked to collect and annotate receipts from all family members, and to record all food expenditures made without receipts. Estimating the nutrient content of food expenditures entails cumbersome data handling, especially since evaluators often have to contend with missing data on the quantities purchased[(14,19)]. This study exploited the huge potential of supermarket receipts for monitoring the nutritional quality of household food purchases to develop a simplified measure of the quality of household food purchases, called the ‘Healthy Purchase Index’ (HPI). Here we present the methodology used to develop the HPI, and the first elements of its validation.

Methods

Study design and population

Sociodemographic and food purchase data were obtained from studies conducted on disadvantaged populations in socioeconomically-deprived neighborhoods of Marseille (south of France): the Opticourses (2012–2014) and the Jassur (2013–2015) projects. Opticourses participants were 91 adults willing to participate in an education program on food and budget[5,20]. Jassur participants were 21 adults from the same neighborhoods with access to a community garden plot[21]. All participants (n = 112) completed a monthly record of their household food purchases. All participants provided written informed consent. The Southern Mediterranean Ethical Research Committee Sud-Méditerranée reviewed and approved the protocols of the Opticourses and Jassur trials (registered at clinicaltrials.gov as NCT02383875 and NCT03175575, respectively).

Categorization, price and nutritional composition of household food purchases

In both studies, participants were asked to provide a detailed record of foods entering their household over a 1-month period (including purchases, gifts, and foods from other sources). As previously described in Marty *et al.*[5], participants were given a notebook with step-by-step instructions on how to collect and annotate all receipts for foods entering the household and record expenditures without receipts. A face-to-face visit was scheduled approximately 15 days after the food supply diary was issued to maintain participants' motivation and to ensure correct filling of the diary. A database of monthly food purchases was created by compiling information on date of purchase, quantity and price of all food items purchased. All food items were then classified into nine groups and twenty-three subgroups (**Table 1**). The "mixed dishes", "sweet products" and "sweet beverages" food groups consist primarily of ultra-processed foods (following NOVA classification) found to be associated with poor dietary quality and obesity[22,23]. For others processed items, such as canned or bottled vegetables, fruits and vegetables or canned fish, various studies have shown no evidence of any extra nutritional benefit of fresh items compared to frozen and canned ones[24–26]. In this regard, fresh and processed items were pooled in the same group, as is the case in most indices of overall diet quality.

For each food item purchased, the quantity 'as purchased' was transformed into a quantity 'as consumed' using a correction coefficient that took into account the changes in weight associated with preparation and waste (e.g. peeling, boning, water loss or gain during cooking, etc.). The nutritional composition of each food item 'as consumed' was then determined by linkage with the closest food from the French food composition table[27]. For each household, energy and nutrient contents of food supplies were calculated as the sum of the energy and nutrient contents of all foods and beverages entering the household during the period of data collection.

As previously described[5], missing receipt information on the weight of a food purchased was estimated using three different methods: 1) information on known packaging sizes (and corresponding weights) for that food was searched for on commercial websites, and the most plausible weight (given the actual expenditure incurred) was chosen; 2) when information on packaging sizes was unavailable but the food item was purchased at least twice (with the receipt showing the weights) among all households, we calculated an observed mean food price per kg and we then estimated the quantity purchased by dividing the actual expenditure by the corresponding observed mean price; 3) if we did not have an observed mean food price and the food item was purchased only once in the sample, the quantity purchased was estimated by dividing the actual expenditure by the corresponding national food price. When the food was gifted, picked from the garden, or came from food aid, we assigned a theoretical price using the mean observed food price.

Indicators of nutritional quality of household food purchases

Mean adequacy ratio (MAR) and mean excess ratio (MER) were used as indicators of the nutritional quality of food purchases and were calculated for 2000 kcal of purchases for each household.

MAR is an indicator of overall good nutritional quality[28]. It was calculated as the mean of 23 nutrient adequacy ratios, corresponding to percentage of the daily recommended intakes for 23 key nutrients as previously described[29]:

$$\text{MAR (\%/2000 kcal)} = \frac{1}{23} \times \sum_{n=1}^{23} (Nut_n / RDA_n) \times 100$$

where Nut_n is quantity of each nutrient *n* per 2000 kcal of purchase, and RDA_n is the French Recommended Dietary Allowance[30] for that nutrient. As is customary, each nutrient adequacy ratio (Nut_n/RDA_n) was truncated at 1, so that a high intake of one nutrient could not compensate for a low intake of another[31].

Conversely, MER is an indicator of bad nutritional quality. Previously proposed by Vieux *et al.*[32], MER is the mean of 3 nutrient excess ratios, corresponding to percentage of daily maximum recommended values for 3 unhealthy nutrients: sodium, saturated fatty acids, and free sugars (added sugars plus sugars naturally present in honey, syrups, and fruit juices), as follows:

$$\text{MER (\%/2000 kcal)} = \frac{1}{3} \times \sum_{p=1}^{3} (Nut_p / MRV_p) \times 100$$

where Nut_p is the quantity of each nutrient *p* per 2000 kcal of purchase, and MRV_p is the maximum recommended value for that nutrient. Here, unlike the previously published MER[32], each nutrient excess ratio lower than 100 was not truncated to 100 in order to avoid non-normal distribution of the indicator.

Development of the Healthy Purchase Index (HPI)

Food expenditure shares corresponding to the percent expenditure of each food group and subgroup in monthly food expenditure were calculated for each household. Two subscores were defined, the *purchase diversity subscore* and the *purchase quality subscore*, and the HPI was calculated as the sum of the two subscores.

Purchase diversity subscore

The *purchase diversity subscore* is a 5-component score derived from a previously published individual "Dietary Diversity Score" that reflects the presence in diet of 5 food groups and subgroups, namely fruits, vegetables, starches, dairy products, and meat ,fish & eggs[33]. We considered that an expenditure share of 5% of total food expenditure would likely correspond to the share accounting for a non-negligible but easily achievable contribution of a food group or subgroup to household food purchases. Therefore, for each of the 5 food groups and subgroups, one point was given when its expenditure share was greater than 5%, leading to a maximum value of 5 for the *purchase diversity subscore*.

Purchase quality subscore

The *purchase quality subscore* is a 7-component score. It was based on food groups and subgroups identified according to known relationships between diet and health[34] and/or for which expenditure shares best reflected the nutritional quality of purchases. Identification of best predictors was performed separately for food groups and subgroups. In a first step, regressions were conducted to capture the relationship between each indicator of nutritional quality (i.e. MAR and MER), as the dependent variable, and each food group and subgroup. We then performed multivariate linear regressions for MAR and MER separately, including all main terms yielding $p < 0.20$ in the first step. A change-in-estimate method was further applied to select the best subset of predictors. The MAR, MER and food groups and subgroups expenditure shares were log-transformed to improve normality. Log transformation of food subgroups rarely purchased (i.e. by less than a third of households) did not reduce skewness and so were coded as binary variables (purchased/not purchased). These binary variables were subsequently added to the multivariate models, and only the variables proved significant were kept in the final model. In addition to the identified predictors, several refinements were incorporated based on expert advice from the 2016 report of the French Agency for Food, Environmental and Occupational Health & Safety (Anses) on the update of the French dietary guidelines[(34)].

For each predictor significantly associated with one of the nutritional quality indicators, minimum or maximum expenditure shares were defined by identifying breaks in plots crossing predictor expenditure share and nutritional quality indicator. For predictors associated with both MAR and MER, the plot that better reflected breaks in the distribution was chosen to define the cut-off values.

First elements of validation of the HPI

A common method for validating a dietary quality index consists in comparing the new index against a previously validated one[(35)]. Here we used Spearman non-parametric correlations to compare the HPI to the MAR and to the MER (expressed as adequacy and excess ratios, respectively, per 2000 kcal of purchases), as well as to each of their constitutive nutrient ratios individually. The association with a modified version of the PNNS–Guideline Score (PNNS-GS), assessing adherence to official French dietary guidelines, was also investigated. Briefly, the PNNS-GS is a 15-point score comprising 13 components: 8 components capture French dietary guidelines, 4 components concern nutrients and food groups whose consumption is to be limited, and 1 component covers adherence to physical activity recommendations[(36)]. Here, a modified PNNS-GS (PNNS-GSmod), excluding both the physical activity and alcohol components (absent from our database), was computed on each household's monthly food purchases. To do so, weight and energy of household food supplies were divided by number of household members and by number of days of data collection, as French dietary guidelines are stated in terms of individual recommended daily servings.

Sensitivity analysis was also performed by testing the addition of two penalties to the HPI. A first penalty was added when the red & processed meat expenditure share was higher than the 75^{th} percentile in the study population, given epidemiologic evidence linking high consumption of red and processed meat to diseases[37,38]. A second penalty was added when food expenditure was below 3.5 €/day per person, as previous research showed that it is almost impossible to obtain a nutritionally adequate diet below this threshold in France[3,39], and so it is unlikely that food purchases below this threshold have good nutritional quality.

All analyses were performed with the SAS statistical software package Ver. 9.4 for Windows (SAS Institute, Cary, NC, USA), with statistical significance at $p < 0.05$.

Results

Characteristics of the households

Average household size was 3.3 persons (range: 1–7) including 1.6 children (range: 0–6); 20.5% were single-person households (data not shown). Almost a third (33.1%) declared severe financial difficulties, 45.5% were in a precarious financial situation, 16.1% were in a stable financial situation, and 5.3% did not answer the question. During the 1-month food records, each household shopped in an average of five different stores. A total of 849 different food items were purchased or the whole sample.

The *purchase diversity subscore*

Regarding the expenditure share distributions of the five components of the *purchase diversity subscore*, 56% of the population reached the minimum expenditure share of 5% for fruits, 75% for vegetables, 93% for starches, 97% for meat, fish & eggs and 85% for dairy products.

The *purchase quality subscore*

Identification of food groups and subgroups for which expenditure shares best predict the nutritional quality of purchases

The major contributors to total household food expenditure were meat, fish & eggs (26.7 ± 12.8%), starches (17.4 ± 11.3%), fruit & vegetables (16.6 ± 10.0%), sweet products (12.4 ± 7.2%), dairy products (10.3 ± 5.3%) for the food groups, and red & processed meat (15.0 ± 10.9%), refined grains (14.2 ±11.2%), sweet snacks (10.9 ± 6.7%) and vegetables (9.5 ± 6.3%) for the subgroups. The expenditure share for condiments was negligible (i.e. less than 1.5%) and this subgroup was thus excluded from the analysis. Of the 22 subgroups, 10 were coded as binary variables. Results from bivariate associations and final multivariate models are presented in **Table 2**. A total of 14 predictors—6 food groups and 8 subgroups—were found to be significantly associated with at least one indicator of nutritional quality of purchases in final multivariate models. Expenditure shares for fruit & vegetables (including the fruits, dried fruits, and vegetables subgroups) and meat, fish & eggs were positively associated with MAR, while the added fats & seasonings group (especially vegetable fats) was negatively associated with MAR. Expenditure shares for sweet products, and sweet beverages (especially sugary drinks), and for the cheese and sweet snacks subgroups, were positively associated with MER. Expenditure shares for starches and for refined grains were negatively associated with both MAR and MER.

Choice of components included in the purchase quality subscore

Owing to their nutritional specificity, subgroups were preferentially selected over food groups to be included in the *purchase quality subscore*, apart from the fruit & vegetables group (given that all its subgroups were predictors of the nutritional quality of purchases). Refined grains were not encouraged as they were found to be negatively associated with both MAR and MER. Thus, the *purchase quality subscore* was primarily built on 5 components: fruit & vegetables (with minimum expected expenditure share), sweet snacks, cheese, sugary drinks (with maximum expected expenditure share), and added fats & seasonings (with maximum expenditure share and consideration of vegetable fats purchases). Two further components were added in the light of the updated French national dietary guidelines(34) : *1)* one limiting the expenditure share of the refined grains subgroup within the starches food group, since cutting back on refined grains and choosing whole grains and higher-quality sources of starches is recommended for health; *2)* one encouraging expenditure for the fish subgroup, since fish (especially fatty fish) is a unique source of important nutrients such as vitamin D and omega-3 fatty acids.

Finally, the *purchase quality subscore* is a 10-point score that comprises 7 components: 2 with an expenditure share to increase (fruit & vegetables, fish) and 5 with an expenditure share to limit (added fats & seasonings, sweet snacks, cheese; sugary drinks, refined grains). One or two cut-off values were graphically identified for each component, providing the basis for constructing the subscore (Table 3).

The Healthy Purchase Index

The HPI, aimed at evaluating the nutritional quality of monthly household food purchases, is obtained by summing the *purchase diversity subscore* and the *purchase quality subscore*. Scoring and cut-off values of the HPI are presented in **Table 3.** The HPI has a maximum of 15 points, where a higher score reflects a higher quality of the household food purchases. The distributions of the HPI score and its subscores in the food purchases of the studied population are presented in **Figure 1**. Average HPI score was 7.4 ± 2.1 (range: 3–12 out of 15), with an average *purchase diversity subscore* of 4.1 ± 0.9 (range: 1–5 out of 5) and an average *purchase quality subscore* of 3.3 ± 1.8 (range: 0–8 out of 10) (**Table 4**).

The HPI was positively associated with the MAR ($r_s = 0.552$, $p < 0.001$) and with the PNNS-GS$_{mod}$ ($r_s = 0.378$, $p < 0.001$) and negatively associated with the MER ($r_s = -0.426$, $p < 0.001$). Correlations were higher for the *purchase quality subscore* than for the *purchase diversity subscore*.

Adding a penalty to HPI for households with expenditure shares for red & processed meat ≥ 20% (75th percentile) barely attenuated the associations with the three indicators [MAR: $r_s = 0.492$; MER: $r_s = -0.396$; PNNS-GS$_{mod}$ $r_s = 0.334$; all $p < 0.001$]. Adding a penalty for food budget below 3.5 €/day per person (62% of households) barely changed the associations [MAR: $r_s = 0.523$; MER: $r_s = -0.398$; PNNS-GS$_{mod}$ $r_s = 0.401$; all $p < 0.001$] (data not shown).

Associations with nutrient adequacy ratios and nutrient excess ratios of each component of the MAR and MER, respectively, are presented in **Table 5**. HPI correlated significantly with 19 nutrients of the MAR ($-0.277 < r_s < 0.557$) and with 2 nutrients of the MER ($-0.478 < r_s < -0.217$).

Discussion

Since healthy diet results in part from healthier choices at the grocery store, the HPI was designed as a tool to evaluate the nutritional quality of household food purchases. Its major strength is that the HPI only needs expenditure shares of specific food groups and subgroups to be calculated. The methodology used to develop the HPI followed a step-by-step process guiding the identification of food groups and subgroups for which expenditure shares best predict the nutritional quality of purchases, the choice of the cut-off values for the identified predictors, and the development of the scoring system.

Compared to declarative dietary surveys, food expenditure surveys present the advantage of limiting memory bias and social desirability bias. In particular, when both expenses and quantities are recorded through annotated receipt collection, very detailed data on household food purchases can be obtained(11). Quantities purchased are more difficult to obtain, but when recorded in addition to expenditure data, they yield reliable information on the cost of food(3). Moreover, when linked to a food composition table, till receipts were found to provide good estimates of the household intakes of energy and percentage energy from fat(12,16). More recently, Appelhans *et al.* found that household food purchases yielded a reasonable estimate of overall diet quality for primary household food shoppers(17). However, using this information (expenditure on food quantities purchased, energy and nutrient contents) to assess household food purchases patterns and nutritional quality is a tedious and costly task (data entry, coding, linkage with nutrition information, analysis, etc.), and can burden both research staff and participants. Such methodological difficulties in evaluating the quality of household food purchases can be solved by an approach based solely on food expenditure. To the best of our knowledge, only two studies have used food budget shares to assess the nutritional quality of food purchases. In 2012, considering that most food choices are made at the supermarket or grocery store, the United States Department of Agriculture proposed several tools to assess the overall healthfulness of food purchases, including scores based on food category expenditure shares (40). These scores compared observed expenditure shares to reference expenditure shares, the latter being derived from mathematically-optimized food baskets meeting the recommended dietary allowance for all nutrients(41). However, the cultural acceptability of such theoretical baskets has been questioned(42). In 2015, the *Healthy Trolley Index*—in which daily servings of food groups (in % of total recommended daily serving) were simply translated into proportion of monthly expenditure per food groups—was developed by an Australian research team to compare food expenditure with the Australian Guide to Healthy Eating[43]. The HPI, by design, has the advantage of directly accounting for food group and subgroup expenditure shares without needing information on the weight and nutritional composition of the foods. The HPI thus overcomes the fact that proportion by weight does not necessarily align with proportion by price, as some food groups are more expensive than others[44]. This food price hierarchy was ignored in the Australian *Healthy Trolley Index*[43], which did not take into account that fruit, vegetables and meat provide more costly calories than starches and fats[3].

To be consistent with many dietary guidelines that emphasize the importance of increasing both diversity and quality to achieve a healthy balanced diet[45–47], the HPI included two subscores: the *purchase diversity subscore* and *the purchase quality subscore*. Various indices differing in the number of food categories used have been developed to assess dietary diversity[28,48]. For the *purchase diversity subscore* we settled on fruit, vegetables, starches, meat, fish & eggs, and dairy products, as an omission of one or more of these 5 categories was found to be associated with increased risk of mortality[49,50].The *purchase diversity subscore* is therefore a 5-component score designed to reflect the presence of 5 food groups (and subgroups) in total household food expenditure. Rather than encouraging diversity, the subscore can be viewed as a way to penalize unbalanced food baskets in which at least one of the 5 food groups (and subgroups) is lacking. The *purchase quality subscore* is aimed at capturing the nutritional quality of household food purchases through expenditure shares of specific groups (and subgroups) and French dietary guidelines. The *purchase quality subscore* is a 7-component score: 2 components with expenditure shares to be increased and 5 components with expenditure shares to be limited to pursue health objectives. Furthermore, the *purchase quality subscore* indirectly encourages intra-group diversity through its design including various food groups and subgroups. The HPI, which sums the two subscores, showed good agreement with MAR and MER, two indicators of diet quality based on nutrients only. This association may have resulted in part from the fact that MAR and MER were closely related to the HPI, as they were used to construct the *purchase quality subscore*. However, similar correlations were obtained with an unrelated indicator of diet quality based on foods and food groups (the PNNS-GSmod), thereby providing preliminary evidence of the capacity of the HPI index to assess food purchase quality. In addition, associations between the HPI and either MAR, MER or PNNS-GSmod were relatively strong, of the same order of magnitude as or greater than values previously found between MAR and other diet quality indicators[51,52]. No stronger association was found between HPI and the other index scores when adding penalties for expenditure shares for red & processed meat ≥ 20% of food budget, and for household food purchases below 3.5 €/day per person. However, given the specific economic constraints and cultural habits of the studied population[5], which may impact food purchase patterns, it might be worth considering the use of penalties on a larger population with more diverse purchasing behaviors.

Our study has limitations. First, the degree to which HPI reflects actual household consumption patterns is limited by a number of factors: it is based on data at the household level without knowledge of food allocation between different household members or visitors, information on meals eaten away from home was not collected, and what is purchased is not necessarily eaten (waste, leftovers, etc.)[17]. For all these reasons, it is clear that the HPI cannot claim to be a tool to assess the quality of diets. Second, the HPI was developed based on data from a convenient sample of a limited number of households. Using relatively small convenient samples is a common limitation of studies estimating the nutritional quality of household food purchases [5,11,12,14–18]. This limitation is explained by the technical complexity of exploiting annotated supermarket receipts and records, fully justifying the development of a simplified tool like the HPI. Third, keeping records of foods entering the household over a 1-month period places demands on participants that may increase the risks of errors and omissions. Nevertheless, a shorter time-window for recordkeeping does not seem relevant when salaries and social benefits are paid monthly (as is the case in France). This might be particularly true in disadvantaged populations, where dietary quality was shown to decline over the 30 days following the receipt of a household's major source of income [53]. Fifth, the HPI was developed based on expenditure shares in deprived households with specific food purchase patterns. Individuals involved in the 'Opticourses' and 'Jassur' studies[5,20], which provided the data, are people living in very poor neighborhoods, many of them born abroad, in North Africa in particular. It would be useful to assess the external validity of the HPI based on food purchasing data from a more heterogeneous population. Testing the method in other socioeconomic and geographical contexts will help refine the index. In particular, it is important to examine HPI ability to capture the influence of sociodemographic and economic determinants on the nutritional quality of food choices. Spending on food is a key indicator of household welfare. Engel's law[54] states that as income drops, the proportion of income spent on food increases, but the absolute amount of money available to buy food decreases. Assessing the validity of the HPI at different income levels is therefore a research priority.

Another line of enquiry would be to examine how the index is affected by the variability of food prices.

Conclusion

The Healthy Purchase Index is a score evaluating the nutritional quality of household food purchases based exclusively on food expenses incurred. The HPI offers a simple and effective tool to assess the nutritional quality of household food purchases that may help improve the healthfulness of food purchases.

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Ethical Standards Disclosure: The protocol of the Opticourses and Jassur trails were reviewed by the Comité de Protection des Personnes Sud-Méditerranée which stated that no institutional review board approval was necessary for this research. Written informed consent was obtained from all participants at enrolment and the trials were registered at clinicaltrials.gov as NCT02383875 and NCT03175575, respectively.

Abbreviations: Healthy Purchase Index (HPI); month (mo); Mean Adequacy Ratio (MAR); Mean Excess Ratio (MER); modified PNNS—Guideline Score (PNNS-GSmod);

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Tables

Table 1. Food group and subgroup categorizations of food items purchased by *n* = 112 socially-disadvantaged households of Marseille (France)

Food group	Food subgroup	Examples of food items included
Fruit & vegetables	Fruits	Fresh fruit, canned fruit, stewed fruit
	Dried fruits	Unsalted dried fruit, nuts, seeds
	Vegetables	Fresh vegetables, vegetable soup, canned vegetables
Starches	Refined grains	Bread rolls, fresh bread, pasta, rice, flour
	Unrefined starches	Potatoes, legumes, wholegrain products
Dairy products	Cheese	Hard cheese, soft cheese, cream cheese
	Milk & yogurt	Refrigerated and long-life milk, plain yogurt, sweetened yogurt, fruit yogurt, yoghurt drink
Meat, fish & eggs	Eggs & poultry	Hard-boiled egg, fried egg, omelet, chicken, duck, turkey
	Red & processed meat	Beef, pork, lamb, sausages, bacon, offal
	Fish	Fresh fish, canned fish, shellfish, surimi
Mixed dishes	Ready meals	Frozen ready meals, canned meals, salads
	Savory snacks	Crackers, chips, salted and roasted nuts, olives
	Other snacks	Sandwiches, burgers, quiche, pizza
Sweet products	Sweet snacks	Cakes, biscuits, pastries, candies, chocolate
	Breakfast cereals	Breakfast cereals
	Dairy desserts	Cream dessert, ice cream
Added fats & seasonings	Animal fats	Cream, butter
	Vegetable fats	Vegetable oil, margarine, salad dressing
	Sauces	Ketchup, sauces including soy/tomato/barbecue, etc.
Sweet beverages	Sugary drinks	Soda, nectars
	Fruit juices	Fresh fruit juice, concentrated fruit juice
	Diet soft drinks	Diet soft drinks
Condiments	Spices	Salt, pepper, herbs, spices, mustard, pickles

Table 2. Bivariate and multivariate associations between indicators of nutritional quality (MAR: mean adequacy ratio, and MER: mean excess ratio) of 2000 kcal of food purchases (as dependent variables) and food-group and subgroup expenditure shares (in %) (as independent variables) for *n* = 112 socially-disadvantaged households of Marseille (France).

	Bivariate associations		Final multivariable models[a]	
	MAR	**MER**	**MAR**	**MER**
Food groups				
Fruit & vegetables[b]	0.088***	-0.006	0.098***	
Starches[b]	-0.051**	-0.224***	-0.043**	-0.186***
Dairy products[b]	0.018	0.180***		0.104**
Meat, fish & eggs[b]	0.039*	-0.042	0.048**	
Mixed dishes[b]	-0.017	0.096**		
Sweet products[b]	-0.025	0.188***		0,107***
Added fats & seasonings[b]	-0.033*	0.056	-0,042**	
Sweet beverages[b]	-0.023*	0.142***		0,114***
Food subgroups				
Refined grains[b]	-0.051**	-0.196***	-0.048***	-0.139***
Unrefined starches[b]	0.030*	-0.005		
Fruit[b]	0.060***	-0.052	0.039**	
Dried fruits[c]	0.046*	0.134**	0.045**	
Vegetables[b]	0.068***	0.013	0.043**	
Cheese[b]	0.015	0.157***		0.109***
Milk & yogurt[b]	0.020	0.085**		
Eggs & poultry[b]	-0.011	0.026		
Red & processed meat[b]	0.021	0.015		
Fish[b]	0.030**	-0.020		
Ready meals[c]	0.020	0.110**		
Savory snacks[c]	-0.031	0.193***		
Other snacks[c]	0.010	0.160**		
Sweet snacks[b]	-0.032*	0.197***		0.109***
Breakfast cereals[c]	0.016	0.021		
Dairy desserts[c]	-0.004	0.191***		
Animal fats[c]	0.049*	0.198***		
Vegetable fats[b]	-0.055**	-0.003	-0.065***	
Sauces[c]	0.008	0.095*		
Sugary drinks[b]	-0.033**	0.154***		0.115***
Fruit juices[c]	-0.016	0.146**		
Diet soft drinks[c]	0.049	0.141		

[a]The final multivariate models included all independent variables with p <0.20 in the bivariate analyses, followed by change-in-estimate analyses to select the best subset of predictors.
[b]Variables were log-transformed. Bivariate associations were assessed by simple linear regressions.
[c]Variables were coded as binary variables (purchasers/non-purchasers). Bivariate associations were assessed by analysis of variance models with non-purchasers as reference**.**
*p < 0.1; **p < 0.05; ***p < 0.001.

Table 3. Construction of the Healthy Purchase Index (total out of 15)

Components	**Scoring criteria**[a]	**Score**
Purchase diversity subscore		
Fruit	[0–5[	0
	≥ 5	1
Vegetables	[0–5[	0
	≥ 5	1
Starches	[0–5[	0
	≥ 5	1
Meat, fish & eggs	[0–5[	0
	≥ 5	1
Dairy products	[0–5[	0
	≥ 5	1
Purchase quality subscore		
Fruit & vegetables	[0–15[	0
	[15–25[	1
	≥ 25	2
Added fats and seasoning	≥ 3	0
	[0–3[, and Vegetable fats = 0	0
	[0–3[, and Vegetable fats > 0	1
Sweet snacks	[0–5[	2
	[5–10[	1
	≥ 10	0
Cheese	[0–5[	1
	≥ 5	0
Sugary beverages	[0–3[	1
	≥ 3	0
Refined grains	≥ 1/2 Starches[b]	0
	< 1/2 Starches	1
Fish	[0–5[	0
	[5–10[	1
	≥ 10	2

[a]Expressed as percentage of household monthly food expenditure, unless indicated otherwise.
[b] Expenditure share of the refined grains subgroup within the starches group.

Table 4. Spearman correlations between HPI and its subscores and the mean adequacy ratio (MAR), mean excess ratio (MER), and modified PNNS–Guideline Score (PNNS-GS_{mod})

	Mean score	Spearman correlations		
		MAR	**MER**	**PNNS-GS_{mod}**
HPI	7.4±2.1	0.522***	-0.426***	0.378***
Purchase diversity subscore	4.1±0.9	0.386***	-0.001	0.135
Purchase quality subscore	3.3±1.8	0.419***	-0.499***	0.403***

*p <0.1; **p < 0.05; ***p < 0.001.

Table 5. Spearman correlations between HPI and its subscores and the adequacy and excess ratios of each nutrient included in the MAR and MER, respectively

	Purchase diversity subscore	**Purchase quality subscore**	**HPI**
Nutrient adequacy ratios[a]			
Proteins	0.0243	0.301**	0.274**
DHA	0.161*	0.263**	0.255**
Vitamin A	0.429***	0.194**	0.360***
Fiber	0.378***	0.452***	0.543***
Linolenic acid	-0.011	0.026	0.036
Linoleic acid	0.0014	-0.328***	-0.277**
Thiamin	0.192**	0.360***	0.388***
Riboflavin	0.283**	0.075	0.149
Niacin	-0.010	0.231**	0.172*
Vitamin B-6	0.123	0.398***	0.355***
Folates	0.374***	0.411***	0.519***
Vitamin B-12	-0.068	0.135	0.054
Vitamin C	0.224	0.135	0.197*
Vitamin E	0.014	-0.193**	-0.127
Vitamin D	0.110	0.231**	0.231**
Calcium	0.268**	0.027	0.127
Potassium	0.278**	0.438***	0.469***
Magnesium	0.307**	0.498***	0.557***
Iodine	0.279**	0.373***	0.431***
Selenium	0.175*	0.484***	0.483***
Copper	0.318***	0.414***	0.480***
Zinc	0.009	0.241**	0.201**
Iron	0.152	0.263**	0.271**
Nutrient excess ratios[b]			
Sodium	-0.047	-0.083	-0.089
Saturated fatty acids	0.077	-0.308***	-0.217**
Free sugars	-0.037	-0.526***	-0.478***

[a] Percentage of the daily recommended intakes for 2000 kcal of purchases

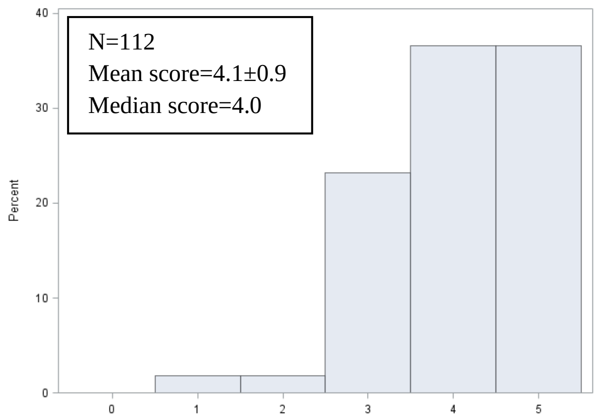
[b] Percentage of daily maximum recommended values for 2000 kcal of purchases

*$p < 0.1$; **$p < 0.05$; ***$p < 0.001$.

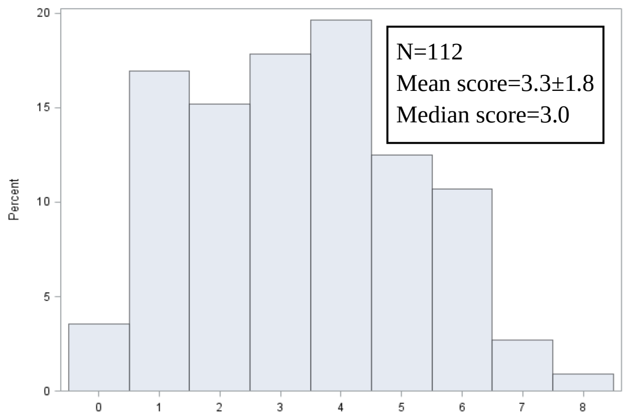
Figures

Figure 1. Distribution of the *purchase diversity subscore* (out of 5), *purchase quality subscore* (out of 10) and final Healthy Purchase Index score (out of 15)

A) Distribution of the *purchase diversity subscore* (out of 5)



B) Distribution of the *purchase quality subscore* (out of 10)



C) Distribution of the HPI (out of 15)