Nutrition, Metabolism & Cardiovascular Diseases (2024) **34**, 2789–2798

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

journal homepage: www.elsevier.com/locate/nmcd

RESEARCH PAPER

The role of Nutri-Score and NutrInform Battery in guiding the food choices of consumers with specific nutritional needs: A controlled study

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Received 25 March 2024; received in revised form 13 July 2024; accepted 2 August 2024
Handling Editor: A. Siani
Available online 10 August 2024

KEYWORDS
Front-of-pack labeling;
NutrInform Battery;
Nutri-score;
Food choice behavior;
Nutritional needs

Abstract *Background and aims:* There is a significant knowledge gap regarding the effectiveness of front-of-pack labeling (FoPL) systems in helping food choices that meet specific nutritional requirements. This study sought to compare the effectiveness of the Nutri-Score (NS) and NutrInform Battery (NIB) labels in assisting consumers to select food products with low sodium or low saturated fat.
Methods and results: Utilizing a controlled experimental design, a sample of 1512 participants (aged 18–70, 50.8% females) was exposed to scenarios through computer-assisted web interviewing, where they selected food products suitable for people with suboptimal blood pressure or plasma cholesterol levels, labeled with either NS, NIB, or no label (blind). The NIB proved significantly more efficacious than NS in guiding participants towards making selections in better agreement with nutritional needs, for blood pressure or cholesterol control. Furthermore, the NIB was generally viewed more favorably, with participants rating it as more trustworthy, informative, and useful for the required task. Notably, younger participants, those with higher nutritional knowledge, and those less inclined towards intuitive or spontaneous decision-making demonstrated a greater propensity for making health-congruent food choices when using the NIB.
Conclusion: The findings suggest that the informative FoPL system, NIB, may offer greater advantages in addressing specific dietary requirements. This underscores the important role of FoPL systems in promoting public health and meeting diverse and specific consumer needs. Further research is needed to confirm these results in broader contexts and for additional health conditions.

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https://doi.org/10.1016/j.numecd.2024.08.007

1. Introduction

Consumer attitudes toward the diet-health relationship are swiftly changing [1], highlighting an increased focus on the nutritional content of food and the multitude of nutritional information sources [2]. This shift is evident in most industrialized countries, where dietary improvements aim primarily at reducing the risk factors of non-communicable diseases such as obesity and cardiometabolic diseases. In this context, body weight, blood pressure, plasma LDL cholesterol, and glucose levels above recommended thresholds are targets for preventive interventions [3]. The prevalence of these conditions is high in Europe, with about one-third of adults suffering from hypertension [4], and likely an even higher percentage of adults with elevated plasma LDL cholesterol, overweight and obesity [5]. The positive impact of dietary intervention on these risk factors is well-documented [6].

Thus, nutrition labels on product packaging emerge as significant contributors to this shift. Within the European Union, a nutrition declaration specifying the energy value and quantities of total fat, saturated fats, carbohydrates, sugars, protein, and salt per 100 g of food is mandatory. Additional details, like nutrient content per serving or consumption unit and nutrition and health claims as defined by Regulation (EC) No. 1924/2006 [7], may also be included. Furthermore, Regulation (EU) No. 1169/2011 [8] allows the provision of harmonized simplified nutrition information through the front-of-pack labeling (FoPL).

A variety of FoPL schemes have been developed in recent years as the result of consultation with a wide range of stakeholders, aiming to offer simplified and immediate nutritional information [9,10]. Indeed, previous research on consumers underscored the efficacy of visual over textual information on packaging in capturing consumer attention. Studies by Tang et al. (2004), Carillo et al. (2014), and Miklavec et al. (2016) [11–13] highlight that symbols and graphical representations are more effective than written words, facilitating quicker and less effort-intensive information processing by consumers. This insight is crucial in designing FoPL that are not only informative but also user-friendly and effective in conveying necessary dietary information [14,15]. However, these schemes vary in their complexity, colors used, and the type and amount of information provided. Consequently, as part of Farm to Fork Strategy, the European Commission is going to propose a mandatory harmonized nutrition FoPL across EU Member States [16]. This provision has sparked an active debate centered on identifying the most effective method for informing consumers about the nutritional contribution of specific foods and drinks to their overall diet [17].

The NS and the NIB, the latter proposed by the Italian government, are among the systems under consideration. These systems have been described in detail elsewhere [18]. The comparison between these labeling schemes is challenging due to their different approach [19]. Indeed, NS aims to provide an overall assessment of food quality, rather than focusing on food composition. Conversely, the NIB provides more information on nutrients but the correct understanding and interpretation of its graphical representation necessitates consumer education [20]. Based on these differences, it is possible to hypothesize that the NIB, unlike the NS, could be particularly beneficial for those who need to monitor predefined dietary components due to specific health conditions [21], perceiving this FOPL as more reliable, informative and simple to use. For instance, persons with hypertension can immediately see the salt content per serving and determine whether the product fits within their dietary restrictions. However, existing literature does not sufficiently address individual nutritional needs, assuming uniform applicability of FOPLs.

Previous studies on FOPL effectiveness, carried out on healthy consumers, yield contrasting results. Research by Fialon et al. (2022) [22] suggested NS's superiority in guiding consumers towards healthier choices due to its perceived simplicity and informativeness. Conversely, other studies found NIB more effective in enhancing consumer understanding and preference for its detailed nutritional information [23]. In particular, consumers view NIB as more informative and useful for understanding product composition [24]. Moreover, the perception of these labels also depends on the personal characteristics of consumers. Indeed, the socio-demographic and psycho-social characteristics of individuals, as well as their decision-making styles, have been shown to significantly influence the interpretation of food labels and the purchase decisions [10,25,26]. However, to the best of our knowledge, no studies have yet delved into how these aspects can impact on the interpretation and use of FoPL.

Therefore, this study seeks to fill the knowledge gap in how these two labeling schemes impact consumers' food selection, particularly for those with specific nutritional needs, in the context of the incidence of diet-related non-communicable diseases in Europe and the importance of dietary interventions in managing these conditions.

Based on these premises, the study hypothesizes that.

(H1) The NIB label is more effective than NS in guiding consumers towards food choices that align with their dietary needs, particularly for those with high blood pressure and plasma cholesterol levels.

(H2) The NIB label is more reliable, informative and easier to use than NS, particularly for those with high blood pressure and plasma cholesterol levels.

(H3) The socio-demographic and psychological characteristics of individuals impact the perception and use of FOPLs.

2. Methods

2.1. Participants

This quasi-experimental study was conducted using a CAWI (Computer Assisted Web Interviewing) methodology between 4 and June 13, 2023 on a sample of 1512 participants randomly selected from the consumers' panel managed by Norstat srl (https://norstat.it/), representative of the adult (>18 years of age) Italian population, with gender, age, profession, inhabited centre size and geographical area extracted by stratified sampling. Survey weights were used to assure representativeness for the stratification variables previous mentioned. The percentages relating to the Italian population were taken from the website of ISTAT and reported in the last column of Table 1.

This study has been performed following the Declaration of Helsinki and has been approved by an independent ethics committee (CERPS), protocol number 69-23.

2.2. Design and stimuli

To test the effectiveness of FoPLs in aiding consumers to make healthy food choices, defined as being in line with individual nutritional needs, two different scenarios were presented to study participants using two typical Italian products, well-recognized by consumers, and exhibiting notable nutritional differences concerning saturated fat and salt content: Margherita pizza and raw ham [27] (Fig. 1). The salt content in a 50 g standard portion of raw ham may vary between 2 g (equivalent to 800 mg of sodium) for a less salted raw ham, and more than 3 g

Table 1 Demographic profiles per group (n = 1512).

	Blind group (n = 504)		Nutri-Score group (n = 504)		NutrInform Battery group (n = 504)		Population
	N	%	N	%	N	%	%
1. Gender							
Male	248	49.2	248	49.2	248	49.2	49.3
Female	256	50.8	256	50.8	256	50.8	50.7
2. Age							
18–24	52	10.3	52	10.3	51	10.2	10.0
25–34	83	16.4	83	16.4	82	16.3	16.3
35–44	109	21.6	109	21.6	109	21.6	21.5
45–54	114	22.6	114	22.6	114	22.6	22.7
55–59	54	10.8	54	10.8	55	10.8	10.8
60–70	92	18.3	92	18.3	93	18.5	18.8
3. Education							
Elementary-Junior high	166	33	166	33.0	166	33.0	–
Senior high	237	47.0	237	47.0	237	47.0	–
College or university	101	20.0	101	20.0	101	20.0	–
4. Geographic area							
North-West	135	26.8	135	26.8	135	26.8	26.3
North-East	99	19.6	99	19.6	99	19.6	18.6
Centre	100	19.8	100	19.8	100	19.8	19.7
South and Islands	170	33.8	170	33.8	170	33.8	35.5
5. Inhabited centre size							
Until 10.000 inhabitants	128	25.4	120	23.8	116	23.0	32.1
10/100,000 inhabitants	225	44.6	217	43.1	213	42.2	44.0
100/500,000 inhabitants	70	13.9	80	15.9	71	14.1	10.9
More than 500,000	73	14.5	81	16.0	98	19.5	12.9
I do not know	8	1.6	6	1.2	6	1.2	–
6. Profession							
Entrepreneur/freelancer	62	12.4	62	12.4	62	12.4	12.4
Manager/middle manager	19	3.8	19	3.8	19	3.8	3.8
Employee/teacher/military	97	19.2	97	19.2	97	19.2	19.2
Worker/shop assistant/apprentice	106	21.0	106	21.0	106	21.0	21.0
Housewife	76	15.0	76	15.0	76	15.0	15.0
Student	26	5.2	26	5.2	26	5.2	5.3
Retired	40	8.0	40	8.0	40	8.0	7.9
Unoccupied	78	15.4	78	15.4	78	15.4	15.4
7. Household net monthly income level							
Up to 600 €	25	5.0	18	3.5	18	3.6	–
601-900 €	22	4.4	23	4.6	23	4.6	–
901-1200 €	40	8.0	45	8.9	32	6.3	–
1201-1500 €	56	11.2	53	10.5	62	12.4	–
1501-1800 €	59	11.7	51	10.1	39	7.8	–
1801-2500 €	88	17.4	83	16.5	91	18.1	–
2501–3500	68	13.4	74	14.7	73	14.4	–
More than 3501 €	77	15.4	76	15.0	80	16.0	–
Missing	69	13.5	81	16.2	85	16.8	–

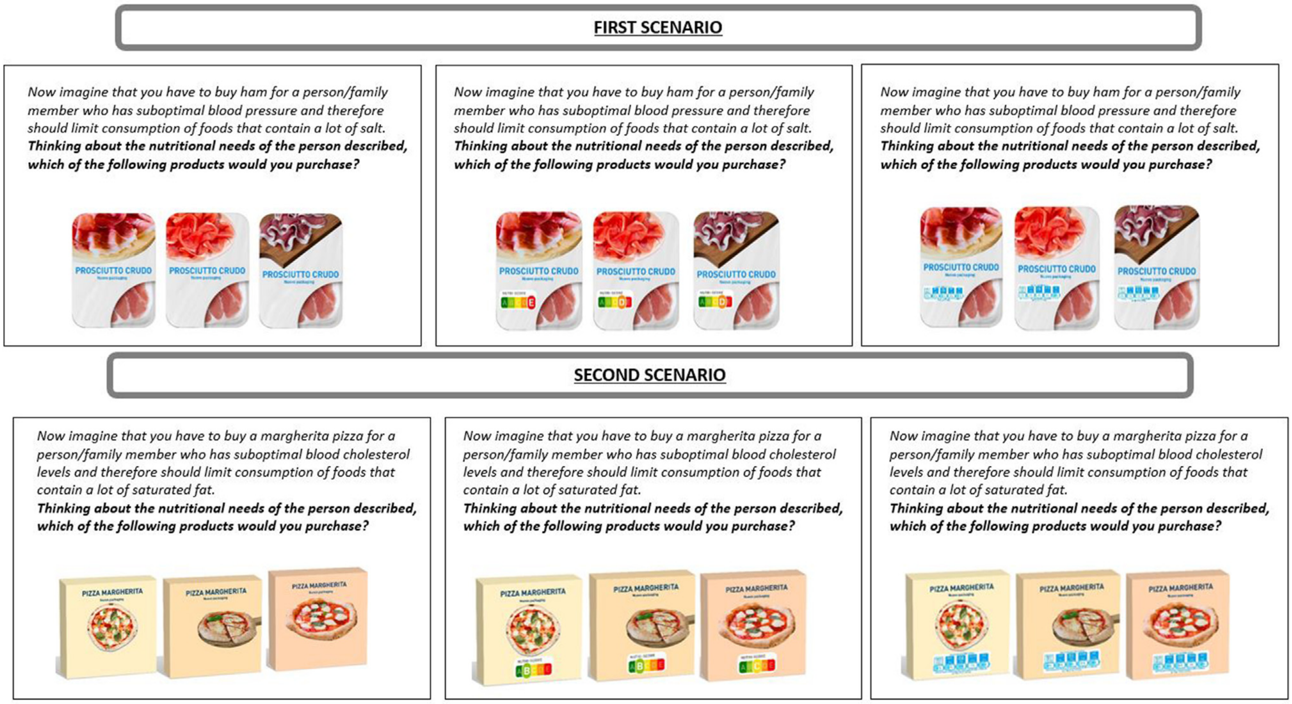

Figure 1 Choice tasks and stimuli presented for raw ham and Margherita pizza.

(equivalent to about 1200 mg of sodium) for a more salted ham. These amounts correspond to about 33–50 % of the daily reference value set for salt by Regulation (EU) N. 1169/2011 [8] and 40–60 % of the maximum intake according to the Italian food-based guidelines (and WHO), which set the total salt supply with the diet not to exceed 5 g per day (2 g of sodium).

The saturated fat content of Margherita pizza generally ranges from 5 to more than 20 g for a 350 g portion (essentially depending on the amount of mozzarella cheese and fats used in the preparation), corresponding to 50 to more the 100% of the daily reference intake set by Regulation (EU) N. 1169/2011 [8] (and of the daily amount not to be exceeded for saturated fat according to the Italian food based guidelines, equivalent to 10% of total calories).

In both cases the selected food products are significant sources of critical nutrients, and the differences of their content between product and product can have a significant nutritional impact and consequently a significant effect on blood pressure and plasma cholesterol, and on the overall cardiovascular disease risk.

In the first scenario, participants were asked to imagine buying raw ham for a person/family member with slightly increased blood pressure, who should therefore limit the consumption of foods high in salt/sodium. In the second scenario, participants were asked to imagine buying a Margherita pizza for a person/family member with suboptimal (i.e., slightly increased) blood cholesterol levels, who should therefore limit the intake of saturated fats. In each scenario, three choice tasks were constructed and proposed to participants: in the first task, three food items with no FoPL (in blind) were shown, while in the second and in the third task NS and NIB labels were added, respectively. In total, 6 choice tasks were presented (3 belonging to the first scenario and 3 belonging to the second scenario) using 18 different images.

All the products shown to participants are really existing in the Italian market, however, the colors of the packaging were modified by the researchers to prevent the consumer from recognizing the product brand by influencing the choice task. NS and NIB were positioned on the food product image and the zoom function was available to allow participants to enlarge any area of the package including the FoPL. The nutritional values reported on the actual labels were used to calculate the NS (by using the version 20,210,921 of the algorithm available at www.santepubliquefrance.fr/en/nutri-score) and to create NIB (by entering the data on the dedicated website: www.nutrinformbattery.it/). Notably, the nutritional appropriateness of the food options proposed varied significantly, with the more and less appropriate pizza options differing by approximately 10 g of saturated fats per portion, representing 50% of the recommended daily intake. A similar disparity was observed in the salt content between the most and least appropriate ham options. These variances underline the importance of accurate and comprehensible nutritional labelling in assisting consumers to make proper dietary choices.

Back-of-pack information such as ingredients or nutritional values was not available to avoid information overload.

2.3. Measures

In the first part of the questionnaire, the following measures were used.

- Assessment of subjective knowledge about nutrition used previously by Fialon et al. (2022) [22] was measured using a single item on a 7-step Likert scale from 1 (not at all informed) to 7 (very informed).
- Objective nutrition knowledge with the first section of Nutrition Knowledge Questionnaire validated by Rosi et al. (2020) [28] which was related to recommendations of expert in nutrition (NK1—four questions). The resulting questionnaire consisted of multiple-choice questions and the scoring system used for Nutrition Knowledge (NK) measurements was +1 point for a correct answer, 0 points for "do not know," and wrong answers [29].
- General Interest in own health with a sub-scale, called General Health Interest, belonging to the validated questionnaire the Health and Taste Attitudes Questionnaires consisting of 8 items measured using a 7-step Likert scale (from 1 = Totally Disagree to 7 = Totally Agree) validated by Roininen et al. (1999) [30].
- Interest in food with the Psychological Food Involvement Scale (PFIS) validated by Castellini et al. (2003) [31], which measures the level of food involvement, consisting of 19 items measured using a 7-step Likert scale (1 = Totally disagree to 7 = Totally agree).
- Type of decision-making style with the General Decision Making Style questionnaire (GDMS): developed by Scott and Bruce (1995) [32] and validated in Italian by Gambetti et al. (2008) [33], consisting of 25 items measured using a 5-step Likert scale (from 1 = Totally disagree, to 5 = Totally agree) and identifying 4 decision-making styles: rational, intuitive, dependent, avoidant, and spontaneous. Following this first section, participants were randomly divided in three groups composed of 504 persons each, similar regarding the main socio-demographic characteristics and representative of the Italian population.

Participants who were shown the choice tasks with the NS or NIB label were asked to give their opinions about FoPL regarding.

- Utility: participants were asked to indicate how much the front-of-pack labels had helped them in choosing the best food product for the person described in the different scenarios through an ad hoc item measured on a four-step Likert scale (1 = not at all and 4 = very much).
- Capacity to inform: using 4 statements and a nine-point Likert scale (1: "strongly disagree"; 5: "neither agree nor disagree"; 9: "strongly agree") it was evaluated whether labels gave enough information on the nutritional composition of the product.
- Trust: using 3 statements and a nine-point Likert scale (1: "strongly disagree"; 5: "neither agree nor disagree"; 9: "strongly agree") the level of trust that consumers placed in these labels was evaluated.

These questions were adapted considering the study of Fialon et al. (2022) [22] the complete questionnaire is shown in Supplementary material A.

3. Data analysis

To understand the distribution of responses in the scenarios of people with suboptimal blood pressure or with suboptimal cholesterol values, two contingency tables (3-choice tasks: Blind, NS and NIB X 3-products) were conducted. Pearson's chi-square was also carried out. Whenever the χ^2 result was significant, column percentages were confronted as post hoc with a *z*-test (corrected with Bonferroni method), as suggested by Sharpe (2008) [34].

After checking the normality of distributions of quantitative variables calculating asymmetry and kurtosis ($<\pm 2$ accepted value) [35,36] and the reliability of the scales using Cronbach's alpha method (>0.70 good value) [37] (See supplementary material B), the association between tasks (Blind, NS and NIB) and the ability to make the correct food choice was measured by two binary logistic regression models, one for each scenario. The choice of product was treated as a dependent dichotomous variable (1 = correct answer; 0 = wrong answer) while the tasks (Blind, NS and NIB) as independent variable. Socio-demographic variables (i.e., gender, age, educational level), general health interest, Food Involvement, subjective and objective nutrition knowledge, and the decision-making style were used as covariates.

Additionally, differences in perceptions regarding utility, trust, and information capabilities of NS and NIB labels were assessed using independent T-tests, with effect sizes calculated using Cohen's d [38].

Finally, to understand the psycho-social and socio-demographic differences between the groups of participants who did or did not choose the correct product labeled with NIB in the two different scenarios, contingency tables and independent t-tests were conducted. These analyses were not conducted for the NS condition due to the large difference in the number of participants who chose the correct product compared to those who did not The presented analyses incorporated Norstat's provided survey weights to present nationally representative results. All statistical tests were bilateral and a p-value below 0.05 was considered significant. All tests were conducted using IBM SPSS 20 Software (release 20.0.0.0).

4. Results

4.1. Description of the sample

The sample included 1512 individuals, of which 768 were females (50.8%), aged between 18 and 70 years (M = 44.9,

SD = ±13.9). Data per group and the percentages relating to the Italian population are reported in Table 1.

4.2. Food choices in different scenarios: raw ham and margherita pizza

The distribution of responses in the scenario in which participants were asked to imagine buying raw ham for a person with slightly increased blood pressure and therefore should limit consumption of foods with a high content of salt is shown in Table 2. The percentage of correct answers (product A) was significantly higher compared to the other tasks when the raw ham was presented with the NIB label (44.7%) while percentage does not change if the product was presented in Blind (19%) or with the NS label (17%).

When participants were asked to imagine buying a Margherita pizza for a person/family member who has slightly increased blood cholesterol and therefore should limit consumption of foods with a high content of saturated fats, the percentage of correct answers (product C) was significantly higher compared to the other tasks if the product is presented with the NIB label (59.3%) while it was significantly lower if presented with the NS label (26.6%).

After checking the normality of the distribution of responses and the internal consistency of the scales through the calculation of Cronbach's Alpha considering the total sample (See Supplementary material B), two binary logistic regressions were carried out. The results indicate that showing the product in blind or labeled NS and NIB impacts the choice made by participants for both foods presented (ham and pizza margherita). In particular, the odds of a person choosing the right ham labeled with the NIB are about 4 times higher than the odds of a person choosing the right ham under blind or NS labeled conditions. However, there is no difference in the choice compared with the control condition (in blind) and the experimental situation in which the raw ham is shown with the NS label. Considering the Pizza Margherita, the results indicate that the odds of a person choosing the right pizza labeled with the NIB are about 4 times higher than the odds of a person choosing the right pizza with NS label. In addition, the results show that presenting pizza with the NS label decreases the likelihood, albeit only slightly, of choosing the correct pizza compared to the control situation (in blind) (Table 3). Thus, H1 is supported.

4.3. Perception of FoPL: utility, trust, and capacity to inform

The results of comparison of consumers' perceptions regarding the NS and NIB labels show that NIB was perceived as more reliable (6.32 ± 1.81 vs. 5.54 ± 1.98, p = 0.000) and more helpful for distinguishing the nutritional composition of food products (6.20 ± 1.49 vs. 5.23 ± 1.65, p = 0.000). Finally, the NIB was considered

Table 3 Associations between FoPLs and correct food choices, by pizza Margherita and raw ham choice tasks (n = 1512).

Scenario	β	OR (95% CI)	p-Value
Raw ham			
Blind– > NutrInform Battery	1.27	3.57 (2.68–4.77)	0.000
Nutri-Score– > NutrInform Battery	1.37	3.94 (2.94–5.29)	0.000
Blind→ Nutri-Score	−0.09	0.90 (0.65–1.25)	0.554
Pizza margherita			
Blind– > NutrInform Battery	0.41	1.51 (1.17–1.94)	0.001
Nutri-Score– > NutrInform Battery	1.40	4.08 (3.12–5.34)	0.000
Blind→ Nutri-Score	−0.99	0.37 (0.28–0.48)	0.000

Note: CI = confidence interval; OR = odds ratio; The logistic model was adjusted for gender, age, educational level, general health interest, Food Involvement, subjective and objective nutrition knowledge, and decision-making styles.

Table 2 Percentage distributions of the answers relating to the choice of raw ham and Margherita pizza.

Scenario	Answers	Choice tasks		
		Blind	*Nutri-Score*	*NutrInform Battery*
Now imagine that you have to buy ham for a person/family member who has suboptimal blood pressure and therefore should limit consumption of foods that contain a lot of salt. Thinking about the nutritional needs of the person described, which of the following products would you buy? (Pearson's $\chi^2 = 134.130$; $p < 0.000$)	Product A (Correct)	18.5%a	16.9%a	44.7%b
	Product B	60.7%a	55.4%a	36.8%b
	Product C	20.8%a	27.8%b	18.5%a
Now imagine that you have to buy a Margherita pizza for a person/family member who has suboptimal blood cholesterol levels and therefore should limit consumption of foods that contain a lot of saturated fat. Thinking about the nutritional needs of the person described, which of the following products would you buy? (Pearson's $\chi^2 = 142.452$; $p < 0.000$)	Product A	24.9%[a]	46.6%[b]	17.5%[c]
	Product B	25.8%[a]	26.8%[a]	23.2%[a]
	Product C (Correct)	49.3%[a]	26.6%[b]	59.3%[c]

Note: Percentages were compared by column. Those with the same subscript letter do not differ significantly from each other (Bonferroni's post hoc test; p-value<0.05). The line highlighted in gray shows the response distributions for the correct product.

more useful in choosing the correct food product (2.76 ± 0.80 vs. 2.56 ± 0.79, p = 0.000), both in the scenario related to raw ham and Margherita pizza (Table 4). Thus, H2 is supported.

4.4. Socio-demographic and psycho-social differences regarding the use and perception of NutrInform Battery label

The results show that participants who chose the correct ham item perceived the NIB as more helpful in making the choice, easier to use, more informative about the nutritional components of the product. They showed a less intuitive and spontaneous decision-making style than those who made the wrong choice (Table 5) (see Supplementary material B for a complete view of the results).

The same differences between groups can be observed if we consider the scenario related to Margherita pizza (Table 6) (see Supplementary material B for a complete view of the results). However, in this scenario, socio-demographic variables, objective knowledge about nutrition and interest in food also differed between the two groups. Those who made a correct choice in the NIB task were younger, with greater nutrition knowledge and with a lower level of involvement in food. Thus, H3 is supported.

5. Discussion

One of the main purposes of FoPL is to help consumers towards healthier dietary choices, which enhances overall diet quality and fosters improved health outcomes. This is particularly pivotal for individuals at risk of cardiovascular

Table 4 Overall perception of FoPLs.

Variable	Nutri-Score (n = 504)		NutrInform Battery (n = 504)		T-Value	Degree of freedom	Effect Size Cohen's d	p-value
	mean	±SD	mean	±SD				
Overall perception								
Trust	5.54	±1.98	6.32	±1.81	−6.51	1005	0.41	0.000
Capacity to inform	5.23	±1.65	6.20	±1.49	−9.81	1005	0.61	0.000
Utility	2.56	±0.79	2.76	±0.80	−3.82	1005	0.24	0.000
Utility by scenario								
Raw ham	2.58	±0.84	2.78	±0.82	−3.86	1005	0.24	0.000
Pizza margherita	2.55	±0.85	2.73	±0.89	−3.28	1005	0.20	0.001

Note: the Likert of Utility range from 1 (not at all) to 4 (very much); the Likert scale of capacity to inform and trust range from 1 (strongly disagree) to 9 (strongly agree).

Table 5 Differences between groups related to the choice of raw ham in the NutrInform Battery task.

Variables	Group 1 (Correct answer) (n = 225)	Group 2 (Wrong answers) (n = 279)	Pearson X^2/ T-Value	Degree of freedom	Effect Size Cohen's d	p-Value
Decision-making style (mean)						
Intuitive	3.39 (±0.61)	3.59 (±0.65)	3.63	502	0.32	**0.000**
Spontaneous	2.81 (±0.80)	3.01 (±0.78)	2.80	502	0.25	**0.010**
NutrInform Battery perceptions (mean)						
Utility	3.02 (±0.86)	2.59 (±0.73)	−6.11	502	0.53	**0.000**
Trust	6.59 (±1.72)	6.10 (±1.85)	−3.06	502	0.27	**0.000**
Capacity to inform	6.61 (±1.57)	5.87 (±1.35)	−5.58	502	0.50	**0.000**

Table 6 Differences between groups related to the choice of Margherita Pizza in the NutrInform Battery task.

Variables	Group 1 (Correct answer) (n = 299)	Group 2 (Wrong answers) (n = 205)	Pearson X^2/ T-Value	Degree of freedom	Effect Size Cohen's d	p-Value
Age (mean)	44 (±13.87)	47 (±13.72)	2.10	502	0.19	**0.036**
General Nutrition Knowledge (mean)	3.86 (±1.25)	3.44 (±1.50)	−3.24	502	0.29	**0.001**
Psychological Food Involvement (mean)	4.67 (±1.00)	4.98 (±1.02)	3.35	502	0.30	**0.001**
Decision-making style (mean)						
Spontaneous	2.83 (±0.77)	3.06 (±0.81)	3.12	502	0.28	**0.002**
NutrInform Battery perceptions (mean)						
Utility	2.82 (±0.82)	2.65 (±0.75)	−2.38	502	0.21	**0.018**
Trust	6.45 (±1.73)	6.12 (±1.90)	−2.01	502	0.18	**0.045**
Capacity to inform	6.44 (±1.47)	5.86 (±1.46)	−4.36	502	0.39	**0.000**

diseases, given the substantial proportion of the population bearing one or more cardiovascular risk factors. It is essential, therefore, that such critical nutritional information is readily visible and accessible. In particular, this study aims to evaluate the impact of two distinct FoPL systems—NS and NIB—on the choices of participants with specific health needs, assessing the efficacy of these labelling schemes in promoting heart-healthy food selections.

The study's findings, related to H1, reveal a marked difference in the impact of the NS and NIB labels on consumer food choices. Specifically, the accuracy of healthy food selection was substantially higher when products were presented with the NIB label. This suggests that the NIB, by offering detailed nutritional composition, is more effective in guiding consumers towards food choices aligned with specific health requirements, such as lower salt or saturated fat intake for managing hypertension or high plasma cholesterol levels.

The effectiveness gap between the NS and NIB stems from their inherent differences. The NS, which provides an overall nutritional grade but lacks detailed nutrient composition, leads to variability in products with the same score, limiting its utility for consumers needing specific nutrient information for health management and nutritional literacy improvement [39,40]. Conversely, the NIB's comprehensive nutritional details better serve these needs, enabling informed food choices. Supporting this, a large EU study demonstrated that the NIB enhanced consumer understanding and preference compared to the NS, indicating its effectiveness in guiding health-aligned food choices [23].

Furthermore, the study highlights that the NS's reliance on nutrient content per 100 g of product, regardless of serving size, can lead to misconceptions about the actual nutrient intake from consuming typical portions of different foods, as already observed in literature [41]. This aspect is critical when considering foods which have significantly different recommended serving sizes. The two food products chosen for the study, raw ham and frozen pizza, have different reference serving size: 50 g for ham and 350 g for pizza. Consequently, 2 g of salt in the raw ham portion would contribute the same points, to the final NS mark, as 14 g of salt in a pizza portion. Assuming that one portion of each food is correctly eaten, this may lead to a wrong perception of nutrients or ingredients really consumed.

The study found that participants favored the NIB due to its perceived trustworthiness, informativeness, and usefulness (H2). Consumer trust in labeling systems significantly impacts their effectiveness, potentially improving adherence to dietary recommendations and enhancing public health outcomes. This aligns with research emphasizing the importance of transparency and accuracy in front-of-pack labeling systems [42], suggesting that systems like the NIB, seen as transparent and informative, foster greater consumer trust.

This paper also examined the association of socio-demographic and psycho-social characteristics with the efficacy of FoPL in guiding food choices. Results, related to H3, indicated that individuals with an intuitive or spontaneous decision-making style, who decide based on intuition and feelings, found it more challenging to utilize the NIB for selecting nutritionally appropriate food products. Conversely, participants who found the label easy to understand and informative were more likely to make suitable food selections.

Interestingly, the study observed a lower rate of adequate food selection with the NIB for pizza compared to raw ham. This may be attributed to the inclusion in the labels of both total fats and saturated fats, potentially confusing for consumers with limited nutritional knowledge. Additionally, the emotional attachment to certain foods, like pizza for Italians, may have influenced choices, with some participants possibly swayed by factors unrelated to nutritional content (e.g., image and sensations given by the image on the packaging, etc.).

These results align with previous research which identified how the socio-demographic and psycho-social characteristics of participants can be associated with the use of labels and related consumption choice. A widely used and well-known framework, developed by Grunert et al. (2007) [10], shows that those who have a good knowledge in nutrition, who are interested in food and who perceive the label as easier to read, more informative and useful, are more likely to use it correctly [25,26]. Moreover, people's decision-making style has been investigated as an aspect that impacts the use of food labels, being correlated with information seeking and exposure [43,44]. Specifically, participants with spontaneous and intuitive decision-making styles tend to read labels only after accidental exposure to them, while those with rational decision-making styles show interest in nutrition labels, looking for them actively [45].

Despite this study having notable strengths, such as its ability to understand how different front-of-pack labels impact food choices for individuals with specific dietary needs using a randomized controlled protocol applied to a representative Italian population sample, it also has some limitations. Indeed, lack of observational data and the use of a self-reported survey prompts investigation into real-life settings' validity. Moreover, this study presents purely correlational analyses and not cause-and-effect relationships among the variables investigated. Additionally, the study's focus on two product categories limits insights into overall dietary behaviors. Finally, it did not analyze socio-demographic and psychosocial traits of those correctly choosing products with the NS due to experimental setup constraints. Given these limitations, future research should expand food categories and food products on which to most accurately test these label formats and consider cross-national studies to gauge cultural influences.

In summary, this study suggests that nutrient-specific FoPL systems like NIB is more effective than directive systems like NS in assisting individuals with cardiovascular risk factors in making suitable dietary choices. While further research is necessary to explore the applicability of these findings to other risk factors and populations with specific dietary needs, the results underscore the importance of considering these factors in the decision-making process for selecting a harmonized FoPL system in Europe.

This study has significant implications for the food industry, dietary health promotion, and food policy. The nutrient-specific FOPLs can boost a brand's health-conscious image and support healthier consumer choices. Public health policy could benefit from the nutrient-specific FoPLs to address diet-related issues like hypertension and hypercholesterolemia. Policymakers should promote labeling systems with comprehensive nutritional information to aid healthier choices. Italy's proposal to adopt a detailed labeling systems underscores this shift towards informative content, a trend supported by our findings and potentially a model for other nations.

Funding

This study was made possible by an unconditional grant from NFI - Nutrition Foundation of Italy to EngageMinds HUB - Consumer, Food & Health Engagement Research Centre, Università Cattolica del Sacro Cuore, Milan, Italy.

Research partially supported by "National Research Centre for Agricultural Technologies (Agritech)" CN00000022. PNRR-M4C2, Investment 1.4 - Funded by the European Union - NextGenerationEU" - CUP: J33C22001160007. However, the views and opinions expressed are only those of the authors and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Authors' contributions

This paper derives from a collaboration of the authors: **G. C.:** Conceptualization, Methodology, Data Curation, Formal analysis, Writing - Original Draft; **S. B.:** Writing - Original Draft, Methodology, Data Curation; **M.C.:** Writing - Review and Editing, Supervision; **L.M.D.:** Writing - Review and Editing, Supervision; **D.M.:** Writing - Review and Editing, Supervision; **G.G:** Conceptualization, Methodology, Writing - Review and Editing, Supervision. All authors have approved the final article.

Ethical statement

This study has been performed in accordance with the Declaration of Helsinki and Ethical approval for the involvement of human subjects and was approved by University Research Ethics Committee (CERPS), Reference number 69-23.

Declaration of competing interest

The authors 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.numecd.2024.08.007.

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