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# Impact of the Nutri-Score front-of-pack nutrition label on purchasing intentions of individuals with chronic diseases: results of a randomized trial

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## ABSTRACT

**Objective** : The effect of front-of-pack nutrition labels such as the Nutri-Score on food purchases has never been assessed among individuals suffering from nutrition-related chronic diseases specifically, while dietary modifications are generally part of their care. This study aimed to investigate the effect of the Nutri-Score on the nutritional quality of purchasing intentions among adults suffering from a cardiometabolic disease, compared to no label and the Reference Intakes (RIs), a label already implemented by some food manufacturers in France.

**Setting:** Secondary prevention – mainland France

**Participants :** 2,431 eligible participants were randomly assigned and 1,180 participants (65.5% women, mean age 65.0±7.1 years) completed the shopping task and were included in the analyses.

**Intervention:** A three-arm randomized controlled trial using an experimental online supermarket was conducted in 2017. Participants with cardiometabolic diseases were invited to simulate food purchases with the Nutri-Score, or with the RIs or no label.

**Primary and secondary outcome measures :** The primary outcome was the nutritional quality of the shopping cart, estimated using the French-modified Food Standard Agency Nutrient Profiling System (FSAm-NPS), and secondary outcomes included the nutrient content of purchases.

**Results:** The mean (SD) FSAm-NPS score was significantly lower in the Nutri-Score arm (1.29(3.61) points), reflecting a higher overall nutritional quality of purchases, compared to the RIs (1.86(3.23) points) and no label (1.92(2.90) points) arms (p-value=0.01). Moreover, the Nutri-Score led to significantly lower content in calories and saturated fatty acids compared to the two other arms.

**Conclusions:** The Nutri-Score appears to encourage healthier food choices among individuals suffering from cardiometabolic chronic diseases, for which an improvement of the dietary quality is often part of the treatment.

**Trial registration** : NCT02769455

## Article summary

Strengths and limitations of this study

- Inclusion of a rarely explored population in a randomized controlled trial pertaining to the effectiveness of front-of-package labelling on food choices
- This controlled experimental environment allowed assessing the effect of the Nutri-Score in standardized conditions and optimizing internal validity of the study.
- Limitation pertaining to a high rate of participants who did not complete the shopping task.
- The trial investigated purchasing intentions rather than actual food purchases.

**Keywords:** Front-of-pack nutrition label; cardiometabolic diseases; Food purchases; Nutritional quality; Experimental online supermarket

## INTRODUCTION

Non-Communicable Diseases (NCDs), such as obesity, type 2 diabetes, cardiovascular diseases and cancer have become a major burden for the current health systems.[1] For these diseases, dietary factors have been recognized to be one of the major leading risk factors in developed countries, resulting in 11 million deaths worldwide in 2017, and represent modifiable determinants through primary prevention.[2] In France, cardiovascular diseases remain the second leading cause of deaths by NCDs, accounting for 30% approximately of mortality.[3] Regarding obesity, the prevalence was estimated at 17% within the French adult population in 2015,[4] and the prevalence of type 2 diabetes was around 5% in 2016.[5]

Hence, in the context of secondary or tertiary prevention, many treatment guidelines highlight the importance to modify dietary habits to improve the nutritional status of individuals and thus control these nutrition-related NCDs.[1] For example, controlling for Saturated Fatty Acids (SFA), sugars and salt intakes and increasing fruits and vegetables, pulses, and fibres consumption are encouraged in the management of several NCDs or risk factors such as obesity, arterial hypertension and diabetes.[1] Nutritional labelling has been suggested to be an interesting tool in helping individuals suffering from NCDs achieve balanced nutritional intakes.[6] However, it has been shown that nutritional information on the back of packages were poorly understood and used during food choices.[7] While few studies have suggested that individuals suffering from nutrition-related NCDs would pay more attention to nutritional information and check for specific nutrients,[8,9] another study has observed no difference of nutritional information use between patients and individuals with no chronic condition.[6]

In the last decade, Front-of-Pack nutrition Labels (FoPLs) have been identified to improve the nutritional quality of food choices at the point-of-purchase in the general population,[10–19] and to encourage reformulation and innovation of food products.[20,21] In France, the summary FoPL Nutri-Score has been adopted in October 2017 (and then in several European countries) to indicate the nutritional quality of products in supermarkets.[22] By the end of 2019, the brands which adopted the Nutri-Score represented approximately 25% of the volume of pre-packed foods sales with more than 300 manufacturers engaged.[23] The Nutri-Score has been demonstrated to be well perceived, understood and to have a positive effect on food purchases in the general French population[14,18,24–27] and students.[28] However, as the measure is implemented on a voluntary basis, it coexists on the French market with the Reference Intakes label (RIs),[29] used by multiple food manufacturers since 2006 in Europe, and the absence of any front-of-pack labelling.

To our knowledge, no study has specifically investigated the effect of FoPLs, including the Nutri-Score, on food purchases of patients suffering from nutrition-related NCDs only. Thus, the study aimed to determine the effect of the Nutri-Score on purchasing intentions of individuals suffering from nutrition-related cardiometabolic chronic diseases, compared to the current French labelling situations, i.e. the RIs or no FoPL, as a secondary or primary prevention tool.

## METHODS

### Trial design and participants

A three-arm parallel group randomized trial was conducted in 2017 targeting individuals suffering from cardiometabolic NCDs. The study was approved by the Institutional Review Bard of the INSERM (IRB n°IRB0000388 FWA00005831), the National Commission for Data Protection and Liberties (CNIL n° 909216) and the *Comité consultatif sur le traitement de l'information en matière de recherche dans le domaine de la santé*, and registered at https://clinicaltrials.gov/ct2/show/NCT02769455. Electronic consent was obtained from each participant. A methodology similar to a trial targeting students was used.[28]

Participants were recruited from the NutriNet-Santé cohort by a targeted emailing campaign in 2016, using the following criteria: age, BMI, and the declaration of one of the diseases included in the present study. Briefly, the NutriNet-Santé is an ongoing web-based prospective observational cohort study launched in France in May 2009, including adult volunteers recruited by multi-media campaigns.[30] Each individual who agreed to participate was asked to fulfil an inclusion questionnaire and provide information on gender, age, occupation, educational level, household composition, and weekly budget for grocery shopping. They were also asked to self-estimate their nutrition knowledge level on a 4-point scale (between "I am very knowledgeable about nutrition" and "I do not know anything about nutrition"), and to provide information on their grocery shopping frequency in general and online ("Always", "Often", "Sometimes" and "Never"). Finally, they were invited to declare if they had been diagnosed or were currently under medical supervision for at least one of the following nutrition-related chronic diseases: obesity, type 2 diabetes, dyslipidaemia, arterial hypertension,

cardiovascular disease. Thus, individuals involved in grocery shopping, over 50 years old, and with at least one of the chronic diseases from the list above, were eligible to participate.

**Patient and public involvement**

The research question underlying the study was driven by considerations regarding tools to improve patients' empowerment concerning their diets. Patients were not directly involved in the development of the protocol or in recruitment of participants. Dissemination of the research results will be done through the NutriNet-Santé cohort platform, with an abstract in the French language, allowing for all participants to be informed.

**Randomization and blinding**

Eligible participants were randomly allocated to one of the three arms using a random block method with permuted blocks of size 3, 6, 9 and 12, without stratification. The randomization list was only available to the independent statistician who generated the randomization sequence and the computer programmer who uploaded the list on the secured platform. Given the nature of the intervention, participants could not be blinded of the intervention; however, they were only informed about the main objectives of the experimental online supermarket, aiming to investigate determinants of purchasing behaviour. No information was given on the FoPLs or the explicit purpose of the trial.

**Intervention and procedure**

Experimental arm

The experimental arm consisted on the Nutri-Score applied on the front of package of all pre-packed foods included in the online supermarket. The Nutri-Score is a summary FoPL characterizing the overall nutritional quality of foods. The label is based on the Food Standards

Agency Nutrient Profiling System, modified by the High Council of Public Health to better discriminate foods from specific categories (cheese, fats and beverages) consistently with nutritional recommendations (FSAm-NPS).[18] The FSAm-NPS is calculated for 100g (or 100mL) of food, and allocates from 0 to 10 points for each nutrient which should be limited (energy (kJ), SFA (g), sugars (g), and sodium (mg)) and from 0 to 5 points to each favourable nutrient which should be encouraged (proteins (g), fibres (g), and the content in fruits, vegetables, legumes and nuts (%)). A discrete score is finally obtained by subtracting the favourable points from the unfavourable points, ranging therefore between -15, for food products with higher nutritional quality, to +40 points for food products with lower nutritional quality. Then, the Nutri-Score is represented by a 5-colour scale with a corresponding letter, from dark green (A) indicating the highest nutritional quality to dark orange (E) for products with the lowest nutritional quality.

Control arms

Two control arms were also included: (1) the RIs FoPL was affixed on all pre-packed food items, and (2) no front-of-pack nutritional labelling at all. The RIs is a nutrient-specific monochromatic label endorsed by some manufacturers, indicating the kilocalories and the amount of fat, SFA, sugars and sodium in gram per serving, and their contribution in percentages to the guideline-based daily intakes.[29] In the no label arm, no nutrition label was applied on the front of food packages on the experimental online supermarket.

The experimental online supermarket was composed of three sections. First, the upper section included the logo of the supermarket, a search bar, an access to the shopping cart, and the tabs for the different food categories. Second, a central section displaying advertisements and showing shoppers in a supermarket aisle was included. The rotating banner ad on the left side

of the central section included one specific ad and four ads on non-dietary information such as information on national campaigns of health promotion. In the two arms with a FoPL, the specific ad drew awareness on the label with additional information on its computation and use. In the no label arm, additional information was provided on the proper conservation of fresh food products. On the central section, the participant could also view the different products depending on the food categories, and access the information (name, brand, price, nutritional information, etc) by clicking on the product. For the two label arms, the nutritional label was affixed on the front of the package and next to the product on a larger scale to improve its readability. Third, the lower section included links to the various food categories, links for information and links towards account information. An example of a food item included in the experimental online supermarket with its three versions depending on the trial arm is shown in Figure 1 and a picture of the experimental online supermarket is presented in Figure S1 [28].

Procedure

For this specific purpose, an experimental online supermarket was developed, similar to previous trials.[18,28] Eligible participants were invited to simulate a shopping task as if they were in their usual supermarket, but without any payment required and no instruction on the amount, the duration or the number of participants they were asked to shop for. The experimental online supermarket resembled existing grocery shopping websites with a virtual shopping cart, a virtual payment procedure, a search tab and promotional banners. As in real shopping websites, participants could choose products categorized in multiple food groups and subgroups, using a hierarchical structure and names of the categories similar to existing online supermarkets. The food offer was a representative sample of the products commonly sold on French online supermarkets and included 751 foods and beverages (pre-packed products carrying a FoPL on the Nutri-Score and RIs arms, and raw products without any label in the

three arms according to the European regulation), divided into twenty food categories. For all products, name, brand, price (per unit and per kg or litter), a picture of the product (with or without a FoPL, depending on the arm) and the nutritional composition as well as the list of ingredients were provided. For each food item, at least two different products were proposed, including a national brand and a retailer's brand. The number of brands proposed balanced the nutritional variability observed for a given type of food.

**Outcomes**

The primary outcome was the overall nutritional quality of the shopping cart, assessed by the mean of the FSAm-NPS score across all the items in the cart, computed for 100g. A lower overall FSAm-NPS score of the shopping cart reflects a higher nutritional quality of the entire selection of products within the cart.

Secondary outcomes were, by order of importance, the content of the shopping cart in energy, SFA, sugars, sodium, fibres, fruits and vegetables, and proteins, for 100g of the shopping cart.

**Statistical analyses**

The final sample size was calculated for an effect size of 0.2 (for the main outcome, FSAm-NPS score), a power of 90% and a p-value of 0.02 considering the three-arm design, resulting in 1,956 individuals, i.e. 652 participants per arm. To reach this final sample size while considering non-respondents, 2,431 individuals were initially randomized and the number of individuals validating their shopping cart was monitored.

Per protocol analyses were carried out, given that only one measure was collected for the outcome. All participants meeting the inclusion criteria and who completed the shopping task were included in the analyses. The primary outcome was compared between the three trial arms using one-way ANOVA (p-value≤0.05 significant). Pairwise comparisons among FoPLs were

performed using Tukey tests to consider multiple comparisons (p-value≤0.05 significant). Then, secondary outcome variables were also compared between the three arms using a hierarchical gatekeeping strategy[28] with the following order: 1. Energy, 2. SFA, 3. Sugars, 4. Sodium, 5. Fibres, 6. Fruits and vegetables, 7. Proteins. When the comparison across the three arms for a component was not significant, the comparison of following secondary outcomes was stopped. The gatekeeping strategy order was determined using the relative importance of the various nutrients to health (with the most unfavourable elements first) and the results of previous studies assessing FoPL effects on the nutritional quality of food purchases.[18] Analyses were performed considering the FSAm-NPS score of all products from the experimental supermarket, including also raw items that were not labelled in any trial arm (i.e. fruits, vegetables, meat and poultry). Multiple sensitivity analyses were then performed. First, sensitivity analyses were computed (1) including only labelled food products (i.e. pre-packed foods and beverages), (2) excluding participants whose spending amount was below the 5$^{th}$ percentile or over the 95$^{th}$ percentile of the distribution of the cost of the shopping carts in the sample, and (3) using multiple imputations on missing outcomes (25 imputed sets) to consider the non-response rate. Missing primary and secondary outcomes of non-respondents were imputed using the individual characteristics of the individuals, including sociodemographic and nutrition-related lifestyle data collected in the inclusion questionnaire. The total quantities of calories, SFA, sugars, sodium, fibres, and proteins in the shopping carts were also calculated and compared across the three arms using ANOVA. The composition of the shopping cart across the different food categories was calculated in percentage of the total number of products in the cart (mean and standard error). The contributions of each food group to the nutrient amounts in the shopping carts were then calculated and expressed a mean percentage and standard error. Finally, the distribution of the products across the different Nutri-Score classes

was also compared between the three arms, taking into account all food products including raw foods that were non-labelled.

All tests of significance were two-sided, and analyses were carried out with the SAS software (version 9.4; SAS Institute, Inc.).

## RESULTS

Among 3,728 individuals with chronic diseases assessed for eligibility, 1,297 did not meet inclusion criteria, resulting in 2,431 participants randomly assigned to one of the three arms (Figure 2). Among them, 1,180 individuals with a nutrition-related chronic disease fully completed the shopping task and were finally included in the analyses. The other subjects who did not complete their shopping cart were excluded from the analyses, as their purchasing behaviour may not be representative of their habits. Overall, participants of the trial included 65.5% of women, 27.8% of subjects with primary educational level, and their mean age was 65.0±7.1 years (Table 1). Regarding purchasing behaviour, 61.2% declared doing always their grocery shopping and 29.7% reported having purchased foods online at least once. Among them, 16.2% reported purchasing online at least one time per week. 57.2% of the included participants declared having an intermediate self-estimated nutrition knowledge level, and 51.4% often reading the nutrition facts. The two main chronic diseases represented in the trial were arterial hypertension (65.7%) and dyslipidaemia (33.9%), then followed by cardiovascular diseases (15.2%), type 2 diabetes (14.7%), and obesity (13.8%). Approximately 30% of participants reported having more than one of the diseases included in the trial. Individual characteristics of participants were globally similar between the three arms. The mean cost of

the shopping cart was 75.0±51.5 euros overall, 80.0±57.8 euros in the Nutri-Score arm, 73.9±48.3 euros in the RIs arm and 71.2±47.3 euros in the no label arm. The mean weight of the shopping carts was 16.6±14.3 kg in the Nutri-Score arm with 22.9±21.9 products on average, 24.2±14.7 kg in the Reference Intakes arm with 33.6±22.0 products on average, and 22.7±14.2 kg in the no label arm with 31.1±21.3 products on average

According to the flow diagram, approximately 50% of participants did not complete the virtual shopping task. Individual characteristics between respondents and non-respondents were compared and results are displayed in Table S1. Even if non-respondents had some small disparities on their sociodemographic and lifestyle characteristics compared to respondents, this potential bias was similar in the three arms. Indeed, the interaction term between each individual characteristic and the arm to model the probability of no response was not statistically significant (p-value≥0.1).

**Table 1** Individual characteristics of included participants, NutriNet-Santé cohort (N=1,180)

| | Nutri-Score | Reference Intakes | No label | Total |
|---|---|---|---|---|
| **Total (n)** | 394 | 392 | 394 | 1180 |
| **Gender, n(%)** | | | | |
| Men | 131 (33.3) | 124 (31.6) | 152 (38.6) | 407 (34.5) |
| Women | 263 (66.7) | 268 (68.4) | 242 (61.4) | 773 (65.5) |
| **Age, years** | 64.8 ± 6.9 | 64.8 ± 7.3 | 65.4 ± 7.1 | 65.0 ± 7.1 |
| **Educational level, n(%)** | | | | |
| Primary | 122 (31.0) | 102 (26.0) | 104 (26.4) | 328 (27.8) |
| Secondary | 53 (13.4) | 51 (13.0) | 74 (18.8) | 178 (15.1) |
| University, undergraduate degree | 103 (26.1) | 122 (31.2) | 99 (25.1) | 324 (27.4) |
| University, postgraduate degree | 98 (24.9) | 102 (26.0) | 103 (26.1) | 303 (25.7) |
| Other | 18 (4.6) | 15 (3.8) | 14 (3.6) | 47 (4.0) |
| **Grocery shopping frequency, n(%)** | | | | |
| Always | 231 (58.63) | 252 (64.3) | 239 (60.6) | 722 (61.2) |
| Often | 122 (30.96) | 107 (27.3) | 113 (28.7) | 342 (29.0) |
| Sometimes | 41 (10.41) | 33 (8.4) | 42 (10.7) | 116 (9.8) |
| **Online grocery shopping, yes n(%)** | 119 (30.2) | 129 (32.9) | 103 (26.1) | 351 (29.7) |
| **Online grocery shopping frequency, n(%)** | | | | |
| At least one time per week | 16 (13.4) | 20 (15.5) | 21 (20.4) | 57 (16.2) |
| One or two times per month | 22 (18.5) | 26 (20.1) | 15 (14.5) | 63 (18.0) |
| One time every two or three months | 29 (24.4) | 33 (25.6) | 17 (16.5) | 79 (22.5) |
| One or two times per year | 23 (19.3) | 21 (16.3) | 29 (28.2) | 73 (20.8) |
| Less than one time per year | 29 (24.4) | 29 (22.5) | 21 (20.4) | 79 (22.5) |
| **Weekly budget for grocery shopping (€), n(%)** | | | | |
| < 30€ | 13 (3.3) | 17 (4.3) | 16 (4.1) | 46 (3.9) |
| 30 – 50€ | 76 (19.3) | 74 (18.9) | 63 (16.0) | 213 (18.0) |
| 50 – 100€ | 151 (38.3) | 168 (42.9) | 160 (40.6) | 479 (40.6) |
| > 100€ | 151 (38.3) | 130 (33.1) | 147 (37.3) | 428 (36.3) |
| Missing | 3 (0.8) | 3 (0.8) | 8 (2.0) | 14 (1.2) |
| **Perceived nutritional knowledge, n(%)** | | | | |
| High | 38 (9.6) | 38 (9.7) | 22 (5.6) | 98 (8.3) |
| Intermediate | 222 (56.4) | 220 (56.1) | 233 (59.1) | 675 (57.2) |
| Low | 125 (31.7) | 125 (31.9) | 124 (31.5) | 374 (31.7) |
| No | 9 (2.3) | 7 (1.8) | 9 (2.3) | 25 (2.1) |
| Missing data | 0 | 2 (0.5) | 6 (1.5) | 8 (0.7) |
| **Nutrition facts reading frequency, n(%)** | | | | |
| Always | 63 (16.0) | 55 (14.0) | 54 (13.7) | 172 (14.6) |
| Often | 202 (51.3) | 199 (50.8) | 206 (52.3) | 607 (51.4) |

| | | | | |
|---|---|---|---|---|
| Sometimes | 117 (29.7) | 122 (31.1) | 119 (30.2) | 358 (30.3) |
| Never | 12 (3.0) | 14 (3.6) | 9 (2.3) | 35 (3.0) |
| Missing data | 0 | 2 (0.5) | 6 (1.5) | 8 (0.7) |
| **Chronic disease diagnosed, n(%)** | | | | |
| Arterial hypertension | 265 (67.3) | 256 (65.3) | 254 (64.5) | 775 (65.7) |
| Diabetes mellitus | 51 (12.9) | 55 (14.0) | 67 (17.0) | 173 (14.7) |
| Cardiovascular disease | 65 (16.5) | 48 (12.2) | 66 (16.8) | 179 (15.2) |
| Dyslipidemia | 141 (35.8) | 127 (32.4) | 132 (33.5) | 400 (33.9) |
| Obesity | 43 (10.9) | 58 (14.8) | 62 (15.7) | 163 (13.8) |
| Total cost of the shopping cart (€) | 80.0 ± 57.8 | 73.9 ± 48.3 | 71.2 ± 47.3 | 75.0 ± 51.5 |
| Number of products in the shopping cart | 22.9 ± 21.9 | 33.6 ± 22.0 | 31.1 ± 21.3 | 29.2 ± 22.2 |
| Weight of the shopping cart (kg) | 16.6 ± 14.3 | 24.2 ± 14.7 | 22.7 ± 14.2 | 21.2 ± 14.8 |

Values are mean ± standard deviation or n (%) as appropriate.

## Outcomes

The FSAm-NPS score was lower in the Nutri-Score arm (1.29±3.61 points), reflecting a higher overall nutritional quality of the shopping carts, followed by the RIs arm (1.86±3.23 points) and no label (1.92±2.9 points) (Table 2). The difference of FSAm-NPS scores were statistically significant between the Nutri-Score and the RIs groups (mean difference=-0.57[-1.11;-0.02]; p-value=0.04), and between the Nutri-Score and no label (-0.63[-1.17;-0.08]; p-value=0.02). No significant difference was observed between the RIs and no label (-0.06[-0.61;0.48]; p-value=1.0). Furthermore, the Nutri-Score label led to a significantly lower content of the shopping carts in calories and SFA, compared to the RIs and no label (p-values≤0.0001 for comparisons of calories between the Nutri-Score and both RIs and no label; p-values=0.01 for comparisons of SFA between the Nutri-Score and both RIs and no label). The differences between the RIs and no label arms were not significant. The differences of sugars content between the three arms were not significant; then comparisons of subsequent secondary outcomes were stopped.

**Table 2** Overall nutritional quality, energy and nutrient content for 100g of the shopping cart

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=394 | N=392 | N=394 | | Difference[a] | P[b] | Difference[a] | P[b] | Difference[a] | P[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 1.29 (3.61) | 1.86 (3.23) | 1.92 (2.9) | **0.01** | -0.63 (-1.17;-0.08) | **0.02** | -0.57 (-1.11;-0.02) | **0.04** | -0.06 (-0.61;0.48) | 1.0 |
| Calories (kcal/100g) | 153.53 (76.96) | 184.06 (64.38) | 175.38 (64.22) | **<0.0001** | -21.85 (-33.35;-10.35) | **<0.0001** | -30.53 (-42.05;-19.02) | **<0.0001** | 8.68 (-2.83;20.20) | 0.2 |
| Saturated fatty acids (g/100g) | 3.24 (3.13) | 3.78 (2.13) | 3.77 (2.36) | **0.004** | -0.53 (-0.96;-0.10) | **0.01** | -0.53 (-0.96;-0.10) | **0.01** | 0.01 (-0.42;0.44) | 1.0 |
| Sugars (g/100) | 5.92 (3.58) | 5.89 (3.25) | 5.65 (3.81) | 0.5 | 0.27 (-0.32;0.87) | 0.5 | 0.03 (-0.56;0.63) | 1.0 | 0.24 (-0.35;0.84) | 0.6 |
| Sodium (mg/100g) | 189.83 (200.21) | 195.51 (104.13) | 212.73 (158.16) | | | | | | | |
| Fibers (g/100g) | 1.37 (0.99) | 1.89 (1.17) | 1.65 (0.97) | | | | | | | |
| Fruits and vegetables (%) | 34.12 (22.87) | 29.51 (16.03) | 28.90 (14.81) | | | | | | | |
| Proteins (g/100g) | 7.36 (3.43) | 7.29 (2.20) | 7.58 (3.33) | | | | | | | |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

When analyses considered pre-packed products only, the overall difference of shopping carts' FSAm-NPS score between the three arms was no longer significant suggesting inter-food group substitutions (Table S2). However, results for the secondary outcomes remained consistent with the main analyses. In sensitivity analyses excluding outliers on the spending amount, similar results were observed for primary and secondary outcomes (Table S3). Results of the sensitivity analyses using multiple imputations are presented in Table S4 for analyses considering all food products and Table S5 for analyses considering only labelled food items. Results using multiple imputations were consistent with the main analyses; however, the amplitude of differences between arms was lower and comparisons were no longer significant, except for calories for which the Nutri-Score also led to lower contents compared to the two other arms (Tables S4 and S5). The participants in the Nutri-Score am purchased less calories, SFA, sugars, sodium, fibres, and proteins compared to the two other arms (Table S6).

Table S7 describes the shopping carts composition in terms of the mean number of products per food category in each of the three arms. In the Nutri-Score arm, participants tended to purchase more products from the fruits (especially fresh fruit), meat and water categories (compared to the RIs), and fewer products from vegetables, dairy products, cheeses, sweets and starchy foods such as pasta, rice, rush potatoes and semolina. The average percentages of raw products (i.e. not labelled in the label arms) purchased by participants were 32.9%±18.4% in the no label arm, 33.2%±18.2% in the RIs arm, and 42.0%±28.1% in the Nutri-Score arm. The percentage contributions of food groups to nutrient intakes in the overall shopping carts are presented in Table S8 (only for nutrients where a difference between arms was observed in the main analyses). Thus, the lower calorie and SFA contents of the shopping carts in the Nutri-Score arm compared to the RIs arms could be explained by fewer products purchased in the dairy products, cheese, but also sweets and starchy foods. Finally, the proportion of healthier

food products in the shopping carts classified as A was significantly higher in the Nutri-Score arm compared to the two other arms (difference = 5.63 [2.02;9.24], p-value=0.0008 compared to no label; difference = 4.85 [1.24;8.47], p-value=0.005 compared to the RIs), which can be partly explained by the higher proportion of raw fruits and meats in the shopping carts of participants from the Nutri-Score group – corresponding to products with higher nutritional quality (Table S9). On the contrary, the proportion of unhealthier products classified as D or E was significantly lower in the Nutri-Score arm compared to the two other arms or the RIs only. No significant difference was observed between the RIs and no label.

## DISCUSSION

Results of the present study showed that the Nutri-Score label significantly led to an improvement of the overall nutritional quality of food purchases in individuals with cardiometabolic chronic disease. Moreover, the Nutri-Score led to lower contents of the shopping carts in energy and SFA compared to the two other arms. Similar trends were observed with multiple imputations; nevertheless, differences were no longer statistically significant. No significant difference was observed between the RIs and no label. Moreover, in both FoPLs arms, and particularly in the Nutri-Score arm, substitutions between food groups were observed, with more raw products purchased – corresponding mainly to fruits and butcher's meats from higher nutritional quality. It appeared that the participants exposed to the Nutri-Score purchased less products and from higher overall nutritional quality (i.e. lower FSAm-NPS score).

The present findings are consistent with studies which observed a positive effect of interpretive FoPLs and especially the Nutri-Score on the nutritional quality of intentional or real food

purchases, while the RIs demonstrated a limited or non-significant effect in the general population[14,18] or students.[28] This could be partly explained by the features of the schemes. Indeed, the summary indicator of the Nutri-Score, combining colours and text, would be easier to read and understand.[16,18,19,31–37] On the contrary, the RIs with its nutrient-specific and monochromatic format, has been shown to be more complicated to identify and understand in the general population,[18,36,37] creating notably potential decisional conflicts and prioritization of nutrients.[38] Nevertheless, to our knowledge, this is the first study to assess the effect of FoPLs on purchasing intentions among individuals suffering from nutrition-related NCDs. Only one study investigated the effect of the Traffic Lights nutrient-specific label and the three-stars summary label on food purchases in vending machine among patients in an Australian hospital and observed a positive effect of the labels to identify healthier products. However, the experiment was performed in a specific context and no focus was made on patients suffering specifically from nutrition-related NCDs.[12]

Interestingly, while previous studies among patients with hypertension, hypercholesterolemia, type 2 diabetes or hyperlipidaemia found that they were more likely to read information on salt and SFA respectively,[39] and have lower intakes in energy and SFA,[9] in the present study, the RIs did not help consumers to select products with significantly less SFA compared to no label. On the contrary, the Nutri-Score which does not provide numerical data but rather summarized information, led to significantly lower contents of the shopping carts in SFA compared to no label and the RIs. These results on the Nutri-Score effect are particularly important, given that a decrease of the intakes in energy, SFA and salt with an increase of fruits and vegetables consumption are recommended among patients suffering from nutrition-related NCDs.[1] Moreover, despite these recommendations, it has been observed in a study within the NutriNet-Santé cohort that adults with a cardiometabolic disease tended to have unhealthier

dietary habits overall (e.g. lower intakes of fruits, higher intakes of meat, processed meat and added fats) compared to healthy controls,[40] which supports the interest of public health measures encouraging healthier food choices among these individuals.

When analyses were restricted to labelled items only, no significant difference of the overall nutritional quality between the Nutri-Score and the other arms was found. These results reflect that the use of the Nutri-Score may encourage also substitutions between food categories. Indeed, participants who were exposed to the Nutri-Score tended to purchase more non-labelled raw products, in particular fruits, meat and poultry, characterized by healthier nutritional quality.

The present study provides insights regarding the effect of the Nutri-Score on purchasing intentions of individuals with nutrition-related NCDs compared to the current labelling situation in France and other European countries. First, strength of the study pertained in the inclusion of a specific population rarely explored in the nutritional labelling field, and its randomized controlled design, which resulted in comparable groups allowing accurate estimations of the labels' effect. Furthermore, the experiment was conducted on an experimental online supermarket, closed to real online grocery shopping conditions, with a range of different products with distinct nutritional profiles, brands and the use of real packaging. This controlled experimental environment allowed assessing the effect of the Nutri-Score in standardized conditions and optimizing internal validity of the study. Nevertheless, some limitations should be acknowledged. First, a high rate of participants did not complete the shopping task. Hence, respondents may have different individual characteristics, leading however to a potential non-differential bias which could limit the generalizability of the results. In addition, the reduced sample size could have led to a decreased statistical power preventing us from detecting some

potential small differences. Moreover, it is important to notice that analyses with multiple imputations led to similar trends but with non-significant differences given the increase of variance in the sample. Second, the trial involved voluntary participants, who may have greater interest and knowledge in nutrition than the French population of patients. Thus, participants in the no label arm might have made healthier food choices than the general population and the effects of FoPLs in comparison could have been underestimated. Third, despite the diversity of the food offer proposed, the number of products was somewhat limited, and some participants may not have found their usual product and chose foods they would not buy in real shopping situation. In addition, the representativity of the experimental food offer was not carefully assessed. These elements would limit the extern validity of the study and the generalisability of the results to a real online supermarket. Moreover, compared to the French average, the higher proportion of subjects who declared doing often their grocery shopping online, may have led to a sample with sociodemographic differences compared to the French population of patients. Fourth, the trial investigated purchasing intentions rather than actual food purchases that may have led the participants to take the experiment less seriously or to spend more money than they would actually do. Complementary studies should be conducted in real-life settings to provide additional elements on the Nutri-Score effectiveness. Nevertheless, virtual purchasing behaviours of individuals have been suggested to be good predictors of real behaviours.[41] Finally, the study included cases of self-reported cardiometabolic chronic conditions with no validation required. Therefore, we were not able to ascertain whether the participants were following specific diets or nutritional recommendations during the period of the trial, which could have modified their purchasing behaviours. The present study focused on the Nutri-Score effect as a secondary or tertiary prevention tool of NCDs, and complement previous studies which have been conducted on the general population including individual without any chronic conditions, or on specific subgroups such as students. Furthermore, it could have been

interesting to also include individuals having someone in the household with a chronic condition.

These results support that the Nutri-Score may improve the nutritional quality of food choices of consumers suffering from nutrition-related chronic diseases. This is particularly important given that an improvement of the dietary habits and the nutritional status of these individuals is a major element in the secondary prevention and the management of these non-communicable diseases. These findings are complementary to studies having observed a favourable effect of the Nutri-Score or its underlying nutrient profiling system on chronic diseases risk, in a context of primary prevention, through an improvement of food purchases and nutrient intakes.[18,42]

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**Competing interests**

All authors declare no competing interests.

**Author contributorship**

ME, CJ and IB wrote the statistical analysis plan, analysed the data, and drafted and revised the paper. SP, PD, MT, PG, LF, RP, PR, SH and EKG analysed the data and critically revised the paper for important intellectual content. SH and CJ designed data collection tools, implemented the study, monitored data collection for the whole study, and critically revised the draft paper for important intellectual content. All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. All authors have read and approved the final manuscript.

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**Ethics approval and consent to participate**

The study was approved by the Institutional Review Board of INSERM (IRB Inserm n°IRB0000388 FWA00005831) and the National Commission for Data Protection and Liberties (CNIL n° 909216), and registered at: https://clinicaltrials.gov/ct2/show/NCT02769455. Electronic consent was obtained from each participant of the trial.

**Data sharing**

All data supporting the findings of this study are included in the present article or the supplemental material. No additional data available.

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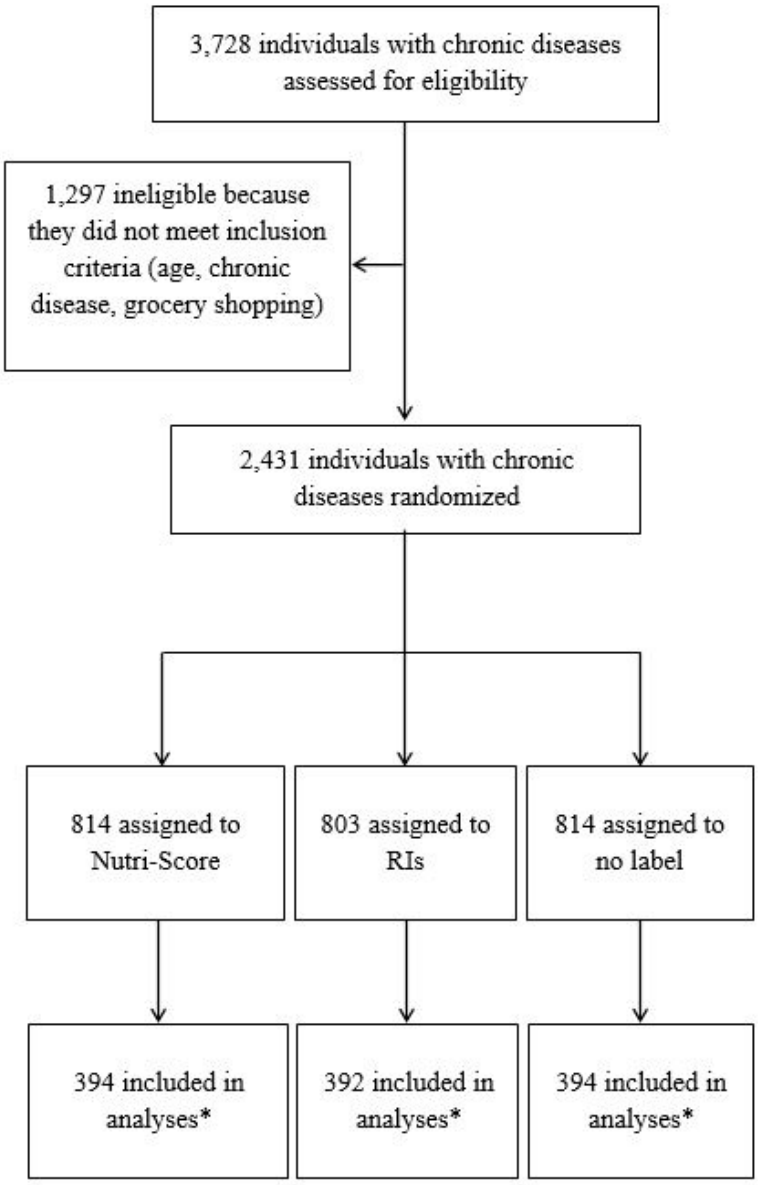
**Figure 1**An example of a food product in the Nutri-Score (1), Reference Intakes (2), and no label (3) arms

**Figure 2** Flow diagram of the randomized controlled trial

* Subjects who validated their online shopping cart and did not encounter technical issues


(1) (2) (3)

56x28mm (300 x 300 DPI)




36x55mm (300 x 300 DPI)

**Table S1** Individual characteristics of respondents and non-respondents in the randomized controlled trial by randomization group, France, 2017

| | Nutri-Score | | Reference Intakes | | No label | | |
|---|---|---|---|---|---|---|---|
| | Respondents | Non-respondents | Respondents | Non-respondents | Respondents | Non-respondents | *P*[a] |
| **Total (n)** | 394 | 420 | 392 | 411 | 394 | 420 | |
| **Sex, n(%)** | | | | | | | 0.5 |
| Men | 131 (33.2) | 158 (37.6) | 124 (31.6) | 143 (34.8) | 152 (38.6) | 157 (37.4) | |
| Women | 263 (66.8) | 262 (62.4) | 268 (68.4) | 268 (65.2) | 242 (61.4) | 263 (62.6) | |
| **Age, years** | 64.8 ± 6.9 | 65.8 ± 7.5 | 64.8 ± 7.3 | 66.5 ± 7.1 | 65.4 ± 7.1 | 66.2 ± 7.2 | 0.5 |
| **Educational level** | | | | | | | 0.2 |
| Primary | 122 (31) | 131 (31.2) | 102 (26) | 140 (34.1) | 104 (26.4) | 131 (31.2) | |
| Secondary | 53 (13.5) | 83 (19.8) | 51 (13) | 77 (18.7) | 74 (18.8) | 71 (16.9) | |
| University, undergraduate degree | 103 (26.1) | 94 (22.4) | 122 (31.1) | 98 (23.8) | 99 (25.1) | 103 (24.5) | |
| University, postgraduate degree | 98 (24.9) | 93 (22.1) | 102 (26) | 77 (18.7) | 103 (26.1) | 102 (24.3) | |
| Other | 18 (4.6) | 19 (4.5) | 15 (3.8) | 19 (4.6) | 14 (3.6) | 13 (3.1) | |
| **Grocery shopping frequency, n(%)** | | | | | | | 0.6 |
| Always | 231 (58.6) | 235 (56) | 252 (64.3) | 229 (55.7) | 239 (60.7) | 245 (58.3) | |
| Often | 122 (31) | 134 (31.9) | 107 (27.3) | 128 (31.1) | 113 (28.7) | 127 (30.2) | |
| Sometimes | 41 (10.4) | 51 (12.1) | 33 (8.4) | 54 (13.1) | 42 (10.7) | 48 (11.4) | |
| **Online grocery shopping, yes n(%)** | 119 (30.2) | 96 (22.9) | 129 (32.9) | 102 (24.8) | 103 (26.1) | 109 (26) | 0.2 |
| **Online grocery shopping frequency, n(%)** | | | | | | | 0.4 |
| At least one time per week | 16 (13.4) | 8 (8.3) | 20 (15.5) | 14 (13.7) | 21 (20.4) | 13 (11.9) | |
| One or two times per month | 22 (18.5) | 25 (26) | 26 (20.2) | 20 (19.6) | 15 (14.6) | 25 (22.9) | |
| One time every two or three months | 29 (24.4) | 15 (15.6) | 33 (25.6) | 23 (22.5) | 17 (16.5) | 22 (20.2) | |
| One or two times per year | 23 (19.3) | 23 (24) | 21 (16.3) | 29 (28.4) | 29 (28.2) | 32 (29.4) | |
| Less than one time per year | 29 (24.4) | 25 (26) | 29 (22.5) | 16 (15.7) | 21 (20.4) | 17 (15.6) | |
| **Weekly budget for grocery shopping (€)** | | | | | | | 0.2 |
| <30€ | 13 (3.3) | 20 (4.8) | 17 (4.3) | 10 (2.4) | 16 (4.1) | 6 (1.4) | |
| 30 – 50€ | 76 (19.3) | 65 (15.5) | 74 (18.9) | 78 (19) | 63 (16) | 65 (15.5) | |
| 50 – 100€ | 151 (38.3) | 159 (37.9) | 168 (42.9) | 158 (38.4) | 160 (40.6) | 164 (39) | |
| >100€ | 151 (38.3) | 154 (36.7) | 130 (33.2) | 140 (34.1) | 147 (37.3) | 167 (39.8) | |
| Missing | 3 (0.8) | 22 (5.2) | 3 (0.8) | 25 (6.1) | 8 (2) | 18 (4.3) | |
| **Perceived nutritional knowledge, n(%)** | | | | | | | 0.1 |
| High | 38 (9.6) | 33 (7.9) | 38 (9.7) | 26 (6.3) | 22 (5.6) | 44 (10.5) | |
| Intermediate | 222 (56.3) | 226 (53.8) | 220 (56.1) | 231 (56.2) | 233 (59.1) | 221 (52.6) | |
| Low | 125 (31.7) | 135 (32.1) | 125 (31.9) | 125 (30.4) | 124 (31.5) | 132 (31.4) | |
| No | 9 (2.3) | 9 (2.1) | 7 (1.8) | 7 (1.7) | 9 (2.3) | 6 (1.4) | |
| Missing data | 0 | 17 (4) | 2 (0.5) | 22 (5.4) | 6 (1.5) | 17 (4) | |
| **Nutrition facts reading frequency, n(%)** | | | | | | | 0.3 |
| Always | 63 (16) | 68 (16.2) | 55 (14) | 58 (14.1) | 54 (13.7) | 71 (16.9) | |
| Often | 202 (51.3) | 190 (45.2) | 199 (50.8) | 210 (51.1) | 206 (52.3) | 177 (42.1) | |
| Sometimes | 117 (29.7) | 127 (30.2) | 122 (31.1) | 106 (25.8) | 119 (30.2) | 142 (33.8) | |
| Never | 12 (3) | 18 (4.3) | 14 (3.6) | 15 (3.6) | 9 (2.3) | 13 (3.1) | |
| Missing data | 0 | 17 (4) | 2 (0.5) | 22 (5.4) | 6 (1.5) | 17 (4) | |

Values are mean ± standard deviation or n (%) as appropriate.

[a] A multivariable logistic regression was conducted to model the probability of non-response depending on the individual sociodemographic and lifestyle characteristics and the arm of randomization. The *P* corresponds to the p-value of the interaction term between the individual characteristic and the trial arm. The comparison of the educational level and weekly budget for grocery shopping variables between respondents and non-respondents were not performed given that information was missing for non-respondents.

**Table S2** Overall nutritional quality, energy and nutrient content for 100g of the shopping cart among labelled products only

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=369 | N=390 | N=392 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P- value[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 4.35 (3.5) | 4.27 (3.43) | 4.49 (3.41) | 0.7 | -0.13 (-0.72;0.45) | 0.9 | 0.08 (-0.51;0.67) | 0.9 | -0.21 (-0.79;0.36) | 0.7 |
| Calories (kcal/100g) | 188.42 (111.64) | 237.94 (80.74) | 226.59 (85.24) | **<0.0001** | -38.16 (-54.02;-22.3) | **<0.0001** | -49.52 (-65.39;-33.64) | **<0.0001** | 11.35 (-4.28;26.99) | 0.2 |
| Saturated fatty acids (g/100g) | 4.60 (4.48) | 5.34 (2.97) | 5.43 (3.28) | **0.003** | -0.83 (-1.45;-0.22) | **0.004** | -0.74 (-1.36;-0.13) | **0.01** | -0.09 (-0.70;0.52) | 0.9 |
| Sugars (g/100) | 5.80 (5.16) | 6.45 (4.23) | 6.43 (6.00) | 0.1 | -0.63 (-1.51;0.25) | 0.2 | -0.66 (-1.54;0.23) | 0.2 | 0.03 (-0.84;0.9) | 1.0 |
| Sodium (mg/100g) | 267.67 (284.89) | 252.19 (130.25) | 267.10 (200.7) | | | | | | | |
| Fiber (g/100g) | 1.45 (1.56) | 2.27 (1.74) | 1.95 (1.54) | | | | | | | |
| Fruits and vegetables (%) | 17.98 (20.94) | 17.48 (13.99) | 16.95 (12.61) | | | | | | | |
| Proteins (g/100g) | 6.35 (4.31) | 7.89 (2.87) | 7.99 (3.92) | | | | | | | |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S3** Sensitivity analyses: overall nutritional quality, energy and nutrient content for 100g of the shopping cart excluding outliers on the spending amount

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=351 | N=354 | N=357 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P- value[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 0.99 (3.30) | 1.69 (2.84) | 1.8 (2.58) | **0.0004** | -0.81 (-1.32;-0.29) | **0.0007** | -0.69 (-1.21;-0.17) | **0.005** | -0.12 (-0.63;0.40) | 0.9 |
| Calories (kcal/100g) | 152.06 (74.84) | 180.89 (58.10) | 173.53 (57.8) | **<0.0001** | -21.47 (-32.77;-10.17) | **<0.0001** | -28.83 (-40.15;-17.51) | **<0.0001** | 7.36 (-3.91;18.63) | 0.3 |
| Saturated fatty acids (g/100g) | 3.19 (2.73) | 3.76 (2.02) | 3.78 (2.03) | **0.0005** | -0.59 (-0.99;-0.18) | **0.002** | -0.58 (-0.98;-0.17) | **0.002** | -0.01 (-0.41;0.39) | 1.0 |
| Sugars (g/100) | 5.9 (3.31) | 5.79 (2.93) | 5.61 (3.10) | 0.5 | 0.29 (-0.26;0.84) | 0.4 | 0.11 (-0.44;0.66) | 0.9 | 0.18 (-0.36;0.73) | 0.7 |
| Sodium (mg/100g) | 171.75 (144.16) | 193.37 (96.17) | 205.5 (143.31) | | | | | | | |
| Fiber (g/100g) | 1.41 (1.01) | 1.91 (1.17) | 1.67 (0.96) | | | | | | | |
| Fruits and vegetables (%) | 35.29 (22.57) | 30.66 (14.69) | 30.11 (13.93) | | | | | | | |
| Proteins (g/100g) | 7.30 (3.25) | 7.25 (2.03) | 7.53 (2.92) | | | | | | | |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). Participants whose spending amount was below the 5$^{th}$ or over the 95$^{th}$ percentile of the distribution of the cost of the shopping carts in the sample were excluded. FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S4** Sensitivity analyses using multiple imputations: overall nutritional quality, energy and nutrient content for 100g of the shopping cart

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=814 | N=803 | N=814 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P-value[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 1.51 (1.87) | 1.78 (1.87) | 1.84 (2.04) | 0.1 | -0.33 (-0.69;0.03) | 0.07 | -0.27 (-0.63;0.08) | 0.1 | -0.06 (-0.43;0.32) | 0.8 |
| Calories (kcal/100g) | 162.95 (41.32) | 177.21 (39.24) | 173.24 (44.67) | **0.0009** | -10.28 (-18.26;2.31) | **0.01** | -14.26 (-21.87;6.65) | **0.0003** | 3.98 (-4.09;12.05) | 0.3 |
| Saturated fatty acids (g/100g) | 3.43 (1.62) | 3.68 (1.41) | 3.70 (1.64) | 0.1 | -0.27 (-0.56;0.02) | 0.07 | -0.25 (-0.54;0.04) | 0.1 | -0.02 (-0.32;0.28) | 0.9 |
| Sugars (g/100) | 5.86 (2.11) | 5.86 (2.02) | 5.74 (2.22) | 0.6 | 0.12 (-0.32;0.55) | 0.6 | -0.01 (-0.46;0.45) | 1.0 | 0.12 (-0.30;0.54) | 0.6 |
| Sodium (mg/100g) | 194.73 (102.46) | 196.38 (97.05) | 205.54 (113.03) | | | | | | | |
| Fiber (g/100g) | 1.51 (0.62) | 1.76 (0.64) | 1.64 (0.68) | | | | | | | |
| Fruits and vegetables (%) | 32.25 (10.94) | 30.12 (10.35) | 29.78 (11.19) | | | | | | | |
| Proteins (g/100g) | 7.41 (1.73) | 7.35 (1.86) | 7.48 (1.97) | | | | | | | |

[a] Mean difference (95% Confidence Interval)
[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S5** Sensitivity analyses using multiple imputations: overall nutritional quality, energy and nutrient content for 100g of the shopping cart among labelled products only

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Rference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=789 | N=801 | N=812 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P- value[b] |
| Overall nutritional quality (FSA score/100g) | 3.51 (11.8) | 3.52 (11.82) | 3.61 (11.53) | 0.6 | -0.10 (-0.57;0.36) | 0.7 | -0.01 (-0.46;0.43) | 1.0 | -0.09 (-0.53;0.35) | 0.7 |
| Calories (kcal/100g) | 176.66 (343.52) | 201.81 (344.94) | 195.53 (330.17) | **0.001** | -18.87 (-31.27;-6.5) | **0.003** | -25.15 (-38.22;-12.09) | **0.0002** | -6.29 (-5.17;17.74) | 0.3 |
| Saturated fatty acids (g/100g) | 3.97 (14.84) | 4.34 (15.04) | 4.37 (14.67) | 0.2 | -0.41 (-0.88;0.06) | 0.09 | -0.38 (-0.88;0.12) | 0.1 | -0.03 (-0.47;0.41) | 0.9 |
| Sugars (g/100) | 4.64 (19.27) | 4.99 (19.48) | 4.96 (19.33) | 0.5 | -0.32 (-0.97;0.33) | 0.3 | -0.35 (-0.97;0.28) | 0.3 | 0.02 (-0.63;0.68) | 0.9 |
| Sodium (mg/100g) | 220.7 (688.19) | 216.53 (675.15) | 221.69 (672.91) | | | | | | | |
| Fiber (g/100g) | 1.43 (5.42) | 1.83 (5.44) | 1.68 (5.27) | | | | | | | |
| Fruits and vegetables (%) | 16.76 (50.37) | 16.55 (50.69) | 16.43 (49.19) | | | | | | | |
| Proteins (g/100g) | 6.12 (14.32) | 6.86 (13.06) | 6.89 (12.84) | | | | | | | |

[a] Mean difference (95% Confidence Interval)
[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S6** Total quantities of calories and nutrients in the shopping carts purchased in the three arms of the trial

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | Mean (SD) | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P-value[b] |
| Calories (kcal) | 2229.74(2336.45) | 3395.80(2232.5) | 3173.73(2235.09) | **<0.0001** | -943.99(-1323.29;-564.7) | **<0.0001** | -1166.06(-1545.84;-786.29) | **<0.0001** | 222.07(-157.71;601.85) | 0.4 |
| Saturated fatty acids (g) | 35.88(40.21) | 53.08(37.21) | 52.60(38.35) | **<0.0001** | -16.72(-23.18;-10.27) | **<0.0001** | -17.20(-23.66;-10.73) | **<0.0001** | 0.47(-5.99;6.94) | 1.0 |
| Sugars (g) | 78.09(71.76) | 116.70(90.74) | 103.08(79.66) | **<0.0001** | -24.99(-38.54;-11.43) | **<0.0001** | -38.60(-52.17;-25.03) | **<0.0001** | 13.61(0.04;27.19) | **0.05** |
| Sodium (mg) | 1914.81(2121.69) | 2875.46(2298.01) | 2803.92(2232.81) | **<0.0001** | -889.11(-1260.04;-518.19) | **<0.0001** | -960.66(-1332.06;-589.26) | **<0.0001** | 71.54(-299.86;442.95) | 0.9 |
| Fiber (g) | 17.13(17.45) | 29.81(21.11) | 26.17(20.05) | **<0.0001** | -9.04(-12.32;-5.76) | **<0.0001** | -12.68(-15.96;-9.4) | **<0.0001** | 3.64(0.36;6.92) | **0.03** |
| Proteins (g) | 98.66(92.33) | 145.51(93.35) | 142.44(94.72) | **<0.0001** | -43.78(-59.41;-28.15) | **<0.0001** | -46.85(-62.5;-31.2) | **<0.0001** | 3.07(-12.58;18.72) | 0.9 |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). SD: Standard Deviation

**Table S7** Percentage of the number of products in the shopping cart from the different food categories

| Food groups | Nutri-Score | Reference Intakes | No label |
|---|---|---|---|
| **Fruits, vegetables, legumes, grains and starchs** | | | |
| Fresh fruits | 17,69(22,1) | 7,14(6,76) | 7,07(6,68) |
| Processed fruits | 1,96(8,99) | 0,73(1,72) | 0,82(2,05) |
| Fresh vegetables | 6,13(10,74) | 10,76(9,87) | 9,73(8,82) |
| Processed vegetables | 2,79(5,09) | 4,22(5,14) | 3,43(4,69) |
| Legumes and potatoes | 1,50(3,45) | 3,08(4,64) | 2,49(5,28) |
| Seeds and dried fruits | 0,81(2,44) | 0,83(1,82) | 1,08(3,14) |
| **Dairy products** | 10,25(11,77) | 12,46(10,36) | 13,33(14,06) |
| **Cheeses** | 2,96(5,01) | 4,84(7,39) | 5,17(6,15) |
| **Meat, fish and processed foods** | | | |
| Pre-packed meat | 0,11(0,68) | 0,20(0,99) | 0,21(0,83) |
| Meat | 12,52(14,99) | 6,02(6,04) | 6,94(10,14) |
| Processed meats | 4,64(11,25) | 3,35(4,93) | 3,5(5,25) |
| Fresh fish | 2,66(6,6) | 2,71(5,94) | 2,44(3,51) |
| Processed fish | 0,51(1,84) | 0,68(1,89) | 0,79(3) |
| Sea delicatessen and canned fish | 1,85(3,88) | 2,58(3,83) | 3,67(10,21) |
| **Sweet products** | | | |
| Biscuits | 1,09(2,95) | 2,40(8,16) | 1,17(2,26) |
| Sweets | 3,17(5,26) | 5,24(5,39) | 4,88(6,35) |
| Breakfast cereals | 0,18(0,86) | 0,32(1,27) | 0,26(1,11) |
| Breads, rusks and pastries | 1,78(4,90) | 2,53(4,19) | 3,56(9,43) |
| Ice creams | 0,58(1,84) | 0,73(2,09) | 0,71(2,39) |
| **Salty products** | | | |
| Prepared dishes | 1,26(3,39) | 2,06(6,4) | 1,75(3,68) |
| Pasta, rice, mashed potatoes and semolina | 2,21(4,07) | 4,68(9,44) | 3,47(5,85) |
| Savoury aperitif products | 0,44(1,40) | 1,05(2,85) | 0,66(1,79) |
| Salads | 0,35(1,34) | 0,40(1,53) | 0,18(0,95) |
| Soups | 0,49(2,21) | 1,12(6,57) | 1,08(7,57) |
| Sauces and condiments | 3,75(9,23) | 3,86(4,47) | 4,26(6,07) |
| **Oils and fats** | 4,43(9,22) | 4,06(4,02) | 3,92(4,04) |
| **Beverages** | | | |
| Waters | 8,95(14,68) | 5,96(8,85) | 8,71(16,74) |
| Fruit juices | 2,36(6,58) | 1,52(5,77) | 1,07(2,55) |
| Sweetened drinks and sodas | 2,58(5,50) | 4,48(6,51) | 3,64(4,38) |

Values correspond to mean (Standard deviation).

**Table S8** Percent contributions of food groups to nutrient intakes of the overall shopping cart

| Food groups | Calories | | | Saturated Fatty Acids | | |
|---|---|---|---|---|---|---|
| | Nutri-Score | Reference Intakes | No label | Nutri-Score | Reference Intakes | No label |
| **Fruits, vegetables, legumes, grains and starchs** | | | | | | |
| Fresh fruits | 12,03(21,1) | 2,76(4,93) | 2,53(2,98) | 5,64(21,07) | 0,43(5,11) | 0,12(0,29) |
| Processed fruits | 1,46(8,67) | 0,31(0,91) | 0,34(0,88) | 0,92(8,48) | 0,06(0,49) | 0,05(0,15) |
| Fresh vegetables | 1,93(6,41) | 2,48(3,77) | 2,06(2,48) | 0,82(7,1) | 0,30(1,19) | 0,15(0,24) |
| Processed vegetables | 0,92(2,29) | 1,38(2,42) | 1,18(3,18) | 0,48(4,45) | 0,43(1,60) | 0,36(1,19) |
| Legumes and potatoes | 2,47(5,55) | 5,15(8,23) | 4,10(7,97) | 0,39(2,42) | 0,63(3,61) | 0,78(5,35) |
| Seeds and dried fruits | 2,19(5,88) | 2,33(5,16) | 2,97(6,77) | 1,49(4,68) | 1,60(4,44) | 1,87(6,25) |
| **Oils and fats** | 7,61(11,16) | 8,01(8,74) | 9,57(13,59) | 10,79(16,63) | 12,86(15,25) | 14,02(18,27) |
| **Beverages** | 5,38(9,19) | 8,32(11,10) | 9,81(10,39) | 11,87(18,7) | 19,59(21,72) | 22,38(21,8) |
| **Meat, fish and processed foods** | | | | | | |
| Pre-packed meat | 0,08(0,52) | 0,20(1,20) | 0,23(0,98) | 0,1(0,81) | 0,37(3,46) | 0,37(1,85) |
| Meat | 18,07(24,94) | 6,51(8,20) | 7,63(12,95) | 22,31(34,83) | 6,99(12,52) | 6,25(12,70) |
| Processed meats | 4,77(11,74) | 3,68(7,20) | 3,84(5,55) | 5,66(15,52) | 4,29(9,25) | 4,65(9,43) |
| Fresh fish | 2,17(7,01) | 2,2(6,38) | 1,62(2,62) | 1,69(8,35) | 1,46(7,16) | 0,67(1,69) |
| Processed fish | 0,38(1,58) | 0,58(2,17) | 0,63(2,16) | 0,22(1,05) | 0,45(3,01) | 0,46(2,49) |
| Sea delicatessen and canned fish | 1,92(5,13) | 2,64(4,66) | 3,51(10,18) | 1,43(5,13) | 1,85(4,58) | 2,41(9,00) |
| **Sweet products** | | | | | | |
| Biscuits | 2,41(5,96) | 4,77(11,63) | 3,05(6,08) | 2,23(6,55) | 4,9(13,55) | 2,75(6,73) |
| Sweets | 5,54(10,11) | 8,64(9,86) | 8,42(10,7) | 7,24(14,58) | 11,47(16,33) | 10,06(14,67) |
| Breakfast cereals | 0,33(1,55) | 0,66(2,51) | 0,58(2,45) | 0,10(0,54) | 0,25(1,34) | 0,15(0,77) |
| Breads, rusks and pastries | 3,16(7,95) | 4,28(6,62) | 5,76(11,22) | 0,94(3,49) | 0,94(2,46) | 2,09(10,59) |
| Ice creams | 0,50(1,58) | 0,7(2,44) | 0,65(2,83) | 0,89(3,63) | 1,10(4,07) | 0,82(3,77) |
| **Salty products** | | | | | | |
| Prepared dishes | 1,44(3,66) | 2,24(6,88) | 2,22(4,84) | 1,25(3,46) | 2,07(7,24) | 2,06(7,47) |
| Pasta, rice, mashed potatoes and semolina | 4,05(7,18) | 8,37(13,13) | 6,57(9,03) | 0,86(3,79) | 2,33(10,33) | 1,10(3,15) |
| Savoury aperitif products | 0,97(3,09) | 2,30(5,50) | 1,6(4,26) | 0,43(1,82) | 1,16(3,53) | 0,76(2,21) |
| Salads | 0,21(0,83) | 0,25(1,06) | 0,12(0,67) | 0,08(0,34) | 0,12(0,62) | 0,04(0,22) |
| Soups | 0,16(1,29) | 0,57(5,53) | 0,67(7,40) | 0,15(1,35) | 0,52(5,39) | 0,61(7,41) |
| Sauces and condiments | 2,72(8,87) | 1,94(3,23) | 2,20(5,24) | 1,90(8,97) | 0,96(2,07) | 1,14(4,45) |
| **Oils and fats** | 14,60(18,45) | 16,48(14,66) | 16,68(15,00) | 19,52(25,10) | 21,53(20,74) | 22,84(21,77) |
| **Beverages** | | | | | | |
| Waters | 0(0,03) | 0(0,03) | 0(0,03) | 0(0,05) | 0(0,10) | 0,01(0,11) |
| Fruit juices | 1,26(4,70) | 0,63(5,25) | 0,36(1,03) | 0(0) | 0(0) | 0(0) |
| Sweetened drinks and sodas | 1,29(5,36) | 1,62(4,61) | 1,12(3,61) | 0,62(3,36) | 1,36(5,99) | 1,04(4,14) |

The relatively high contributions of calories and saturated fatty acids for fruits and vegetables in the Nutri-Score arm could be partly explained by participants having only fruits or vegetables in their shopping carts, thus increasing the overall contribution at the sample level, even though they are low in calories and saturated fatty acids.

**Table S9** Distribution of the products across the five Nutri-Score classes

| Nutri-Score | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean proportion | Mean proportion | Mean proportion | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P-value[b] |
| A | 58.16±25.02 | 53.3±20.26 | 52.53±20.07 | **0.0004** | 5.63(2.02;9.24) | **0.0008** | 4.85(1.24;8.47) | **0.005** | 0.78(-2.86;4.41) | 0.9 |
| B | 10.55±10.43 | 13.87±10.09 | 15.55±14.14 | **<0.0001** | -5.01(-6.93;-3.08) | **<0.0001** | -3.33(-5.26;-1.4) | **0.0002** | -1.68(-3.62;0.26) | 0.1 |
| C | 15.60±19.08 | 12.14±10.82 | 11.52±11.2 | **<0.0001** | 4.08(1.73;6.43) | **0.0001** | 3.46(1.10;5.81) | **0.002** | 0.62(-1.74;2.99) | 0.8 |
| D | 12.30±12.92 | 16.05±11.51 | 15.98±12.02 | **<0.0001** | -3.68(-5.69;-1.68) | **<0.0001** | -3.75(-5.76;-1.74) | **<0.0001** | 0.06(-1.95;2.08) | 1.0 |
| E | 3.40±5.69 | 4.63±8.57 | 4.42±5.42 | **0.02** | -1.02(-2.12;0.08) | 0.07 | -1.23(-2.34;-0.13) | **0.02** | 0.21(-0.90;1.33) | 0.9 |

[a] Mean difference (95% Confidence Interval)
[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). All products were taken into account, including also raw foods that were non-labelled.

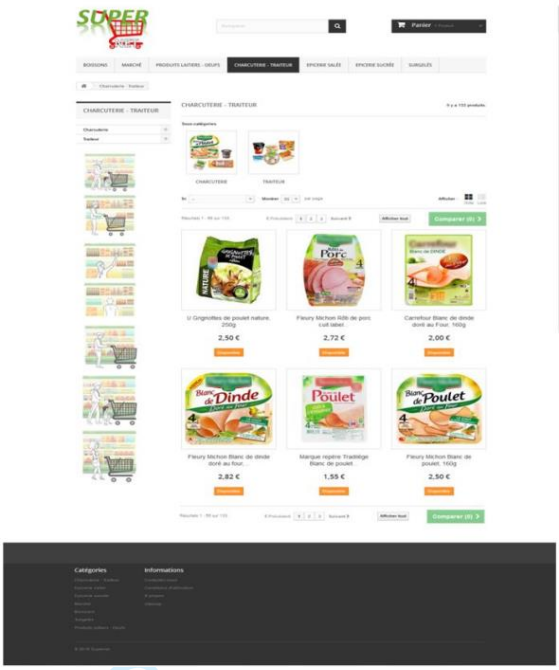


**Figure S1** Screenshot of the experimental online supermarket

# CONSORT 2010 checklist of information to include when reporting a randomised trial*

| Section/Topic | Item No | Checklist item | Reported on page No |
|---|---|---|---|
| **Title and abstract** | | | |
| | 1a | Identification as a randomised trial in the title | 1 |
| | 1b | Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts) | 2 |
| **Introduction** | | | |
| Background and objectives | 2a | Scientific background and explanation of rationale | 3-4 |
| | 2b | Specific objectives or hypotheses | 4 |
| **Methods** | | | |
| Trial design | 3a | Description of trial design (such as parallel, factorial) including allocation ratio | 4-5 |
| | 3b | Important changes to methods after trial commencement (such as eligibility criteria), with reasons | NA |
| Participants | 4a | Eligibility criteria for participants | 5 |
| | 4b | Settings and locations where the data were collected | 5 |
| Interventions | 5 | The interventions for each group with sufficient details to allow replication, including how and when they were actually administered | 6-7 |
| Outcomes | 6a | Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed | 8 |
| | 6b | Any changes to trial outcomes after the trial commenced, with reasons | NA |
| Sample size | 7a | How sample size was determined | 8 |
| | 7b | When applicable, explanation of any interim analyses and stopping guidelines | NA |
| Randomisation: | | | |
| Sequence generation | 8a | Method used to generate the random allocation sequence | 5-6 |
| | 8b | Type of randomisation; details of any restriction (such as blocking and block size) | 5 |
| Allocation concealment mechanism | 9 | Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned | NA |
| Implementation | 10 | Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions | 5 |
| Blinding | 11a | If done, who was blinded after assignment to interventions (for example, participants, care providers, those | NA |

| | | | |
|---|---|---|---|
| | | assessing outcomes) and how | |
| | 11b | If relevant, description of the similarity of interventions | NA |
| Statistical methods | 12a | Statistical methods used to compare groups for primary and secondary outcomes | 8-9 |
| | 12b | Methods for additional analyses, such as subgroup analyses and adjusted analyses | 9 |
| **Results** | | | |
| Participant flow (a diagram is strongly recommended) | 13a | For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome | 9 |
| | 13b | For each group, losses and exclusions after randomisation, together with reasons | Figure 2 |
| Recruitment | 14a | Dates defining the periods of recruitment and follow-up | 4-5 |
| | 14b | Why the trial ended or was stopped | NA |
| Baseline data | 15 | A table showing baseline demographic and clinical characteristics for each group | Table 1 |
| Numbers analysed | 16 | For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups | Figure 2 |
| Outcomes and estimation | 17a | For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval) | 12 |
| | 17b | For binary outcomes, presentation of both absolute and relative effect sizes is recommended | NA |
| Ancillary analyses | 18 | Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory | 14 |
| Harms | 19 | All important harms or unintended effects in each group (for specific guidance see CONSORT for harms) | NA |
| **Discussion** | | | |
| Limitations | 20 | Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses | 17 |
| Generalisability | 21 | Generalisability (external validity, applicability) of the trial findings | 17 |
| Interpretation | 22 | Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence | 15-17 |
| **Other information** | | | |
| Registration | 23 | Registration number and name of trial registry | 5 |
| Protocol | 24 | Where the full trial protocol can be accessed, if available | NA |
| Funding | 25 | Sources of funding and other support (such as supply of drugs), role of funders | 19 |

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

BMJ Open

# Impact of the Nutri-Score front-of-pack nutrition label on purchasing intentions of individuals with chronic diseases: results of a randomized trial



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# Impact of the Nutri-Score front-of-pack nutrition label on purchasing intentions of individuals with chronic diseases: results of a randomized trial

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## ABSTRACT

**Objective** : To our knowledge, the effect of front-of-pack nutrition labels such as the Nutri-Score on food purchases has never been assessed among individuals suffering from nutrition-related chronic diseases specifically, while dietary modifications are generally part of their care. This study aimed to investigate the effect of the Nutri-Score on the nutritional quality of purchasing intentions among adults suffering from a cardiometabolic disease, compared to no label and the Reference Intakes (RIs), a label already implemented by some food manufacturers in France.

**Setting:** Secondary prevention – mainland France

**Participants :** 2,431 eligible participants were randomly assigned and 1,180 participants (65.5% women, mean age 65.0±7.1 years) completed the shopping task and were included in the analyses.

**Intervention:** A three-arm randomized controlled trial using an experimental online supermarket was conducted in 2017. Participants with cardiometabolic diseases were invited to simulate food purchases with the Nutri-Score, the RIs or no label.

**Primary and secondary outcome measures :** The primary outcome was the nutritional quality of the shopping cart, estimated using the French-modified Food Standard Agency Nutrient Profiling System (FSAm-NPS), and secondary outcomes included the nutrient content of purchases.

**Results:** The mean (SD) FSAm-NPS score was significantly lower in the Nutri-Score arm (1.29(3.61) points), reflecting a higher overall nutritional quality of purchasing intentions, compared to the RIs (1.86(3.23) points) and no label (1.92(2.90) points) arms (p-value=0.01). Moreover, the Nutri-Score led to significantly lower content in calories and saturated fatty acids compared to the two other arms. These differences resulted from participants avoiding some

packaged products (sweets, dairy and starches) and purchasing larger amounts of fresh fruit and meat.

**Conclusions:** The Nutri-Score exhibited a significant higher nutritional quality of purchasing intentions, encouraging healthier food choices among individuals suffering from cardiometabolic chronic diseases.

**Trial registration** : NCT02769455

## Article summary

Strengths and limitations of this study

- Inclusion of a rarely explored population in a randomized controlled trial pertaining to the effectiveness of front-of-package labelling on food choices
- This controlled experimental environment allowed assessing the effect of the Nutri-Score in standardized conditions and optimizing internal validity of the study.
- Limitation pertaining to a high rate of participants who did not complete the shopping task.
- The trial investigated purchasing intentions rather than actual food purchases.

**Keywords:** Front-of-pack nutrition label; cardiometabolic diseases; Food purchases; Nutritional quality; Experimental online supermarket

## INTRODUCTION

Non-Communicable Diseases (NCDs), such as obesity, type 2 diabetes, cardiovascular diseases and cancer have become a major burden for the current health systems.[1] For these diseases, dietary factors have been recognized to be one of the major leading risk factors in developed countries, resulting in 11 million deaths worldwide in 2017, and represent modifiable determinants through primary prevention.[2] In France, cardiovascular diseases remain the second leading cause of deaths by NCDs, accounting for 30% approximately of mortality.[3] Regarding obesity, the prevalence was estimated at 17% within the French adult population in 2015,[4] and the prevalence of type 2 diabetes was around 5% in 2016.[5]

Hence, in the context of secondary or tertiary prevention, many treatment guidelines highlight the importance to modify dietary habits to improve the nutritional status of individuals and thus control these nutrition-related NCDs.[1] For example, controlling for saturated satty acids (SFA), sugars and salt intakes and increasing fruits and vegetables, pulses, and fibres consumption are encouraged in the management of several NCDs or risk factors such as obesity, arterial hypertension and diabetes.[1] Nutritional labelling has been suggested to be an interesting tool in helping individuals suffering from NCDs achieve balanced nutritional intakes.[6] However, it has been shown that nutritional information on the back of packages were poorly understood and used during food choices.[7] While few studies have suggested that individuals suffering from nutrition-related NCDs would pay more attention to nutritional information and check for specific nutrients,[8,9] another study has observed no difference of nutritional information use between patients and individuals with no chronic condition.[6]

In the last decade, Front-of-Pack nutrition Labels (FoPLs) have been identified to improve the nutritional quality of food choices at the point-of-purchase in the general population,[10–19] and to encourage reformulation and innovation of food products.[20,21] In France, the summary FoPL Nutri-Score has been adopted in October 2017 (and then in several European countries) to indicate the nutritional quality of products in supermarkets.[22] By the end of 2019, the brands which adopted the Nutri-Score represented approximately 25% of the volume of pre-packed foods sales with more than 300 manufacturers engaged.[23] The Nutri-Score has been demonstrated to be well perceived, understood and to have a positive effect on food purchases in the general French population[14,18,24–27] and students.[28] However, as the measure is implemented on a voluntary basis, it coexists on the French market with the Reference Intakes label (RIs),[29] used by multiple food manufacturers since 2006 in Europe, and the absence of any front-of-pack labelling.

To our knowledge, no study has specifically investigated the effect of FoPLs, including the Nutri-Score, on food purchasing intentions of patients suffering from nutrition-related NCDs only. Thus, the study aimed to determine the effect of the Nutri-Score on purchasing intentions of individuals suffering from nutrition-related cardiometabolic chronic diseases, compared to the current French labelling situations, i.e. the RIs or no FoPL, as a secondary or primary prevention tool.

## METHODS

### Trial design and participants

A three-arm parallel group randomized trial was conducted in 2017 targeting individuals suffering from cardiometabolic NCDs. The study was approved by the Institutional Review Bard of the INSERM (IRB n°IRB0000388 FWA00005831), the National Commission for Data Protection and Liberties (CNIL n° 909216) and the *Comité consultatif sur le traitement de l'information en matière de recherche dans le domaine de la santé*, and registered at https://clinicaltrials.gov/ct2/show/NCT02769455. Electronic consent was obtained from each participant. A methodology similar to a trial targeting students was used.[28]

Participants were recruited from the NutriNet-Santé cohort by a targeted emailing campaign in 2016, using the following criteria: age, BMI, and the declaration of one of the diseases included in the present study. Briefly, the NutriNet-Santé is an ongoing web-based prospective observational cohort study launched in France in May 2009, including adult volunteers recruited by multi-media campaigns.[30] Each individual who agreed to participate was asked to fulfil an inclusion questionnaire and provide information on gender, age, occupation, educational level, household composition, and weekly budget for grocery shopping. They were also asked to self-estimate their nutrition knowledge level on a 4-point scale (between "I am very knowledgeable about nutrition" and "I do not know anything about nutrition"), and to provide information on their grocery shopping frequency in general and online ("Always", "Often", "Sometimes" and "Never"). Finally, they were invited to declare if they had been diagnosed or were currently under medical supervision for at least one of the following nutrition-related chronic diseases: obesity, type 2 diabetes, dyslipidaemia, arterial hypertension,

cardiovascular disease. Thus, individuals involved in grocery shopping, over 50 years old, and with at least one of the chronic diseases from the list above, were eligible to participate.

**Patient and public involvement**

The research question underlying the study was driven by considerations regarding tools to improve patients' empowerment concerning their diets. Patients were not directly involved in the development of the protocol or in recruitment of participants. Dissemination of the research results will be done through the NutriNet-Santé cohort platform, with an abstract in the French language, allowing for all participants to be informed.

**Randomization and blinding**

Eligible participants were randomly allocated to one of the three arms using a random block method with permuted blocks of size 3, 6, 9 and 12, without stratification. The randomization list was only available to the independent statistician who generated the randomization sequence and the computer programmer who uploaded the list on the secured platform. Given the nature of the intervention, participants could not be blinded of the intervention; however, they were only informed about the main objectives of the experimental online supermarket, aiming to investigate determinants of purchasing behaviour. No information was given on the FoPLs or the explicit purpose of the trial.

**Intervention and procedure**

Experimental arm

The experimental arm consisted on the Nutri-Score applied on the front of package of all pre-packed foods included in the online supermarket. The Nutri-Score is a summary FoPL characterizing the overall nutritional quality of foods. The label is based on the Food Standards

Agency Nutrient Profiling System, modified by the High Council of Public Health to better discriminate foods from specific categories (cheese, fats and beverages) consistently with nutritional recommendations (FSAm-NPS).[18] The FSAm-NPS is calculated for 100g (or 100mL) of food, and allocates from 0 to 10 points for each nutrient which should be limited (energy (kJ), SFA (g), sugars (g), and sodium (mg)) and from 0 to 5 points to each favourable nutrient which should be encouraged (proteins (g), fibres (g), and the content in fruits, vegetables, legumes and nuts (%)). A discrete score is finally obtained by subtracting the favourable points from the unfavourable points, ranging therefore between a minimum of -15, for food products with higher nutritional quality, to a maximum of +40 points for food products with lower nutritional quality. Hence, the lower the FSAm-NPS score, the healthier the products. Then, the Nutri-Score is represented by a 5-colour scale with a corresponding letter, from dark green (A) indicating the highest nutritional quality to dark orange (E) for products with the lowest nutritional quality.

Control arms

Two control arms were also included: (1) the RIs FoPL was affixed on all pre-packed food items, and (2) no front-of-pack nutritional labelling at all. The RIs is a nutrient-specific monochromatic label endorsed by some manufacturers, indicating the kilocalories and the amount of fat, SFA, sugars and sodium in gram per serving, and their contribution in percentages to the guideline-based daily intakes.[29] In the no label arm, no nutrition label was applied on the front of food packages on the experimental online supermarket.

The experimental online supermarket was composed of three sections. First, the upper section included the logo of the supermarket, a search bar, an access to the shopping cart, and the tabs for the different food categories. Second, a central section displaying advertisements and

showing shoppers in a supermarket aisle was included. The rotating banner ad on the left side of the central section included one specific ad and four ads on non-dietary information such as information on national campaigns of health promotion. In the two arms with a FoPL, the specific ad drew awareness on the label with additional information on its computation and use. In the no label arm, additional information was provided on the proper conservation of fresh food products. On the central section, the participant could also view the different products depending on the food categories, and access the information (name, brand, price, nutritional information, etc) by clicking on the product. For the two label arms, the nutritional label was affixed on the front of the package and next to the product on a larger scale to improve its readability. Third, the lower section included links to the various food categories, links for information and links towards account information. An example of a food item included in the experimental online supermarket with its three versions depending on the trial arm is shown in Figure 1 and a picture of the experimental online supermarket is presented in Figure S1 [28].

Procedure

For this specific purpose, an experimental online supermarket was developed, similar to previous trials.[18,28] Eligible participants were invited to simulate a shopping task as if they were in their usual supermarket, but without any payment required and no instruction on the amount, the duration or the number of participants they were asked to shop for. The experimental online supermarket resembled existing grocery shopping websites with a virtual shopping cart, a virtual payment procedure, a search tab and promotional banners. As in real shopping websites, participants could choose products categorized in multiple food groups and subgroups, using a hierarchical structure and names of the categories similar to existing online supermarkets. The food offer was a representative sample of the products commonly sold on French online supermarkets and included 751 foods and beverages (pre-packed products

carrying a FoPL on the Nutri-Score and RIs arms, and raw products without any label in the three arms according to the European regulation), divided into twenty food categories. For all products, name, brand, price (per unit and per kg or litter), a picture of the product (with or without a FoPL, depending on the arm) and the nutritional composition as well as the list of ingredients were provided. For each food item, at least two different products were proposed, including a national brand and a retailer's brand. The number of brands proposed balanced the nutritional variability observed for a given type of food.

**Outcomes**

The primary outcome was the overall nutritional quality of the shopping cart, assessed by the mean of the FSAm-NPS score across all the items in the cart, computed for 100g. A lower overall FSAm-NPS score of the shopping cart reflects a higher nutritional quality of the entire selection of products within the cart. Minimal theoretical value is -15, maximal theoretical value is +40.

Secondary outcomes were, by order of importance, the content of the shopping cart in energy, SFA, sugars, sodium, fibres, fruits and vegetables, and proteins, for 100g of the shopping cart.

**Statistical analyses**

The final sample size was calculated for an effect size of 0.2 (for the main outcome, FSAm-NPS score, calculated by minimization of estimates from previous studies showing a 0.62 point difference between Nutri-Score and control arm, with an SD of 2.55 of the average FSAm-NPS of the shopping cart [26]), a power of 90% and a p-value of 0.02 considering the three-arm design, resulting in 1,956 individuals, i.e. 652 participants per arm. To reach this final sample size while considering non-respondents, 2,431 individuals were initially randomized and the number of individuals validating their shopping cart was monitored.

Per protocol analyses were carried out, given that only one measure was collected for the outcome. All participants meeting the inclusion criteria and who completed the shopping task were included in the analyses. The primary outcome was compared between the three trial arms using one-way ANOVA (p-value≤0.05 significant). Pairwise comparisons among FoPLs were performed using Tukey tests to consider multiple comparisons (p-value≤0.05 significant). Then, secondary outcome variables were also compared between the three arms using a hierarchical gatekeeping strategy[28] with the following order: 1. Energy, 2. SFA, 3. Sugars, 4. Sodium, 5. Fibres, 6. Fruits and vegetables, 7. Proteins. When the comparison across the three arms for a component was not significant, the comparison of following secondary outcomes was stopped. The gatekeeping strategy order was determined using the relative importance of the various nutrients to health (with the most unfavourable elements first) and the results of previous studies assessing FoPL effects on the nutritional quality of food purchases.[18] Analyses were performed considering the FSAm-NPS score of all products from the experimental supermarket, including also raw items that were not labelled in any trial arm (i.e. fruits, vegetables, meat and poultry). Multiple sensitivity analyses were then performed. First, sensitivity analyses were computed (1) including only labelled food products (i.e. pre-packed foods and beverages), (2) excluding participants whose spending amount was below the 5$^{th}$ percentile or over the 95$^{th}$ percentile of the distribution of the cost of the shopping carts in the sample, and (3) using multiple imputations on missing outcomes (25 imputed sets) to consider the non-response rate and thus provide intention-to-treat estimates. Missing primary and secondary outcomes of non-respondents were imputed using the individual characteristics of the individuals, including sociodemographic and nutrition-related lifestyle data collected in the inclusion questionnaire. The total quantities of calories, SFA, sugars, sodium, fibres, and proteins in the shopping carts were also calculated and compared across the three arms using ANOVA. The composition of the shopping cart across the different food categories was

calculated in percentage of the total number of products in the cart (mean and standard error). The contributions of each food group to the nutrient amounts in the shopping carts were then calculated and expressed a mean percentage and standard error. Finally, the distribution of the products across the different Nutri-Score classes was also compared between the three arms, taking into account all food products including raw foods that were non-labelled.

All tests of significance were two-sided, and analyses were carried out with the SAS software (version 9.4; SAS Institute, Inc.).

## RESULTS

Among 3,728 individuals with chronic diseases assessed for eligibility, 1,297 did not meet inclusion criteria, resulting in 2,431 participants randomly assigned to one of the three arms (Figure 2). Among them, 1,180 individuals with a nutrition-related chronic disease fully completed the shopping task and were finally included in the analyses. The other subjects who did not complete their shopping cart were excluded from the analyses, as their purchasing behaviour may not be representative of their habits. Overall, participants of the trial included 65.5% of women, 27.8% of subjects with primary educational level, and their mean age was 65.0±7.1 years (Table 1). Regarding purchasing behaviour, 61.2% declared doing always their grocery shopping and 29.7% reported having purchased foods online at least once. Among them, 16.2% reported purchasing online at least one time per week. 57.2% of the included participants declared having an intermediate self-estimated nutrition knowledge level, and 51.4% often reading the nutrition facts. The two main chronic diseases represented in the trial were arterial hypertension (65.7%) and dyslipidaemia (33.9%), then followed by cardiovascular

diseases (15.2%), type 2 diabetes (14.7%), and obesity (13.8%). Approximately 30% of participants reported having more than one of the diseases included in the trial. Individual characteristics of participants were globally similar between the three arms. The mean cost of the shopping cart was 75.0±51.5 euros overall, 80.0±57.8 euros in the Nutri-Score arm, 73.9±48.3 euros in the RIs arm and 71.2±47.3 euros in the no label arm. The mean weight of the shopping carts was 16.6±14.3 kg in the Nutri-Score arm with 22.9±21.9 products on average, 24.2±14.7 kg in the Reference Intakes arm with 33.6±22.0 products on average, and 22.7±14.2 kg in the no label arm with 31.1±21.3 products on average.

According to the flow diagram, approximately 50% of participants did not complete the virtual shopping task. Individual characteristics between respondents and non-respondents were compared for intention-to-treat analyses and results are displayed in Table S1. Even if non-respondents had some small disparities on their sociodemographic and lifestyle characteristics compared to respondents, this potential bias was similar in the three arms. Indeed, the interaction term between each individual characteristic and the arm to model the probability of no response was not statistically significant (p-value≥0.1).

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**Table 1** Individual characteristics of included participants, NutriNet-Santé cohort (n=1,180)

| | Nutri-Score | Reference Intakes | No label | Total |
|---|---|---|---|---|
| **Total (n)** | 394 | 392 | 394 | 1180 |
| **Gender, n(%)** | | | | |
| Men | 131 (33.3) | 124 (31.6) | 152 (38.6) | 407 (34.5) |
| Women | 263 (66.7) | 268 (68.4) | 242 (61.4) | 773 (65.5) |
| **Age, years** | 64.8 ± 6.9 | 64.8 ± 7.3 | 65.4 ± 7.1 | 65.0 ± 7.1 |
| **Educational level, n(%)** | | | | |
| Primary | 122 (31.0) | 102 (26.0) | 104 (26.4) | 328 (27.8) |
| Secondary | 53 (13.4) | 51 (13.0) | 74 (18.8) | 178 (15.1) |
| University, undergraduate degree | 103 (26.1) | 122 (31.2) | 99 (25.1) | 324 (27.4) |
| University, postgraduate degree | 98 (24.9) | 102 (26.0) | 103 (26.1) | 303 (25.7) |
| Other | 18 (4.6) | 15 (3.8) | 14 (3.6) | 47 (4.0) |
| **Grocery shopping frequency, n(%)** | | | | |
| Always | 231 (58.63) | 252 (64.3) | 239 (60.6) | 722 (61.2) |
| Often | 122 (30.96) | 107 (27.3) | 113 (28.7) | 342 (29.0) |
| Sometimes | 41 (10.41) | 33 (8.4) | 42 (10.7) | 116 (9.8) |
| **Online grocery shopping, yes n(%)** | 119 (30.2) | 129 (32.9) | 103 (26.1) | 351 (29.7) |
| **Online grocery shopping frequency, n(%)** | | | | |
| At least one time per week | 16 (13.4) | 20 (15.5) | 21 (20.4) | 57 (16.2) |
| One or two times per month | 22 (18.5) | 26 (20.1) | 15 (14.5) | 63 (18.0) |
| One time every two or three months | 29 (24.4) | 33 (25.6) | 17 (16.5) | 79 (22.5) |
| One or two times per year | 23 (19.3) | 21 (16.3) | 29 (28.2) | 73 (20.8) |
| Less than one time per year | 29 (24.4) | 29 (22.5) | 21 (20.4) | 79 (22.5) |
| **Weekly budget for grocery shopping (€), n(%)** | | | | |
| < 30€ | 13 (3.3) | 17 (4.3) | 16 (4.1) | 46 (3.9) |
| 30 – 50€ | 76 (19.3) | 74 (18.9) | 63 (16.0) | 213 (18.0) |
| 50 – 100€ | 151 (38.3) | 168 (42.9) | 160 (40.6) | 479 (40.6) |
| > 100€ | 151 (38.3) | 130 (33.1) | 147 (37.3) | 428 (36.3) |
| Missing | 3 (0.8) | 3 (0.8) | 8 (2.0) | 14 (1.2) |
| **Perceived nutritional knowledge, n(%)** | | | | |
| High | 38 (9.6) | 38 (9.7) | 22 (5.6) | 98 (8.3) |
| Intermediate | 222 (56.4) | 220 (56.1) | 233 (59.1) | 675 (57.2) |
| Low | 125 (31.7) | 125 (31.9) | 124 (31.5) | 374 (31.7) |
| No | 9 (2.3) | 7 (1.8) | 9 (2.3) | 25 (2.1) |
| Missing data | 0 | 2 (0.5) | 6 (1.5) | 8 (0.7) |
| **Nutrition facts reading frequency, n(%)** | | | | |
| Always | 63 (16.0) | 55 (14.0) | 54 (13.7) | 172 (14.6) |
| Often | 202 (51.3) | 199 (50.8) | 206 (52.3) | 607 (51.4) |
| Sometimes | 117 (29.7) | 122 (31.1) | 119 (30.2) | 358 (30.3) |
| Never | 12 (3.0) | 14 (3.6) | 9 (2.3) | 35 (3.0) |
| Missing data | 0 | 2 (0.5) | 6 (1.5) | 8 (0.7) |
| **Chronic disease diagnosed, n(%)** | | | | |
| Arterial hypertension | 265 (67.3) | 256 (65.3) | 254 (64.5) | 775 (65.7) |
| Diabetes mellitus | 51 (12.9) | 55 (14.0) | 67 (17.0) | 173 (14.7) |
| Cardiovascular disease | 65 (16.5) | 48 (12.2) | 66 (16.8) | 179 (15.2) |
| Dyslipidemia | 141 (35.8) | 127 (32.4) | 132 (33.5) | 400 (33.9) |
| Obesity | 43 (10.9) | 58 (14.8) | 62 (15.7) | 163 (13.8) |
| Total cost of the shopping cart (€) | 80.0 ± 57.8 | 73.9 ± 48.3 | 71.2 ± 47.3 | 75.0 ± 51.5 |

| | | | | |
|---|---|---|---|---|
| Number of products in the shopping cart | 22.9 ± 21.9 | 33.6 ± 22.0 | 31.1 ± 21.3 | 29.2 ± 22.2 |
| Weight of the shopping cart (kg) | 16.6 ± 14.3 | 24.2 ± 14.7 | 22.7 ± 14.2 | 21.2 ± 14.8 |

Values are mean ± standard deviation or n (%) as appropriate.

## Outcomes

The FSAm-NPS score was lower in the Nutri-Score arm (1.29±3.61 points), reflecting a higher overall nutritional quality of the shopping carts, followed by the RIs arm (1.86±3.23 points) and no label (1.92±2.9 points) (Table 2). The difference of FSAm-NPS scores were statistically significant between the Nutri-Score and the RIs groups (mean difference=-0.57[-1.11;-0.02]; p-value=0.04), and between the Nutri-Score and no label (-0.63[-1.17;-0.08]; p-value=0.02). No significant difference was observed between the RIs and no label (-0.06[-0.61;0.48]; p-value=1.0). Furthermore, the Nutri-Score label led to a significantly lower content of the shopping carts in calories and SFA, compared to the RIs and no label (p-values≤0.0001 for comparisons of calories between the Nutri-Score and both RIs and no label; p-values=0.01 for comparisons of SFA between the Nutri-Score and both RIs and no label). The differences between the RIs and no label arms were not significant. The differences of sugars content between the three arms were not significant; then comparisons of subsequent secondary outcomes were stopped.

**Table 2** Overall nutritional quality, energy and nutrient content for 100g of the shopping cart

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n=394 | n=392 | n=394 | | Difference[a] | P[b] | Difference[a] | P[b] | Difference[a] | P[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 1.29 ±3.61 | 1.86 ± 3.23 | 1.92 ±2.9 | **0.01** | -0.63 (-1.17;-0.08) | **0.02** | -0.57 (-1.11;-0.02) | **0.04** | -0.06 (-0.61;0.48) | 1.0 |
| Calories (kcal/100g) | 153.53 ±76.96 | 184.06 ±64.38 | 175.38 ±64.22 | **<0.0001** | -21.85 (-33.35;-10.35) | **<0.0001** | -30.53 (-42.05;-19.02) | **<0.0001** | 8.68 (-2.83;20.20) | 0.2 |
| Saturated fatty acids (g/100g) | 3.24 ±3.13 | 3.78 ±2.13 | 3.77 ±2.36 | **0.004** | -0.53 (-0.96;-0.10) | **0.01** | -0.53 (-0.96;-0.10) | **0.01** | 0.01 (-0.42;0.44) | 1.0 |
| Sugars (g/100) | 5.92 ±3.58 | 5.89 ±3.25 | 5.65 ±3.81 | 0.5 | 0.27 (-0.32;0.87) | 0.5 | 0.03 (-0.56;0.63) | 1.0 | 0.24 (-0.35;0.84) | 0.6 |
| Sodium (mg/100g) | 189.83 ±200.21 | 195.51 ±104.13 | 212.73 ±158.16 | | | | | | | |
| Fibers (g/100g) | 1.37 ± 0.99 | 1.89 ±1.17 | 1.65 ±0.97 | | | | | | | |
| Fruits and vegetables (%) | 34.12 ± 22.87 | 29.51 ±16.03 | 28.90 ±14.81 | | | | | | | |
| Proteins (g/100g) | 7.36 ± 3.43 | 7.29 ±2.20 | 7.58 ±3.33 | | | | | | | |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

When analyses considered pre-packed products only, the overall difference of shopping carts' FSAm-NPS score between the three arms was no longer significant suggesting inter-food group substitutions (Table S2). However, results for the secondary outcomes remained consistent with the main analyses. In sensitivity analyses excluding outliers on the spending amount, similar results were observed for primary and secondary outcomes (Table S3). Results of the sensitivity analyses using multiple imputations and providing intention-to-treat estimates are presented in Table S4 for analyses considering all food products and Table S5 for analyses considering only labelled food items. Results using multiple imputations were consistent with the main analyses; however, the amplitude of differences between arms was lower and comparisons were no longer significant, except for calories for which the Nutri-Score also led to lower contents compared to the two other arms (Tables S4 and S5). The participants in the Nutri-Score am purchased less calories, SFA, sugars, sodium, fibres, and proteins compared to the two other arms (Table S6).

Table S7 describes the shopping carts composition in terms of the mean number of products per food category in each of the three arms. In the Nutri-Score arm, participants tended to purchase more products from the fruits (especially fresh fruit), meat and water categories (compared to the RIs), and fewer products from vegetables, dairy products, cheeses, sweets and starchy foods such as pasta, rice, rush potatoes and semolina. The average percentages of raw products (i.e. not labelled in the label arms) purchased by participants were 32.9%±18.4% in the no label arm, 33.2%±18.2% in the RIs arm, and 42.0%±28.1% in the Nutri-Score arm. The percentage contributions of food groups to nutrient intakes in the overall shopping carts are presented in Table S8 (only for nutrients where a difference between arm was observed in the main analyses). Thus, the lower calorie and SFA contents of the shopping carts in the Nutri-Score arm compared to the RIs arms could be explained by fewer products purchased in the dairy products, cheese, but also sweets and starchy foods. Finally, the proportion of healthier

food products in the shopping carts classified as A was significantly higher in the Nutri-Score arm compared to the two other arms (difference = 5.63 [2.02;9.24], p-value=0.0008 compared to no label; difference = 4.85 [1.24;8.47], p-value=0.005 compared to the RIs), which can be partly explained by the higher proportion of raw fruits and meats in the shopping carts of participants from the Nutri-Score group – corresponding to products with higher nutritional quality (Table S9). On the contrary, the proportion of unhealthier products classified as D or E was significantly lower in the Nutri-Score arm compared to the two other arms or the RIs only. No significant difference was observed between the RIs and no label.

## DISCUSSION

Results of the present study showed that the Nutri-Score label significantly led to an improvement of the overall nutritional quality of food purchasing intentions in individuals with cardiometabolic chronic disease. Moreover, the Nutri-Score led to lower contents of the shopping carts in energy and SFA compared to the two other arms. Similar trends were observed with multiple imputations; nevertheless, differences were no longer statistically significant. No significant difference was observed between the RIs and no label. Moreover, in both FoPLs arms, and particularly in the Nutri-Score arm, substitutions between food groups were observed, with more raw products purchased – corresponding mainly to fruits and butcher's meats from higher nutritional quality. It appeared that the participants exposed to the Nutri-Score purchased less products and from higher overall nutritional quality (i.e. lower FSAm-NPS score).

The present findings are consistent with studies which observed a positive effect of interpretive FoPLs and especially the Nutri-Score on the nutritional quality of intentional or real food

purchases, while the RIs demonstrated a limited or non-significant effect in the general population [14,18] or students.[28] This could be partly explained by the features of the schemes. Indeed, the summary indicator of the Nutri-Score, combining colours and text, would be easier to read and understand.[16,18,19,31–37] On the contrary, the RIs with its nutrient-specific and monochromatic format, has been shown to be more complicated to identify and understand in the general population,[18,36,37] creating notably potential decisional conflicts and prioritization of nutrients.[38] Nevertheless, to our knowledge, this is the first study to assess the effect of FoPLs on purchasing intentions among individuals suffering from nutrition-related NCDs. Only one study investigated the effect of the Traffic Lights nutrient-specific label and the three-stars summary label on food purchases in vending machine among patients in an Australian hospital and observed a positive effect of the labels to identify healthier products. However, the experiment was performed in a specific context and no focus was made on patients suffering specifically from nutrition-related NCDs.[12]

Interestingly, while previous studies among patients with hypertension, hypercholesterolemia, type 2 diabetes or hyperlipidaemia found that they were more likely to read information on salt and SFA respectively,[39] and have lower intakes in energy and SFA,[9] in the present study, the RIs did not help consumers to select products with significantly less SFA compared to no label. On the contrary, the Nutri-Score which does not provide numerical data but rather summarized information, led to significantly lower contents of the shopping carts in SFA compared to no label and the RIs. These results on the Nutri-Score effect are particularly important, given that a decrease of the intakes in energy, SFA and salt with an increase of fruits and vegetables consumption are recommended among patients suffering from nutrition-related NCDs.[1] Moreover, despite these recommendations, it has been observed in a study within the NutriNet-Santé cohort that adults with a cardiometabolic disease tended to have unhealthier

dietary habits overall (e.g. lower intakes of fruits, higher intakes of meat, processed meat and added fats) compared to healthy controls,[40] which supports the interest of public health measures encouraging healthier food choices among these individuals.

When analyses were restricted to labelled items only, no significant difference of the overall nutritional quality between the Nutri-Score and the other arms was found. These results reflect that the use of the Nutri-Score may encourage also substitutions between food categories. Indeed, participants who were exposed to the Nutri-Score tended to purchase more non-labelled raw products, in particular fruits, meat and poultry, characterized by healthier nutritional quality. This substitution between food categories has been observed in other populations under the same or similar experimental conditions [28,41,42]. Some hypotheses could explain these results. In general, the impact of front-of-pack labelling has been found to vary according the food category [43], partly in relation to consumer motivation [44]. More specifically, the Nutri-Score provides an explicit comparative scale of the nutritional quality of pre-packed foods and may have raised awareness as to the lower nutritional value of some pre-packed products. By comparison, this may have heightened the perceived healthiness fruit or meat products, even in the absence of any labelling. As to beverages, water being the only beverage receiving a 'A' Nutri-Score, its promotion is particularly straightforward in the system. Another hypothesis relates to the overall awareness to the importance of food choices that the presence of the Nutri-Score may have spurred, acting as a global reminder of previously received nutritional education in patients. In doing so, the Nutri-Score scheme may cue concerns/motivations about eating healthier products overall[45]. Finally, the choice to purchase more fresh fruits, meats, and water (perceived as A-grade products) may also suggest compensatory behaviours designed to offset choosing some less healthy products. It may also be worth noting that in choosing more fresh fruits, meats, and water, (rather than increasing the purchase of vegetables),

consumers may also seek to balance the perceived healthiness of their choices with perceived taste/palatability. These speculations as to the motivations and goals underlying specific food choices patterns following the introduction of a front-of-pack labelling scheme should be further explored in future studies, to devise efficient strategies to reinforce the observed trends.

The present study provides insights regarding the effect of the Nutri-Score on purchasing intentions of individuals with nutrition-related NCDs compared to the current labelling situation in France and other European countries. First, strength of the study pertained in the inclusion of a specific population rarely explored in the nutritional labelling field, and its randomized controlled design, which resulted in comparable groups allowing accurate estimations of the labels' effect. Furthermore, the experiment was conducted on an experimental online supermarket, closed to real online grocery shopping conditions, with a range of different products with distinct nutritional profiles, brands and the use of real packaging. This controlled experimental environment allowed assessing the effect of the Nutri-Score in standardized conditions and optimizing internal validity of the study. Finally, we provided intention-to-treat analyses of the participants (Table S1) and intention-to-treat estimates through multiple imputation methods. Nevertheless, some limitations should be acknowledged. First, a high rate of participants did not complete the shopping task. Hence, respondents may have different individual characteristics, leading however to a potential non-differential bias which could limit the generalizability of the results. In addition, the reduced sample size could have led to a decreased statistical power preventing us from detecting some potential small differences. Moreover, it is important to notice that analyses with multiple imputations led to similar trends but with non-significant differences given the wide variance in the sample. Second, the trial involved voluntary participants, who may have greater interest and knowledge in nutrition than the French population of patients. Thus, participants in the no label arm might have made

healthier food choices than the general population and the effects of FoPLs in comparison could have been underestimated. Third, despite the diversity of the food offer proposed, the number of products was somewhat limited, and some participants may not have found their usual product and chose foods they would not buy in real shopping situation. In addition, the representativity of the experimental food offer was not carefully assessed. These elements would limit the extern validity of the study and the generalisability of the results to a real online supermarket. Moreover, compared to the French average, the higher proportion of subjects who declared doing often their grocery shopping online, may have led to a sample with sociodemographic differences compared to the French population of patients. Fourth, the trial investigated purchasing intentions rather than actual food purchases that may have led the participants to take the experiment less seriously or to spend more money than they would actually do. Complementary studies should be conducted in real-life settings to provide additional elements on the Nutri-Score effectiveness. Nevertheless, virtual purchasing behaviours of individuals have been suggested to be good predictors of real behaviours.[46] Finally, the study included cases of self-reported cardiometabolic chronic conditions with no validation required. Therefore, we were not able to ascertain whether the participants were following specific diets or nutritional recommendations during the period of the trial, which could have modified their purchasing behaviours. The present study focused on the Nutri-Score effect as a secondary or tertiary prevention tool of NCDs, and complement previous studies which have been conducted on the general population including individual without any chronic conditions, or on specific subgroups such as students. Furthermore, it could have been interesting to also include individuals having someone in the household with a chronic condition.

These results support that the Nutri-Score may improve the nutritional quality of food choices of consumers suffering from nutrition-related chronic diseases. This is particularly important given that an improvement of the dietary habits and the nutritional status of these individuals is a major element in the secondary prevention and the management of these non-communicable diseases. These findings are complementary to studies having observed a favourable effect of the Nutri-Score or its underlying nutrient profiling system on chronic diseases risk, in a context of primary prevention, through an improvement of food purchases and nutrient intakes.[18,47]

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**Competing interests**

All authors declare no competing interests.

**Author contributorship**

ME, CJ and IB wrote the statistical analysis plan, analysed the data, and drafted and revised the paper. SP, PD, MT, PG, LF, RP, PR, SH and EKG analysed the data and critically revised the paper for important intellectual content. SH and CJ designed data collection tools, implemented the study, monitored data collection for the whole study, and critically revised the draft paper for important intellectual content. All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. All authors have read and approved the final manuscript.

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**Competing interests**

The authors do not report any conflicts of interest

**Ethics approval and consent to participate**

The study was approved by the Institutional Review Board of INSERM (IRB Inserm n°IRB0000388 FWA00005831) and the National Commission for Data Protection and Liberties (CNIL n° 909216), and registered at: https://clinicaltrials.gov/ct2/show/NCT02769455. Electronic consent was obtained from each participant of the trial.

**Data sharing**

All data supporting the findings of this study are included in the present article or the supplemental material. No additional data available.

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**Figure 1**An example of a food product in the Nutri-Score (1), Reference Intakes (2), and no label (3) arms. Images developed by the co-authors.

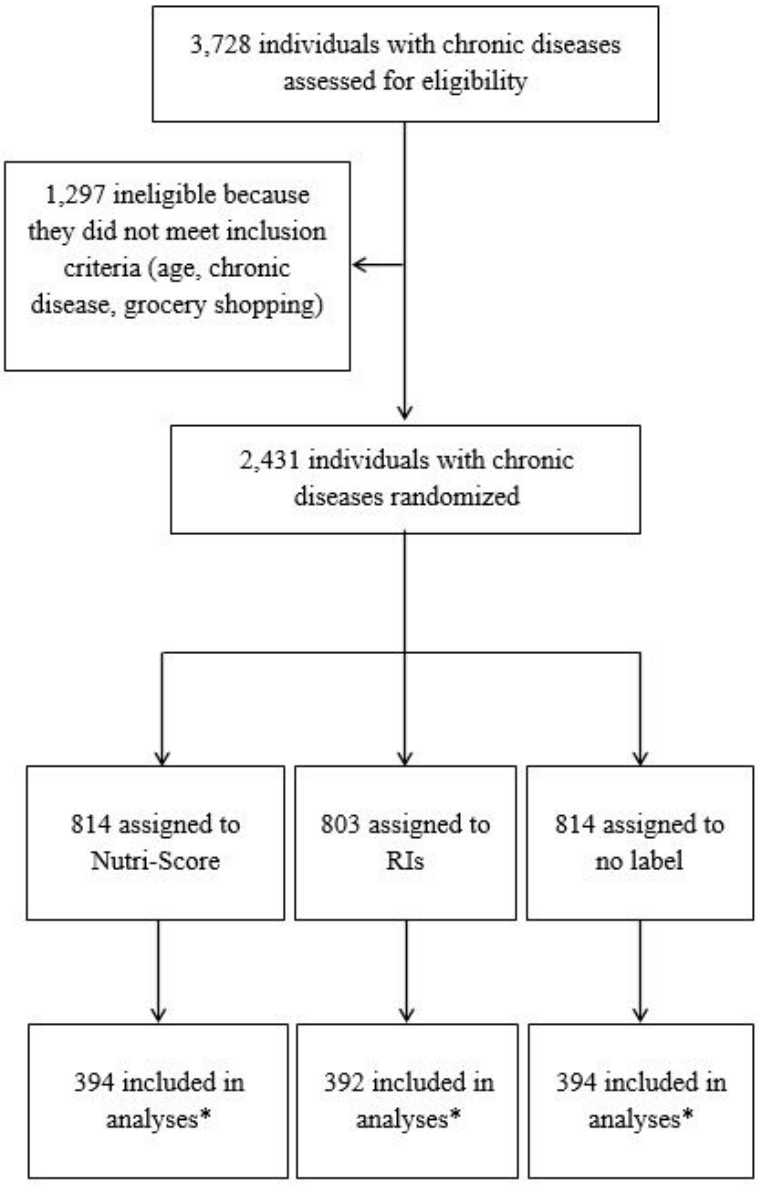
**Figure 2** Flow diagram of the randomized controlled trial

* Subjects who validated their online shopping cart and did not encounter technical issues


(1) (2) (3)

An example of a food product in the Nutri-Score (1), Reference Intakes (2), and no label (3) arms. Images developed by the co-authors.

56x28mm (300 x 300 DPI)




Flow diagram of the randomized controlled trial

36x55mm (300 x 300 DPI)

**Table S1** Individual characteristics of respondents and non-respondents in the randomized controlled trial by randomization group, France, 2017

| | Nutri-Score | | Reference Intakes | | No label | | |
|---|---|---|---|---|---|---|---|
| | Respondents | Non-respondents | Respondents | Non-respondents | Respondents | Non-respondents | *P*[a] |
| **Total (n)** | 394 | 420 | 392 | 411 | 394 | 420 | |
| **Sex, n(%)** | | | | | | | 0.5 |
| Men | 131 (33.2) | 158 (37.6) | 124 (31.6) | 143 (34.8) | 152 (38.6) | 157 (37.4) | |
| Women | 263 (66.8) | 262 (62.4) | 268 (68.4) | 268 (65.2) | 242 (61.4) | 263 (62.6) | |
| **Age, years** | 64.8 ± 6.9 | 65.8 ± 7.5 | 64.8 ± 7.3 | 66.5 ± 7.1 | 65.4 ± 7.1 | 66.2 ± 7.2 | 0.5 |
| **Educational level** | | | | | | | 0.2 |
| Primary | 122 (31) | 131 (31.2) | 102 (26) | 140 (34.1) | 104 (26.4) | 131 (31.2) | |
| Secondary | 53 (13.5) | 83 (19.8) | 51 (13) | 77 (18.7) | 74 (18.8) | 71 (16.9) | |
| University, undergraduate degree | 103 (26.1) | 94 (22.4) | 122 (31.1) | 98 (23.8) | 99 (25.1) | 103 (24.5) | |
| University, postgraduate degree | 98 (24.9) | 93 (22.1) | 102 (26) | 77 (18.7) | 103 (26.1) | 102 (24.3) | |
| Other | 18 (4.6) | 19 (4.5) | 15 (3.8) | 19 (4.6) | 14 (3.6) | 13 (3.1) | |
| **Grocery shopping frequency, n(%)** | | | | | | | 0.6 |
| Always | 231 (58.6) | 235 (56) | 252 (64.3) | 229 (55.7) | 239 (60.7) | 245 (58.3) | |
| Often | 122 (31) | 134 (31.9) | 107 (27.3) | 128 (31.1) | 113 (28.7) | 127 (30.2) | |
| Sometimes | 41 (10.4) | 51 (12.1) | 33 (8.4) | 54 (13.1) | 42 (10.7) | 48 (11.4) | |
| **Online grocery shopping, yes n(%)** | 119 (30.2) | 96 (22.9) | 129 (32.9) | 102 (24.8) | 103 (26.1) | 109 (26) | 0.2 |
| **Online grocery shopping frequency, n(%)** | | | | | | | 0.4 |
| At least one time per week | 16 (13.4) | 8 (8.3) | 20 (15.5) | 14 (13.7) | 21 (20.4) | 13 (11.9) | |
| One or two times per month | 22 (18.5) | 25 (26) | 26 (20.2) | 20 (19.6) | 15 (14.6) | 25 (22.9) | |
| One time every two or three months | 29 (24.4) | 15 (15.6) | 33 (25.6) | 23 (22.5) | 17 (16.5) | 22 (20.2) | |
| One or two times per year | 23 (19.3) | 23 (24) | 21 (16.3) | 29 (28.4) | 29 (28.2) | 32 (29.4) | |
| Less than one time per year | 29 (24.4) | 25 (26) | 29 (22.5) | 16 (15.7) | 21 (20.4) | 17 (15.6) | |
| **Weekly budget for grocery shopping (€)** | | | | | | | 0.2 |
| <30€ | 13 (3.3) | 20 (4.8) | 17 (4.3) | 10 (2.4) | 16 (4.1) | 6 (1.4) | |
| 30 – 50€ | 76 (19.3) | 65 (15.5) | 74 (18.9) | 78 (19) | 63 (16) | 65 (15.5) | |
| 50 – 100€ | 151 (38.3) | 159 (37.9) | 168 (42.9) | 158 (38.4) | 160 (40.6) | 164 (39) | |
| >100€ | 151 (38.3) | 154 (36.7) | 130 (33.2) | 140 (34.1) | 147 (37.3) | 167 (39.8) | |
| Missing | 3 (0.8) | 22 (5.2) | 3 (0.8) | 25 (6.1) | 8 (2) | 18 (4.3) | |
| **Perceived nutritional knowledge, n(%)** | | | | | | | 0.1 |
| High | 38 (9.6) | 33 (7.9) | 38 (9.7) | 26 (6.3) | 22 (5.6) | 44 (10.5) | |
| Intermediate | 222 (56.3) | 226 (53.8) | 220 (56.1) | 231 (56.2) | 233 (59.1) | 221 (52.6) | |
| Low | 125 (31.7) | 135 (32.1) | 125 (31.9) | 125 (30.4) | 124 (31.5) | 132 (31.4) | |
| No | 9 (2.3) | 9 (2.1) | 7 (1.8) | 7 (1.7) | 9 (2.3) | 6 (1.4) | |
| Missing data | 0 | 17 (4) | 2 (0.5) | 22 (5.4) | 6 (1.5) | 17 (4) | |
| **Nutrition facts reading frequency, n(%)** | | | | | | | 0.3 |
| Always | 63 (16) | 68 (16.2) | 55 (14) | 58 (14.1) | 54 (13.7) | 71 (16.9) | |
| Often | 202 (51.3) | 190 (45.2) | 199 (50.8) | 210 (51.1) | 206 (52.3) | 177 (42.1) | |
| Sometimes | 117 (29.7) | 127 (30.2) | 122 (31.1) | 106 (25.8) | 119 (30.2) | 142 (33.8) | |
| Never | 12 (3) | 18 (4.3) | 14 (3.6) | 15 (3.6) | 9 (2.3) | 13 (3.1) | |
| Missing data | 0 | 17 (4) | 2 (0.5) | 22 (5.4) | 6 (1.5) | 17 (4) | |

Values are mean ± standard deviation or n (%) as appropriate.

[a] A multivariable logistic regression was conducted to model the probability of non-response depending on the individual sociodemographic and lifestyle characteristics and the arm of randomization. The *P* corresponds to the p-value of the interaction term between the individual characteristic and the trial arm. The comparison of the educational level and weekly budget for grocery shopping variables between respondents and non-respondents were not performed given that information was missing for non-respondents.

**Table S2** Overall nutritional quality, energy and nutrient content for 100g of the shopping cart among labelled products only

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=369 | N=390 | N=392 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P- value[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 4.35 (3.5) | 4.27 (3.43) | 4.49 (3.41) | 0.7 | -0.13 (-0.72;0.45) | 0.9 | 0.08 (-0.51;0.67) | 0.9 | -0.21 (-0.79;0.36) | 0.7 |
| Calories (kcal/100g) | 188.42 (111.64) | 237.94 (80.74) | 226.59 (85.24) | **<0.0001** | -38.16 (-54.02;-22.3) | **<0.0001** | -49.52 (-65.39;-33.64) | **<0.0001** | 11.35 (-4.28;26.99) | 0.2 |
| Saturated fatty acids (g/100g) | 4.60 (4.48) | 5.34 (2.97) | 5.43 (3.28) | **0.003** | -0.83 (-1.45;-0.22) | **0.004** | -0.74 (-1.36;-0.13) | **0.01** | -0.09 (-0.70;0.52) | 0.9 |
| Sugars (g/100) | 5.80 (5.16) | 6.45 (4.23) | 6.43 (6.00) | 0.1 | -0.63 (-1.51;0.25) | 0.2 | -0.66 (-1.54;0.23) | 0.2 | 0.03 (-0.84;0.9) | 1.0 |
| Sodium (mg/100g) | 267.67 (284.89) | 252.19 (130.25) | 267.10 (200.7) | | | | | | | |
| Fiber (g/100g) | 1.45 (1.56) | 2.27 (1.74) | 1.95 (1.54) | | | | | | | |
| Fruits and vegetables (%) | 17.98 (20.94) | 17.48 (13.99) | 16.95 (12.61) | | | | | | | |
| Proteins (g/100g) | 6.35 (4.31) | 7.89 (2.87) | 7.99 (3.92) | | | | | | | |

[a] Mean difference (95% Confidence Interval)
[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S3** Sensitivity analyses: overall nutritional quality, energy and nutrient content for 100g of the shopping cart excluding outliers on the spending amount

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=351 | N=354 | N=357 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P- value[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 0.99 (3.30) | 1.69 (2.84) | 1.8 (2.58) | **0.0004** | -0.81 (-1.32;-0.29) | **0.0007** | -0.69 (-1.21;-0.17) | **0.005** | -0.12 (-0.63;0.40) | 0.9 |
| Calories (kcal/100g) | 152.06 (74.84) | 180.89 (58.10) | 173.53 (57.8) | **<0.0001** | -21.47 (-32.77;-10.17) | **<0.0001** | -28.83 (-40.15;-17.51) | **<0.0001** | 7.36 (-3.91;18.63) | 0.3 |
| Saturated fatty acids (g/100g) | 3.19 (2.73) | 3.76 (2.02) | 3.78 (2.03) | **0.0005** | -0.59 (-0.99;-0.18) | **0.002** | -0.58 (-0.98;-0.17) | **0.002** | -0.01 (-0.41;0.39) | 1.0 |
| Sugars (g/100) | 5.9 (3.31) | 5.79 (2.93) | 5.61 (3.10) | 0.5 | 0.29 (-0.26;0.84) | 0.4 | 0.11 (-0.44;0.66) | 0.9 | 0.18 (-0.36;0.73) | 0.7 |
| Sodium (mg/100g) | 171.75 (144.16) | 193.37 (96.17) | 205.5 (143.31) | | | | | | | |
| Fiber (g/100g) | 1.41 (1.01) | 1.91 (1.17) | 1.67 (0.96) | | | | | | | |
| Fruits and vegetables (%) | 35.29 (22.57) | 30.66 (14.69) | 30.11 (13.93) | | | | | | | |
| Proteins (g/100g) | 7.30 (3.25) | 7.25 (2.03) | 7.53 (2.92) | | | | | | | |

[a] Mean difference (95% Confidence Interval)
[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). Participants whose spending amount was below the 5th or over the 95th percentile of the distribution of the cost of the shopping carts in the sample were excluded. FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S4** Sensitivity analyses using multiple imputations: overall nutritional quality, energy and nutrient content for 100g of the shopping cart

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=814 | N=803 | N=814 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P-value[b] |
| Overall nutritional quality (FSAm-NPS score/100g) | 1.51 (1.87) | 1.78 (1.87) | 1.84 (2.04) | 0.1 | -0.33 (-0.69;0.03) | 0.07 | -0.27 (-0.63;0.08) | 0.1 | -0.06 (-0.43;0.32) | 0.8 |
| Calories (kcal/100g) | 162.95 (41.32) | 177.21 (39.24) | 173.24 (44.67) | **0.0009** | -10.28 (-18.26;2.31) | **0.01** | -14.26 (-21.87;6.65) | **0.0003** | 3.98 (-4.09;12.05) | 0.3 |
| Saturated fatty acids (g/100g) | 3.43 (1.62) | 3.68 (1.41) | 3.70 (1.64) | 0.1 | -0.27 (-0.56;0.02) | 0.07 | -0.25 (-0.54;0.04) | 0.1 | -0.02 (-0.32;0.28) | 0.9 |
| Sugars (g/100) | 5.86 (2.11) | 5.86 (2.02) | 5.74 (2.22) | 0.6 | 0.12 (-0.32;0.55) | 0.6 | -0.01 (-0.46;0.45) | 1.0 | 0.12 (-0.30;0.54) | 0.6 |
| Sodium (mg/100g) | 194.73 (102.46) | 196.38 (97.05) | 205.54 (113.03) | | | | | | | |
| Fiber (g/100g) | 1.51 (0.62) | 1.76 (0.64) | 1.64 (0.68) | | | | | | | |
| Fruits and vegetables (%) | 32.25 (10.94) | 30.12 (10.35) | 29.78 (11.19) | | | | | | | |
| Proteins (g/100g) | 7.41 (1.73) | 7.35 (1.86) | 7.48 (1.97) | | | | | | | |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S5** Sensitivity analyses using multiple imputations: overall nutritional quality, energy and nutrient content for 100g of the shopping cart among labelled products only

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Rference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N=789 | N=801 | N=812 | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P- value[b] |
| Overall nutritional quality (FSA score/100g) | 3.51 (11.8) | 3.52 (11.82) | 3.61 (11.53) | 0.6 | -0.10 (-0.57;0.36) | 0.7 | -0.01 (-0.46;0.43) | 1.0 | -0.09 (-0.53;0.35) | 0.7 |
| Calories (kcal/100g) | 176.66 (343.52) | 201.81 (344.94) | 195.53 (330.17) | **0.001** | -18.87 (-31.27;-6.5) | **0.003** | -25.15 (-38.22;-12.09) | **0.0002** | -6.29 (-5.17;17.74) | 0.3 |
| Saturated fatty acids (g/100g) | 3.97 (14.84) | 4.34 (15.04) | 4.37 (14.67) | 0.2 | -0.41 (-0.88;0.06) | 0.09 | -0.38 (-0.88;0.12) | 0.1 | -0.03 (-0.47;0.41) | 0.9 |
| Sugars (g/100) | 4.64 (19.27) | 4.99 (19.48) | 4.96 (19.33) | 0.5 | -0.32 (-0.97;0.33) | 0.3 | -0.35 (-0.97;0.28) | 0.3 | 0.02 (-0.63;0.68) | 0.9 |
| Sodium (mg/100g) | 220.7 (688.19) | 216.53 (675.15) | 221.69 (672.91) | | | | | | | |
| Fiber (g/100g) | 1.43 (5.42) | 1.83 (5.44) | 1.68 (5.27) | | | | | | | |
| Fruits and vegetables (%) | 16.76 (50.37) | 16.55 (50.69) | 16.43 (49.19) | | | | | | | |
| Proteins (g/100g) | 6.12 (14.32) | 6.86 (13.06) | 6.89 (12.84) | | | | | | | |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). FSAm-NPS: modified Food Standards Agency Nutrient Profiling System.

**Table S6** Total quantities of calories and nutrients in the shopping carts purchased in the three arms of the trial

| | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | Mean (SD) | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P-value[b] |
| Calories (kcal) | 2229.74(2336.45) | 3395.80(2232.5) | 3173.73(2235.09) | **<0.0001** | -943.99(-1323.29;-564.7) | **<0.0001** | -1166.06(-1545.84;-786.29) | **<0.0001** | 222.07(-157.71;601.85) | 0.4 |
| Saturated fatty acids (g) | 35.88(40.21) | 53.08(37.21) | 52.60(38.35) | **<0.0001** | -16.72(-23.18;-10.27) | **<0.0001** | -17.20(-23.66;-10.73) | **<0.0001** | 0.47(-5.99;6.94) | 1.0 |
| Sugars (g) | 78.09(71.76) | 116.70(90.74) | 103.08(79.66) | **<0.0001** | -24.99(-38.54;-11.43) | **<0.0001** | -38.60(-52.17;-25.03) | **<0.0001** | 13.61(0.04;27.19) | **0.05** |
| Sodium (mg) | 1914.81(2121.69) | 2875.46(2298.01) | 2803.92(2232.81) | **<0.0001** | -889.11(-1260.04;-518.19) | **<0.0001** | -960.66(-1332.06;-589.26) | **<0.0001** | 71.54(-299.86;442.95) | 0.9 |
| Fiber (g) | 17.13(17.45) | 29.81(21.11) | 26.17(20.05) | **<0.0001** | -9.04(-12.32;-5.76) | **<0.0001** | -12.68(-15.96;-9.4) | **<0.0001** | 3.64(0.36;6.92) | **0.03** |
| Proteins (g) | 98.66(92.33) | 145.51(93.35) | 142.44(94.72) | **<0.0001** | -43.78(-59.41;-28.15) | **<0.0001** | -46.85(-62.5;-31.2) | **<0.0001** | 3.07(-12.58;18.72) | 0.9 |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). SD: Standard Deviation

**Table S7** Percentage of the number of products in the shopping cart from the different food categories

| Food groups | Nutri-Score | Reference Intakes | No label |
|---|---|---|---|
| **Fruits, vegetables, legumes, grains and starchs** | | | |
| Fresh fruits | 17,69(22,1) | 7,14(6,76) | 7,07(6,68) |
| Processed fruits | 1,96(8,99) | 0,73(1,72) | 0,82(2,05) |
| Fresh vegetables | 6,13(10,74) | 10,76(9,87) | 9,73(8,82) |
| Processed vegetables | 2,79(5,09) | 4,22(5,14) | 3,43(4,69) |
| Legumes and potatoes | 1,50(3,45) | 3,08(4,64) | 2,49(5,28) |
| Seeds and dried fruits | 0,81(2,44) | 0,83(1,82) | 1,08(3,14) |
| **Dairy products** | 10,25(11,77) | 12,46(10,36) | 13,33(14,06) |
| **Cheeses** | 2,96(5,01) | 4,84(7,39) | 5,17(6,15) |
| **Meat, fish and processed foods** | | | |
| Pre-packed meat | 0,11(0,68) | 0,20(0,99) | 0,21(0,83) |
| Meat | 12,52(14,99) | 6,02(6,04) | 6,94(10,14) |
| Processed meats | 4,64(11,25) | 3,35(4,93) | 3,5(5,25) |
| Fresh fish | 2,66(6,6) | 2,71(5,94) | 2,44(3,51) |
| Processed fish | 0,51(1,84) | 0,68(1,89) | 0,79(3) |
| Sea delicatessen and canned fish | 1,85(3,88) | 2,58(3,83) | 3,67(10,21) |
| **Sweet products** | | | |
| Biscuits | 1,09(2,95) | 2,40(8,16) | 1,17(2,26) |
| Sweets | 3,17(5,26) | 5,24(5,39) | 4,88(6,35) |
| Breakfast cereals | 0,18(0,86) | 0,32(1,27) | 0,26(1,11) |
| Breads, rusks and pastries | 1,78(4,90) | 2,53(4,19) | 3,56(9,43) |
| Ice creams | 0,58(1,84) | 0,73(2,09) | 0,71(2,39) |
| **Salty products** | | | |
| Prepared dishes | 1,26(3,39) | 2,06(6,4) | 1,75(3,68) |
| Pasta, rice, mashed potatoes and semolina | 2,21(4,07) | 4,68(9,44) | 3,47(5,85) |
| Savoury aperitif products | 0,44(1,40) | 1,05(2,85) | 0,66(1,79) |
| Salads | 0,35(1,34) | 0,40(1,53) | 0,18(0,95) |
| Soups | 0,49(2,21) | 1,12(6,57) | 1,08(7,57) |
| Sauces and condiments | 3,75(9,23) | 3,86(4,47) | 4,26(6,07) |
| **Oils and fats** | 4,43(9,22) | 4,06(4,02) | 3,92(4,04) |
| **Beverages** | | | |
| Waters | 8,95(14,68) | 5,96(8,85) | 8,71(16,74) |
| Fruit juices | 2,36(6,58) | 1,52(5,77) | 1,07(2,55) |
| Sweetened drinks and sodas | 2,58(5,50) | 4,48(6,51) | 3,64(4,38) |

Values correspond to mean (Standard deviation).

**Table S8** Percent contributions of food groups to nutrient intakes of the overall shopping cart

| Food groups | Calories | | | Saturated Fatty Acids | | |
|---|---|---|---|---|---|---|
| | Nutri-Score | Reference Intakes | No label | Nutri-Score | Reference Intakes | No label |
| **Fruits, vegetables, legumes, grains and starchs** | | | | | | |
| Fresh fruits | 12,03(21,1) | 2,76(4,93) | 2,53(2,98) | 5,64(21,07) | 0,43(5,11) | 0,12(0,29) |
| Processed fruits | 1,46(8,67) | 0,31(0,91) | 0,34(0,88) | 0,92(8,48) | 0,06(0,49) | 0,05(0,15) |
| Fresh vegetables | 1,93(6,41) | 2,48(3,77) | 2,06(2,48) | 0,82(7,1) | 0,30(1,19) | 0,15(0,24) |
| Processed vegetables | 0,92(2,29) | 1,38(2,42) | 1,18(3,18) | 0,48(4,45) | 0,43(1,60) | 0,36(1,19) |
| Legumes and potatoes | 2,47(5,55) | 5,15(8,23) | 4,10(7,97) | 0,39(2,42) | 0,63(3,61) | 0,78(5,35) |
| Seeds and dried fruits | 2,19(5,88) | 2,33(5,16) | 2,97(6,77) | 1,49(4,68) | 1,60(4,44) | 1,87(6,25) |
| **Oils and fats** | 7,61(11,16) | 8,01(8,74) | 9,57(13,59) | 10,79(16,63) | 12,86(15,25) | 14,02(18,27) |
| **Beverages** | 5,38(9,19) | 8,32(11,10) | 9,81(10,39) | 11,87(18,7) | 19,59(21,72) | 22,38(21,8) |
| **Meat, fish and processed foods** | | | | | | |
| Pre-packed meat | 0,08(0,52) | 0,20(1,20) | 0,23(0,98) | 0,1(0,81) | 0,37(3,46) | 0,37(1,85) |
| Meat | 18,07(24,94) | 6,51(8,20) | 7,63(12,95) | 22,31(34,83) | 6,99(12,52) | 6,25(12,70) |
| Processed meats | 4,77(11,74) | 3,68(7,20) | 3,84(5,55) | 5,66(15,52) | 4,29(9,25) | 4,65(9,43) |
| Fresh fish | 2,17(7,01) | 2,2(6,38) | 1,62(2,62) | 1,69(8,35) | 1,46(7,16) | 0,67(1,69) |
| Processed fish | 0,38(1,58) | 0,58(2,17) | 0,63(2,16) | 0,22(1,05) | 0,45(3,01) | 0,46(2,49) |
| Sea delicatessen and canned fish | 1,92(5,13) | 2,64(4,66) | 3,51(10,18) | 1,43(5,13) | 1,85(4,58) | 2,41(9,00) |
| **Sweet products** | | | | | | |
| Biscuits | 2,41(5,96) | 4,77(11,63) | 3,05(6,08) | 2,23(6,55) | 4,9(13,55) | 2,75(6,73) |
| Sweets | 5,54(10,11) | 8,64(9,86) | 8,42(10,7) | 7,24(14,58) | 11,47(16,33) | 10,06(14,67) |
| Breakfast cereals | 0,33(1,55) | 0,66(2,51) | 0,58(2,45) | 0,10(0,54) | 0,25(1,34) | 0,15(0,77) |
| Breads, rusks and pastries | 3,16(7,95) | 4,28(6,62) | 5,76(11,22) | 0,94(3,49) | 0,94(2,46) | 2,09(10,59) |
| Ice creams | 0,50(1,58) | 0,7(2,44) | 0,65(2,83) | 0,89(3,63) | 1,10(4,07) | 0,82(3,77) |
| **Salty products** | | | | | | |
| Prepared dishes | 1,44(3,66) | 2,24(6,88) | 2,22(4,84) | 1,25(3,46) | 2,07(7,24) | 2,06(7,47) |
| Pasta, rice, mashed potatoes and semolina | 4,05(7,18) | 8,37(13,13) | 6,57(9,03) | 0,86(3,79) | 2,33(10,33) | 1,10(3,15) |
| Savoury aperitif products | 0,97(3,09) | 2,30(5,50) | 1,6(4,26) | 0,43(1,82) | 1,16(3,53) | 0,76(2,21) |
| Salads | 0,21(0,83) | 0,25(1,06) | 0,12(0,67) | 0,08(0,34) | 0,12(0,62) | 0,04(0,22) |
| Soups | 0,16(1,29) | 0,57(5,53) | 0,67(7,40) | 0,15(1,35) | 0,52(5,39) | 0,61(7,41) |
| Sauces and condiments | 2,72(8,87) | 1,94(3,23) | 2,20(5,24) | 1,90(8,97) | 0,96(2,07) | 1,14(4,45) |
| **Oils and fats** | 14,60(18,45) | 16,48(14,66) | 16,68(15,00) | 19,52(25,10) | 21,53(20,74) | 22,84(21,77) |
| **Beverages** | | | | | | |
| Waters | 0(0,03) | 0(0,03) | 0(0,03) | 0(0,05) | 0(0,10) | 0,01(0,11) |
| Fruit juices | 1,26(4,70) | 0,63(5,25) | 0,36(1,03) | 0(0) | 0(0) | 0(0) |
| Sweetened drinks and sodas | 1,29(5,36) | 1,62(4,61) | 1,12(3,61) | 0,62(3,36) | 1,36(5,99) | 1,04(4,14) |

The relatively high contributions of calories and saturated fatty acids for fruits and vegetables in the Nutri-Score arm could be partly explained by participants having only fruits or vegetables in their shopping carts, thus increasing the overall contribution at the sample level, even though they are low in calories and saturated fatty acids.

**Table S9** Distribution of the products across the five Nutri-Score classes

| Nutri-Score | Nutri-Score | Reference Intakes | No label | P-value | Nutri-Score vs no label | | Nutri-Score vs Reference Intakes | | Reference Intakes vs no label | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean proportion | Mean proportion | Mean proportion | | Difference[a] | P-value[b] | Difference[a] | P-value[b] | Difference[a] | P-value[b] |
| A | 58.16±25.02 | 53.3±20.26 | 52.53±20.07 | **0.0004** | 5.63(2.02;9.24) | **0.0008** | 4.85(1.24;8.47) | **0.005** | 0.78(-2.86;4.41) | 0.9 |
| B | 10.55±10.43 | 13.87±10.09 | 15.55±14.14 | **<0.0001** | -5.01(-6.93;-3.08) | **<0.0001** | -3.33(-5.26;-1.4) | **0.0002** | -1.68(-3.62;0.26) | 0.1 |
| C | 15.60±19.08 | 12.14±10.82 | 11.52±11.2 | **<0.0001** | 4.08(1.73;6.43) | **0.0001** | 3.46(1.10;5.81) | **0.002** | 0.62(-1.74;2.99) | 0.8 |
| D | 12.30±12.92 | 16.05±11.51 | 15.98±12.02 | **<0.0001** | -3.68(-5.69;-1.68) | **<0.0001** | -3.75(-5.76;-1.74) | **<0.0001** | 0.06(-1.95;2.08) | 1.0 |
| E | 3.40±5.69 | 4.63±8.57 | 4.42±5.42 | **0.02** | -1.02(-2.12;0.08) | 0.07 | -1.23(-2.34;-0.13) | **0.02** | 0.21(-0.90;1.33) | 0.9 |

[a] Mean difference (95% Confidence Interval)

[b] P-value using Tukey's multiple comparisons tests. Boldface indicates statistical significance (p-value≤0.05). All products were taken into account, including also raw foods that were non-labelled.

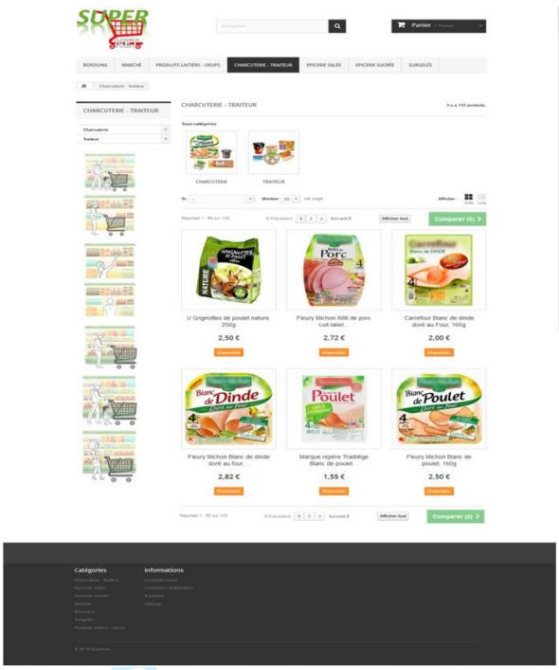



**Figure S1** Screenshot of the experimental online supermarket

# CONSORT 2010 checklist of information to include when reporting a randomised trial*

| Section/Topic | Item No | Checklist item | Reported on page No |
|---|---|---|---|
| **Title and abstract** | | | |
| | 1a | Identification as a randomised trial in the title | 1 |
| | 1b | Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts) | 2 |
| **Introduction** | | | |
| Background and objectives | 2a | Scientific background and explanation of rationale | 3-4 |
| | 2b | Specific objectives or hypotheses | 4 |
| **Methods** | | | |
| Trial design | 3a | Description of trial design (such as parallel, factorial) including allocation ratio | 4-5 |
| | 3b | Important changes to methods after trial commencement (such as eligibility criteria), with reasons | NA |
| Participants | 4a | Eligibility criteria for participants | 5 |
| | 4b | Settings and locations where the data were collected | 5 |
| Interventions | 5 | The interventions for each group with sufficient details to allow replication, including how and when they were actually administered | 6-7 |
| Outcomes | 6a | Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed | 8 |
| | 6b | Any changes to trial outcomes after the trial commenced, with reasons | NA |
| Sample size | 7a | How sample size was determined | 8 |
| | 7b | When applicable, explanation of any interim analyses and stopping guidelines | NA |
| Randomisation: | | | |
| Sequence generation | 8a | Method used to generate the random allocation sequence | 5-6 |
| | 8b | Type of randomisation; details of any restriction (such as blocking and block size) | 5 |
| Allocation concealment mechanism | 9 | Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned | NA |
| Implementation | 10 | Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions | 5 |
| Blinding | 11a | If done, who was blinded after assignment to interventions (for example, participants, care providers, those | NA |

| | | | |
|---|---|---|---|
| | | assessing outcomes) and how | |
| | 11b | If relevant, description of the similarity of interventions | NA |
| Statistical methods | 12a | Statistical methods used to compare groups for primary and secondary outcomes | 8-9 |
| | 12b | Methods for additional analyses, such as subgroup analyses and adjusted analyses | 9 |
| **Results** | | | |
| Participant flow (a diagram is strongly recommended) | 13a | For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome | 9 |
| | 13b | For each group, losses and exclusions after randomisation, together with reasons | Figure 2 |
| Recruitment | 14a | Dates defining the periods of recruitment and follow-up | 4-5 |
| | 14b | Why the trial ended or was stopped | NA |
| Baseline data | 15 | A table showing baseline demographic and clinical characteristics for each group | Table 1 |
| Numbers analysed | 16 | For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups | Figure 2 |
| Outcomes and estimation | 17a | For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval) | 12 |
| | 17b | For binary outcomes, presentation of both absolute and relative effect sizes is recommended | NA |
| Ancillary analyses | 18 | Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory | 14 |
| Harms | 19 | All important harms or unintended effects in each group (for specific guidance see CONSORT for harms) | NA |
| **Discussion** | | | |
| Limitations | 20 | Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses | 17 |
| Generalisability | 21 | Generalisability (external validity, applicability) of the trial findings | 17 |
| Interpretation | 22 | Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence | 15-17 |
| **Other information** | | | |
| Registration | 23 | Registration number and name of trial registry | 5 |
| Protocol | 24 | Where the full trial protocol can be accessed, if available | NA |
| Funding | 25 | Sources of funding and other support (such as supply of drugs), role of funders | 19 |

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.