

BMJ Open Perception of different formats of front-of-pack nutrition labels according to sociodemographic, lifestyle and dietary factors in a French population: cross-sectional study among the NutriNet-Santé cohort participants

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ABSTRACT

Objective Four formats for a front-of-pack (FOP) nutrition label are currently considered in France: the Nutriscore (or 5-Colour Nutrition Label, developed by a public research team), the SENS (supported by retailers), Multiple Traffic Lights (MTL, currently used in UK) and a modified version of the Reference Intakes (mRIs, supported by industry). Our objective was to investigate the perception of these FOP labels, according to sociodemographic, lifestyle and dietary factors.

Design Cross-sectional study.

Setting Web-based French cohort.

Main outcome measure FOP labels perception.

Participants Participants in the NutriNet-Santé cohort received a specific questionnaire on the perceptions of the four label formats identified. Sociodemographic, lifestyle and dietary data (three 24-hours dietary records) were collected through self-administered questionnaires. Mutually exclusive clusters of FOP labels perception were identified through a multiple correspondence analysis followed by a hierarchical clustering procedure. Sociodemographic, lifestyle and dietary factors associated with the clusters were explored using multivariable multinomial logistic regression. All analyses were weighted according to 2009 French census data.

Results Among the 21,702 participants in the study, the Nutriscore received the most important number of favourable responses on positive perception dimensions by participants, followed by MTL and SENS. The five identified clusters were characterised by marked preferences for Nutriscore (cluster 1, 43.2% of participants, crude n=9,399), MTL (cluster 2, 27.3%, crude n=6,163), SENS (cluster 3, 17.05%, crude n=3,546), mRIs (cluster 4, 7.31%, crude n=1,632) and none of the presented formats (cluster 5, 5.10%, crude n=965). The cluster 1 (Nutriscore) was associated with lower adherence to nutritional recommendations, while cluster 2 (MTL) was associated with younger age and higher level of education.

Conclusion The Nutriscore appears to have a wide reach in the population and to appeal to subjects with lower adherence to nutritional recommendations.

Strengths and limitations of this study

- Cross-sectional study in a large population using validated data collection tools.
- Investigation of multiple dimensions of the perception of front-of-pack (FOP) labels (awareness, liking, perceived cognitive workload and trustworthiness) across various formats that are currently proposed in the French debate on FOP nutrition labelling.
- Identification of clustered preferences toward each type of format, and investigation of the association between sociodemographic and dietary factors with FOP label preferences.
- Sample consisting of volunteer subjects included in a cohort study on nutrition, who are therefore more likely health conscious.
- Focus on the perception of FOP labels and not on understanding or use of FOP labels in purchasing situations.

INTRODUCTION

Preventing non-communicable diseases has become a top priority for most industrialised countries, as they represent a major part of the burden of diseases.¹ In France, cardiovascular diseases and cancers are the first causes of death, contributing each to approximately 30% of overall deaths every year.² Diet has been recognised as a key modifiable factor which can influence—as preventive or risk factor—a wide range of non-communicable diseases, from cardiovascular disease to cancer, type 2 diabetes, metabolic syndrome or obesity.^{3–5} Given its potential lever for improvement of the health status of the population, most Western countries have invested in state-level public health programmes on nutrition, promoting healthy diets and

physical activity.^{6–8} In France, the National Nutrition and Health Program (Programme National Nutrition Santé, PNNS), launched in 2001,⁹ sets a regulatory environment that promotes synergistic actions toward healthy eating and physical activity. The most pervasive actions that have been taken toward the population have consisted in the dissemination of nutrition recommendations in multimedia campaigns and booklets.^{10–11} Those recommendations act on the nutrition knowledge of individuals, prompting them to modify their dietary behaviour by promoting consumption of some food groups (eg, fruits and vegetables, whole-grain cereals, water) or limiting excessive intakes of others (saturated fat, added sugar and sodium).¹² Recently, novel complementary strategies have been put forward in a report to the French Minister of Health in 2014, highlighting the need for specific measures to modify the nutritional environment beyond the actions at the individual level.¹³ The report stressed in particular measures pertaining to nutrition labelling, in the form of a simplified front-of-pack (FOP) nutrition label, advertising regulation and nutritional taxation.¹³ Among the proposals of this report, the implementation of a FOP nutrition labelling system was considered as an effective opportunity by the health minister, and its principle was introduced in the 2016 French Health Law.¹⁴ Many countries have implemented FOP nutrition labels worldwide, either nutrient specific, such as the ‘Multiple Traffic Light’ system in the UK,¹⁵ or summary measures, either simple, such as the Dutch ‘Choices’ logo¹⁶ or the Nordic ‘Green Keyhole’,¹⁷ or graded, such as the ‘Health Star Rating System’ in New Zealand and Australia.¹⁸ Summary systems have been considered as more easily understood and interpreted than nutrient-specific labels, in particular for vulnerable populations.^{19–20} Moreover, colour-coded systems are considered more favourably perceived than monochrome systems.^{20–21} The initial report to the French Health Minister contained a detailed proposal for a simple colour-coded and graded label, supported by scientific studies^{22–34} and independent government agencies evaluations^{35–36} in the form of the 5-Colour Nutrition Label (5-CNL). However, alternative proposals were put forward during the debate by industry and retailers, in a vast lobbying campaign.³⁷ Finally, four alternative formats emerged in the debate: the Nutriscore (an updated graphical version of the 5-CNL), SENS (a summary, graded and colour-coded label, developed and promoted by retailers), Multiple Traffic Lights (MTL, nutrient-specific and colour-coded label, currently used in the UK) and a modified version of the Reference Intakes (mRIs, a nutrient-specific and monochrome label promoted by industry) (figure 1). However, to date, no scientific study has directly compared the perception of the four proposed formats. Some studies tend to indicate that the 5-CNL would be more favourably perceived than MTL or Reference Intakes (RIs)²⁵ and that it may help consumers identifying^{24–25} and purchasing healthier foods,^{26–34} but no data have been published on the mRIs or the SENS formats.

The objective of the present study was therefore to investigate the perception of the four formats that have been put forward in France in the debate on FOP nutrition labelling, in a comparative design carried out in the NutriNet-Santé cohort.

MATERIALS AND METHODS

Population

Participants were selected from the NutriNet-Santé cohort. Briefly, the NutriNet-santé study is a prospective cohort study set in France in which inclusion and follow-up of volunteer participants are entirely performed on the Internet.³⁸ The main objectives of the NutriNet-Santé study are (1) to investigate the relationship between nutrition and health outcomes and (2) to investigate the determinants of dietary patterns and nutritional status. Inclusion in the study began in May 2009 and is still ongoing. Volunteer participants aged >18 years subscribe to the study and are included when they have completed a set of questionnaires assessing diet (through repeated 24 hours dietary records), physical activity, anthropometry, lifestyle and socioeconomic conditions and health status. These five types of questionnaires are repeated yearly and have been validated against traditional assessment methods (paper or interview by dietitians).^{39–41} Once the subjects are included in the cohort, they receive monthly web questionnaires pertaining to various aspects of dietary behaviour, physical activity and health, which are optional, and graded according to their relative importance for research. The participation rate for any optional questionnaires in the NutriNet-Santé study is usually around 40%. Participants do not receive any form of incentive or compensation to participate in the online surveys. One of these questionnaires pertained to the perception of the various FOP labelling systems that have been proposed in the French context and was sent to all participants in the cohort in June 2016.

Detailed information on the NutriNet-Santé study can be found elsewhere.³⁸

Ethics

The NutriNet-Santé study is conducted in accordance with the Declaration of Helsinki, and all procedures have been approved by the institutional review board of the French Institute for Health and Medical Research (0000388FWA00005831) and the Commission Nationale de l’Informatique et des Libertés (908450 and 909216). Electronic informed consent was obtained from all participants. The NutriNet-Santé study is registered under EudraCT registration number 2013-000929-31.

Perception of FOP labels

A specific questionnaire was developed using survey items from previously published research to investigate participants’ perceptions of the four FOP labelling formats that are currently being debated in France.^{25–42} The questionnaire also included other dimensions of FOP nutrition labelling evaluation (objective understanding

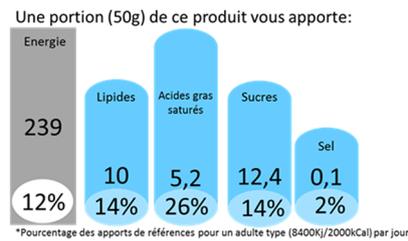
Nutriscore



SENS



Modified Reference Intakes



Multiple Traffic Lights

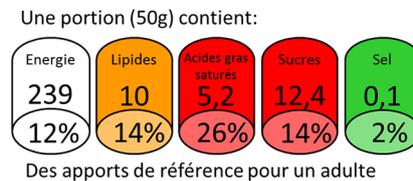


Figure 1 Formats proposed for a front-of-pack nutrition label in France. Nutriscore developed by the EREN research team is based on the British Food Standards Agency nutrient profiling system and presents for each food or beverage the overall nutritional quality on a five-point colour-coded scale from green to red. SENS, supported by retailers, is based on a nutrient profiling system developed by a research team and presents for each food or beverage a recommended frequency of consumption, with a four-point colour-coded scale (green, blue, orange and purple). Multiple Traffic Lights, supported by industry and implemented in Great Britain since 2005, presents the numerical values of the contribution of a portion of the food to the intakes in a balanced diet (in grams and percentage of reference intakes, corresponding to the Reference Intakes label) for energy, fats, saturated fats, sugar and sodium, with a colour coding (green, amber and red) for each of these components of the food. Modified Reference Intakes present the numerical values of the Reference Intakes, in both grams and percentage of reference intakes, with bars varying in height depending on the amount of the component in the food.

and legitimacy), which were not used in this study. A brief presentation of the four FOP labels was provided for the participants at the beginning of the questionnaire on the perceptions of FOP labels. The presentation made no mention of the origin or support by researchers or industry of each format, in order not to influence the participants based on this information.

Briefly, the Nutriscore, developed by the Nutritional Epidemiology Research Team (Equipe de Recherche en Epidémiologie Nutritionnelle, authors of this paper, EREN), an independent scientific research team, and based on the British Food Standards Agency nutrient profiling system and adapted for the French context by the High Council for Public Health³⁶ presents for each food or beverage the overall nutritional quality on a five-point colour-coded scale from green to red (figure 1).

SENS, supported by retailers, is based on a nutrient profiling system developed by a research team and presents for each food or beverage a recommended frequency of consumption, with a 4-point colour-coded scale (green, blue, orange and purple) (figure 1). MTL, implemented in Great Britain since 2005, presents the numerical values of the contribution of a portion of the food to the intakes in a balanced diet (in grams and percentage of reference intakes, corresponding to the RI label) for energy, fats, saturated fats, sugar and sodium, with a colour coding (green, amber and red) for each of these components of the food (figure 1). The mRIs present the numerical values of the reference intakes, in both grams and percentage of reference intakes, with bars varying in height depending on the amount of the component in the food (figure 1).

Overall, 13 questions were asked on various aspects of liking (eg, “This is my preferred FOP label”), trustworthiness (eg, “This FOP label provides reliable information”), awareness (eg, “This FOP label is easy to identify”) and perceived cognitive workload (eg, “This label is too complex for understanding”) (see online supplemental table 1). For each question, subjects were asked to select among the four formats the label that best corresponded to them. The participants could also select that ‘none’ of the proposed labels corresponded to his/her perception.

Sociodemographic and lifestyle data

Sociodemographic and lifestyle data were collected through self-administered questionnaires and included age, sex, education (no diploma and up to secondary education, university ≤ 2 years, university > 2 years), marital status (in couple, single/divorced/widowed), income per household unit⁴³ ($< \text{€}1200$, $\text{€}1200\text{--}\text{€}1800$, $\text{€}1800\text{--}\text{€}2700$, $\geq \text{€}2700$ per month) and smoking status (current smoker, former smoker and never smoker). Physical activity was computed using self-declared data from the validated International Physical Activity Questionnaire (low, moderate and high physical activity levels).⁴⁴ The data collected in the questionnaire closest in time to the questionnaire on the perceptions of FOP labels were taken into account for the analyses.

Dietary data

Dietary data were derived from three repeated 24 hours records randomly distributed in a 2-week period, with 2 weekdays and 1 weekend day. Food consumption was weighted according to the day of the week of each record. The participants are asked to estimate the portion size for each reported food and beverage item using validated photographs.⁴⁵ Nutrient intake was computed using a published food composition database reflecting foods usually consumed in the French diet.⁴⁶ Under-reporters for energy intake were identified using Goldberg/Black’s method and were excluded.⁴⁷ The dietary data from the 24 hours dietary record in the NutriNet-Santé study have been validated against interviewer-led dietary recalls conducted by trained dietitians and against biomarkers of nutritional status.^{40 48 49}

Statistical analysis

For the present study, all participants who had completed the questionnaire on the perception of FOP labels and having completed information on all covariates were eligible to the present study. Subjects were excluded if they stated that they never engaged in grocery shopping. The records and questionnaires closest to the questionnaire on the perceptions of FOP labels were taken into account for the analyses.

Weighting of the data

All data were weighted using the SAS CALMAR (CALage sur MARges) macro developed in France by the Institute of National Statistics to weight survey data to be representative of the French census population.⁵⁰ Data used for

weighting were sex, age, educational level, occupation and area of residence.

Adherence to dietary recommendations

Adherence to French dietary recommendations was assessed using a modified version of the PNNS guidelines score (namely, the ‘Programme National Nutrition Santé’-guideline score, PNNS-GS), taking into account only dietary recommendations. The PNNS-GS development, including food groupings, serving sizes, scoring, cut-off and penalties, has been previously described in detail.⁵¹ Briefly, this 15-point score is based on French national guidelines and includes 13 components. The eight components referring to food serving recommendations and four components referring to moderation in consumption were included in the modified version of the PNNS-GS (mPNNS-GS).⁵² The last component focusing on adherence to physical activity recommendations was not taken into account.

A penalty for overconsumption was assigned to individuals with energy intakes higher than estimated energy expenditure.⁵¹ Age and self-reported weight and height at inclusion were used to estimate Schofield’s basal metabolic rate (BMR).⁵³ Energy expenditures were estimated using BMR and physical activity level. In case of energy intake greater than 5% over the estimated energy expenditure, an identical part was subtracted from the score. Quartiles of mPNNS-GS were computed and used throughout the analyses.

Dietary cluster identification

The responses from the 13 ‘perception’ questions were used in a multiple correspondence analysis, which yielded four dimensions of FOP labelling perception. The dimensions were selected based on their adjusted inertia (33.6%, 23.0%, 18.4% and 17.2%, respectively, for a total of 92.3%). The selected dimensions were used as input variables in a two-way clustering procedure based on hierarchical and K-means methods (SAS CLUSTER and FASCLUST procedures). The plot of semipartial R^2 , the semipartial T^2 and the cubic clustering criterion by the number of clusters were used to identify the optimal number of clusters.

Statistical analysis

All analyses were weighted according to the CALMAR macro, except the clustering procedure for which no weighting option is available. The responses to each of the 13 questions were mapped across clusters, in order to identify the FOP perception characteristics of each cluster. Sociodemographic, lifestyle and dietary variables were mutually adjusted against clusters in a multivariable multinomial regression. Adjusted percentages for each sociodemographic, lifestyle and dietary characteristic were extracted from this procedure across clusters.

All tests were two sided and a p value < 0.01 was considered significant, given the high number of statistical tests performed and the large sample size. Statistical analyses

were performed using SAS software (V.9.3, SAS Institute, Cary, NC, USA).

RESULTS

Overall, 38604 subjects completed the questionnaire on the perceptions of FOP labels. Among these, 714 (1.85%) were excluded because they never engaged in grocery shopping. Among the 37890 remaining subjects, 16188 (42.72%) were excluded for incomplete data on covariates (the vast majority of which (n=13066, 80.71% of excluded subjects) for incomplete data on mPNNS-GS computation, which requires the presence of three 24 hours records, frequency questionnaire on alcohol consumption and frequency of seafood consumption), leading to an overall sample of 21702 participants for analysis (eg, 56.22%).

Characteristics of the crude and weighted sample are presented in table 1. The crude sample exhibited a higher percentage of females (73.42%), older subjects (68.36% were ≥50 years old), educated (37.54% had above 2 years of university training) and with high incomes (38.49% had incomes >€2700/month).

Overall, the Nutriscore was the label receiving the most important number of favourable responses on positive perception dimensions by participants, followed by MTL and SENS (43.79% of participants considered the Nutriscore as their preferred FOP label, followed by 24.92% for MTL and 17.17% for SENS) (table 2). Conversely, RIs yielded the highest number of responses on negative dimensions of perception (complexity and time processing). A majority of participants considered that none of the proposed labels were guilt laden (50.23%), followed by SENS (21.19%).

The clustering procedure resulted in the identification of five mutually exclusive groups of subjects according to their perception of FOP nutrition labels. Clusters represented 43.23% (crude n=9399), 27.31% (crude n=6163), 17.05% (crude n=3546), 7.31% (crude n=1632) and 5.10% (crude n=965) of participants, respectively. The mapping of perception responses across clusters showed that each cluster was characterised by a marked preference for one of the proposed FOP nutrition label formats: cluster 1 displayed a marked preference for the Nutriscore, cluster 2 for the MTL, cluster 3 for the SENS, cluster 4 for the RIs and cluster 5 for none of the presented labels (figure 2; see online supplemental table 2 for detail). Therefore, clusters were termed according to their label preference. These preferences across cluster were particularly prominent for the following aspects: label wanted on the front of the packages (>85% for each specific FOP label in their respective cluster), preferred label (>80% for each specific label in their respective cluster), label allowing to choose healthier products (>65% for each specific label in their respective cluster), trustworthiness (>74% for each specific label in their respective cluster) (figure 2; see online supplemental table 2 for detail). However, for some dimensions of perception, responses were

Table 1 Characteristics of the study population, crude and after weighting

| | Crude | | Weighted |
|------------------------------------|-------|-------|----------|
| | n | % | % |
| Sex | | | |
| Men | 5768 | 26.58 | 39.97 |
| Women | 15934 | 73.42 | 60.03 |
| Age | | | |
| 18–29 years | 968 | 4.46 | 12.28 |
| 30–49 years | 5900 | 27.19 | 31.05 |
| 50–64 years | 7899 | 36.40 | 29.39 |
| ≥65 years | 6935 | 31.96 | 27.28 |
| Educational level | | | |
| Up to secondary | 6804 | 31.35 | 70.54 |
| University, up to 2 years | 6750 | 31.10 | 13.86 |
| University, ≥3 years | 8148 | 37.54 | 15.60 |
| Income per consumption unit | | | |
| <€1200/month | 2068 | 9.53 | 20.28 |
| €1200–€1800/month | 4766 | 21.96 | 30.24 |
| €1800–€2700/month | 6514 | 30.02 | 28.67 |
| ≥€2700/month | 8354 | 38.49 | 20.81 |
| Household composition | | | |
| Adults only | 17118 | 78.88 | 78.05 |
| Adults and children | 4584 | 21.12 | 21.95 |
| Smoking status | | | |
| Current smoker | 1923 | 8.86 | 10.16 |
| Former smoker | 8710 | 40.13 | 39.81 |
| Never smoker | 11069 | 51.00 | 50.03 |
| Physical activity level | | | |
| High | 8007 | 36.90 | 39.01 |
| Moderate | 9128 | 42.06 | 37.28 |
| Low | 4567 | 21.04 | 23.72 |
| mPNNS-GS | | | |
| Quartile 1 | 5425 | 25.00 | 23.70 |
| Quartile 2 | 5582 | 25.72 | 23.86 |
| Quartile 3 | 5933 | 27.34 | 26.20 |
| Quartile 4 | 4762 | 21.94 | 26.24 |

Weighting was obtained using the SAS CALMAR macro. mPNNS-GS, modified version of Programme National Nutrition Santé-guideline score.

somewhat less marked for each specific FOP label and more concurrent across clusters. For example, >23% of participants in all clusters considered that the Nutriscore was quick to process, >19% considered it easy to identify and >17% considered it easy to understand (figure 2; see online supplemental table 2 for detail). Conversely, >20% of participants in all clusters considered the mRIs to be too complex for understanding (except in its own where it obtained 10.90% of opinions), >19% considered it too

Table 2 Crude percentage of responses to the dimensions of perception of FOP labels

| | Nutriscore | MTL | SENS | mRIs | None |
|--|------------|-------|-------|-------|-------|
| This FOP label is helpful to choose healthier products | 40.02 | 26.93 | 17.33 | 9.14 | 6.57 |
| I want to see this FOP label on the front of packages | 44.22 | 25.15 | 17.15 | 7.43 | 6.05 |
| This is my preferred FOP label | 43.79 | 24.92 | 17.17 | 6.68 | 7.45 |
| This FOP label provides me with the information I need | 24.51 | 43.06 | 15.78 | 11.44 | 5.21 |
| This FOP label is trustworthy | 37.64 | 28.83 | 15.23 | 8.52 | 9.79 |
| This FOP label provides reliable information | 26.76 | 40.32 | 10.55 | 11.75 | 10.62 |
| This FOP label is easy to identify | 62.53 | 8.78 | 21.37 | 2.75 | 4.56 |
| This label is easy to understand | 52.22 | 7.86 | 33.5 | 3.43 | 2.99 |
| This FOP label is quick to process | 64.09 | 8.07 | 22.27 | 2.9 | 2.68 |
| This FOP label is too complex for understanding | 4.49 | 19.9 | 5.7 | 48.22 | 21.7 |
| This FOP label takes too long to understand | 2.52 | 25.45 | 2.86 | 50.81 | 18.36 |
| This is the FOP label I appreciate the least | 9.67 | 12.58 | 17.44 | 51.33 | 8.98 |
| This FOP label is guilt laden | 12.42 | 9.32 | 21.19 | 6.83 | 50.23 |

FOP, front of pack; mRIs, modified Reference Intakes; MTL, Multiple Traffic Lights.

long to understand (except in its own cluster, with 12.73% of opinions) and it was considered as the least appreciated FOP nutrition label for 66.88% of subjects in the cluster Nutriscore, 61.86% of subjects in the cluster SENS, 39.88% of subjects in the cluster MTL and 10.78% of subjects in the cluster none (figure 2; see online supplemental table 2 for detail). Finally, participants considered that none of the presented labels was guilt laden: 87.12% of cluster none, 49.93% of cluster Nutriscore, 47.89% of cluster MTL, 47.80% of cluster mRIs and 44.78% of cluster SENS (figure 2; see online supplemental table 2 for detail).

Multivariable-adjusted sociodemographic characteristics according to specific clusters are shown in table 3. Less educated subjects were more frequent in cluster none and cluster mRIs and highly educated subjects in cluster MTL (table 2). Smokers were more likely in cluster none, while never smokers were more likely in cluster Nutriscore. Subjects with low physical activity were more likely in cluster SENS and cluster Nutriscore (table 2). Finally, subjects with lower adherence to dietary recommendations (quartile 1 of mPNNS-GS) were more likely in cluster none and cluster Nutriscore, while subjects with high adherence to dietary recommendations (quartile 4 of mPNNS-GS) were more likely in cluster mRIs and cluster MTL (table 2).

DISCUSSION

Our study showed that the perception of FOP labels can be clustered according to consistent preferences for specific formats. Among the proposed labels in the current French debate, the Nutriscore appeared to be the most preferred format, followed by MTL. Moreover, although each cluster presented marked preferences for one type of format or another, the Nutriscore appeared to reach to participants beyond its specific cluster, as it was

considered easy to identify and understand by a significant number of participants in other clusters. Finally, socio-demographic characteristics appeared to be associated with each cluster, with a specific cluster (cluster 5, none), concentrating high percentages of subjects presenting disadvantaged sociodemographic characteristics (lower levels of education) and lifestyle risks (smoking, low level of physical activity and low adherence to dietary recommendations).

Compared with a previous study conducted in early 2015 using a similar methodology and among participants in the same cohort study, the results of the present analyses show that the reach of the Nutriscore has somewhat broadened since then.²⁵ The Nutriscore appeared to have a wide reach in the population and to appeal to subjects with lower adherence to dietary recommendations. This result shows that the Nutriscore may be an effective complementary strategy to current public health nutrition policies, which promote healthy eating through widely disseminated nutritional recommendations.⁵⁴ Although this strategy has led to an increase in the knowledge of nutritional recommendations, consumers somehow struggle to translate such advice into action.^{55 56} Disseminated nutrition information is suggested to appeal more to those already having the capacity to implement nutritional knowledge (through higher education or income) and may lead to an increase in social disparities in health.^{57 58} Therefore, the fact that the Nutriscore appears to appeal to subjects with low adherence to nutrition recommendations may be a key element to help translating nutritional recommendations into practice, in particular for those with low nutritional knowledge.

The MTL appeared as the second preferred FOP label in the population, particularly in younger subjects, with university education and lower incomes. Moreover, it was



Figure 2 Responses to each of the dimensions of perception in the various clusters. Each circle represents a cluster; each response to a dimension is scaled within the cluster. Positive dimensions are situated on the right hand side of the figure, while negative dimensions are situated on the left hand side of the figure. FOPL, front-of-pack label; mRIs, modified Reference Intakes; MTL, Multiple Traffic Lights.

considered to be providing reliable and useful information beyond its own cluster. The fact that direct numeric information on nutrient content (such as the information provided by mRIs) received a much lower support in the population shows that the appeal of the MTL is very probably associated with the colour feature of this FOPL label,⁵⁹ as multiple numerical information is typically considered difficult to understand.⁶⁰ Indeed, compared with mRIs, the MTL only adds an interpretation of the level of nutrients using a colour coding. However, the interpretation of the colour coding has appeared to be challenging in certain populations.⁵⁹ Indeed, MTL is a nutrient-specific FOP label, giving individual information for energy and four nutrients (sugars, fat, saturated fat and salt). Multiple nutrient-related information implies first that consumers are able to identify the nutrients that are referred to and, second, that they are able to prioritise the information provided for each nutrient.^{42 61} Indeed, MTL can lead to conflicting choice options: for example, the comparison between two products, with the same

number of nutrients coded in 'red' but not for the same nutrients (eg, one with a 'red' code for sugar and the other for saturated fatty acids), implies for the consumer to be able to single out one of the nutrients in order to make a choice.²¹ These characteristics of the label may in part explain the fact that the MTL appeared to appeal more particularly to young, educated subjects with a high level of adherence to nutritional recommendations. This more favourable perception among these participants may stem from their higher nutritional knowledge, which allows them to better interpret the label and act on it in purchasing situations.^{21 60} However, this specific reach in terms of population might also lead to widen inequalities in health and nutrition if implemented in the overall population.⁶²

The SENS system was the preferred system for 17% of the population, more particularly in households with children. The graphical system the SENS originated from was developed by a marketing team from a retailer in September 2014 and received later support from the

Table 3 Multivariable-adjusted sociodemographic, lifestyle and dietary characteristics according to the various clusters of preference for front-of-pack nutrition labelling

| | Nutriscore | MTL | SENS | mRIs | None | p |
|-----------------------------|------------|-------|-------|-------|-------|---------|
| | 43.23 | 27.31 | 17.05 | 7.31 | 5.10 | |
| Sex | | | | | | <0.0001 |
| Men | 41.88 | 37.23 | 37.48 | 35.67 | 40.14 | |
| Women | 58.12 | 62.77 | 62.52 | 64.33 | 59.86 | |
| Age | | | | | | <0.0001 |
| 18–29 years | 11.11 | 13.90 | 11.06 | 11.82 | 3.93 | |
| 30–49 years | 64.66 | 68.43 | 67.53 | 66.86 | 64.92 | |
| 50–64 years | 21.40 | 15.86 | 19.04 | 18.05 | 25.76 | |
| ≥65 years | 2.84 | 1.81 | 2.37 | 3.27 | 5.40 | |
| Educational level | | | | | | <0.0001 |
| Up to secondary | 72.64 | 67.59 | 72.05 | 77.71 | 77.84 | |
| University, up to 2 years | 15.26 | 16.81 | 15.72 | 12.79 | 12.21 | |
| University, ≥3 years | 12.09 | 15.61 | 12.23 | 9.50 | 9.95 | |
| Income per consumption unit | | | | | | <0.0001 |
| <€1200/month | 14.57 | 20.07 | 16.36 | 17.17 | 13.95 | |
| €1200–€1800/month | 32.61 | 31.47 | 35.57 | 35.71 | 36.83 | |
| €1800–€2700/month | 30.96 | 29.29 | 29.41 | 29.17 | 30.45 | |
| ≥€2700/month | 21.85 | 19.16 | 18.66 | 17.96 | 18.77 | |
| Household composition | | | | | | <0.0001 |
| Adults only | 87.76 | 88.57 | 86.99 | 88.60 | 90.35 | |
| Adults and children | 12.24 | 11.43 | 13.01 | 11.40 | 9.65 | |
| Smoking status | | | | | | <0.0001 |
| Current smoker | 10.91 | 11.33 | 9.94 | 9.35 | 15.59 | |
| Former smoker | 31.74 | 34.95 | 34.21 | 35.63 | 32.69 | |
| Never smoker | 57.35 | 53.72 | 55.85 | 55.02 | 51.73 | |
| Physical activity level | | | | | | <0.0001 |
| High | 31.73 | 34.19 | 31.12 | 35.93 | 29.38 | |
| Moderate | 40.97 | 44.91 | 41.20 | 41.62 | 43.90 | |
| Low | 27.30 | 20.90 | 27.68 | 22.44 | 26.71 | |
| mPNNS-GS | | | | | | <0.0001 |
| Quartile 1 | 28.28 | 25.09 | 23.90 | 21.63 | 32.47 | |
| Quartile 2 | 25.90 | 22.09 | 26.67 | 20.08 | 30.08 | |
| Quartile 3 | 26.86 | 28.44 | 26.96 | 30.87 | 21.86 | |
| Quartile 4 | 18.96 | 24.37 | 22.47 | 27.42 | 15.59 | |

Mutually adjusted percentages obtained with multinomial regression.

mPNNS-GS, modified version of Programme National Nutrition Santé-guideline score; mRIs, modified Reference Intakes; MTL, Multiple Traffic Lights.

French retailers' federation.³⁷ As for Nutriscore or MTL, it is based on colour coding (although not based on the polychromatic green–red scale), with the addition of recommended frequencies of consumption for each level of the label. This latter feature may in part explain the higher appeal of the SENS system on participants with children, as it gives a more specific guidance for consumption, which can be used for children. However, these specific consumption frequencies for each level of

the label could also be interpreted as an oversimplification and a form of paternalism for many consumers.⁶³ This may be one of the reasons the SENS label was considered as a guilt-laden label for 21.2% of the population.

Moreover, although Nutriscore and MTL rely on the well-known polychromatic scale from green to red (corresponding to recognised signals), which are easier to interpret, the SENS colour coding does not refer directly to any known colour scale (its levels

are green-blue-orange-purple). Colours are considered helpful to generally increase the salience of a FOP label; however, studies that have shown a specific advantage of colour coding have used readily interpretable colour coding.^{63–66} In the study by Bialkova and van Trijp,⁶⁴ which used polychromatic RIs, but with no readily interpretable colours (yellow, orange, purple, blue), the polychromatic RIs indeed had lower performance than monochromatic RIs.⁶⁴ Therefore, beyond preference only, the use of highly interpretable colours (eg, 'green' and 'red') in a FOP labelling system might be an important feature of a colour coding.

Finally, our study shows that a portion of the population appeared to disregard or even reject FOP nutrition labels entirely. Indeed, participants in cluster 5 (none, corresponding to 5.1% of the population) consistently responded 'none' for all dimensions of perception that were investigated. Moreover, the sociodemographic characteristics of this specific population suggested that they may in fact be more vulnerable and more at nutritional risk than the rest of the population. Indeed, this cluster included more specifically older participants, subjects with lower educational levels, current smokers and subjects with lower adherence to nutritional recommendations. This result is in line with a study in Australia showing that males and subjects with lower socioeconomic status were more likely to report no preference for a FOP label.⁶⁷ These results also pose a challenge to the design of efficient public health policies, as some of the subjects who would certainly benefit from them appear to reject them. Novel and targeted interventions in public health nutrition should therefore be devised to appeal to this vulnerable population to entice them toward healthier diets, taking into account the broader environment related to risk behaviours.⁶⁸ Alternatively, policies targeting the environment and not depending on individual choices, such as the reformulation of existing products, may have an indirect impact on these populations.⁶⁹

Strengths of our study include its large sample size for an online survey, based on an ongoing dynamic cohort study performed exclusively online. Moreover, the data used for the investigation of dietary intakes used validated data collection tools, using repeated dietary records.⁴⁰ We were also able to investigate multiple dimensions of the perception of FOP labels (awareness, liking, perceived cognitive workload and trustworthiness), across various formats that are currently proposed in the French debate on FOP nutrition labelling. Finally, we were able to identify clustered preferences toward each type of format and relate them to sociodemographic and dietary factors, which highly contributed to the interpretation of such preferences in a public health perspective.

Our study is subject to some limitations. First, our sample consists of volunteer subjects included in a cohort study on nutrition, who are therefore more likely health conscious. The completion of the questionnaire was optional, and the participation rate was therefore

not optimal, which could have also added to a selection bias in our study population. However, our data show a wide variety of dietary profiles, somewhat lessening the importance of this bias. Moreover, the use of weighting partially controlled for the selection bias of our study population.⁷⁰ Second, our study focused on the perception of FOP labels and not on understanding or use of FOP labels in purchasing situations. However, following the theoretical framework for the use of FOP nutrition labels, favourable perception is a crucial pre-requisite for the efficiency of a given label.^{71–72} Third, the participants in the NutriNet-Santé study had already been involved in a previous survey on the perception of various FOP nutrition labels.²⁵ However, the formats presented in the two versions of the questionnaire were somewhat different, and there was delay between the two questionnaires of more than a year, therefore limiting the familiarity of the participants with the FOP nutrition labels formats displayed in this study. However, the participants were aware of FOP nutrition labelling, which could have affected their responses. Finally, the questionnaire for the online survey and the measures that were used in this study were not formally validated but based on scientific literature. They derived from previously published work which took into account the literature on the perception of FOP nutrition labelling.^{42 61 73}

To conclude, FOP nutrition labels could be useful strategies to tackle social inequalities in nutrition and health, provided that the graphical format that is selected has a wide reach in the population. This is all the more important that subjects who are more concerned about their diet (and more likely to have a healthier diet) are also more likely to use a nutrition label when grocery shopping.²⁰ As such, the Nutriscore, which has a favourable perception among subjects with low adherence to nutritional recommendations, may be a helpful strategy to lead them toward healthier diets.

Correction notice This paper has been amended since it was published Online First. Owing to a scripting error, some of the publisher names in the references were replaced with 'BMJ Publishing Group'. This only affected the full text version, not the PDF. We have since corrected these errors and the correct publishers have been inserted into the references.

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

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