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## **Co-construction and evaluation of a prevention program for improving the nutritional quality of food purchases at no additional cost in a socio-economically disadvantaged population**

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**List of abbreviations**: CIQUAL: Centre d'Information sur la Qualité des Aliments; HFSS: foods high in fat/salt/sugar; MAR: mean adequacy ratio; NQP: nutritional quality for price, RDA: recommended dietary allowance; SED: solid energy density, SFA: saturated fatty acid

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**Short running head**: Improving nutritional quality of food purchases

**Clinical Trial Registry number**: This trial was registered at [clinicaltrials.gov](http://clinicaltrials.gov) as NCT02383875

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1 **Abstract**

2 **Background:** Food prices influence food choices. Purchasing foods with higher nutritional  
3 quality for their price may help improve the diet quality of socio-economically disadvantaged  
4 individuals.

5 **Objective:** To describe the co-construction and evaluation of the ‘Opticourses’ prevention  
6 program promoting healthy eating among participants in deprived socio-economical situations  
7 by improving the nutritional quality of their household food purchases with no additional cost.

8 **Methods:** Individuals were recruited in poor districts of Marseille, France. The intervention  
9 and evaluation tools and protocols were co-constructed with 96 individuals. Then, 93 adults  
10 willing to participate in a standardized intervention comprising five participative workshops  
11 on “diet and budget” were enrolled. Impact on food purchases was estimated with  
12 experimental economics: 2-days experimental food purchase intents were observed at baseline  
13 and endline for workshop participants (WP,  $n=35$ ) and controls ( $n=23$ ), using monetary  
14 incentives to limit social-desirability bias. Changes in food and nutrient content and energy  
15 cost (€/2000kcal) of experimental purchases were assessed.

16 **Results:** Participative workshops including playful activities around food purchase practices  
17 and nutritional quality, taste and price of foods were co-constructed. Experimental purchases  
18 contained a large amount of energy at baseline for both WP and controls (5114 and  
19 4523kcal/d.pers). For WP only, the mean energy content decreased between baseline and  
20 endline ( $-1729$  kcal/d.pers,  $p<0.01$ , medium effect size: Cohen’s  $d=0.5$ ), and percentage  
21 energy from free sugars and from foods high in fat, sugar and salt also decreased (both  $p<0.05$   
22 and medium effect sizes), while energy cost remained unchanged. No significant changes  
23 between baseline and endline were observed for controls.

24 **Conclusion:** After the intervention, the energy content of participants’ experimental  
25 purchases was closer to their needs, suggesting that workshops helped them to plan and

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26 rationalize their food purchases better. Nutritional quality of the experimental purchases  
27 increased but not energy cost, showing that the co-constructed ‘Opticourses’ prevention  
28 program can favorably change food purchasing behaviors of socio-economically  
29 disadvantaged individuals with no additional cost.

30 **Keywords:** Intervention; low-income; diet; nutritional quality; food purchasing behavior;  
31 experimental economics; cost; food prices

32

### 33 **Introduction**

34 The diets of the most socially disadvantaged individuals in industrialized countries are  
35 characterized by low intakes of fruit and vegetables, and by an overall poorer nutritional  
36 quality (1). This is partly explained by the high price per calorie ratio of fruits and vegetables  
37 compared with that of high-fat high-sugar products (2,3). Socially disadvantaged individuals  
38 perceive food prices as a barrier to adopting healthier diets (4,5). It is especially important for  
39 these populations to develop strategies to achieve good nutritional quality with a small  
40 budget. An intervention targeting socially disadvantaged populations must take into account  
41 their actual beliefs and expectations. A co-construction approach is thus recommended,  
42 involving participants at each step of the intervention, in order to maximize its impact (6,7).  
43 It is more difficult to have a balanced diet with a low food budget (8), and a minimal food  
44 budget (estimated at around 3.5€/d.person in France) is strictly needed to design diets that are  
45 both nutritious and socially acceptable (9,10). When the food budget is low but above this  
46 critical threshold, designing a balanced diet involves favoring a selection of foods with good  
47 nutritional quality for their price (11). Additionally, for a given food product, replacing  
48 national brands by generic products can lower cost without impairing nutritional quality.  
49 Branded products have been found to be up to four times more costly than generic products  
50 with equivalent nutritional contents (12,13).  
51 Experimental economics is a powerful methodology for evaluating the impact of a public  
52 policy. The principle is to bring participants revealing their real choices by using incentive-  
53 compatible mechanisms (14). In nutrition, experimental economics has been used for *ex ante*  
54 evaluations of policies such as taxes and subsidies or nutritional labeling systems (15–18).  
55 Evaluating the impact of an intervention is a key step that has to be rigorous, feasible and  
56 controlled (19,20). However, when nutrition prevention interventions are evaluated, the  
57 methodology generally used exhibits limitations due to declarative and social desirability bias

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58 (21–23). To reduce such bias, the present study implemented a framed field experiment (24)  
59 to evaluate the impact of the intervention on food purchasing behavior.

60 The Opticourses project is multi-factorial, territorial and participative. It was implemented in  
61 disadvantaged neighborhoods in Marseille (France) with the aim of improving the nutritional  
62 quality of food purchases in populations with budgetary constraints (25,26). The project  
63 addressed both the supply side, through an in-store intervention (27), and the demand side,  
64 through a prevention program based on participatory workshops. By focusing on household  
65 food supply, a daily activity that everyone knows and feels able to handle, the Opticourses  
66 program is engaging and pragmatic, in accordance with the principles of health promotion  
67 (28). The objective of the current study was to describe the co-construction of the Opticourses  
68 program with participants in deprived social situations and the evaluation of its impact on the  
69 nutritional quality and cost of household food purchases, using experimental economics.

## 70 **Methods**

### 71 **Population characteristics**

72 Recruitment of socio-economically disadvantaged individuals was carried out in community  
73 centers ( $n=9$ ) and health & care centers ( $n=2$ ) whose staff showed interest in the intervention  
74 and motivation to be involved. All were located in socio-economically deprived districts of  
75 Marseille, France. The participants volunteered to take part in an intervention that included a  
76 set of five two-hour workshops on “Diet and Budget”. Inclusion criteria were: voluntary  
77 consent to participate in the study, residence in a socio-economically deprived district of  
78 Marseille (13th, 14th or 15th district), involvement in household food purchases, and financial  
79 difficulties as assessed by social workers. All the participants gave their written informed  
80 consent to participate in the study. No institutional review board approval was required for  
81 this research, as stated by the Comité de Protection des Personnes Sud-Méditerranée, which

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82 reviewed the protocol of the Opticourses intervention. This trial was registered at  
83 [clinicaltrials.gov](http://clinicaltrials.gov) as NCT02383875.

#### 84 **Co-construction of protocol and tools**

85 To maximize its effectiveness, the intervention was designed on the basis of the principles of  
86 co-construction and participative research. Participants were involved in the elaboration of the  
87 intervention, in order to implement a non-binding, playful intervention tailored to the target  
88 population. This co-construction approach integrates the principles of health promotion (28)  
89 and social cognitive theory (29). It was applied to develop the protocol, and the tools of the  
90 intervention and evaluation process. The intervention tools were developed through an  
91 iterative process (**Figure 1**): initial proposition of a tool by the research team, based on  
92 operational objectives, participants' expectations expressed in early workshops, estimated  
93 feasibility and cost; design of a first version by the research team; testing of the first version  
94 by the participants during the workshops and collection of information, both qualitative  
95 (understanding, participants' opinion, time of use) and quantitative (test answers, consistency  
96 of results); development of improved versions that were re-tested; validation and finalization.  
97 Different versions of the intervention protocol were also tested in the co-construction stage.  
98 The standardized tools and protocol were then used in the intervention stage.

#### 99 **Intervention**

100 The Opticourses workshops aimed at guiding the participants toward household food  
101 purchases of good nutritional quality at no additional cost, building on better knowledge of  
102 food groups and nutritional quality of foods, awareness of foods combining good nutritional  
103 quality with a "fair price", knowledge and know-how sharing among participants (discussions  
104 on "tips and tricks", beliefs about food, recipes, etc.), collection of all the household food  
105 supply over a month (26), and advice based on the analysis of actual participants' food  
106 purchase practices.

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107 The standardized protocol resulting from the co-construction stage took the form of five two-  
108 hour workshops held every two weeks, except for the last workshop, mainly dedicated to  
109 evaluation, held one month after the fourth workshop. Workshops were group sessions (6–12  
110 participants) organized in the community or health & care centers, and led by a professional  
111 in health promotion and nutrition and dietetics. An assistant took charge of data collection and  
112 helped in conducting the workshops. The workshops were built on real food purchases,  
113 including participants' household purchase receipts they collected over a month. Complete  
114 information on the Opticourses program content was provided during the first workshop, so  
115 that individuals not interested could decide to not attend the subsequent workshops. The main  
116 activities set during workshops were: discussions about food purchase strategies; information  
117 on the characteristics of food groups using a food group categorization game; information on  
118 the nutritional quality of foods using a game where food was classified into four nutritional  
119 quality classes based on the SAIN,LIM nutrient profile system (30); overview of the notion of  
120 nutritional quality for price (NQP) based on a list of foods with both good nutritional quality  
121 and a low price within each food group, and the “fair price booklet” tool (31) (tool providing  
122 a list of foods with good nutritional quality and the price below which the product could be  
123 considered as relatively inexpensive); analysis of real food purchases by the participants using  
124 a game consisting in classifying food expenditure by food groups; working on beliefs about  
125 food using a tasting game (participants blindly compared the taste of commonly consumed  
126 foods of equivalent nutritional quality but of different prices and brands). During the fourth  
127 workshop, after an analysis of monthly household food receipts, the research team gave  
128 individual feedback to participants on the nutritional quality of their food purchases and the  
129 contribution of each food group to total food expenditure, and offered advice on how to  
130 improve the nutritional quality of their food purchases at no additional cost.

### 131 **Quantitative evaluation**



132 ***Evaluating the impact of the intervention on knowledge***

133 Two tools were developed to evaluate the impact of the intervention on knowledge: the “food  
134 group test” and “NQP test”. Both tests were taken voluntarily by the participants, before and  
135 after the intervention. In the “food group test”, the participants were asked to assign a color  
136 code (e.g., green for fruit and vegetables, blue for dairy products, etc.) to 14 foods pictures. In  
137 the “NQP test”, 10 pairs of foods were presented to the participants, each pair made up of  
138 foods differing in their NQP. Each pair was composed either of similar foods with a similar  
139 price but different nutritional content (e.g. whole-grain sliced bread at 1.75€ per kg vs. white  
140 sliced bread at 1.73€ per kg), or foods belonging to the same food group, with similar prices  
141 and different nutritional quality (e.g. canned chickpeas at 1.62€ per kg vs. frozen fried  
142 potatoes at 1.64€ per kg), or foods with similar nutritional quality but different prices (e.g.,  
143 two types of potato flakes at 3.90 € per kg (National brand) or 1.78 € per kg (Discount  
144 version)), or two different foods (i.e., of different nutritional quality) but consumed similarly  
145 during meals (e.g. sweet flan at 2.60€ per kg vs. fruit compote at 2.75€ per kg). Participants  
146 were instructed to pick the food in each pair they would advise a friend to buy when he/she  
147 wants to balance his/her food purchases with a limited budget. For both tests, a global score  
148 was computed as the total points obtained from correct answers (wrong or non-responses were  
149 ignored).

150 ***Evaluating the impact of the intervention on food purchasing behavior using***  
151 ***experimental economics***

152 A catalogue of 300 food items (<http://www.opticourses.fr/node/24>) was specifically  
153 developed for the study, based on prices and pictures of foods collected a few months before  
154 the intervention from a supermarket located in the participants’ neighborhood. Each page  
155 displayed pictures of food front packages, unit prices (€) and prices per kilo, as done in  
156 supermarket advertising catalogues. Use of the same catalogue ensured that participants were

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157 faced with the same supply and diversity of foods throughout the study. Foods were grouped  
158 in the catalogue according to a retail-based categorization (22 categories, **Supplemental**  
159 **Table 1**). The participants' task consisted in selecting foods for the next two days for their  
160 household, based on food items featured in the catalogue. This selection constituted a food  
161 purchase intent. Just as when doing their regular shopping, participants were free to choose  
162 the nature and amount of food they wanted to select. To avoid potential bias related to the  
163 declarative nature of these purchase intents, the task was made incentive-compatible, by  
164 informing participants that they could earn a 10€ coupon if their next food purchases in a real  
165 store reflected their purchase intent during the experiment. They were thus prompted to shop  
166 in the experiment as they would in a real food store. At the following workshop, shopping  
167 receipts of real food purchases brought by participants were confronted with their  
168 experimental food purchases. To get the coupon, the shopping receipts had to feature at least  
169 six items corresponding to the experimental purchase intents. The objective of this incentive  
170 was to assess true changes in food purchase behaviors by limiting the effects of social  
171 desirability, i.e. when participants direct their choices to please or impress the workshop  
172 facilitator. Workshop participants (intervention group) took part in two experimental sessions  
173 (at the first and last workshops), and the changes in their experimental purchases were  
174 compared between baseline and endline. In addition, to assess if having already performed the  
175 test affects the experimental purchases of the subsequent session, a control group composed  
176 of 23 persons recruited in the same community centers, but who did not participate in the  
177 workshops, also took part in two experimental sessions of food purchase intents at three-week  
178 intervals (baseline and endline), based on the same instructions and protocol than workshop  
179 participants i.e. using the catalogue and incentive with coupon.

180 Our hypothesis was that workshops could help improving the balance of food purchases, and  
181 consequently their nutrient content, with no additional cost. Thus, the nutritional

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182 characteristics of the experimental purchases were assessed both at the food group and  
183 nutrient levels. For that purpose, each food in the catalogue was associated with a nutritional  
184 composition for 100g of food as consumed, based on the French CIQUAL database (Centre  
185 d'Information sur la Qualité des Aliments, <https://pro.anses.fr/tableciqual/index.htm>) that  
186 states the nutritional composition and edible portion of French food products. Total weight  
187 (grams per day per person) and total energy content (kcal per day per person) were estimated  
188 for each experimental purchase by summing the weight (as consumed) and energy content of  
189 all the foods and drinks selected, and dividing it by the number of household members and  
190 days for which purchases were planned. In addition to the classification into 22 categories  
191 relevant to the retail environment, as mentioned previously, all foods in the catalogue were  
192 classified into 8 groups (Starch, Fruit and Vegetables, Meat-Fish-Eggs, Dairy products, Fats,  
193 Foods high in fat/salt/sugar (HFSS), Mixed dishes, and Juices and soft drinks) derived from  
194 the French National Nutrition and Health Program (32). Contribution of these 8 food groups  
195 to total food purchases was estimated in weight and energy. Water was excluded from all the  
196 analyses since it was mainly tap water.

197 The Mean Adequacy Ratio (MAR) and the Solid Energy Density (SED) were used to assess  
198 the nutritional quality of the experimental food purchases, as previously described by Vieux *et*  
199 *al.* (33). In addition, three nutrients to be limited were also assessed, namely sodium, saturated  
200 fatty acids (SFAs) and free sugars. The nutritional quality assessment methodology is fully  
201 described in Supplemental File.

202 Based on experimental food purchases selected by the participants and food prices from the  
203 catalogue, the total expenditure (€/pers\*d) and energy cost (€ per 2000kcal) were estimated  
204 for each experimental food purchase.

## 205 **Qualitative evaluation**

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206 How the participants perceived the impact of the workshops on their food purchases was  
207 assessed by a qualitative evaluation. Individual semi-directed interviews and one group  
208 interview were conducted by an external evaluator one month after the intervention, using an  
209 interview grid including questions about modification of food purchases. These interviews  
210 were proposed to participants coming from the different community or health centers,  
211 yielding a sub-sample of 19 interviews. Interviews were recorded using field notes and  
212 transcribed. Interview transcriptions were analyzed using conventional content analysis (34)  
213 and categorized thematically.

#### 214 **Statistical analysis**

215 Descriptive and statistical analyses were performed using the SAS 9.4 software. Socio-  
216 demographic characteristics were compared (a) between workshop participants who  
217 performed the experimental economics quantitative evaluation (evaluated intervention group)  
218 vs. those who did not (non-evaluated intervention group), and (b) between intervention vs.  
219 control groups using the non-parametric chi-squared test for qualitative variables and the  
220 Mann-Whitney test for continuous variables. Within the evaluated intervention group, the  
221 scores of the 'Food group' and 'NQP' tests, and the nutritional characteristics and food  
222 composition of the experimental purchases were compared between baseline and endline (i.e.  
223 before vs. after the intervention) using a paired *t*-test and a generalized linear mixed model for  
224 repeated measures (with a compound symmetry covariance matrix) for adjustment on age,  
225 gender, the financial situation, number of individuals in the household and number of  
226 children. Within the control group, the nutritional characteristics and food composition of  
227 experimental food purchases were compared between the first and second session of  
228 experimental food purchases (i.e., baseline vs. endline) using paired *t*-tests as well with a  
229 generalized linear mixed model for repeated measures for adjustment on age, gender, the  
230 financial situation, number of individuals. Effect sizes for dependent groups (Cohen's *d* (35))

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231 were computed for significant variables. The significance level was set at 5% ( $p < 0.05$ ) for  
232 all the tests.

## 233 **Results**

### 234 **Characteristics of the population**

235 In all, 96 persons (9 groups, 8 centers) participated in the co-construction stage (September  
236 2012–April 2013). Then, 93 persons (14 groups, 7 centers) took part in the intervention stage,  
237 with intervention in site 1 starting in April 2013 and intervention in site 7 ending in June  
238 2014. Thirty-five persons took part in the evaluation of knowledge and in the food purchase  
239 experiment, i.e. 38% of the intervention participants; 23 other persons (3 sites) also took part  
240 in the food purchase experiments, but without participating in the workshops (control group)  
241 (**Supplemental Figure 1**). Socio-demographic characteristics were not significantly different  
242 between the workshop participants who completed the evaluation and those who did not  
243 (**Table 1**). Evaluated workshop participants were mainly women (77%), with a mean age of  
244 51y and a mean number of household members of 3.1, including 1.3 children; 44% declared  
245 severe financial difficulties (**Table 1**). Socio-demographic characteristics were not  
246 significantly different between evaluated workshops participants and the control group, except  
247 for age, which was significantly lower in the control group (45.4y vs. 50.9y,  $p=0.038$ ) (**Table**  
248 **1**). Participation rates in the five workshops varied (**Figure 2**): 94% of intervention  
249 participants attended the first workshop, and the participation rate then remained relatively  
250 stable (40–48%) over the following four workshops.

### 251 **Impact on knowledge**

252 Scores obtained in the “food group test” were significantly higher after the participative  
253 workshops than those obtained before the intervention ( $13.2 \pm 1.8$  and  $12.1 \pm 1.9$  respectively,  
254  $p<0.01$ ). Scores of the “NQP test” were not significantly different before and after the  
255 intervention ( $6.6 \pm 1.4$  and  $6.9 \pm 1.6$ , respectively,  $p=0.30$ ).

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256 **Impact on food purchasing behavior: experimental economics evaluation**

257 **Table 2** shows the nutritional characteristics and cost of experimental food purchases of  
258 workshops participants before and after the intervention. The energy content of the  
259 experimental food purchases significantly decreased by 38% after the participative workshops  
260 (5114 vs. 3385 kcal per person per day,  $p<0.01$  for both crude and adjusted p-values), as did  
261 the food expenditure (9.73 vs 7.22 € per person per day,  $p<0.01$  for both crude and adjusted p-  
262 values). However, energy cost remained unchanged. The SED decreased from 128 kcal/100g  
263 to 119 kcal/100g after the intervention (crude  $p<0.04$ ), i.e. a reduction of 7.6%, but the  
264 significance was lost after adjustment. The MAR did not change significantly. The energy  
265 contribution of free sugars decreased significantly from 8.5% to 5.8% ( $p<0.01$  for both crude  
266 and adjusted p-values), while that of SFA and sodium content expressed for 2000kcal  
267 remained similar. The contribution of food groups to the total energy of the experimental  
268 purchases was significantly different at baseline and endline (**Table 2**). Percent energy from  
269 the HFSS group was halved (from 11.0 to 5.5%,  $p<0.01$  for both crude and adjusted p-values).  
270 In parallel, a decrease occurred in the energy contribution from fruit and vegetables (from  
271 10.1 to 13.6% of total energy, crude  $p=0.03$ ) and from meat-fish-eggs (from 15.8 to 21.1% of  
272 total energy, crude  $p=0.02$ ), but the statistical significances of those changes were lost after  
273 adjustment (adjusted  $p=0.06$  for both food groups). Based on the classification proposed by  
274 Cohen (36), the calculated effect sizes (d) were medium for energy content (d=0.5) and the  
275 energy contributions from proteins (d=0.6), free sugars (d=0.5), meat-fish-eggs (d=0.5) and  
276 HFSS (d=0.5). Effect sizes were small for the food expenditure (d=0.4), the SED (d=0.3) and  
277 the energy contribution from fruits and vegetables (d=0.4) (**Table 2**).  
278 In the control group, none of the characteristics of experimental food purchases were  
279 significantly different between the two sessions (all  $p>0.05$ , **Table 3**). In particular, the mean

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280 energy contents were 4523 and 4711 kcal/pers\*d at baseline and endline respectively  
281 ( $p=0.71$ ).

## 282 **Qualitative evaluation**

283 The analysis of participants' declarations highlighted their improved knowledge about the  
284 nutritional quality of foods (e.g., the difference in nutritional quality between potatoes and  
285 vegetables, and between sweet dairy desserts and yogurts), and their awareness of the share of  
286 their food budget allocated to the different food groups. Fifteen out of the 19 participants  
287 interviewed 1 month after the intervention gave concrete examples indicating how they had  
288 modified their food purchase behavior. The analysis of participants' declarations identified  
289 three types of modification: changes in the type of foods purchased, changes in purchasing  
290 attitudes and strategies, and changes in culinary practices. Among changes in the type of  
291 foods purchased, soft drinks were the most frequently cited. One person in three declared they  
292 had reduced or even stopped their purchases of sodas and/or replaced their purchases of fruit  
293 'nectars' (i.e. sugared fruit juices) by fruit juices. Other modifications of foods purchased  
294 were expressed in terms of quantity (e.g. increased legumes or fruits and vegetables  
295 purchases) and quality (e.g. substitution of white bread by whole-grain bread). The changes in  
296 purchasing attitudes and strategies included more attention paid to labeled information  
297 (product composition and price per kilo), changes and/or diversification of purchasing points,  
298 improved opinion of cheaper brand products, retrieval and purchases of these products, and  
299 better control of food budget. The changes in culinary practices included cooking oneself, or  
300 cooking differently (e.g., less fat, more vegetables). The following synthesis of transcripts  
301 illustrates the different modifications to food purchase behaviors:

302 *“Now, after shopping for food, I still keep the receipts. They help me check if I've managed*  
303 *my budget well. I look at the price per kilo of foods and don't get confused with orange juices*  
304 *anymore (sugar and fruit). I've bought canned fish, and several times I've prepared some*

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305 *lovely dishes with raw vegetables and sardines. When I'm cooking starches, I add some fresh*  
306 *vegetables. I shared the tips and tricks with my friends who by the way have noticed that I've*  
307 *changed the way I cook.” (Female, 51y)*

308 *“I buy too much fat, I've cut back a bit. I buy more fruit and vegetables, it doesn't get too*  
309 *expensive for me, I do my shopping at Noailles [very popular market in the center of the*  
310 *town]. I already used to, but I wasn't buying much fruit and legumes. I also buy more legumes*  
311 *(red beans and lentils). I used to shop at Dia or Simply markets and now I go to Carrefour,*  
312 *the other participants told me it's less expensive and it's true. I pay more attention to labels*  
313 *and especially the price per kilo” (Female, 46y).*

314 *“I buy cheaper brand products, before I never did because I thought they were poorer quality.*  
315 *I know how to tell the real juices from the ones with only sugar: I buy the real ones and I*  
316 *don't buy sodas anymore. I buy whole-grain bread instead of white bread. For minced meat, I*  
317 *look and I take no more than 12% fat, 5% I can't, it's too expensive. I've changed many*  
318 *things, I spend 330€ (per month) instead of 360€ before, so it's a bit cheaper and I'm*  
319 *purchasing better things. I use more different oils, I like canola oil, I blend them. I also try to*  
320 *add less salt. I used to buy a lot of sweet products. I buy a bit more fish, beef and chicken and*  
321 *less pork. I diversify shops a bit (Aldi, Leader Price) but I don't have a car, it's not easy.”*  
322 *(Female, 51y)*

323 Participants were able to analyze their own food purchases and identify ways to improve  
324 them, as supported by several transcripts: *“I realized the burden of sweet products in my food*  
325 *budget” (group interview); “For me it's easy since I save money and it's a true motivation”*  
326 *(Female, 59y); “Now I look at what I purchase, I used not to necessarily” (group interview);*  
327 *“I look differently when I do my shopping” (Female, 42y); “I look at labels more carefully,*  
328 *especially the price per kilo.”(Female, 53y).*

## 329 **Discussion**



330 The present study shows that co-constructed participative workshops based on recreational-  
331 entertaining activities around food purchase practices and nutritional quality and price of  
332 foods can favorably change food purchasing behaviors of individuals in deprived social  
333 situations without significantly increasing their food expenditure. Interviews revealed three  
334 types of change in purchasing behaviors: changes in the type of foods purchased, changes in  
335 purchasing attitudes and strategies (attention paid to label information, purchasing points, and  
336 opinion on cheaper brand products), and changes in culinary practices. Quantitative  
337 evaluation of the intervention was performed on food purchase intents using experimental  
338 economics to limit social desirability bias. Unlike controls, workshop participants decreased  
339 the total energy of their experimental food purchases (toward more realistic energy levels),  
340 suggesting a better ability to assess the needs of their households for 2 days and adapt  
341 purchases accordingly. The evaluation also showed that the intervention improved food  
342 purchasing behaviors, as indicated by decreased energy contribution from free sugars and  
343 from products high in fat, salt, and sugar, and nearly significant increased energy contribution  
344 from fruit and vegetables (adjusted p-value=0.06) at the endline in the intervention group  
345 only, and at no additional cost.

346 Similar reduction in the total number of calories purchased were previously observed in low-  
347 income families in the US who received home-based nutrition education sessions (37). To our  
348 knowledge, most individual-directed interventions to promote healthy eating are based on  
349 activities around food consumption or cooking skills (38–40). Yet, changing food  
350 consumption behavior implies changing food purchasing behavior. An originality and asset of  
351 the present study was to use food purchases and prices as an entry point to address the  
352 question of healthy diet with individuals in deprived social situations. Implementing  
353 workshops on food purchases □ a major daily, tangible concern for this population – rather

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354 than on food intake can induce a stronger motivation of the participants, which is a success  
355 factor for interventions in health education (6).

356 Many population-directed policies designed to improve the nutritional quality of food  
357 purchase rely on enhancing access to information (41). The underlying assumption is that  
358 people act rationally when making food choices. In economics jargon, rationality means that  
359 consumers maximize their lifetime happiness when they allocate their scarce resources of  
360 time and money (42). Nonetheless, various studies have shown that the provision of  
361 nutritional information has moderate effects (41,43–46). The main reason may be that  
362 consumers do not behave as *Econ* (47). For instance, consumers have a limited capacity to  
363 process information and may even be distracted when provided with additional information  
364 (48). In that respect, the Opticourses workshops focused on tacit knowledge (*know-how*)  
365 rather than explicit knowledge (*know-what*). With tips & tricks on food purchasing (fair price  
366 booklet, real purchase analyses), the intervention provided participants with practical  
367 knowledge on how to build healthy diets. By doing so, the Opticourses workshops provide  
368 participants with the necessary tools for fast and frugal food decision making, allowing the  
369 construction of healthier diets despite bounded rationality (49).

370 Different reports and studies explored the levers for effective interventions on diet, in  
371 particular for socioeconomically disadvantaged populations (6,7,20,38–40,50,51). A WHO  
372 report assessing the evidence on effective interventions on diet and physical activity (7)  
373 underlined that multi-component interventions adapted to the local context and involving  
374 participants in the planning and implementation stages were found to be the most successful.  
375 Co-construction was a key component of the present study to engage participants, with a  
376 specific attention given to the format of the intervention to be both playful, with multiple,  
377 diversified activities, and with reachable goals. Empowerment is known to be a success factor  
378 in health promotion in the field of nutrition (50). This is particularly true for vulnerable

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379 populations, who are more prone to low self-esteem (20). The present workshops enabled  
380 participants to appropriate tools and knowledge to act favorably on their purchases, thus  
381 enhancing auto-efficacy and self-esteem. Moreover, conducting the intervention in the form  
382 of group workshops has been identified as a key lever to improve the effectiveness of  
383 interventions promoting nutrition and physical activity among socioeconomically  
384 disadvantaged populations (51).

385 Interventions promoting healthy eating are generally evaluated through self-reported and so  
386 potentially biased dietary intakes or behaviors (40,52). The experimental economics approach  
387 has already been used in public health and nutrition to assess food tax (15) and labeling  
388 policies (17). To our knowledge, the present study is the first to implement this approach in an  
389 innovative way to evaluate the impact of a nutritional intervention in a real setting.  
390 Experimental economics limits social desirability bias, and so reveals true consumer  
391 preferences by using incentive mechanisms (53). Also, placing participants under controlled  
392 conditions, as close as possible to those of the real world, ensured that the observed changes  
393 in purchasing behavior were not influenced by modifications in the purchasing environment  
394 (diversity and price of food supply, purchasing points, etc.). In addition, the conditions of  
395 implementation of the evaluation method were tailored for a target population with potentially  
396 low literacy skills. While questionnaires could be perceived as demanding, normative and  
397 difficult to fill out, the food catalogue and instructions given placed the participants in a  
398 comfortable day-to-day activity that preserved their self-esteem. The main strength of this  
399 study is that it improved food purchasing behaviors despite the limited room for maneuver in  
400 terms of economical means. Participants had a low budget for food (previously estimated at  
401 3.65€/pers\*d (26)), very close to the lowest cost at which a nutritionally adequate diet can be  
402 achieved (~3.5€/pers\*d) as estimated by Darmon et al. (9), and very close to the cost of  
403 2000kcal of experimental food purchases in the present study. The beneficial changes in food

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404 purchasing behaviors could be explained by the anticipation and rationalization of food  
405 purchasing highlighted by the decrease in the total energy of experimental food purchases  
406 after the intervention. Workshop participants may have realized the importance of the act of  
407 purchase, and of purchasing foods rationally rather than automatically/routinely.

408 The present study has limitations. In the intervention stage, attrition rate was approximately  
409 50% after the first workshop. This was expected, because recruitment is known to be difficult  
410 in low-income populations (20,54). The high attrition rate may reflect a sensible economic  
411 decision about the time/benefit ratio of attending the workshops (42). However, the  
412 participation rate in the following workshops, once the participants had understood and agreed  
413 with the format and contents of the intervention, remained stable, which highlights the  
414 importance of providing complete information and engaging people during the first workshop.

415 Another limitation is that the quantitative evaluation was only performed by a sub-sample of  
416 intervention participants, was not randomized, and did not assess the long-term effect of the  
417 intervention. However, the participants who carried out the quantitative evaluation ( $n=35$ )  
418 were not significantly different in terms of socio-demographic characteristics from those who  
419 did not ( $n=58$ ), the specificity of the observed changes were tested with a control group  
420 ( $n=23$ ), and the sample sizes were sufficient to highlight significant differences between the  
421 control and intervention groups. In addition, the endline experimental food purchases of the  
422 control group were assessed after a shorter interval of time (3 weeks) than the intervention  
423 group (10 weeks). This may have introduced a bias in the design but allowed to limit the  
424 attrition rate that might have been higher in control after 10 weeks. Also, the evaluation tools  
425 were new and not quantitatively validated, but face validity was assessed by researchers and  
426 participants who evaluated whether the items were relevant to assess the measured concept,  
427 and acceptability and feasibility were tested with the co-construction group. Finally, the size  
428 of the effects was medium or small. However, moderate effects were expected since it is

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429 unlikely that an intervention on its own induces radical shifts in food purchase behaviors.  
430 These moderate effects can comfort the idea that social desirability bias was limited and that  
431 participants revealed true choices.  
432 The present study shows that co-constructed participative workshops, based on actual food  
433 purchase practices, can guide individuals in deprived social situations towards household food  
434 purchases of better nutritional quality without increasing their food expenditure. It shows  
435 relevance and feasibility of using experimental economics for evaluating the impact on food  
436 purchasing behavior of a public health nutrition intervention conducted in a real setting. The  
437 “game-like” aspect of the experimental economics approach enables participants to deliver  
438 unbiased evaluations, while preserving their self-esteem.  
439

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446 and BR designed the experimental economic assessment and were involved in the  
447 interpretation of the results. All authors critically reviewed the manuscript and approved the  
448 final version.

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592 **Tables**

## 593 Table 1. Population characteristics

594

	Co-construction (n=96)		Intervention (n=93)			Control (n=23)	
			Evaluated (n=35)	Non-evaluated (n=58)	<i>p</i> -value <sup>1</sup>		<i>p</i> -value <sup>2</sup>
<b>Age, y (n)</b>	48.4 ± 7.7 (67)		50.9 ± 11.2 (34)	47.0 ± 13.0 (27)	0.094	45.4 ± 9.6 (23)	0.038
<b>Number in household (n)</b>	3.7 ± 2.0 (62)		3.1 ± 1.8 (35)	2.3 ± 1.4 (25)	0.080	3.3 ± 1.6 (23)	0.186
<b>Number of children (n)</b>	2.0 ± 1.7 (59)		1.3 ± 1.5 (35)	1.2 ± 1.4 (22)	0.941	1.6 ± 1.3 (23)	0.135
<b>Women, % (n)</b>	80.0 (96)		77.1 (35)	70.7 (58)	0.496	91.3 (23)	0.163
<b>Financial situation, % (n)</b>		(48)		(17)		(23)	
Stable	12.5		11.8	17.7	0.770	13.0	0.932
Precarious	52.1		44.1	47.1		47.8	
Severe difficulties	35.4		44.1	35.3		39.1	

Results are mean ± SD or %, <sup>1</sup> from Chi-squared test of homogeneity for qualitative variables and Mann and Whitney test for continuous variables to test difference between participants who did vs. did not complete the evaluation; <sup>2</sup> from Chi-squared test of homogeneity for qualitative variables and Mann and Whitney test for continuous variables to test difference between evaluated intervention participants vs. controls.

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595 Table 2. Nutritional and cost characteristics of experimental food purchases of workshops  
596 participants ( $n=35$ ) before the intervention (baseline) and after it (endline).

597

	Baseline	Endline	$p$ -value <sup>1</sup>	Adjusted $p$ -value <sup>2</sup>	Effect size <sup>3</sup>
<b>Energy (kcal/pers*d)</b>	5114 ± 3883	3385 ± 2374	<0.01	<0.01	0.5
<b>Expenditure (€/pers*d)</b>	9.73 ± 7.10	7.22 ± 4.78	<0.01	<0.01	0.4
<b>Energy cost (€/2000kcal)</b>	3.03 ± 1.45	3.44 ± 2.00	0.30	0.36	
<b>SED (kcal/100g)</b>	128.4 ± 25.5	118.7 ± 30.1	0.04	0.10	0.3
<b>MAR (% adequacy/2000 kcal)</b>	81.3 ± 8.5	82.1 ± 7.4	0.56	0.42	
<b>Proteins (% of total energy)</b>	18.7 ± 4.3	21.5 ± 5.6	<0.01	0.02	0.6
<b>Carbohydrates (% of total energy)</b>	52.7 ± 9.7	49.7 ± 10.7	0.11	0.08	
<b>Free sugars (% of total energy)</b>	8.5 ± 6.0	5.8 ± 6.1	<0.01	<0.01	0.5
<b>Fats (% of total energy)</b>	25.5 ± 7.1	25.4 ± 8.1	0.94	0.65	
<b>SFA (% of total energy)</b>	10.7 ± 3.9	10.6 ± 4.2	0.95	0.72	
<b>Sodium (mg/2000 kcal)</b>	2038 ± 430	2182 ± 754	0.20	0.13	

Food group	Baseline	Endline	$p$ -value <sup>1</sup>	Adjusted $p$ -value <sup>2</sup>	Effect size <sup>3</sup>
<b>Fruits and Vegetables (% of total energy)</b>	10.1 ± 5.8	13.6 ± 10.0	0.03	0.06	0.4
<b>Starch (% of total energy)</b>	43.4 ± 19.7	40.8 ± 19.0	0.44	0.47	
<b>Meat Fish Eggs (% of total energy)</b>	15.8 ± 9.1	20.1 ± 9.6	0.02	0.06	0.5
<b>Mixed dishes (% of total energy)</b>	1.9 ± 3.3	2.6 ± 4.8	0.29	0.13	
<b>Dairy products (% of total energy)</b>	12.3 ± 7.7	13.2 ± 9.2	0.56	0.43	
<b>HFSS (% of total energy)</b>	11.0 ± 12.0	5.5 ± 11.0	<.01	0.01	0.5
<b>Drinks (% of total energy)</b>	3.9 ± 3.8	2.9 ± 4.1	0.11	0.15	
<b>Fats (% of total energy)</b>	1.6 ± 2.3	1.3 ± 2.5	0.55	0.63	

598 Results are mean ± SD or %; <sup>1</sup> from paired  $t$ -test; <sup>2</sup> from mixed model adjusted for age, gender,  
599 financial situation, number in household, number of children; <sup>3</sup> Calculation of effect size  
600 (Cohen's  $d$ ) for dependent sample was described elsewhere (35)

601 HFSS: Foods high in fat, sugar, salt; MAR: Mean adequacy ratio; SED: Solid energy density;

602 SFA: Saturated fatty acids

603

604

605 Table 3. Nutritional and cost characteristics of experimental food purchases of the control  
 606 group ( $n=23$ ) during the first session (baseline) and the second session (endline)  
 607

	Baseline	Endline	$p$ -value <sup>1</sup>	Adjusted $p$ -value <sup>2</sup>
<b>Energy (kcal/pers*d)</b>	4523 ± 2924	4711 ± 2747	0.71	0.63
<b>Expenditure (€/pers*d)</b>	8.75 ± 5.13	8.84 ± 4.43	0.90	0.94
<b>Energy cost (€/2000kcal)</b>	3.17 ± 1.38	3.06 ± 1.36	0.77	0.71
<b>SED (kcal/100g)</b>	136.8 ± 23.9	136.3 ± 020.3	0.91	0.90
<b>MAR (% adequacy/2000kcal)</b>	80.2 ± 07.2	80.9 ± 06.2	0.56	0.77
<b>Proteins (% energy)</b>	17.1 ± 04.8	17.5 ± 03.2	0.61	0.91
<b>Carbohydrates (%energy)</b>	49.9 ± 08.0	50.6 ± 07.4	0.74	0.56
<b>Fats (% energy)</b>	30.2 ± 05.8	29.2 ± 05.9	0.55	0.61
<b>Free sugars (% energy)</b>	11.4 ± 04.5	11.7 ± 05.1	0.79	0.74
<b>SFA (% energy)</b>	13.6 ± 03.6	12.9 ± 02.9	0.43	0.79
<b>Sodium (mg/2000kcal)</b>	1976 ± 0460	1887 ± 0310	0.23	0.55

Food group	Baseline	Endline	$p$ -value <sup>1</sup>	Adjusted $p$ -value <sup>2</sup>
<b>Fruits and Vegetables (% of total energy)</b>	8.7 ± 6.0	8.0 ± 5.3	0.39	0.39
<b>Starch (% of total energy)</b>	34.3 ± 10.4	35.2 ± 13.5	0.82	0.82
<b>Meat Fish Eggs (% of total energy)</b>	11.4 ± 07.7	12.2 ± 07.2	0.51	0.51
<b>Mixed dishes (% of total energy)</b>	3.3 ± 3.5	3.4 ± 3.0	0.93	0.93
<b>Dairy products (% of total energy)</b>	15.3 ± 05.1	16.3 ± 05.0	0.52	0.52
<b>HFSS (% of total energy)</b>	18.4 ± 08.7	17.0 ± 11.2	0.56	0.56
<b>Drinks (% of total energy)</b>	5.7 ± 3.1	5.6 ± 3.6	0.79	0.79
<b>Fats (% of total energy)</b>	2.9 ± 2.5	2.4 ± 2.4	0.44	0.44

608 Results are mean ± SD or %; <sup>1</sup> from paired  $t$ -test; <sup>2</sup> from mixed model adjusted for age, gender,  
 609 financial situation, number in household, number of children  
 610 HFSS: Foods high in fat, sugar, salt; MAR: Mean adequacy ratio; SED: Solid energy density;  
 611 SFA: Saturated fatty acids  
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615 **Figure legends**

616 Figure 1. Principles of the co-construction approach

617 Figure 2. Participation rate at each workshop during the intervention stage (n=93)

618



619 **Online Supporting Material**

620 **Supplemental Table 1: Food categorization of the experimental purchase catalogue**

Food categories

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Fruits and Vegetables

Canned vegetables

Legumes

Frozen vegetables

Breads

Meat

Processed meat

Fish

Prepared dishes

Mashed and fried potatoes

Rice, pasta, semolina

Sauces

Eggs and Cream

Cheese

White cheese

Yogurts and milk

Desserts

Chocolate and sweets

Biscuits

Pastries

Salted snacks

Juices and Drinks

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621

622 **Supplemental method: Nutritional quality of food purchases**

623 The MAR was used as an indicator of nutritional quality, as previously described by Vieux *et*

624 *al.* (1), to evaluate if the workshops helped improve the nutritional content of food purchases

625 for a whole set of nutrients. The MAR, expressed for 2000 kcal, was calculated as the mean

626 percentage of daily recommended intakes for 23 key nutrients (proteins, fiber, Ca, K, Fe, Mg,

627 Zn, Cu, I, Se, DHA, ALA, LA and vitamins A, C, D, E, B1, B2, B3, B6, B9 and B12), as

628 follows:

$$MAR/2000 \text{ kcal} = \frac{1}{23} \sum_{bn=1}^{23} \frac{Q_{bn}}{RDA_{bn}} \times 100$$

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629 where  $Q_{bn}$  is the quantity of each beneficial nutrient ( $bn$ ) adjusted to a total energy of 2000  
630 kcal, and  $RDA_{bn}$  is the corresponding Recommended Dietary Allowance (RDA) for this  
631 nutrient. The age and gender being known for the study participants but not for each member  
632 of their households, the average value of the RDA for adult men and women has been used.  
633 The reference values for the 23 recommended nutrients are given in **Supplemental Table 2**.  
634 The contribution from each nutrient was capped at 100% so that a high intake of one nutrient  
635 could not compensate for the low intake of another (1). The SED, calculated as the ratio  
636 between total energy and total weight and expressed in kcal/100g was also used as an  
637 indicator of nutritional quality. As proposed by Ledikwe *et al.* (2), only items typically  
638 consumed as foods, including soups, were included in the calculation of SED, whereas foods  
639 typically consumed as beverages, such as milk, juices, and other drinks, were excluded. Three  
640 nutrients to be limited were also assessed, namely sodium (expressed in mg/d\*pers and  
641 mg/2000kcal), saturated fatty acids (SFAs) and free sugars, both expressed in percentage of  
642 total energy. The term “free sugars” refers to added sugars plus sugars naturally present in  
643 honey, syrups, and fruit juices (3). The free sugar content of each food item had previously  
644 been added to the CIQUAL database (4).

645

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647 **Supplemental Table 2.** Reference values for the 23 recommended nutrients used in the  
648 calculation of the Mean Adequacy Ratio

<b>Nutrient</b>	<b>Reference value<sup>1</sup></b>
Proteins (g/d)	60
DHA (mg/d)	0.11
Fiber (g/d)	30
Linolenic acid (g/d)	1.8
Linoleic acid (g/d)	9
Vitamin A (mcg/d)	700
Vitamin B6 (mg/d)	1.7
Vitamin D (mcg/d)	5
Thiamin (mg/d)	1.2
Riboflavin (mg/d)	1.6
Niacin (mg/d)	13
Folates (mcg/d)	315
Vitamin B12 (mcg/d)	2.4
Vitamin C (mg/d)	110
Vitamin E (mg/d)	12
Calcium (mg/d)	900
Potassium, (mg/d)	3100
Magnesium, (mg/d)	390
Iodine (mg/d)	150
Selenium (mcg/d)	55
Copper (mg/d)	1.8
Zinc (mg/d)	11
Iron (mg/d)	13

<sup>1</sup> Mean of the recommended dietary allowances for men and women (5)

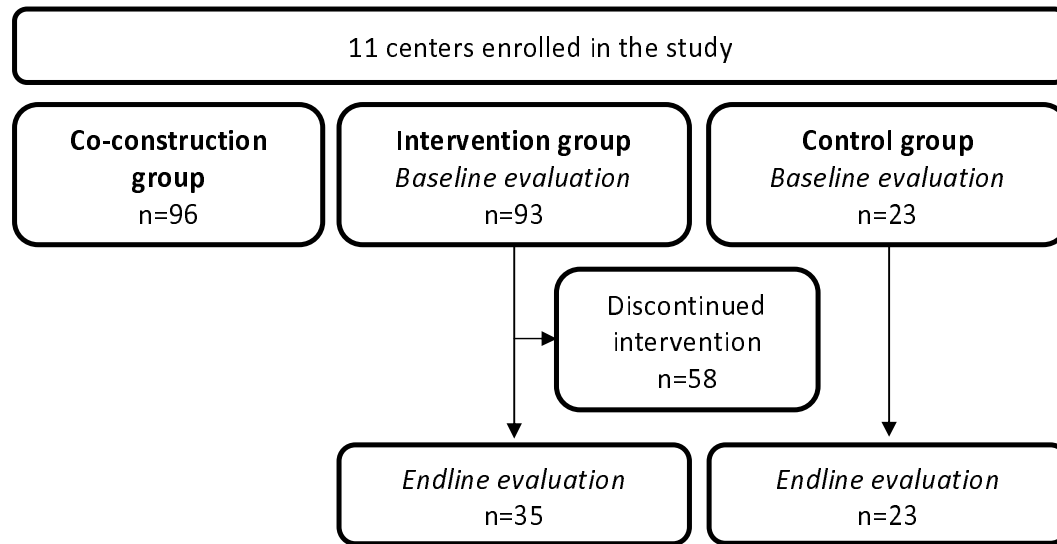
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651 **Supplemental Figure 1:** Flow chart of the study



652

653 **Supplemental References**

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Figure 1.

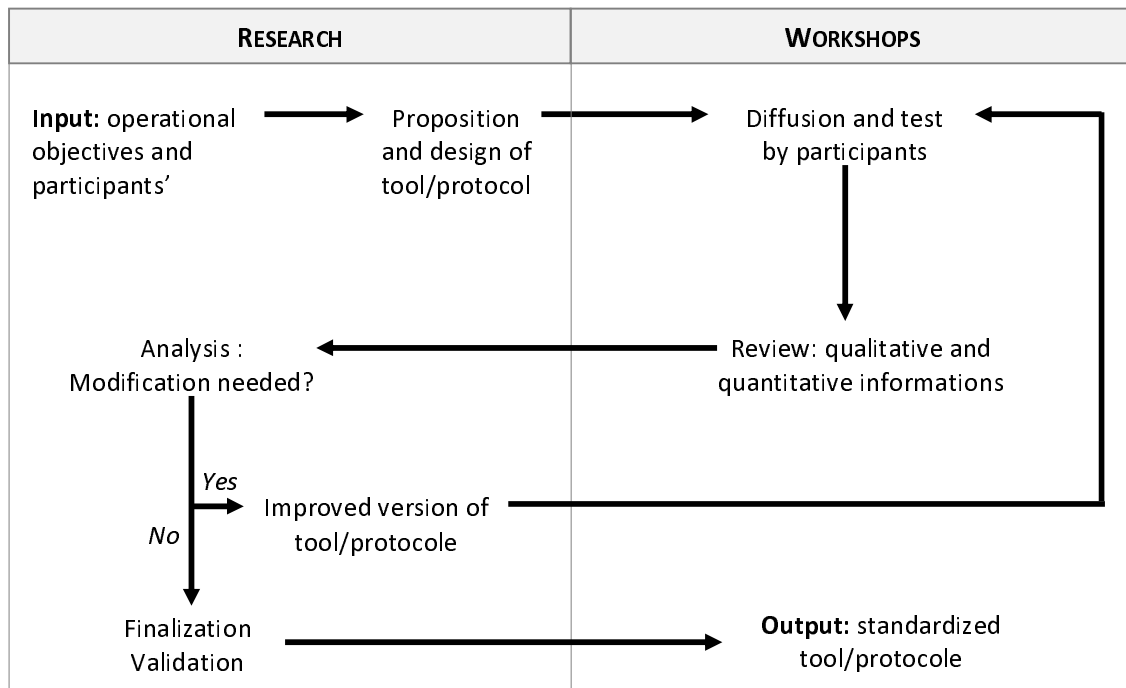


Figure 2.

