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Effectiveness of different front-of-pack nutritional labels in promoting greater adherence to the mediterranean diet among Italian consumers

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ABSTRACT

The prevalence of obesity and non-communicable diseases is progressively increasing worldwide. To address this problem, in 2011, the European Commission declared its intention to adopt a common front-of-pack label (FOPL) to inform European consumers and enable them to choose nutritionally appropriate foods. Therefore, the aim of this study is to evaluate the effectiveness of two labels officially adopted by European countries.

The study was designed as a randomized-controlled trial, consisting of three conditions: use of Nutri-Score label vs. use of Battery label vs. no label (control condition). 1900 Italian adult participants were asked to use for one month a mobile application to visualize food label information and orient their food choices. Adherence to the Mediterranean diet and nutrition knowledge were assessed before and after the intervention.

Data showed low use of labels: more than 6 out of 10 consumers never used them during the 30-day intervention period. The ANOVA test showed no statistically significant differences among groups for adherence to the Mediterranean diet and nutrition knowledge before and after the intervention, as well as after a difference-in-difference regression analysis. Moreover, self-assessed nutrition knowledge and individual diet quality were overestimated by 3.9% and 17.6%, respectively.

FOPLs showed no effectiveness in influencing participants' eating pattern. Future research should explore if the reasons that prevented Italian consumers from using FOPLs are consumer-related (i.e., nutrition knowledge and diet quality overestimations), label-related (i.e., complexity or extreme simplification in information), or related to other contributing factors (i.e., time available for food shopping, economic aspects).

1. Introduction

The prevalence of obesity and non-communicable chronic-degenerative diseases (NCD) is progressively increasing in Western countries (Naghavi et al., 2024). This has significant repercussions on the health status of the population, the level of disability, quality of life, mortality and healthcare costs (Ferrari et al., 2024). To address this problem, there is a need to adopt a healthy lifestyle: from a nutritional point of view, this lifestyle is unanimously identified with the Mediterranean Diet (Caprara, 2021). Nutrition information is one of the major tools for promoting virtuous eating behavior (Grunert et al., 2010). One of the food policies in the attempt to create healthier eating patterns has been nutritional labeling. Nutritional labeling is an attempt to provide consumers, at the time of purchase, with information on the nutritional content of individual food products, in order to allow them to choose nutritionally appropriate foods (Muzzioli et al., 2022). It supports the goal of healthy eating while maintaining consumer freedom of choice and reduces information search costs for consumers, which should increase the likelihood that the information provided will be used (Grunert & Wills, 2007).

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The European Commission decided in 2011 to adopt a simple procedure represented by a front-of-pack nutritional label (FOPL) that can inform consumers and perform an "educational" function to combat the growing prevalence of obesity and NCDs (European Parliament, 2011). In fact, a policy scenario modeling analysis indicates that the implementation of mandatory (FOPL) may help avert NCD deaths by reducing sodium, sugars and saturated fat intakes (Flexner et al., 2025). Depending on their approach, FOPLs can be divided into "directives" and "non-directives". The latter (e.g., the NutrInform Battery) are informative labels that show the nutritional composition of foods and the percentage amounts of nutrients within a standard daily eating pattern. Differently, directive labels, such as Nutri-Score, Health Star Rating, Warning Labels, and Nordic Keyhole, among others, are the result of different algorithms used to classify foods as more or less healthy (Muzzioli, Maddaloni, et al., 2025). They aim at modifying individual food choices by associating each food with a healthiness score, a color of the traffic light scale or approval or warning logos (Donini et al., 2023).

There is currently an ongoing debate on which system is more effective in achieving the objectives set by the European Union, which in the meantime has decided to postpone the decision on which system to adopt at community level (initially scheduled for 2022) while waiting to have solid scientific evidence to support the decision (Donini et al., 2022; Penzavecchia et al., 2022). Very few studies have tried to assess FOPL effectiveness in real-life scenarios. Dubois et al., 2021, investigated the application of Nutri-Score label on 1266 food products in 60 supermarkets, and analyzed the modification in in food product volume of sales and in consumers' diet quality (Dubois et al., 2021). Another study evaluated the impact of the same label when applied to food menus in a restaurant cafeteria. Compared to the pre-intervention period, authors analyzed the change in consumers' intake of calories, saturated fats, and sugars (Julia et al., 2021). Given the high relevance of Mediterranean diet in increasing life expectancy (Sofi et al., 2008), and the strong debate on FOPL in Italy, investigating the food choices of Italian consumer in real-life contexts could add valuable insights to the current body of evidence in this field. Previous studies have focused on the comparison of NutrInform Battery (NIB) and Nutri-Score (NS) on Italian consumers: a study analyzed consumers' subjective understanding in 200 respondents, finding NIB as more informative and helpful than NS (Mazzù, Romani, & Gambicorti, 2021). Moreover, Mazzù, Romani, Baccelloni, & Gambicorti, 2021; Mazzù, Romani, & Gambicorti, 2021, and He et al., 2023, compared those labels in nine and twenty European countries, respectively. Both studies indicated that NIB is more effective in improving subjective understanding and liking (Mazzù, Romani, Baccelloni, & Gambicorti, 2021; He et al., 2023). Lastly, based on a new theoretical framework, namely the Front-Of-Pack Acceptance Model (Mazzù, Romani, et al., 2022), a cross-country investigation has been conducted to assess the role of trust and familiarity in a sample of Italian, French, and English respondents, finding that NS was less effective than NIB on attitude, behavioral intention, and trust (Mazzù, Baccelloni, et al., 2022).

However, to date, no study has verified the capacity of FOP labels to actually steer consumers' food choices toward a better adherence to healthy and sustainable dietary patterns. Given the current literature, we hypothesize that a label intervention could positively improve the adherence to the Mediterranean diet of Italian consumers.

To do that, the primary aim of this study is to estimate how much the use of a front-of-pack label can determine an improvement in the consumer's adherence to the Mediterranean Diet. Secondary objectives are: 1) to compare the effectiveness of front-pack labels created with a different communication models, namely directive versus non-directive approaches; 2) to evaluate the increase in nutrition knowledge given by the use of such tools.

2. Methods

2.1. Study population

In total, 1900 Italian adults were recruited via mail by a specialized market research agency, Norstat Italia. The sample was stratified by gender and age. The data were all collected through online interviews using the CAWI (Computer Assisted Web Interviewing) technique on a sample of adults residing in Italy extracted from a panel that includes more than 20 thousand households. All respondents were required to sign a privacy policy and consent form in accordance with the Italian and European General Data Protection Regulation. Individuals who reported to follow a particular dietary regime for their own choice (e.g., religious, ethical) or under medical prescription and participants who earned a degree or were professionals in the area of nutrition and dietetics were excluded. The protocol of this study was approved by the Ethical Board for Transdisciplinary Research (CERT) of the Sapienza University of Rome. (approval reference: 163/2024).

2.2. Design

The study was designed as a randomized-controlled trial, consisting of three conditions which participants were randomly assigned into: use of Nutri-Score label (NS) vs. use of NutrInform Battery (NIB) label vs. no label (control condition). To test the effectiveness of directive and non-directive labels, participants were asked to use for one month a mobile application, either Open Food Facts or NutrInform Battery, to visualize NS or NIB information on food products and orient their food choices, accordingly.

2.3. Procedure

Eligible participants were asked to provide information on sex, age, employment, educational level, involvement in in household grocery shopping, household composition, monthly household income, self-reported height and weight, self-estimated diet quality (on a seven-point scale between "I eat a very unhealthy diet" and "I eat a very healthy diet"), nutrition knowledge (on a seven-point scale between "I do not know anything about nutrition" and "I am very knowledgeable about nutrition"), if they had heard NS and NIB before the survey and if had used them when shopping at the supermarket. Participants were then randomly assigned to the three condition and asked to answer to an initial set of questionnaires to evaluate the adherence to the Mediterranean diet and the nutrition knowledge. Participants of the two intervention groups were asked to download a mobile application, either Open Food Facts or NutrInform Battery, that displays Nutri-Score or NutrInform Battery nutritional information after scanning the product barcode. At the end of the initial set of questionnaires, participants were mandatorily required to watch a training video explaining how the applications worked and how to visualize the label information, as well as to download a flyer, adapted from Crosetto et al., 2020, explaining the assigned label (Crosetto et al., 2020). Flyers are included in the Supplementary Material. Control group participants received a flyer with some suggestions about the Mediterranean diet. After one month, all participants were asked to answer a second set of questionnaires to assess changes in the adherence to the Mediterranean diet and the nutrition knowledge. Lastly, label use has been assessed at the end of the intervention, and the main difficulties reported by participants during use of mobile applications were recorded. Participants were asked to answer nine questions to evaluate qualitative perceptions of the food labels: each response was on a nine-item Likert scale (1- completely disagree, 9 – completely agree). Participants evaluated only the label they were exposed to.

2.4. Measures

During the survey, the following measures were used:

- Adherence to the Mediterranean diet was measured using the Italian version of the PREDIMED PLUS questionnaire (AMD) which provides a score between 0 (minimum adherence) and 17 (maximum adherence) (Grant et al., 2021);
- Nutrition knowledge was assessed using the Italian Nutrition Knowledge Questionnaire, validated by Scalvedi et al., 2021, which is divided in four modules: Experts' recommendations, 9 questions; Food composition, 10 questions; Food choices and nutrition labels, 13 questions; Diet-associations, 16 questions (Scalvedi et al., 2021);
- Body Mass Index (BMI) was calculated from the reported weight, expressed in Kg, divided per the squared reported height, expressed in meters. For the subgroup analysis, reported BMI were grouped into six categories, according to WHO recommendations: 1) BMI less than 18.5 kg/m^2; 2) BMI between 18.5 and 24.9 kg/m^2; 3) BMI between 25 and 29.9 kg/m^2; 4) BMI between 30 and 34.9 kg/m^2; 5) BMI between 35 and 39.9 kg/m; 6) BMI 40 kg/m^2 or higher (Nuttall, 2015).

2.5. Statistical analysis

Statistical analysis was conducted using SPSS (IBM SPSS Statistics, Version 28.0.1.1. Armonk, NY: IBM Corp.). Sociodemographic data were summarized per randomization group and analyses of variance (ANOVA) were performed to exclude differences between groups. Then, data were analyzed to assess changes in food consumption, estimate the extent of effectiveness based on the type of intervention, and identify relationships based on demographic and non-demographic characteristics of the subjects (i.e., sex, age group, income, level of education, and reported BMI). Finally, the analysis focused on changes in consumption of singular food categories that are typical of the Mediterranean diet.

Groups were initially analyzed individually by calculating the pre- and post-intervention differences in the collected variables and subsequently compared using ANOVA and Fisher's LSD post-hoc analysis. The estimation of the treatment effects was carried out using a difference-in-difference regression analysis, which took the following form:

$$AMD_{ij} = \alpha + \beta_1 Treatment_i + \beta_2 Time_j + \beta_3 (Treatment \cdot Time)_{ij} + \epsilon_{ij} \quad (1)$$

in which the *Treatment* and *Time* variables represent the treatment or control groups and the before or after intervention timing, respectively. The parameter β_3 estimates the between-group difference in the adherence to the Mediterranean diet before and after the intervention. Demographic and non-demographic characteristics (i.e., sex, age group, income, level of education, and reported BMI) were included as covariates to control for individual-level behavioral determinants and reduce residual confounding.

A secondary analysis was performed on the subgroup of participants who reported using the label at least minimally, in order to explore whether actual exposure behaviors modulated the effect of the intervention.

3. Results

A sample of 1900 participants completed the experimental process, divided into three groups: NutrInform Battery, Nutri-Score, and control condition. Demographic characteristics of participants are described in Table 1. The number of household members per household was higher than the Italian average: 2.8 vs. 2.3 (ISTAT, 2022); mean age of adult population was slightly lower than the national average: 50.9 years vs. 52.8 y years (data source: demo.istat.it, accessed on 16 July 2025). Despite similarities, this sample may not reflect the general Italian population because participants were not recruited based on their area of residency.

The ANOVA test for detecting differences between multiple groups revealed no differences in the demographic variables of interest [age, gender, number of household members, education level, income, body mass index (BMI), self-estimated diet quality and nutrition knowledge, use of nutrition facts, label awareness and use].

The answers to the question "During this month, how much did you use the label NutrInform Battery/Nutri-Score to help you choose what to buy?" are showed in Table 2. 62.4% of participants declared they did not use the label. Potential differences were examined between intervention groups; however, Student's *t*-test revealed no statistically significant difference at $p < 0.05$, as shown in Table 2. Moreover, participants were asked to report difficulties encountered during the use of mobile applications: low number of available products = 10.3%; low information clarity = 4.7%; too much information simultaneously = 4.2%; low predisposition to mobile applications = 8.3%; mobile applications are too time-consuming =7.6%; no difficulty encountered = 20.3%; non

Table 1
Individual characteristics of participants, context and use of labels.

		Overall (N = 1900)	Nutrinform Battery (n = 623)	Nutri-Score (n = 636)	Control (n = 641)	ANOVA p-value
Age[a], years		50.9 (14.4)	50.6 (14.6)	50.2 (14.2)	51.7 (14.4)	0.17
Sex, Females: n (%)		928 (48.8%)	303 (48.6%)	323 (50.8%)	302 (47.1%)	0.42
Household members[a], n		2.8 (1.1)	2.8 (1.1)	2.8 (1)	2.71 (1.1)	0.22
Educational level, n (%)	No education	2	0	1	1	0.39
	Primary school	14 (0.1%)	4 (0.1%)	5 (0.1%)	5 (0.1%)	
	Middle school	235 (12.4%)	83 (13.3%)	72 (11.3%)	80 (12.5%)	
	High school	1018 (53.6%)	345 (55.4%)	346 (54.4%)	327 (51.0%)	
	University degree	631 (33.2%)	191 (30.7%)	212 (33.3%)	228 (35.6%)	
Income per month, n (%)	Low (<1200€)	222 (11.7%)	75 (12.0%)	75 (11.8%)	72 (11.2%)	0.55
	Medium	1202 (63.2%)	382 (61.3%)	413 (64.9%)	407 (63.5%)	
	High (>3500€)	476 (25.1%)	166 (26.7%)	148 (23.3%)	162 (25.3%)	
BMI[a], kg/m^2		25.2 (4.6)	25.2 (4.8)	25.1 (4.6)	25.2 (4.5)	0.85
Are you in charge of groceries? (%)		97.1%	97.1%	97.3%	96.9%	0.90
Self-estimated diet quality (score:1–7) [a]		4.66 (1.20)	4.67 (1.20)	4.64 (1.17)	4.66 (1.22)	0.88
Self-estimated nutrition knowledge (score:1–7) [a]		4.78 (1.14)	4.83 (1.14)	4.71 (1.10)	4.79 (1.17)	0.16
Use of nutrition fact table (score:1–7) [a]		3.61 (1.72)	3.72 (1.75)	3.55 (1.67)	3.56 (1.74)	0.13
Did you hear about Nutri-Score before? n (%)		361 (19%)	132 (20.8%)	122 (19.6%)	107 (16.7%)	0.16
Do you use Nutri-Score for food purchasing? n (%)		0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Did you hear about NutrInform Battery before? n (%)		50 (2.6%)	18 (2.8%)	18 (2.9%)	14 (2.2%)	0.68
Do you use NutrInform Battery for food purchasing? n (%)		0 (0%)	0 (0%)	0 (0%)	0 (0%)	

Abbreviations: BMI: Body Mass Index. [a] data expressed in mean (SD).

Table 2
Use of labels during the intervention.

	Overall (N = 1259)	NutrInform Battery (N = 623)	Nutri-Score (N = 636)	Chi-squared test (p-value)
Never	785 (62.4%)	398 (63.9%)	387 (60.8%)	0.695
Sometimes	202 (16%)	107 (17.2%)	95 (15%)	0.398
Often	214 (17%)	95 (16.2%)	123 (19.3%)	0.058
Always	54 (4.3%)	23 (3.7%)	31 (4.9%)	0.276
Overall	1259 (100%)	623 (100%)	636 (100%)	0.714

respondent = 33.7%.

A between-group analysis on the two major variables of interest, i.e., nutrition knowledge and the adherence to the Mediterranean diet was conducted both before and after the intervention (Table 3). ANOVA test did not show any significant difference among groups for both variables, either before or after the intervention. When nutrition knowledge and adherence to MD measured at baseline were compared with participants' self-estimations, the latter were overestimated by 3.9 and 17.6 percentage points, respectively (NK: 59.1% vs. 63%, $p < 0.001$; AMD: 43.3% vs. 61%, $p < 0.001$). Then, a subgroup analysis was conducted to explore potential differences due to sex, age groups, income, level of education, and reported BMI. Nonetheless, none of the sample subgroups showed meaningful differences between intervention and control groups in the I-NK and AMD scores when assessed pre- or post-intervention (Supplementary Material, Tables S1-S4), as well as at a before-after analysis (Supplementary Material, Table S5-S6).

Nutrition knowledge and adherence to the Mediterranean diet were further analyzed with a difference-in-difference regression analysis between intervention groups and the control group to assess label effectiveness. No statistically significant difference was found for NIB or NS either respect to nutrition knowledge or the adherence to the Mediterranean diet (Table 4). Demographic and non-demographic characteristics of the subjects (i.e., sex, age group, income, level of education, and reported BMI) were added as covariates to the regression analysis to control for potential confounding factors. However, none of the outcome variables was affected by this inclusion (data not shown). Furthermore, a per-protocol analysis restricted to participants who used the labels did not reveal any significant difference (Supplementary Material, Tables S7-S8). Label comprehension was assessed by asking participants to answer nine questions at the end of the experiment (Supplementary Material, Table S9). Despite results are not comparative, NS was considered easier to read and to understand while NIB received higher values as more informative on the nutritional composition of foods and in helping consumers make better food choices.

Lastly, a single-item analysis was conducted to evaluate answers to each AMD question (Table 5). Three trends ($p < 0.10$) were observed for fruit, white bread, and sweet consumption. Regarding fruits, all groups indicated a decrease in consumption after the intervention, which was attenuated for NS; white bread was reduced by NS in respect to CG; sweet consumption was increased by NS in comparison to CG.

Table 3
Between-group analysis of nutrition knowledge and adherence to the Mediterranean diet.

	Overall (n = 1900)	NutrInform Battery (n = 623)	Nutri-Score (n = 636)	Control group (n = 641)	ANOVA (p-value)
I-NK $score_{pre}$ (/88)	52 ± 12.4	52.5 ± 11.9	51.9 ± 12.3	51.6 ± 12.8	0.430
I-NK $score_{post}$ (/88)	52.1 ± 13.5	52.5 ± 13.5	52.1 ± 13.4	51.9 ± 13.7	0.751
AMD $score_{pre}$ (/17)	7.4 ± 2.3	7.5 ± 2.4	7.4 ± 2.3	7.3 ± 2.3	0.350
AMD $score_{post}$ (/17)	7.3 ± 2.3	7.4 ± 2.3	7.4 ± 2.3	7.1 ± 2.4	0.055*

Abbreviations: I-NK: Italian Nutrition Knowledge questionnaire; AMD: Adherence to the Mediterranean Diet questionnaire. *$p < 0.10$.

4. Discussion

The aim of this research was to evaluate the effectiveness of FOP labels in changing the eating habits of Italian consumers in real life after an awareness and training phase. The data collected from this study showed low use of FOP labels: more than 6 out of 10 consumers never used them during the 30-day intervention period. Only 3.9% made extensive use of them. There were no significant differences between the two labels. Previous studies conducted under experimental conditions have found the opposite: approximately 6 out of 10 subjects (59.1%, 53.4%, 61.6%) had noticed the FOP label during the experiment (Egnell et al., 2020; Kontopoulou et al., 2021; Vandevijvere et al., 2020). It is plausible that the rate of use may decrease in real-life conditions where the time to make purchasing decisions is shorter and the number of external stimuli can increase dramatically.

From the perspective of effectively steering consumers' eating patterns, this study found no benefit from the use of FOPLs. At the end of the month-long intervention, even if a trend has been observed in the between-group analysis of the AMD score post-intervention, neither dietary adherence nor nutrition knowledge showed any statistically significant change, nor were there any differences between the intervention groups. A single-item analysis also revealed no differences between the groups from pre-intervention to post-intervention phase. However, trends have been identified for the questions regarding the consumption of fruits, white bread, and sweets. In particular, all groups decreased the consumption of fruits in the before-after analysis with NS demonstrating a lower trend. Furthermore, NS tended to decrease the consumption of white bread, while increasing sweets. This last trend seems to confirm the increase in the intake of sugars evidenced by the systematic review of Muzzioli et al., even if the very low certainty of evidence assessed by the GRADE scale prevented from confirming the result (Muzzioli, Scenna, et al., 2025).

As this is the first experiment to study the effectiveness of FOPL in terms of dietary patterns and not simply changes in nutrients, there is no pre-existing data to refer to. However, an experimental study conducted on a sample of 11,100 subjects from 12 different countries showed that on average 81.8% of participants did not change their food choices when faced with the front-of-pack labels, a figure that slightly dropped to 79.9% when faced with the Nutri-Score. In addition, a third of the subjects who changed their purchasing choices did so by choosing foods considered less healthy (NS data overlap with general data) (Talati et al., 2019). These results support the limitations of the application and effectiveness of FOP labels found by the present investigation.

The need to test these tools in real settings arises from the fact that several studies have so far analyzed consumer response to exposure to food labels, but most of the studies showing positive results have been conducted under experimental conditions (Crosetto et al., 2020; Egnell et al., 2019). Only very few have been conducted under real-life conditions (Dubois et al., 2021; Julia et al., 2021). The study by Dubois et al., which can be considered the only large-scale real-life study, highlighted a low effectiveness of NS in changing purchasing behavior. In fact, only one of the investigated categories (Fresh prepared foods) showed a significant variation in terms of sales, but this did not lead to any improvement in the nutrient composition of the shopping cart (Dubois et al., 2021). In contrast, this is the first attempt to investigate NIB in real-life conditions.

Prior to this, other studies have attempted to compare NS with NIB. Two studies, conducted by the same research team, investigated the two

Table 4
Difference-in-difference intervention effect estimation on nutrition knowledge and adherence to the Mediterranean diet.

	Nutrition knowledge				Adherence to the Mediterranean diet			
	Nutrinform Battery (n = 623)		Nutri-Score (n = 636)		Nutrinform Battery (n = 623)		Nutri-Score (n = 636)	
	B	p-value	B	*p*-value	B	p-value	B	p-value
Intercept	51.764	0.000	52.040	0.000	7.325	0.000	7.357	0.000
Treatment	0.727	0.251	−0.110	0.861	0.126	0.265	0.028	0.801
Time	0.216	0.673	0.135	0.793	−0.086	0.347	−0.116	0.210
Treatment*Time	−0.246	0.781	−0.002	0.999	0.016	0.923	0.103	0.518
R^2	0.001		0.000		0.001		0.001	

Table 5
Change in consumer's food category consumption at the end of the intervention, single-item analysis of the AMD questionnaire.

	Overall (n = 1900)	NutrInform Battery (n = 623)	Nutri-Score (n = 636)	Control group (n = 641)	ANOVA (p-value)
Q1 – EVO oil	0.01 ± 0.27	0.02 ± 0.24	0.00 ± 0.27	0.00 ± 0.29	0.456
Q2 – Fruits	−0.05 ± 0.48	−0.09 ± 0.47	−0.02 ± 0.48	−0.05 ± 0.50	0.057*
Q3 – Vegetables	0.01 ± 0.63	−0.02 ± 0.63	0.04 ± 0.63	0.02 ± 0.62	0.198
Q4 – White bread	0.02 ± 0.55	0.03 ± 0.52	−0.02 ± 0.55	0.05 ± 0.56	0.063*
Q5 – Whole cereals	−0.01 ± 0.30	0.01 ± 0.30	−0.02 ± 0.30	−0.01 ± 0.30	0.259
Q6 – Red meat	0.02 ± 0.65	0.05 ± 0.62	0.01 ± 0.66	−0.02 ± 0.67	0.158
Q7 – Butter	0.01 ± 0.64	0.05 ± 0.64	−0.01 ± 0.63	0.01 ± 0.62	0.128
Q8 – Sugary drinks	−0.04 ± 0.63	−0.06 ± 0.64	−0.03 ± 0.64	−0.04 ± 0.62	0.682
Q9 – Legumes	0.00 ± 0.38	0.00 ± 0.37	0.01 ± 0.38	−0.02 ± 0.37	0.445
Q10 – Fish and seafood	0.00 ± 0.27	0.01 ± 0.27	0.01 ± 0.26	0.00 ± 0.29	0.561
Q11 – Sweets	0.00 ± 0.58	−0.01 ± 0.57	0.05 ± 0.56	−0.03 ± 0.60	0.066*
Q12 – Nuts	0.00 ± 0.51	0.00 ± 0.50	−0.01 ± 0.50	0.01 ± 0.51	0.739
Q13 – White meat	−0.01 ± 0.64	−0.01 ± 0.65	0.00 ± 0.64	−0.03 ± 0.62	0.730
Q14 – Tomato sauce	0.01 ± 0.51	0.04 ± 0.49	0.01 ± 0.53	−0.01 ± 0.50	0.246
Q15 – Sweeteners	0.01 ± 0.62	0.00 ± 0.61	0.00 ± 0.61	0.03 ± 0.63	0.737
Q16 – Refined cereals	−0.01 ± 0.64	−0.01 ± 0.62	0.01 ± 0.65	−0.04 ± 0.65	0.440
Q17 – Wine	−0.05 ± 0.61	−0.08 ± 0.59	−0.04 ± 0.62	−0.03 ± 0.62	0.354

Abbreviations: AMD: Adherence to the Mediterranean Diet questionnaire; EVO oil: Extra-Vergin Olive oil. *p < 0.10.

labels among a sample of Italian consumers (Fialon et al., 2022) and a Spanish one (Fialon et al., 2023). In both cases, the Nutri-Score was shown to favor the choice of foods considered healthier and to favor them more strongly among consumers. It should be noted that these studies did not include a control group, and the food catalogue was limited to 3 categories for a total of 22 foods. On the other hand, NIB has proven more effective than NS in subjects with specific nutritional needs (e.g., hypertension, hypercholesterolemia) thanks to the fact that it displays the intake of individual nutrients without screening them with a summary indicator (Castellini et al., 2024; Mazzù et al., 2023).

However, when moving from experimental settings to the multiple stimuli to which consumers are exposed at the point of purchase it is very likely that the positive results initially observed will not be detected. A large set of variables may influence the decision-making process: social, economic, biological, physical, educational, and psychological determinant together with heuristics and cognitive biases can steer consumers' food choices (Muzzioli et al., 2022). Research on food decision-making under time pressure have shown that the cognitive process is subject to changes: the study of Huseynov & Palma, 2021, indicates that subjects tend to accumulate less product information compared to the *no time pressure* condition, but faster decisions do not affect the consistency of food choice (Huseynov & Palma, 2021). However, in general, virtual or experimental settings have high interval validity but low generalizability due to their application in settings different from reality. On the contrary, "field setting studies have high generalizability, but lower internal validity due to the challenges of implementing strong study designs and interventions with high fidelity" (Vogel et al., 2023).

Moreover, a slight change in nutrients may not lead to greater adherence to the Mediterranean model, as this change does not alter the frequency of consumption of different food categories. These considerations are in line with a recent systematic review and meta-analysis that observed how, in experimental settings, NS demonstrated a low effectiveness: it slightly decreases saturated fats and sodium contents of consumers' shopping basket while increasing sugar content, with no change in energy intake (Muzzioli, Scenna, et al., 2025). Moreover, the meta-analysis conducted by Sofi et al., 2008, indicated that a 25% increase in the score for adherence to the Mediterranean diet determines a 9% reduction in overall mortality (Sofi et al., 2008). Conversely, our findings show a change in adherence of less than 1% for both labels. Although small changes in specific nutrients might influence individual health, they are unlikely to be detected by adherence questionnaires, and the effectiveness of such changes may likely be several orders of magnitude lower.

Lastly, the discrepancies observed by this study between population's actual and presumptive nutrition knowledge and, even more, between actual and presumptive diet quality may have been partially responsible for the low usage of FOPLs. In fact, it is known that self-reported knowledge or diet quality are usually overestimated when compared to questionnaire evaluations (Hendrie et al., 2017; Melios et al., 2025; Thomson et al., 2022) or even more to 24-h recalls (Adjoian et al., 2016). On the light of this, the tendency of the adult population to overestimate their diet quality suggests the need to conduct large-scale educational campaigns in the field of food science and nutrition targeted to increase nutrition knowledge, while dealing with food-related fake news and misleading information to prevent misconceptions and unhealthy food choices. It would be important to study whether the low rate of use is due to issues arising from the consumer from the consumer attitude (i.e., overestimating their nutrition knowledge and their diet quality), the label (i.e., complexity in information or, on the contrary, extreme simplification), or a series of contributing factors (i.e., time available for food shopping, economic aspects). Moreover, the null results evidenced by this study raise some questions: should educational campaigns precede the introduction of FOPLs? Should FOPLs be redesigned to be more intuitive or less reliant on consumer initiative (e.g., via mobile

applications)? The integration of FOPLs with education campaigns, the redesign of labels for higher salience, the redesign of label underpinning algorithms that merge healthiness with sustainability parameters (Muzzioli, Di Vincenzo, et al., 2025), or their testing at point-of-sale should be used as future directions of the research in this area.

5. Strength and limitations

This study is the first to evaluate the impact of FOPLs by assessing consumers' adherence to a healthy dietary pattern, such as the MD. Diet quality was, therefore, obtained by assessing the frequency of consumption of all food categories. This is in contrast with the common use, in this research area, of the FSAm-NPS DI score that is food-based index, i.e. it relies on the consumption of single foods. Another strength is that this research was designed as a real-life study, whereas most studies in this field are experimental, thus considering the multiple variables that can alter purchasing behaviors to which a consumer can be exposed to at the PoP.

On the other hand, this article acknowledges some limitations. The choice of a real-life setting and the large sample of patient enrolled impeded to monitor those variables that could have helped explain the results, e.g. decision-making process under time pressure, attention limits, and competing priorities during shopping. The need to use a mobile application to read the FOP label, may have discouraged some of the enrolled subjects, especially those less incline to use smartphones or who have little time available at the point of purchase. Moreover, this additional passage may have influenced the limited use of labels evidenced by this study. However, the results of the present study are in line with those reported by the only other real-life RCT study set in supermarkets (Dubois et al., 2021). Further studies on experimental supermarkets may contribute to confirm these results. Lastly, while no formal manipulation test was conducted, the study instructions were standardized and participants received clear explanations of the labels.

Finally, given the behavioral nature of the intervention, inter-individual variability in response to food labels was expected. Nevertheless, we acknowledge that behavioral responses may show substantial heterogeneity, which can limit analytical power despite appropriate statistical modeling.

6. Conclusions

The study sample did not show any particular interest in FOP labels, at least in the version accessible via a mobile app. No significant differences were found between NS and NIB for any of the variables examined. Future research should further investigate the motivations that prevent consumers from using these tools, attempting to distinguish between the ineffectiveness of the front-of-pack label communication tool and the subjects' low motivation to take care of their diet. In conclusion, labels themselves appear not to improve people's food literacy and eating patterns. This once again highlights the lack of educational opportunities to truly raise public awareness about adequate nutrition and a healthy lifestyle. Introducing individual labels on their own, without including them in a serious nutrition awareness and literacy program, risks being a mere marketing strategy and a double-edged sword.

CRediT authorship contribution statement

Luca Muzzioli: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marianna Minnetti:** Writing – original draft, Methodology, Investigation. **Olivia Di Vincenzo:** Writing – original draft, Methodology, Formal analysis. **Greta Castellini:** Writing – review & editing, Methodology. **Francesco Frigerio:** Writing – original draft, Methodology, Investigation. **Claudia Piciocchi:** Writing – original draft, Methodology, Investigation. **Maria Pintavalle:** Writing – original draft, Formal analysis. **Eleonora Poggiogalle:** Writing – review & editing, Supervision. **Silvia Migliaccio:** Writing – review & editing, Supervision. **Guendalina Graffigna:** Writing – review & editing, Supervision. **Andrea Lenzi:** Writing – review & editing, Funding acquisition, Conceptualization. **Lorenzo Maria Donini:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Ethics approval

The protocol of the study was approved by the Ethics Committee for Transdisciplinary Research (CERT) of the Sapienza University of Rome (n.163/2024 approved on 13/05/2024) and registered on the clinical trial.gov platform on 26 June 2024 (Identifier: NCT06488079).

Ethical statement

Ethical approval for the involvement of human subjects in this study was granted by the Ethics Committee for Transdisciplinary Research (CERT) of the Sapienza University of Rome (n.163/2024 approved on 13/05/2024). Informed consent was obtained from all subjects involved in the study.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Lorenzo Maria Donini reports financial support was provided by Government of Italy Ministry of Economic Development. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2026.105862.

Data availability

Data will be made available on request.

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