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### ► **To cite this version:**

Francisco Goiana-Da-Silva, David Cruz-E-Silva, Catarina Nobre-Da-Costa, Alexandre Morais Nunes, Morgane Fialon, et al.. Nutri-Score: The Most Efficient Front-of-Pack Nutrition Label to Inform Portuguese Consumers on the Nutritional Quality of Foods and Help Them Identify Healthier Options in Purchasing Situations. *Nutrients*, 2021, 13 (12), pp.4335. 10.3390/nu13124335 . hal-03879791

**HAL Id: hal-03879791**

**<https://cnam.hal.science/hal-03879791>**

Submitted on 30 Nov 2022

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

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## Article

# Nutri-Score: The Most Efficient Front-of-Pack Nutrition Label to Inform Portuguese Consumers on the Nutritional Quality of Foods and Help Them Identify Healthier Options in Purchasing Situations

Francisco Goiana-da-Silva <sup>1</sup>, David Cruz-e-Silva <sup>2</sup>, Catarina Nobre-da-Costa <sup>3</sup>, Alexandre Morais Nunes <sup>2</sup>, Morgane Fialon <sup>4,\*</sup>, Manon Egnell <sup>4</sup>, Pilar Galan <sup>4</sup>, Chantal Julia <sup>4,5</sup>, Zenobia Talati <sup>6</sup>, Simone Pettigrew <sup>7</sup>, Ara Darzi <sup>1</sup>, Fernando Araújo <sup>8</sup> and Serge Hercberg <sup>4,5</sup>

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**Citation:** Goiana-da-Silva, F.; Cruz-e-Silva, D.; Nobre-da-Costa, C.; Nunes, A.M.; Fialon, M.; Egnell, M.; Galan, P.; Julia, C.; Talati, Z.; Pettigrew, S.; et al. Nutri-Score: The Most Efficient Front-of-Pack Nutrition Label to Inform Portuguese Consumers on the Nutritional Quality of Foods and Help Them Identify Healthier Options in Purchasing Situations. *Nutrients* **2021**, *13*, 4335. <https://doi.org/10.3390/nu13124335>

Academic Editor: Rosa Casas

Received: 16 November 2021  
Accepted: 29 November 2021  
Published: 30 November 2021

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**Abstract:** Several studies have identified Front-of-Pack Nutrition Labels (FoPLs) as a promising strategy to improve the nutritional quality of consumers' food choices and encourage manufacturers to offer healthier products. This study aims to fill the evidence gap regarding the most effective FoPL among the Portuguese population. In total, 1059 Portuguese participants were recruited through a web panel provider and asked to declare their intended food choices and to rank three sets of products (pizza, cakes and breakfast cereals) according to their nutritional quality, first in the absence of any labelling, and then with a FoPL displayed on-pack (five FoPLs tested). Finally, participants were asked to answer nine statements related to perceptions of FoPLs. Results showed that participants improved their food choices, depending on the FoPL and the food category. All FoPLs led to a higher percentage of correct responses on the ranking task compared to the no label condition. The Nutri-Score was among the FoPLs producing the greatest improvement across all food categories compared to the reference intakes (OR = 6.45 [4.43–9.39],  $p$ -value < 0.0001) and facilitating the highest percentage to correctly rank products according to nutritional quality. This study suggests that, among the available options, Nutri-Score is the most efficient FoPL to inform Portuguese consumers of the nutritional quality of foods and help them identify healthier options in mock purchasing situations.

**Keywords:** Front-of-Pack Nutrition Label; nutritional quality; diet; public health; Portuguese consumers

## 1. Introduction

According to the Global Burden of Disease study, unhealthy diets are the leading risk factor contributing to the loss of healthy life years among the Portuguese population [1,2]. Overweight and obesity are present in over 50% of the Portuguese population [3]. Chronic diseases, which are associated with avoidable behavioural risk factors, and for which

dietary habits are an important determinant [2], represent 86% of the total burden of disease [2,4]. Thus, there is a need for a new philosophy towards public health with increased investment in health promotion and a multi-stakeholder approach involving modifications of the food environment.

Several studies have shown that consumers, in general, are not able to fully understand and interpret food labels [5,6]. Data available for the Portuguese population support these results. A study, which was developed with the World Health Organization (WHO, Geneva, Switzerland), showed that 40% of Portuguese participants do not understand back of pack nutritional information [6]. Furthermore, among people with lower socioeconomic status, this figure increased to 60%. The study also found that FoPLs using colours led to better label comprehension.

FoPLs were first introduced in the 1980s/1990s with some being endorsed by countries and implemented as part of national nutrition prevention programs [7,8] (namely, the Green Keyhole has been used in the Nordic countries since the 1980s, the Multiple Traffic Lights (MTL) in the United Kingdom since 2004, the Warning symbol in Chile since 2016, the Health Star Rating system in New Zealand and Australia since 2014, and the Nutri-Score in France in 2017 and then by several other European countries). Furthermore, the Guideline Daily Amount, which became the Reference Intakes (RIs), was implemented by many manufacturers in 2006 as part of a voluntary initiative by agro-food industries.

Several studies identified FoPLs as a promising strategy to improve the nutritional quality of consumers' food choices and encourage manufacturers to offer healthier products and improve the nutritional profile of existing products [9–13]. The WHO recommended the implementation of FoPLs as a highly cost-effective intervention, also known as 'best-buy' intervention, to prevent non-communicable diseases (NCD) [14] given their effectiveness as a nudging strategy [15].

Nonetheless, the existence of multiple FoPLs may generate confusion among consumers [16]. According to European Regulation, FoPLs are voluntary and different models may coexist within the same market [17]. However, discussions by the European Commission have been taking place since 2018 in order to modify the existing regulation towards a harmonised regulatory context [4]. International government interest in this area has been particularly felt through the inclusion of political discussion with regards to FoPLs within a Codex Alimentarius e-working group [18]. Finally, the European Commission decided to implement, as part of its Farm to Fork strategy in May 2020, a single harmonised nutrition FoPL for Europe in 2022.

Evidence suggests that FoPLs that use colours are the most efficient in providing nutritional information, especially among vulnerable populations [19,20]. These types of labels (such as the Multiple Traffic Lights in England or the Nutri-Score in France) [21–24] allow consumers to better understand the nutritional quality of foods and make healthier food choices.

In Portugal, several proposals of FoPLs have been brought forward to the Parliament. However, to date, none have received political approval. Various kinds of FoPLs can be found in Portuguese supermarkets: the Multiple Traffic Lights (MTL) initially developed by the Food Standards Agency in the United Kingdom, was adopted by the Portuguese retail chain Continente for its brand in 2009; the Reference Intakes format supported by FIPA (Federação das Indústrias Portuguesas Agro-Alimentares) is also visible on many products (e.g., Pingo Doce retail brand). The Ipsos European Union study showed that Portugal was one of six European countries with the most food labelling schemes [25]. Still, as a result of the multiplicity of proposals brought forward from different political parties, the Portuguese Parliament recommended that the Portuguese Government assessed a simplified FoPL model as an alternative to the Traffic Light System.

This article aims to help fill the evidence gap regarding the most effective FoP Labelling system among the Portuguese population by assessing consumer responses to different FoPLs in a Portuguese sample. This study is part of the second wave of the international comparative experimental study initially conducted across 12 countries and then on six addi-

tional European countries that evaluated consumers’ responses to five different FoPLs in the form of perceptions, objective understanding and food choices (FOP-ICE study [26,27]).

## 2. Materials and Methods

### 2.1. Population Sample

A total of 1059 participants were recruited through an ISO accredited international web panel provider (Pureprofile) using advertising and word-of-mouth referrals. Quotas for age (a third in each category: 18–30 years, 31–50 years, over 51 years), sex (50% women) and household income level (a third in each category: low, medium and high) were applied. Income levels were calculated by estimating the median annual household income in Portugal (from national statistical databases) and creating a bracket of 33% around this figure. This represented the “medium” income band. Anything below or above this figure was considered as low- or high-income, respectively. Participants gave their electronic consent and, during an online questionnaire, were asked to provide socio-demographic, lifestyle and nutrition-related information, such as sex, age, monthly household income, educational level, involvement in grocery shopping, self-estimated diet quality, and self-estimated level of knowledge in nutrition. Individuals were excluded if they reported never or rarely buying at least two of the three food categories studied (pizzas, cakes and breakfast cereals)—response options were “always”, “often”, “sometimes” and “never”.

Data collection took place in the second wave of the FOP-ICE study [27] and received approval from the Curtin University Human Research Ethics Committee (approval reference: HRE2017-0760) and the Institutional Review Board of the French Institute for Health and Medical Research (IRB Inserm n\_17-404 and 17-404 bis).

### 2.2. Stimuli

Participants were presented with virtual fictitious food products (designed specifically for this study) (Figure 1). These products (pizzas, cakes and breakfast cereals) were selected due to two main reasons. Firstly, these products are consumed in all the countries where the FOP-ICE study was conducted (including Portugal). Secondly, there was high variability in nutritional quality within the food category.













| Labelling condition       | Example of one food category : Pizzas   |   |   |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
|---------------------------|---|---|---|------|-----------|------|----------|------|-------|------|------|--|--------|-----|-----------|------|-----|----|-----|-----|-----|--|--------|--------|-----|-----------|------|----------|------|-------|------|----|--|--------|-----|-----------|------|-----|----|-----|-----|-----|---|--------|--------|------|-----------|------|----------|------|-------|-------|------|--|--------|-----|-----------|------|-----|----|-----|-----|-----|
| No label                  |    |   |  |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| Health Star Rating system |    |   |  |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| Multiple Traffic Lights   | <p>Each 170g serve contains</p> <table border="1"> <tr> <th>ENERGY</th> <th>LOW</th> <th>MED</th> <th>MED</th> <th>MED</th> </tr> <tr> <td>325 kcal</td> <td>4.6g</td> <td>12.2g</td> <td>4.4g</td> <td>1.5g</td> </tr> <tr> <td></td> <td>Sugars</td> <td>Fat</td> <td>Saturated</td> <td>Salt</td> </tr> <tr> <td>16%</td> <td>5%</td> <td>17%</td> <td>22%</td> <td>24%</td> </tr> </table> <p>of an adult's reference intake<br/>Typical values per 100g; Energy: 193kcal</p> | ENERGY  | LOW   | MED  | MED       | MED  | 325 kcal | 4.6g | 12.2g | 4.4g | 1.5g |  | Sugars | Fat | Saturated | Salt | 16% | 5% | 17% | 22% | 24% | <p>Each 170g serve contains</p> <table border="1"> <tr> <th>ENERGY</th> <th>LOW</th> <th>MED</th> <th>MED</th> <th>HIGH</th> </tr> <tr> <td>393 kcal</td> <td>3.9g</td> <td>18.5g</td> <td>5.1g</td> <td>3g</td> </tr> <tr> <td></td> <td>Sugars</td> <td>Fat</td> <td>Saturated</td> <td>Salt</td> </tr> <tr> <td>20%</td> <td>4%</td> <td>26%</td> <td>26%</td> <td>50%</td> </tr> </table> <p>of an adult's reference intake<br/>Typical values per 100g; Energy: 233kcal</p> | ENERGY | LOW    | MED | MED       | HIGH | 393 kcal | 3.9g | 18.5g | 5.1g | 3g |  | Sugars | Fat | Saturated | Salt | 20% | 4% | 26% | 26% | 50% | <p>Each 170g serve contains</p> <table border="1"> <tr> <th>ENERGY</th> <th>LOW</th> <th>HIGH</th> <th>HIGH</th> <th>HIGH</th> </tr> <tr> <td>406 kcal</td> <td>2.3g</td> <td>28.4g</td> <td>14.7g</td> <td>2.6g</td> </tr> <tr> <td></td> <td>Sugars</td> <td>Fat</td> <td>Saturated</td> <td>Salt</td> </tr> <tr> <td>23%</td> <td>3%</td> <td>41%</td> <td>74%</td> <td>43%</td> </tr> </table> <p>of an adult's reference intake<br/>Typical values per 100g; Energy: 234kcal</p> | ENERGY | LOW    | HIGH | HIGH      | HIGH | 406 kcal | 2.3g | 28.4g | 14.7g | 2.6g |  | Sugars | Fat | Saturated | Salt | 23% | 3% | 41% | 74% | 43% |
| ENERGY                    | LOW   | MED   | MED   | MED  |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 325 kcal                  | 4.6g  | 12.2g   | 4.4g  | 1.5g |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
|                           | Sugars  | Fat   | Saturated   | Salt |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 16%                       | 5%  | 17%   | 22%   | 24%  |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| ENERGY                    | LOW   | MED   | MED   | HIGH |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
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|                           | Sugars  | Fat   | Saturated   | Salt |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 20%                       | 4%  | 26%   | 26%   | 50%  |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| ENERGY                    | LOW   | HIGH  | HIGH  | HIGH |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
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| Nutri-Score               |    |   |  |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
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|                           |   |   |   |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 16%                       | 5%  | 17%   | 22%   | 24%  |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| Energy                    | Sugars  | Fat   | Saturated   | Salt |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 393 kcal                  | 3.9g  | 18.5g   | 5.1g  | 3g   |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
|                           |   |   |   |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 20%                       | 4%  | 26%   | 26%   | 50%  |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| Energy                    | Sugars  | Fat   | Saturated   | Salt |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 406 kcal                  | 2.3g  | 28.4g   | 14.7g   | 2.6g |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
|                           |   |   |   |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| 23%                       | 3%  | 41%   | 74%   | 43%  |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |
| Warning symbol            |   |  |  |      |           |      |          |      |       |      |      |  |        |     |           |      |     |    |     |     |     |  |        |        |     |           |      |          |      |       |      |    |  |        |     |           |      |     |    |     |     |     |   |        |        |      |           |      |          |      |       |       |      |  |        |     |           |      |     |    |     |     |     |

Figure 1. Example of the set of three pizzas with the corresponding labelling conditions.

The mock products, including the brand, were specifically created to resemble real food products. However, the product creation and design accounted for factors that could interfere with respondents' judgment, such as brand and product loyalty and/or familiarity, as well as purchase habits. A zoom function was available for participants to enlarge any area of the image of the mock package.

Within each category, three products were presented to each participant. Each one of these products had a distinct nutritional quality profile (lower, intermediate and higher). Only the FoPL was provided and there were no other labels (e.g., organic label, gluten-free).

### 2.3. Procedure

Firstly, participants were confronted with the sets of three products without any label (i.e., No Label Condition). For each of the three food categories, participants were asked to undergo a food choice task and a ranking task. Secondly, all participants were randomised to one of the five FoPLs groups (Health Star Rating (HSR), Multiple Traffic Lights (MTL), Nutri-Score, Reference Intakes (RIs) or Warning symbol) (Figure 1), with a balanced repartition between the five groups (i.e., approximately 200 participants per group). The two previous tasks were then repeated with the randomly assigned label (FoPL condition). Finally, participants were asked to answer nine statements related to several aspects of perception.

#### 2.3.1. No Label Condition

Participants were asked to choose which product they would buy among the three products of each set. The option "I wouldn't buy any of these products" was also available. Participants were then asked to rank the products according to their nutritional quality. For each product, participants could select "1—Highest nutritional quality", "2—Medium nutritional quality" or "3—Lowest nutritional quality". The option "I don't know" was also available. The two tasks were performed sequentially.

#### 2.3.2. FoPL Condition

Each participant was then presented with one of the five FoPLs, assigned by randomisation. They were asked to repeat the same tasks, but this time with a label on all the products. Participants were not aware that they would be seeing the products twice, or that a FoPL would be present on the second viewing. The order of the products and categories was randomised between participants to avoid undesired order effects. The underlying nutritional ranking of the products was the same regardless of the type of label used. Participants were also asked if they recalled the FoPL to which they were exposed.

#### 2.3.3. Perception

Participants were asked to answer nine statements on a 9-point Likert scale from 1 (strongly disagree) to 9 (strongly agree). These statements were related to perceptions of FoPLs; in particular ease of understanding (e.g., "this label is easy to understand", "this label is too long to understand"), label visibility ("This label does not stand out"), appreciation ("I like this label") and trust ("I trust this label").

### 2.4. Statistical Analysis

#### 2.4.1. Food Choice and Objective Understanding

For food choice, a score between 1 and 3 points was assigned to each product. A score of 3 for the product with the highest nutritional quality, 2 for the intermediate product, 1 for the product with the lowest nutritional quality. Participants' objective understanding, corresponding to the ability of consumers to understand the information provided by labels in the way expected by its designers, was evaluated by calculating the difference between the ranking tasks in the no label and FoPL conditions [28]. For the objective understanding analyses, for each food category, participants were allocated 1 point if they ranked all the



products in the expected order according to the nutritional quality of products, 0 if the answer was “I don’t know” and –1 point if they ranked at least one product out of order.

For each food category, a score was calculated by subtracting the choice/ranking score in the no label condition from the score in the FoPL condition. For each food category and for each task, a discrete score between –2 (which was considered as the highest deterioration) and +2 points (the highest improvement of the food choice) was calculated. Participants’ scores were summed across the three categories, resulting in a final global discrete score ranging from –6 to +6. Only responses from participants who selected a product in both the no label and FoPL conditions were included.

Sensitivity analyses for objective understanding were performed by excluding participants who answered “I don’t know” to the ranking task, drawing upon previously published methodology [27]. The responses of participants who declared never purchasing products from one of the three food categories were excluded from the corresponding food category.

Ordinal logistic regression models were used to evaluate the association of FoPL with better food choices and with the ability to correctly rank products. Since previous literature shows that the RIs are the least efficient FoPL [20], this label was used as the reference category. Covariates considered for the regression models were sex, age, educational level, household income, involvement in grocery shopping, responses to the question “Do you remember having seen this label during the survey?” and self-estimated nutritional knowledge and diet quality. The analyses were done by food category and for all categories. Interactions between FoPLs and these covariates were also tested (a *p*-value below 0.05 was considered statistically significant).

#### 2.4.2. Perception

For perception analyses, participants who gave the same score to all perception questions were excluded. An exception was made for those who gave a score of 5, a neutral perception, on all items. For each perception question, the mean and standard deviation was computed per FoPL. Furthermore, a Principal Component Analysis (PCA) was conducted to investigate the contribution of the different questions to the overall label perception. For the PCA, “This label is confusing”, “I like this label”, “This label does not stand out”, “This label is easy to understand”, “This label takes too long to understand”, “This label provides me the information I need” and “I trust this label” were considered as active variables. The FoPL itself was considered as a qualitative supplementary variable. The contribution and coordinates of each variable on each dimension were computed and the label was mapped on the axes as an illustrative variable. The analysis of a test value allows testing the significance of the deviation from the origin of the qualitative variable. This difference can be considered significant at the 95% level if the test value is greater than or equal to 2 in absolute value [29].

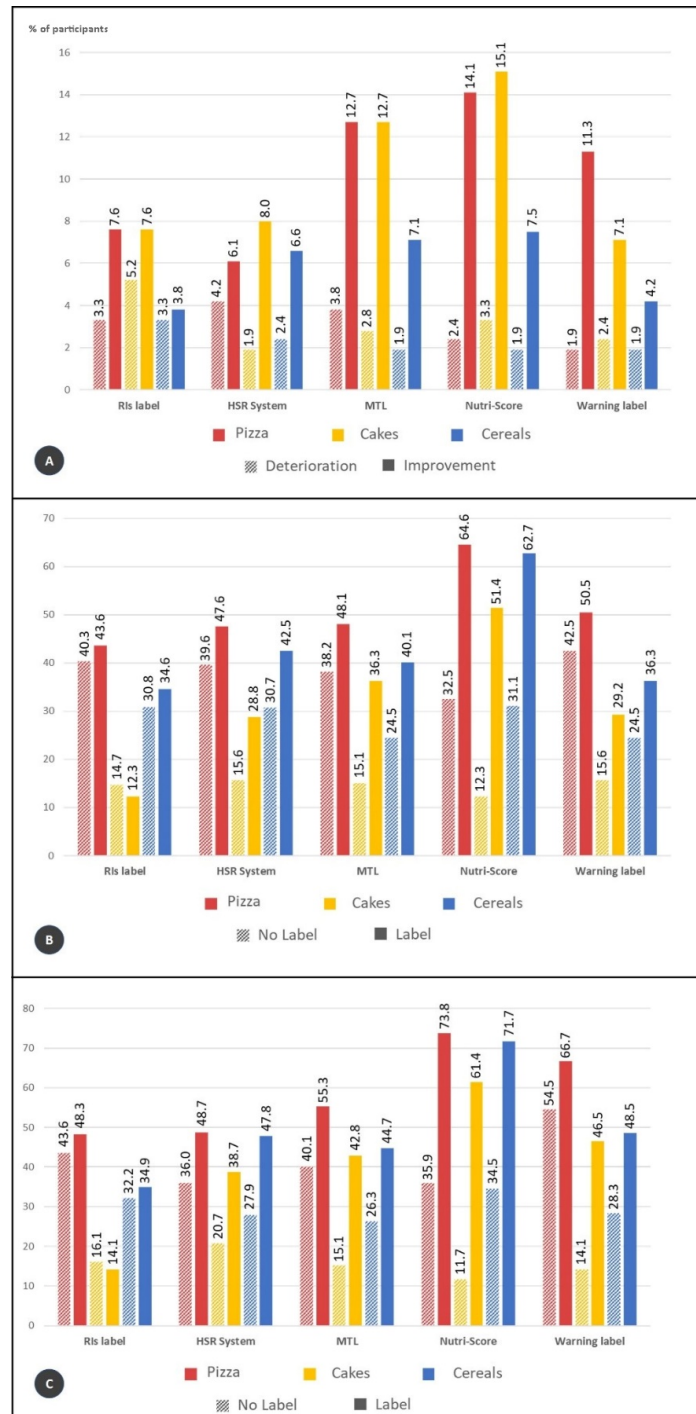
A *p*-value below or equal to 0.05 was considered statistically significant. Statistical analyses were carried out for all food categories combined and for each individual food category, using SAS Software (version 9.3, SAS Institute Inc., Cary, NC, USA). Analysis on perception was carried out using R software (version 3.4.4, R Foundation, Vienna, Austria).

### 3. Results

The sample included 50% of women, 34% of participants between 18 and 30 years old, 33% with a low level of income, as per quota sampling, 34% with a primary or secondary educational level, 40% with an undergraduate degree, and 60% responsible for grocery shopping. A total of 14% declared having a very or mostly unhealthy diet, and 10% were not very knowledgeable about nutrition or did not know anything, whilst 64% felt they were somewhat familiar with nutrition. A total of 62% declared having seen the FoPL during the survey. The Warning symbol and the HSR were the two FoPLs with the lowest recall rate (47% and 52% respectively).

### 3.1. Food Choice and Objective Understanding

Between 3.8% and 15% of participants improved their food choices, depending on the label and food category. Improvement was always higher than deterioration, per FoPL and per food category, which varied between 1.9% and 5.2% depending on the label and the food category. Nutri-Score and the MTL were the FoPLs with the higher percentages of improvement across all food categories (Figure 2A).



**Figure 2.** (A) Percentages of participants whose food choices deteriorated and improved; (B) Percentages of participants providing correct answers for ranking tasks; (C) Percentages of participants providing correct answers for ranking task only among participants who recalled seeing the label during the survey.

For objective understanding, the change in the number of correct responses across the three food categories from the no label to the FoPL condition was computed for each participant. For the three food categories, the Nutri-Score was the FoPL with the highest increase of the number of correct answers compared to no label with a relative increase ranging from 99% for pizzas to 319% for cakes and 102% for breakfast cereals.

The MTL was the FoPL demonstrating the second-best performance for the three categories, but with a much lower effect compared to the Nutri-Score. The relative increase of correct answers compared to the no label condition ranged from 26% for pizzas to 141% for cakes and 63% for breakfast cereals. For the other FoPLs, results were contrasted depending on the food category; however, RIs showed the lowest performance in each category.

Regarding the ranking task, all FoPLs led to a higher percentage of correct responses compared to the no-label condition. Nutri-Score was the FoPL with the highest improvement on the ability to correctly rank products according to nutritional quality, reaching between 32% and 39% of improvement (Figure 2B).

Analyses were also conducted among participants recalling having seen the FoPL only during the survey. The Nutri-Score labelling showed higher results for the three food categories but this time followed by the Warning symbol (Figure 2C).

MTL, Nutri-Score and Warning symbols were more efficient than RIs in helping consumers improve their food choices. Nutri-score was the most efficient FoPL in helping consumers improve the nutritional quality of food choices (OR = 1.98 [1.26–3.12],  $p$ -value = 0.003) (Table 1).

**Table 1.** Association between FoPLs and change in the nutritional quality of food choices.

| Food Category     | <i>n</i> | HSR              |          | MTL              |              | Nutri-Score      |              | Warning Symbol   |              |
|-------------------|----------|------------------|----------|------------------|--------------|------------------|--------------|------------------|--------------|
|                   |          | OR (95% CI)      | <i>p</i> | OR (95% CI)      | <i>p</i>     | OR (95% CI)      | <i>p</i>     | OR (95% CI)      | <i>p</i>     |
| All categories    | 1007     | 1.46 [0.92–2.32] | 0.1      | 1.95 [1.24–3.07] | <b>0.004</b> | 1.98 [1.26–3.12] | <b>0.003</b> | 1.94 [1.22–3.08] | <b>0.005</b> |
| Pizza             | 864      | 1.00 [0.54–1.86] | 1        | 1.56 [0.87–2.81] | 0.1          | 1.92 [1.07–3.43] | <b>0.03</b>  | 1.99 [1.1–3.6]   | <b>0.02</b>  |
| Cakes             | 759      | 1.64 [0.87–3.06] | 0.1      | 1.89 [1.02–3.49] | <b>0.04</b>  | 2.2 [1.2–4.03]   | <b>0.01</b>  | 1.41 [0.75–2.68] | 0.3          |
| Breakfast Cereals | 890      | 1.81 [0.87–3.77] | 0.1      | 1.82 [0.87–3.8]  | 0.1          | 2 [0.96–4.13]    | 0.06         | 1.55 [0.72–3.34] | 0.3          |

The reference for the multivariate ordinal logistic regression for the categorical variable ‘label’ was Reference Intakes. The multivariate model was adjusted on sex, age, educational level, level of household income, responsibility for grocery shopping, self-estimated diet quality, self-estimated nutrition knowledge level, and “Did you see this label during the online survey?”. HSR: Health Star Rating system; MTL: Multiple Traffic Lights; OR: Odds Ratio; CI: Confidence Interval. Bold values correspond to significant results ( $p$ -value  $\leq$  0.05).

No quantitative interaction between labels and individual characteristics was found (data not shown).

According to the association between FoPL and the ability to correctly rank food products matching their nutritional quality, the Nutri-Score was the FoPL associated with the highest improvement in participants’ ability to correctly rank products (OR = 6.45 [4.43–9.39],  $p$ -value < 0.0001) compared to the RIs, followed by the MTL, the HSR and then the Warning symbol. For the three food categories, the Nutri-Score showed stronger performances, while the other labels varied in performance depending on the food category (Table 2).

**Table 2.** Association between FoPLs and the ability to correctly rank products according to nutritional quality.

| Food Category     | <i>n</i> | HSR              |                 | MTL              |                 | Nutri-Score       |                 | Warning Symbol   |                 |
|-------------------|----------|------------------|-----------------|------------------|-----------------|-------------------|-----------------|------------------|-----------------|
|                   |          | OR (95% CI)      | <i>p</i>        | OR (95% CI)      | <i>p</i>        | OR (95% CI)       | <i>p</i>        | OR (95% CI)      | <i>p</i>        |
| All categories    | 1059     | 2.02 [1.39–2.94] | <b>0.0002</b>   | 2.11 [1.46–3.05] | < <b>0.0001</b> | 6.45 [4.43–9.39]  | < <b>0.0001</b> | 2.00 [1.37–2.91] | <b>0.0003</b>   |
| Pizza             | 1031     | 1.42 [0.91–2.22] | 0.1222          | 1.30 [0.84–2.01] | 0.2470          | 3.67 [2.39–5.64]  | < <b>0.0001</b> | 1.33 [0.85–2.08] | 0.2073          |
| Cakes             | 1038     | 2.56 [1.65–3.97] | < <b>0.0001</b> | 3.19 [2.07–4.93] | < <b>0.0001</b> | 7.14 [4.61–11.07] | < <b>0.0001</b> | 2.88 [1.85–4.48] | < <b>0.0001</b> |
| Breakfast Cereals | 1027     | 1.58 [0.98–2.56] | 0.0614          | 1.77 [1.11–2.83] | <b>0.0170</b>   | 3.68 [2.33–5.8]   | < <b>0.0001</b> | 1.56 [0.96–2.53] | 0.0727          |

The reference of the multivariate ordinal logistic regression for the categorical variable ‘label’ was the Reference Intakes. The multivariate model was adjusted on sex, age, educational level, level of household income, responsibility for grocery shopping, self-estimated diet quality, self-estimated nutrition knowledge level, and “Did you see this label during the online survey?”. HSR: Health Star Rating system; MTL: Multiple Traffic Lights; OR: Odds Ratio; CI: Confidence Interval. Bold values correspond to significant results ( $p$ -value  $\leq$  0.05).



As for the sensitivity analyses, results show that excluding participants selecting “I don’t know” led to similar findings for the FoPLs’ performance regarding objective understanding, with even larger effect magnitudes. However, the Warning symbol was the second label to perform best after the Nutri-Score among participants recalling having seen the label during the survey (Table 3).

**Table 3.** Associations between FoPL exposure and ability to rank products among participants recalling seeing the label.

| Food Category     | n   | HSR              |              | MTL              |                   | Nutri-Score       |                   | Warning Symbol   |                   |
|-------------------|-----|------------------|--------------|------------------|-------------------|-------------------|-------------------|------------------|-------------------|
|                   |     | OR (95% CI)      | p            | OR (95% CI)      | p                 | OR (95% CI)       | p                 | OR (95% CI)      | p                 |
| All categories    | 656 | 2.17 [1.37–3.42] | <b>0.001</b> | 2.70 [1.76–4.15] | <b>&lt;0.0001</b> | 8.11 [5.18–12.7]  | <b>&lt;0.0001</b> | 2.81 [1.74–4.52] | <b>&lt;0.0001</b> |
| Pizza             | 640 | 1.35 [0.79–2.30] | 0.3          | 1.49 [0.91–2.44] | 0.1               | 3.78 [2.31–6.19]  | <b>&lt;0.0001</b> | 1.38 [0.80–2.39] | 0.3               |
| Cakes             | 644 | 2.15 [1.28–3.62] | <b>0.004</b> | 3.47 [2.13–5.66] | <b>&lt;0.0001</b> | 7.57 [4.57–12.53] | <b>&lt;0.0001</b> | 4.16 [2.42–7.16] | <b>&lt;0.0001</b> |
| Breakfast Cereals | 635 | 2.11 [1.18–3.79] | <b>0.01</b>  | 2.24 [1.31–3.85] | <b>0.003</b>      | 4.53 [2.65–7.76]  | <b>&lt;0.0001</b> | 2.21 [1.21–4.04] | <b>0.01</b>       |

The reference of the multivariate ordinal logistic regression was the Reference Intakes. The multivariate model was adjusted on sex, age, educational level, level of income, responsibility for grocery shopping, self-estimated diet quality, and self-estimated nutrition knowledge level. HSR: Health Star Rating system; MTL: Multiple Traffic Lights; OR: Odds Ratio; CI: Confidence Interval. Bold values correspond to significant results corrected for multiple testing ( $p$ -value  $\leq 0.05$ ).

No interaction between FoPLs and individual characteristics was found.

### 3.2. Perception

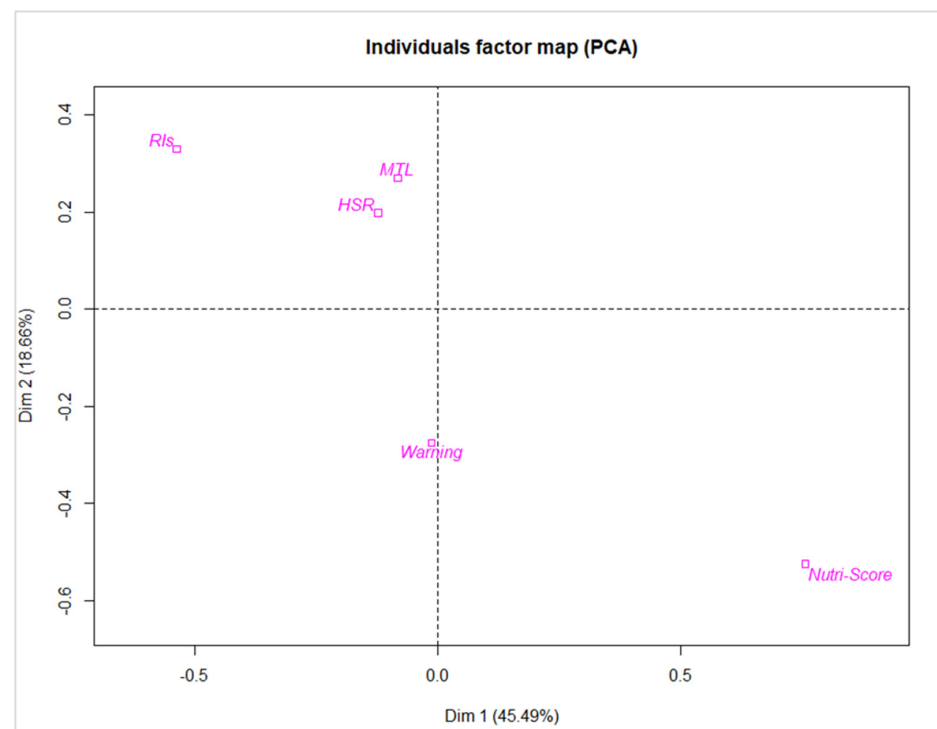
The results regarding the comparison of the average score and the standard deviation of each statement by FoPL were globally homogenous, with less than 1 point of score between different FoPLs for each statement, except for the statement “This label does not stand out” where the average score for the Nutri-Score was equal to 3.7 and for the Warning symbol equal to 5.2 (Table 4).

**Table 4.** Comparison of the average score and the standard deviation of each statement by FoPL.

| Questions                                     | Contributions           |             | Coordinates |             | Label          | v-Test      |             |
|---|-------------------------|-------------|-------------|-------------|----------------|-------------|-------------|
|   | Dimension 1             | Dimension 2 | Dimension 1 | Dimension 2 |                | Dimension 1 | Dimension 2 |
|   | This label is confusing | 20.76       | 9.86        | −1.75       |                | 0.77        | HSR         |
| I like this label                             | 12.49                   | 12.29       | 1.36        | 0.86        | MTL            | −0.35       | 1.76        |
| This label does not stand out                 | 13.13                   | 14.28       | −1.39       | 0.93        | Nutri-Score    | 3.18        | −3.44       |
| This label is easy to understand              | 17.47                   | 1.66        | 1.61        | 0.32        |                |             |             |
| This label takes too long to understand       | 18.51                   | 16.97       | −1.66       | 1.02        | RIs            | −2.26       | 2.17        |
| This label provides me the information I need | 8.46                    | 26.94       | 1.12        | 1.28        |                |             |             |
| I trust this label                            | 9.17                    | 17.99       | 1.17        | 1.05        | Warning symbol | −0.06       | −1.79       |

Two dimensions were retained, explaining respectively 46% and 19% of the variance. After evaluating contributions of active variables, the first dimension (horizontal axis) represented rather preference (including the statements “This label is confusing”, “This label is easy to understand” and “This label takes too long to understand”) whereas the second dimension represented trustworthiness (including the statements “This label provides me the information I need”, “I trust this label”) (Figure 3).

After analysing the PCA and v-test, Nutri-Score and the RIs were opposed on the two dimensions. According to the first dimension, Nutri-Score was less confusing and faster to understand compared to the RIs. According to the second dimension, the RIs provided more information and were more trusted by consumers compared to the Nutri-Score.



**Figure 3.** Principal Component Analysis map.

#### 4. Discussion

While evidence shows that Portuguese consumers use labelling information to make their purchasing decisions [30], roughly 40% of surveyed Portuguese consumers do not understand the back of pack labelling information [6]. Our study shows that FoPLs can increase the nutritional quality of food choices made by Portuguese consumers, which is in line with previous research [31]. In terms of objective understanding, we found that all FoPLs seemed to increase consumers' understanding, however, the Nutri-Score improved consumers' capacity to understand the nutritional quality of products the most. In terms of the quality of food choices, the Nutri-Score showed the greatest increase, therefore, has the most potential to help Portuguese consumers improve their diets. All FoPLs were well perceived by participants, however, the RIs were seen as more confusing and took too long to understand compared to the Nutri-Score.

The results of this study suggest that among the available options, the Nutri-Score, with its summary, graded, color-coded format, appears as the most efficient scheme to inform Portuguese consumers of the nutritional quality of foods and help them identify healthier options in purchasing situations.

The data shown in this study are of particular relevance when taking into account the context in Portugal. The retail market leader in Portugal has been implementing an adapted MTL model for roughly ten years. This has led to the Portuguese population being well exposed to an MTL-like model [32]. In fact, within the sample of Portuguese consumers, Nutri-Score and the MTL were the FoPLs with the higher percentages of improvement across all food categories. Furthermore, when assessing the full sample, the Nutri-Score showed the largest improvement in the ability to correctly rank products according to nutritional quality, closely followed by MTL.

The results of this study were somewhat expected due to existing data on the efficacy of Nutri-Score in France [33–36], in other Mediterranean countries like Spain [37], or Italy [38], as well as in many other European countries [20,26]. The similarities between the Portuguese, Spanish, Italian and French populations, their food environments and behaviours [39] may also explain these findings. The results of this study are consistent with previous findings, particularly with regard to objective understanding and food choices [20,27]. A study, which took place in over 20 stores, showed that summary models

(such as Nutri-Score) are the most effective in improving consumer decision-making [36]. Furthermore, several experimental studies have provided similar findings [34,35].

An increasingly robust body of evidence suggests that the Nutri-Score significantly improves consumers' ability to understand nutritional information and make healthier choices. Several food manufacturers and retailers have followed suit and deployed (or committed to deploying) the Nutri-Score on their products. In Portugal, some food industry players have also publicly announced the use of this FoPL. Furthermore, other Ministries of Health in Europe (i.e., France, Belgium, Spain, Switzerland, Germany, Luxembourg and the Netherlands) have endorsed the label and/or published national recommendations for its adoption. The Nutri-Score also has the support of numerous European consumer associations.

In Portugal, unlike other European countries, little progress has been made in this area. Policy and regulatory levers lying outside the health sector, limited collaboration between different governmental areas, and vested interests within and outside of the health sector have deeply hampered any decisive action from being taken. This study, by using a randomization design to compare the effectiveness of five FoPLs, while combining three dimensions being the potential effect of the FoPLs on food choices, the understanding of labels and their perceptions by consumers brings new insights for public health policymakers in Portugal. Regarding existing evidence on FoPLs in Portugal, a Portuguese study conducting a health impact assessment of FoPLs as a public health measure did not conclude in any specific FoPL format recommendation [40]. Recent research found that MTL was the most preferred FoPL in a sample of Portuguese adults exposed to the same set of FoPLs as this study except for the Warning symbol [32]. However, this result may be explained by the familiarity of Portuguese consumers with MTL as discussed by the authors. Also, this Portuguese study highlighted that Nutri-Score was more adapted for all socioeconomic status subgroups compared to other FoPLs, consistent with findings from Egnell et al. [20] and is of particular interest considering that, as mentioned before, among people with lower socioeconomic status, 60% do not understand back of pack nutritional information [6].

Until now, a lack of evidence on the real impact of the use of foreign FoPL among the Portuguese population has been described as an obstacle to the Portuguese Government endorsing a single FoPL. The multiplicity of FoPLs on Portuguese food products may complicate their understanding and discourage their use by consumers [16]. Results of this study effectively fill the gap previously identified and reinforce the need for standardization of the FoPL used at a national level in order to put a stop to the confusion generated within consumers' minds when exposed to several different FoPLs.

Some limitations of the study should be acknowledged. First, participants were recruited using quotas that are not specific to the Portuguese population which requires caution regarding the extrapolation of the results. Nevertheless, this allowed the inclusion of Portuguese participants from various sociodemographic profiles for whom FoPL effectiveness can vary, as well as comparisons of FoPL effectiveness between multiple countries within the FOP-ICE study. Second, as the meaning of the five FoPLs were not explained to participants, it may have led to an underestimation of the labels' effects, especially for unknown FoPLs compared to the RIs or the MTL labels that can be found in Portuguese supermarkets. Additionally, participants were exposed to virtual food products where factors such as prices were not included. Future studies in real-life environments are needed to take into account Portuguese specificities in the case of FoPLs. Finally, the results could have been impacted by purchasing habits for the food categories used in the study but this bias was minimised by the use of fictional brands and the exclusion of the answers of participants who declared having never purchased one of the food categories.

## 5. Conclusions

Our study suggests that, among the available options, the Nutri-Score appears as the most efficient Front-of-Pack Nutrition Label to inform Portuguese consumers of the

nutritional quality of foods and help them identify healthier options in purchasing situations. These findings are in line with the results of previous investigations performed on FoPLs and strengthen the body of evidence needed to harmonize FoPLs in Portugal for policymakers. Future studies could evaluate the effectiveness of these FoPLs on Portuguese consumers under real-life conditions.

**Author Contributions:** M.E. performed data analyses. F.G.-d.-S., D.C.-e.-S., C.N.-d.C., A.M.N., M.F., M.E., P.G., C.J., Z.T., S.P., A.D., F.A., S.H. interpreted the data, drafted and revised the paper. C.J. and S.P. conceptualised the project in collaboration with S.H. and Z.T. C.J. and S.H. supervised the data analyses and interpretation, participated in the writing, and critically revised the paper for important intellectual content. C.J. is the guarantor. Z.T., P.G., M.E. and S.P. interpreted the data and critically revised the paper for important intellectual content. All authors had full access to all of the data 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 agreed to the published version of the manuscript.

**Funding:** The present study received funding from Santé Publique France (French Agency for Public Health).

**Institutional Review Board Statement:** The methodology was approved by the Institutional Review Board of the French Institute for Health and Medical Research (IRB Inserm n°17–404) and the Curtin University Human Research Ethics Committee (approval reference: HRE2017–0760).

**Informed Consent Statement:** Participants gave their consent to participate in the study.

**Data Availability Statement:** The data used in this study are available on request to the corresponding author.

**Acknowledgments:** The authors would like to thank Mark Orange for creating the mock packages, and all researchers and doctoral students who tested the online survey.

**Conflicts of Interest:** The authors declare no conflict of interest.

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