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## **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

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

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

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

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

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

23

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

## 26 Introduction

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

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

51 However, nutritional analysis of food purchases can prove tedious and time-consuming,  
52 typically restricting studies to a few hundred households<sup>(5,11-18)</sup>. Participants are asked to  
53 collect and annotate receipts from all family members, and to record all food expenditures  
54 made without receipts. Estimating the nutrient content of food expenditures entails  
55 cumbersome data handling, especially since evaluators often have to contend with missing  
56 data on the quantities purchased<sup>(14,19)</sup>. This study exploited the huge potential of supermarket  
57 receipts for monitoring the nutritional quality of household food purchases to develop a

58 simplified measure of the quality of household food purchases, called the 'Healthy Purchase  
59 Index' (HPI). Here we present the methodology used to develop the HPI, and the first  
60 elements of its validation.

## 61 **Methods**

### 62 **Study design and population**

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

### 73 **Categorization, price and nutritional composition of household food purchases**

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

90 For each food item purchased, the quantity ‘as purchased’ was transformed into a quantity ‘as  
91 consumed’ using a correction coefficient that took into account the changes in weight  
92 associated with preparation and waste (e.g. peeling, boning, water loss or gain during

93 cooking, etc.). The nutritional composition of each food item ‘as consumed’ was then  
94 determined by linkage with the closest food from the French food composition table<sup>(27)</sup>. For  
95 each household, energy and nutrient contents of food supplies were calculated as the sum of  
96 the energy and nutrient contents of all foods and beverages entering the household during the  
97 period of data collection.

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

## 110 **Indicators of nutritional quality of household food purchases**

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

114 MAR is an indicator of overall good nutritional quality<sup>(28)</sup>. It was calculated as the mean of 23  
115 nutrient adequacy ratios, corresponding to percentage of the daily recommended intakes for  
116 23 key nutrients as previously described<sup>(29)</sup>:

117

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

122 Conversely, MER is an indicator of bad nutritional quality. Previously proposed by Vieux *et*  
123 *al.*<sup>(32)</sup>, MER is the mean of 3 nutrient excess ratios, corresponding to percentage of daily

124 maximum recommended values for 3 unhealthy nutrients: sodium, saturated fatty acids, and  
125 free sugars (added sugars plus sugars naturally present in honey, syrups, and fruit juices), as  
126 follows:

127

128 where  $Nut_p$  is the quantity of each nutrient  $p$  per 2000 kcal of purchase, and  $MRV_p$  is the  
129 maximum recommended value for that nutrient. Here, unlike the previously published  
130 MER<sup>(32)</sup>, each nutrient excess ratio lower than 100 was not truncated to 100 in order to avoid  
131 non-normal distribution of the indicator.

### 132 **Development of the Healthy Purchase Index (HPI)**

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

#### 137 *Purchase diversity subscore*

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

#### 146 *Purchase quality subscore*

147 The *purchase quality subscore* is a 7-component score. It was based on food groups and  
148 subgroups identified according to known relationships between diet and health<sup>(34)</sup> and/or for  
149 which expenditure shares best reflected the nutritional quality of purchases. Identification of  
150 best predictors was performed separately for food groups and subgroups. In a first step,  
151 regressions were conducted to capture the relationship between each indicator of nutritional  
152 quality (i.e. MAR and MER), as the dependent variable, and each food group and subgroup.  
153 We then performed multivariate linear regressions for MAR and MER separately, including  
154 all main terms yielding  $p < 0.20$  in the first step. A change-in-estimate method was further



155 applied to select the best subset of predictors. The MAR, MER and food groups and  
156 subgroups expenditure shares were log-transformed to improve normality. Log transformation  
157 of food subgroups rarely purchased (i.e. by less than a third of households) did not reduce  
158 skewness and so were coded as binary variables (purchased/not purchased). These binary  
159 variables were subsequently added to the multivariate models, and only the variables proved  
160 significant were kept in the final model. In addition to the identified predictors, several  
161 refinements were incorporated based on expert advice from the 2016 report of the French  
162 Agency for Food, Environmental and Occupational Health & Safety (Anses) on the update of  
163 the French dietary guidelines<sup>(34)</sup>.

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

#### 169 **First elements of validation of the HPI**

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

184 Sensitivity analysis was also performed by testing the addition of two penalties to the HPI. A  
185 first penalty was added when the red & processed meat expenditure share was higher than the  
186 75<sup>th</sup> percentile in the study population, given epidemiologic evidence linking high

187 consumption of red and processed meat to diseases<sup>(37,38)</sup>. A second penalty was added when  
188 food expenditure was below 3.5 €/day per person, as previous research showed that it is  
189 almost impossible to obtain a nutritionally adequate diet below this threshold in France<sup>(3,39)</sup>,  
190 and so it is unlikely that food purchases below this threshold have good nutritional quality.

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

## 193 **Results**

### 194 **Characteristics of the households**

195 Average household size was 3.3 persons (range: 1–7) including 1.6 children (range: 0–6);  
196 20.5% were single-person households (data not shown). Almost a third (33.1%) declared  
197 severe financial difficulties, 45.5% were in a precarious financial situation, 16.1% were in a  
198 stable financial situation, and 5.3% did not answer the question. During the 1-month food  
199 records, each household shopped in an average of five different stores. A total of 849 different  
200 food items were purchased or the whole sample.

### 201 **The *purchase diversity subscore***

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

### 206 **The *purchase quality subscore***

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

209 The major contributors to total household food expenditure were meat, fish & eggs  
210 ( $26.7 \pm 12.8\%$ ), starches ( $17.4 \pm 11.3\%$ ), fruit & vegetables ( $16.6 \pm 10.0\%$ ), sweet products  
211 ( $12.4 \pm 7.2\%$ ), dairy products ( $10.3 \pm 5.3\%$ ) for the food groups, and red & processed meat  
212 ( $15.0 \pm 10.9\%$ ), refined grains ( $14.2 \pm 11.2\%$ ), sweet snacks ( $10.9 \pm 6.7\%$ ) and vegetables  
213 ( $9.5 \pm 6.3\%$ ) for the subgroups. The expenditure share for condiments was negligible (i.e. less  
214 than 1.5%) and this subgroup was thus excluded from the analysis. Of the 22 subgroups, 10  
215 were coded as binary variables. Results from bivariate associations and final multivariate  
216 models are presented in **Table 2**. A total of 14 predictors—6 food groups and 8 subgroups—  
217 were found to be significantly associated with at least one indicator of nutritional quality of  
218 purchases in final multivariate models. Expenditure shares for fruit & vegetables (including  
219 the fruits, dried fruits, and vegetables subgroups) and meat, fish & eggs were positively  
220 associated with MAR, while the added fats & seasonings group (especially vegetable fats)  
221 was negatively associated with MAR. Expenditure shares for sweet products, and sweet  
222 beverages (especially sugary drinks), and for the cheese and sweet snacks subgroups, were

223 positively associated with MER. Expenditure shares for starches and for refined grains were  
224 negatively associated with both MAR and MER.

#### 225 *Choice of components included in the purchase quality subscore*

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

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

#### 245 **The Healthy Purchase Index**

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

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

258 Adding a penalty to HPI for households with expenditure shares for red & processed meat  $\geq$   
259 20% (75<sup>th</sup> percentile) barely attenuated the associations with the three indicators [MAR:  
260  $r_s = 0.492$ ; MER:  $r_s = -0.396$ ; PNNS- $GS_{\text{mod}}$   $r_s = 0.334$ ; all  $p < 0.001$ ]. Adding a penalty for  
261 food budget below 3.5 €/day per person (62% of households) barely changed the associations  
262 [MAR:  $r_s = 0.523$ ; MER:  $r_s = -0.398$ ; PNNS- $GS_{\text{mod}}$   $r_s = 0.401$ ; all  $p < 0.001$ ] (data not shown).

263 Associations with nutrient adequacy ratios and nutrient excess ratios of each component of the  
264 MAR and MER, respectively, are presented in **Table 5**. HPI correlated significantly with 19  
265 nutrients of the MAR ( $-0.277 < r_s < 0.557$ ) and with 2 nutrients of the MER  
266 ( $-0.478 < r_s < -0.217$ ).

## 267 Discussion

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

275 Compared to declarative dietary surveys, food expenditure surveys present the advantage of  
276 limiting memory bias and social desirability bias. In particular, when both expenses and  
277 quantities are recorded through annotated receipt collection, very detailed data on household  
278 food purchases can be obtained<sup>(11)</sup>. Quantities purchased are more difficult to obtain, but when  
279 recorded in addition to expenditure data, they yield reliable information on the cost of food<sup>(3)</sup>.  
280 Moreover, when linked to a food composition table, till receipts were found to provide good  
281 estimates of the household intakes of energy and percentage energy from fat<sup>(12,16)</sup>. More  
282 recently, Appelhans *et al.* found that household food purchases yielded a reasonable estimate  
283 of overall diet quality for primary household food shoppers<sup>(17)</sup>. However, using this  
284 information (expenditure on food quantities purchased, energy and nutrient contents) to assess  
285 household food purchases patterns and nutritional quality is a tedious and costly task (data  
286 entry, coding, linkage with nutrition information, analysis, etc.), and can burden both research  
287 staff and participants. Such methodological difficulties in evaluating the quality of household  
288 food purchases can be solved by an approach based solely on food expenditure. To the best of  
289 our knowledge, only two studies have used food budget shares to assess the nutritional quality  
290 of food purchases. In 2012, considering that most food choices are made at the supermarket  
291 or grocery store, the United States Department of Agriculture proposed several tools to assess  
292 the overall healthfulness of food purchases, including scores based on food category  
293 expenditure shares<sup>(40)</sup>. These scores compared observed expenditure shares to reference  
294 expenditure shares, the latter being derived from mathematically-optimized food baskets  
295 meeting the recommended dietary allowance for all nutrients<sup>(41)</sup>. However, the cultural  
296 acceptability of such theoretical baskets has been questioned<sup>(42)</sup>. In 2015, the *Healthy Trolley*  
297 *Index*—in which daily servings of food groups (in % of total recommended daily serving)  
298 were simply translated into proportion of monthly expenditure per food groups—was  
299 developed by an Australian research team to compare food expenditure with the Australian

300 Guide to Healthy Eating<sup>(43)</sup>. The HPI, by design, has the advantage of directly accounting for  
301 food group and subgroup expenditure shares without needing information on the weight and  
302 nutritional composition of the foods. The HPI thus overcomes the fact that proportion by  
303 weight does not necessarily align with proportion by price, as some food groups are more  
304 expensive than others<sup>(44)</sup>. This food price hierarchy was ignored in the Australian *Healthy*  
305 *Trolley Index*<sup>(43)</sup>, which did not take into account that fruit, vegetables and meat provide more  
306 costly calories than starches and fats<sup>(3)</sup>.

307 To be consistent with many dietary guidelines that emphasize the importance of increasing  
308 both diversity and quality to achieve a healthy balanced diet<sup>(45-47)</sup>, the HPI included two  
309 subscores: the *purchase diversity subscore* and the *purchase quality subscore*. Various indices  
310 differing in the number of food categories used have been developed to assess dietary  
311 diversity<sup>(28,48)</sup>. For the *purchase diversity subscore* we settled on fruit, vegetables, starches,  
312 meat, fish & eggs, and dairy products, as an omission of one or more of these 5 categories was  
313 found to be associated with increased risk of mortality<sup>(49,50)</sup>. The *purchase diversity subscore* is  
314 therefore a 5-component score designed to reflect the presence of 5 food groups (and  
315 subgroups) in total household food expenditure. Rather than encouraging diversity, the  
316 subscore can be viewed as a way to penalize unbalanced food baskets in which at least one of  
317 the 5 food groups (and subgroups) is lacking. The *purchase quality subscore* is aimed at  
318 capturing the nutritional quality of household food purchases through expenditure shares of  
319 specific groups (and subgroups) and French dietary guidelines. The *purchase quality subscore*  
320 is a 7-component score: 2 components with expenditure shares to be increased and 5  
321 components with expenditure shares to be limited to pursue health objectives. Furthermore,  
322 the *purchase quality subscore* indirectly encourages intra-group diversity through its design  
323 including various food groups and subgroups. The HPI, which sums the two subscores,  
324 showed good agreement with MAR and MER, two indicators of diet quality based on  
325 nutrients only. This association may have resulted in part from the fact that MAR and MER  
326 were closely related to the HPI, as they were used to construct the *purchase quality subscore*.  
327 However, similar correlations were obtained with an unrelated indicator of diet quality based  
328 on foods and food groups (the PNNS-GSmod), thereby providing preliminary evidence of the  
329 capacity of the HPI index to assess food purchase quality. In addition, associations between  
330 the HPI and either MAR, MER or PNNS-GSmod were relatively strong, of the same order of  
331 magnitude as or greater than values previously found between MAR and other diet quality  
332 indicators<sup>(51,52)</sup>. No stronger association was found between HPI and the other index scores

333 when adding penalties for expenditure shares for red & processed meat  $\geq 20\%$  of food budget,  
334 and for household food purchases below 3.5 €/day per person. However, given the specific  
335 economic constraints and cultural habits of the studied population<sup>5</sup>, which may impact food  
336 purchase patterns, it might be worth considering the use of penalties on a larger population  
337 with more diverse purchasing behaviors.

338 Our study has limitations. First, the degree to which HPI reflects actual household  
339 consumption patterns is limited by a number of factors: it is based on data at the household  
340 level without knowledge of food allocation between different household members or visitors,  
341 information on meals eaten away from home was not collected, and what is purchased is not  
342 necessarily eaten (waste, leftovers, etc.)<sup>(17)</sup>. For all these reasons, it is clear that the HPI cannot  
343 claim to be a tool to assess the quality of diets. Second, the HPI was developed based on data  
344 from a convenient sample of a limited number of households. Using relatively small  
345 convenient samples is a common limitation of studies estimating the nutritional quality of  
346 household food purchases<sup>(5,11,12,14–18)</sup>. This limitation is explained by the technical complexity  
347 of exploiting annotated supermarket receipts and records, fully justifying the development of  
348 a simplified tool like the HPI. Third, keeping records of foods entering the household over a  
349 1-month period places demands on participants that may increase the risks of errors and  
350 omissions. Nevertheless, a shorter time-window for recordkeeping does not seem relevant  
351 when salaries and social benefits are paid monthly (as is the case in France). This might be  
352 particularly true in disadvantaged populations, where dietary quality was shown to decline  
353 over the 30 days following the receipt of a household's major source of income<sup>(53)</sup>. Fifth, the  
354 HPI was developed based on expenditure shares in deprived households with specific food  
355 purchase patterns. Individuals involved in the 'Opticourses' and 'Jassur' studies<sup>(5,20)</sup>, which  
356 provided the data, are people living in very poor neighborhoods, many of them born abroad,  
357 in North Africa in particular. It would be useful to assess the external validity of the HPI  
358 based on food purchasing data from a more heterogeneous population. Testing the method in  
359 other socioeconomic and geographical contexts will help refine the index. In particular, it is  
360 important to examine HPI ability to capture the influence of sociodemographic and economic  
361 determinants on the nutritional quality of food choices. Spending on food is a key indicator of  
362 household welfare. Engel's law<sup>(54)</sup> states that as income drops, the proportion of income spent  
363 on food increases, but the absolute amount of money available to buy food decreases.  
364 Assessing the validity of the HPI at different income levels is therefore a research priority.



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

## 367 **Conclusion**

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

372

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**Authorship:** ND, CD, MM, FV and MT designed the research; MT and MM conducted the research; MT analyzed the data and wrote the first draft of the manuscript; all the authors interpreted the results, contributed to writing of the manuscript and proposed critical comments; ND had primary responsibility for final content. All authors read and approved the final manuscript.

375 **Ethical Standards Disclosure:** The protocol of the Opticourses and Jassur trials were  
376 reviewed by the Comité de Protection des Personnes Sud-Méditerranée which stated that no  
377 institutional review board approval was necessary for this research. Written informed consent  
378 was obtained from all participants at enrolment and the trials were registered at  
379 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);

380

## References

- 381 1. Darmon N, Drewnowski A. (2008) Does social class predict diet quality? *Am J Clin*  
382 *Nutr* **87**:1107–17.
- 383 2. Aggarwal A, Monsivais P, Cook AJ *et al.* (2011) Does diet cost mediate the relation  
384 between socioeconomic position and diet quality? *Eur J Clin Nutr* **65**:1059–66.
- 385 3. Darmon N, Drewnowski A. (2015) Contribution of food prices and diet cost to  
386 socioeconomic disparities in diet quality and health: a systematic review and analysis.  
387 *Nutr Rev* **73**:643–60.
- 388 4. Beydoun MA, Wang Y. (2008) How do socio-economic status, perceived economic  
389 barriers and nutritional benefits affect quality of dietary intake among US adults? *Eur J*  
390 *Clin Nutr* **62**:303–13.
- 391 5. Marty L, Dubois C, Gaubard MS, *et al.* (2015) Higher nutritional quality at no  
392 additional cost among low-income households: insights from food purchases of  
393 positive deviants. *Am J Clin Nutr* **102**:190–8.
- 394 6. Orfanos P, Naska A, Trichopoulos D, *et al.* (2007) Eating out of home and its correlates  
395 in 10 European countries. The European Prospective Investigation into Cancer and  
396 Nutrition (EPIC) study. *Public Health Nutr* **10**(12):1515-1525.
- 397 7. Agence Française de Sécurité Sanitaire des Aliments. (2009) *Étude Individuelle*  
398 *Nationale des Consommations Alimentaires 2 (INCA 2) 2006–2007*. Version 2. Paris :  
399 Afssa
- 400 8. Seymour J, Yaroch AL, Serdula M, *et al.* (2004) Impact of nutrition environmental  
401 interventions on point-of-purchase behavior in adults: a review. *Prev Med.* **39**:108–36.
- 402 9. Escaron AL, Meinen AM, Nitzke SA, *et al.* (2013) Supermarket and grocery store-  
403 based interventions to promote healthful food choices and eating practices: a systematic  
404 review. *Prev Chronic Dis* **10**:E50.
- 405 10. Gamburzew A, Darcel N, Gazan R, *et al.* (2016) In-store marketing of inexpensive  
406 foods with good nutritional quality in disadvantaged neighborhoods: increased  
407 awareness, understanding, and purchasing. *Int J Behav Nutr Phys Act* **13**.
- 408 11. French SA, Shimotsu ST, Wall M, *et al.* (2008) Capturing the Spectrum of Household

- 409 Food and Beverage Purchasing Behavior: A Review. *J Am Diet Assoc* **108**:2051–8.
- 410 12. Ransley JK, Donnelly JK, Khara TN, *et al.* (2001) The use of supermarket till receipts  
411 to determine the fat and energy intake in a UK population. *Public Health Nutr* **4**:1279–  
412 86.
- 413 13. Rankin JW, Winett RA, Anderson ES, *et al.* (1998) Food Purchase Patterns at the  
414 Supermarket and their Relationship to Family Characteristics. *J Nutr Educ* **30**:81–8.
- 415 14. French SA, Wall M, Mitchell NR, *et al.* (2009) Annotated receipts capture household  
416 food purchases from a broad range of sources. *Int J Behav Nutr Phys Act* **6**:37.
- 417 15. French SA, Wall M, Mitchell NR. (2010) Household income differences in food  
418 sources and food items purchased. *Int J Behav Nutr Phys Act* **7**:77.
- 419 16. Ransley JK, Donnelly JK, Botham H, *et al.* (2003) Use of supermarket receipts to  
420 estimate energy and fat content of food purchased by lean and overweight families.  
421 *Appetite* **41**:141–8.
- 422 17. Appelhans BM, French SA, Tangney CC, *et al.* (2017) To what extent do food  
423 purchases reflect shoppers' diet quality and nutrient intake? *Int J Behav Nutr Phys Act*  
424 **14**:46.
- 425 18. Aaron GJ, Keim NL, Drewnowski A, *et al.* (2013) Estimating dietary costs of low-  
426 income women in California: a comparison of 2 approaches. *Am J Clin Nutr* **97**:835–  
427 41.
- 428 19. Martin SL, Howell T, Duan Y, *et al.* (2006) The feasibility and utility of grocery receipt  
429 analyses for dietary assessment. *Nutr J* **5**:10.
- 430 20. Perignon M, Dubois C, Gazan R, *et al.* (2017) Co-construction and evaluation of a  
431 prevention program for improving the nutritional quality of food purchases at no  
432 additional cost in a socioeconomically disadvantaged population. *Curr Dev Nutr*  
433 **1**(10):e001107.
21. Martin P, Consalès J-N, Scheromm P, *et al.* (2017) Community gardening in poor  
neighborhoods in France: A way to re-think food practices? *Appetite* **116**:589-598.
- 434 22. Louzada ML da C, Baraldi LG, Steele EM, *et al.* Consumption of ultra-processed foods  
435 and obesity in Brazilian adolescents and adults. *Prev Med (Baltim)* **81**:9-15.

- 436 doi:10.1016/j.ypped.2015.07.018.
- 437 23. Louzada ML da C, Ricardo CZ, Steele EM, *et al.* (2018) The share of ultra-processed  
438 foods determines the overall nutritional quality of diets in Brazil. *Public Health Nutr*  
439 **21**(01):94-102.
- 440 24. Rickman JC, Barrett DM, Bruhn CM. (2007) Nutritional comparison of fresh, frozen  
441 and canned fruits and vegetables. Part 1. Vitamins C and B and phenolic compounds. *J*  
442 *Sci Food Agric* **87**(6):930-944
- 443 25. Kapica C, Global Health and Wellness, Ketchum Inc, *et al.* (2012) Canned fruits,  
444 vegetables, beans and fish provide nutrients at a lower cost compared to fresh, frozen  
445 or dried. *Nutr Food Sci*
- 446 26. Miller SR, Knudson WA. (2014) Nutrition and cost comparisons of select canned,  
447 frozen, and fresh fruits and vegetables. *Am J Lifestyle Med* **8**(6):430-437.
- 448 27. The French Information Center on Food Quality. French food composition table  
449 Ciqual. Version 2013. <https://www.anses.fr/fr/content/table-ciqual-2013>. Published  
450 June 2014. Updated June 2014 (accessed January 2017).
- 451 28. Kant AK. (1996) Indexes of Overall Diet Quality. *J Am Diet Assoc* **96**:785–91.
- 452 29. Maillot M, Darmon N, Vieux F, *et al.* (2007) Low energy density and high nutritional  
453 quality are each associated with higher diet costs in French adults. *Am J Clin Nutr*  
454 **86**:690–6.
- 455 30. Martin A. (2001) The “apports nutritionnels conseillés (ANC)” for the French  
456 population. *Reprod Nutr Dev EDP Sci* **41**:119–28.
- 457 31. Madden JP, Goodman SJ, Guthrie HA. (1976) Validity of the 24-hr. recall. Analysis of  
458 data obtained from elderly subjects. *J Am Diet Assoc* **68**:143–7.
- 459 32. Vieux F, Soler L-G, Touazi D, *et al.* (2013) High nutritional quality is not associated  
460 with low greenhouse gas emissions in self-selected diets of French adults. *Am J Clin*  
461 *Nutr* **97**:569–83.
- 462 33. Kant AK, Block G, Schatzkin A, *et al.* (1991) Dietary diversity in the US population,  
463 NHANES II, 1976-1980. *J Am Diet Assoc* **91**:1526–31.
- 464 34. Anses. (2017) *Actualisation des repères du PNNS : révision des repères de*

465 consommations alimentaires. Rapport expertise collective. Edition scientifique 2016.  
466 Maisons-Alfort: Anses.

467 35. Waijers PMCM, Feskens EJM, Ocké MC. (2007) A critical review of predefined diet  
468 quality scores. *Br J Nutr* **97**:219

469 36. Estaquio C, Kesse-Guyot E, Deschamps V, *et al.* (2009) Adherence to the French  
470 Programme National Nutrition Santé Guideline Score Is Associated with Better  
471 Nutrient Intake and Nutritional Status. *J Am Diet Assoc* **109**:1031–41.

472 37. Battaglia Richi E, Baumer B, Conrad B, *et al.* (2015) Health Risks Associated with  
473 Meat Consumption: A Review of Epidemiological Studies. *Int J Vitam Nutr Res* **85**:70–  
474 8.

475 38. Boada LD, Henríquez-Hernández LA, Luzardo OP. (2016) The impact of red and  
476 processed meat consumption on cancer and other health outcomes: *Epidemiological*  
477 *evidences*. *Food Chem Toxicol* **92**:236–44.

478 39. Darmon N, Ferguson EL, Briend A. (2006) Impact of a Cost Constraint on  
479 Nutritionally Adequate Food Choices for French Women: An Analysis by Linear  
480 Programming. *J Nutr Educ Behav* **38**:82–90.

481 40. Volpe R, Okrent A. (2012) *Assessing the Healthfulness of Consumers' Grocery*  
482 *Purchases, EIB-102*. Washington : U.S. Department of Agriculture.

483 41. Carlson A, Lino M, Fungwe TV. (2007) *The Low-Cost, Moderate-Cost, and Liberal*  
484 *Food Plans*. U.S. Department of Agriculture, Center for Nutrition Policy and  
485 Promotion.

486 42. Wilde PE, Llobrera J. (2009) Using the Thrifty Food Plan to Assess the Cost of a  
487 Nutritious Diet. *J Consum Aff* **43**(2):274-304.

488 43. Taylor A, Wilson F, Hendrie GA, *et al.* (2015) Feasibility of a Healthy Trolley Index to  
489 assess dietary quality of the household food supply. *Br J Nutr* **114**:2129–37.

44. Maillot M, Darmon N, Darmon M, *et al.* (2007) Nutrient-dense food groups have high  
energy costs: an econometric approach to nutrient profiling. *J Nutr*. **137**:1815–20.

490 45. U.S. Department of Health and Human Services and U.S. Department of Agriculture.  
491 (2015) *2015-2020 Dietary Guidelines for Americans*. 8th Edition.

- 492 46. Public Health England. (2017) The Eatwell Guide. Version current February 2017.  
493 <https://www.gov.uk/government/publications/the-eatwell-guide>. (accessed January  
494 2017).
- 495 47. French Ministry of Health. (2012) The French National Nutrition and Health Program  
496 2011-2015. Version December 2012. Paris : Ministry of Health.
48. Kennedy G, Ballard T, Dop MC. (2011). *Guidelines for measuring household and individual dietary diversity*. Rome: Food and Agriculture Organization of the United Nations.
- 497 49. Kant AK, Schatzkin A, Harris TB, Ziegler RG *et al.* (1993) Dietary diversity and  
498 subsequent mortality in the First National Health and Nutrition Examination Survey  
499 Epidemiologic Follow-up Study. *Am J Clin Nutr* **57**(3):434-440.
- 500 50. Kant AK, Schatzkin A, Ziegler RG. (1995) Dietary diversity and subsequent cause-  
501 specific mortality in the NHANES I epidemiologic follow-up study. *J Am Coll Nutr*  
502 **14**:233–8.
- 503 51. Dubois L, Girard M, Bergeron N. (2000) The choice of a diet quality indicator to  
504 evaluate the nutritional health of populations. *Public Health Nutr* **3**:357–65.
- 505 52. Cheng G, Duan R, Kranz S, *et al.* (2016) Development of a Dietary Index to Assess  
506 Overall Diet Quality for Chinese School-Aged Children: The Chinese Children Dietary  
507 Index. *J Acad Nutr Diet* **116**:608–17.
- 508 53. Tarasuk V, McIntyre L, Li J. (2007) Low-income women’s dietary intakes are sensitive  
509 to the depletion of household resources in one month. *J Nutr* **137**:1980–7.
- 510 54. Engel E. (1895) Die Productions- und Consumtions verhaltnisse des Konigreichs  
511 Sachsen.Reprint of the original article of 1857. *Bull Int Stat Inst* **9**: 1-54.

512

**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  |

## Tables

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Tharrey, M., Dubois, C., Maillot, C., Vieux, F., Méjean, C., Perignon, M., Darmon, N. (2018). Development of the Healthy Purchase Index (HPI): a scoring system to assess the nutritional quality of household food purchases. *Public Health Nutrition*, First View. , DOI : 10.1017/S1368980018003154



**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 <sup>a</sup> |           |           |
|--------------------------------------|------------------------|---|-----------|-----------|
|                                      | MAR                    | MER                                     | MAR       | MER       |
| <b>Food groups</b>                   |                        |   |           |           |
| Fruit & vegetables <sup>b</sup>      | 0.088***               | -0.006                                  | 0.098***  |           |
| Starches <sup>b</sup>                | -0.051**               | -0.224***                               | -0.043**  | -0.186*** |
| Dairy products <sup>b</sup>          | 0.018                  | 0.180***                                |           | 0.104**   |
| Meat, fish & eggs <sup>b</sup>       | 0.039*                 | -0.042                                  | 0.048**   |           |
| Mixed dishes <sup>b</sup>            | -0.017                 | 0.096**                                 |           |           |
| Sweet products <sup>b</sup>          | -0.025                 | 0.188***                                |           | 0,107***  |
| Added fats & seasonings <sup>b</sup> | -0.033*                | 0.056                                   | -0,042**  |           |
| Sweet beverages <sup>b</sup>         | -0.023*                | 0.142***                                |           | 0,114***  |
| <b>Food subgroups</b>                |                        |   |           |           |
| Refined grains <sup>b</sup>          | -0.051**               | -0.196***                               | -0.048*** | -0.139*** |
| Unrefined starches <sup>b</sup>      | 0.030*                 | -0.005                                  |           |           |
| Fruit <sup>b</sup>                   | 0.060***               | -0.052                                  | 0.039**   |           |
| Dried fruits <sup>c</sup>            | 0.046*                 | 0.134**                                 | 0.045**   |           |
| Vegetables <sup>b</sup>              | 0.068***               | 0.013                                   | 0.043**   |           |
| Cheese <sup>b</sup>                  | 0.015                  | 0.157***                                |           | 0.109***  |
| Milk & yogurt <sup>b</sup>           | 0.020                  | 0.085**                                 |           |           |
| Eggs & poultry <sup>b</sup>          | -0.011                 | 0.026                                   |           |           |
| Red & processed meat <sup>b</sup>    | 0.021                  | 0.015                                   |           |           |
| Fish <sup>b</sup>                    | 0.030**                | -0.020                                  |           |           |
| Ready meals <sup>c</sup>             | 0.020                  | 0.110**                                 |           |           |
| Savory snacks <sup>c</sup>           | -0.031                 | 0.193***                                |           |           |
| Other snacks <sup>c</sup>            | 0.010                  | 0.160**                                 |           |           |
| Sweet snacks <sup>b</sup>            | -0.032*                | 0.197***                                |           | 0.109***  |
| Breakfast cereals <sup>c</sup>       | 0.016                  | 0.021                                   |           |           |
| Dairy desserts <sup>c</sup>          | -0.004                 | 0.191***                                |           |           |
| Animal fats <sup>c</sup>             | 0.049*                 | 0.198***                                |           |           |

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|                               |          |          |           |          |
|-------------------------------|----------|----------|-----------|----------|
| Vegetable fats <sup>b</sup>   | -0.055** | -0.003   | -0.065*** |          |
| Sauces <sup>c</sup>           | 0.008    | 0.095*   |           |          |
| Sugary drinks <sup>b</sup>    | -0.033** | 0.154*** |           | 0.115*** |
| Fruit juices <sup>c</sup>     | -0.016   | 0.146**  |           |          |
| Diet soft drinks <sup>c</sup> | 0.049    | 0.141    |           |          |

<sup>a</sup>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.

<sup>b</sup>Variables were log-transformed. Bivariate associations were assessed by simple linear regressions.

<sup>c</sup>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 <sup>a</sup> | Score |
|------------------------------------|-------------------------------|-------|
| <i>Purchase diversity subscore</i> |                               |       |
| 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     |
| <i>Purchase quality subscore</i>   |                               |       |
| 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 <sup>b</sup>   | 0     |
|                                    | < 1/2 Starches                | 1     |
| Fish                               | [0–5[                         | 0     |
|                                    | [5–10[                        | 1     |
|                                    | ≥ 10                          | 2     |

<sup>a</sup>Expressed as percentage of household monthly food expenditure, unless indicated otherwise.

<sup>b</sup>Expenditure share of the refined grains subgroup within the starches group.

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quality of household food purchases. *Public Health Nutrition, First View.* , DOI : 10.1017/S1368980018003154

**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<sub>mod</sub>)**

|                                    | Mean score | Spearman correlations |           |                        |
|------------------------------------|------------|-----------------------|-----------|------------------------|
|                                    |            | MAR                   | MER       | PNNS-GS <sub>mod</sub> |
| HPI                                | 7.4±2.1    | 0.522***              | -0.426*** | 0.378***               |
| <i>Purchase diversity subscore</i> | 4.1±0.9    | 0.386***              | -0.001    | 0.135                  |
| <i>Purchase quality subscore</i>   | 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       |
|---|-----------------------------|---------------------------|-----------|
| <i>Nutrient adequacy ratios<sup>a</sup></i> |                             |                           |           |
| 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**   |
| <i>Nutrient excess ratios<sup>b</sup></i>   |                             |                           |           |
| Sodium                                      | -0.047                      | -0.083                    | -0.089    |
| Saturated fatty acids                       | 0.077                       | -0.308***                 | -0.217**  |
| Free sugars                                 | -0.037                      | -0.526***                 | -0.478*** |

<sup>a</sup> Percentage of the daily recommended intakes for 2000 kcal of purchases

<sup>b</sup> Percentage of daily maximum recommended values for 2000 kcal of purchases

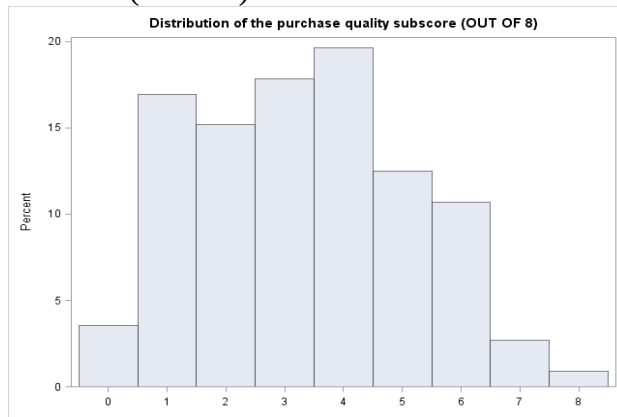
\* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.001$ .

## 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)

