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Front-of-pack nutrition labelling schemes: a comprehensive review

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Abbreviations

5-CNL 5-Colour Nutrition Label (now Nutri-Score)
BMI Body Mass Index
BOP Back-Of-Pack
CFC Consideration of Future Consequences
CVD Cardiovascular disease
DI Daily Intake
en% Percent of daily energy intake
EFSA European Food Safety Authority
FIC Food Information to Consumers
FOP Front-Of-Pack
FSA Food Standards Agency
GDA Guideline Daily Amount(s) (now Reference Intakes)
HR Hazard ratio
HSR Health Star Rating
MTL Multiple Traffic Light(s)
NIP Nutrition Information Panel
OR Odds ratio
PICO Population, Intervention, Comparator, Outcome
PRISMA Preferred Reporting Items for Systematic reviews and Meta-Analysis
RCT Randomised, Controlled Trial
SENS Système d'Etiquetage Nutritionnel Simplifié
TL Traffic Light(s)
WHO World Health Organization

Abstract

This JRC Science for Policy report was produced in support of a Commission report on front-of-pack (FOP) nutrition labelling. It provides a review of the scientific literature concerning FOP nutrition labelling and its effects on consumers, food business operators, and the single market. A major emphasis is placed on consumer attention, preferences, and understanding of different FOP schemes, as well as effects on food purchasing and implications for diet and health. The report also considers in how far producer efforts on food reformulation and innovation may be affected by the introduction of FOP nutrition labelling schemes, describes potential unintended consequences of introducing FOP nutrition labelling, and highlights knowledge gaps and directions for future research. An extensive, yet non-exhaustive overview of FOP schemes around the globe complements the literature review.

Executive summary

Background

As of December 2016, Regulation (EU) No 1169/2011 on the provision of food information to consumers requires the vast majority of pre-packed foods to bear a nutrition declaration, often provided on the back of food packaging, to allow consumers to make informed and health-conscious choices. The mandatory nutrition declaration must include as a minimum the energy value and the amounts of fat, saturates, carbohydrate, sugars, protein and salt.

This declaration can be complemented by a voluntary repetition of its main elements in the principal field of vision (known as the 'front of pack', FOP), in order to help consumers to see at a glance the essential nutrition information when purchasing foods. For this repetition, other forms of expression and/or presentation (*e.g.* graphical forms or symbols) can be used by food business operators or recommended by Member States, in addition to those contained in the nutrition declaration (*e.g.* words or numbers), provided that they comply with the criteria set out in the Regulation.

The Regulation requires the Commission to submit a report to the European Parliament and the Council on the use of FOP nutrition labelling schemes, on their effects on the internal market and on the advisability of further harmonisation of those forms.

This study by the European Commission's Joint Research Centre (JRC) provides a literature review as a scientific evidence basis to the Commission report. Specifically, the JRC was asked by the Directorate-General Health and Food Safety (DG SANTE) to use its expertise in nutrition and consumer behaviour science to provide a detailed analysis of current FOP schemes, their use, understanding and effect on consumers' behaviour, dietary choices and health. The review includes schemes from within and outside the EU.

Aim

The aim of this report is to:

- Map relevant FOP schemes in use or proposed in Europe and beyond.
- Review the scientific literature for evidence concerning the effects of FOP schemes on:
  - consumers' awareness, acceptance, understanding, and use;
  - food purchases;
  - diet and health;
  - food reformulation and innovation;
  - other potential intended or unintended effects or impacts of introducing FOP schemes.
- Identify knowledge gaps.

Methods

Two independent systematic literature reviews were carried out across several electronic databases (PubMed, Web of Science, Google Scholar, Open Grey, and JSTOR). For both reviews, two reviewers screened the abstracts to decide on studies to include or exclude (with consensus discussion where opinion differed), based on criteria matching the study focus agreed with DG SANTE. Altogether, more than 250 unique publications were identified and reviewed. The articles were categorised by topic, from consumer perceptions and understanding of FOP schemes to the impact of FOP nutrition labelling on consumer behaviour, food product improvement, and the internal market.

Findings

A variety of FOP schemes – all voluntary as per EU law – have been developed by public institutions, public health Non-Governmental Organisations (NGOs) and the private sector, sometimes collaboratively. These vary from purely numerical schemes that repeat some of the information contained in the nutrition declaration (so-called reductive schemes), to colour-coded versions thereof, to summary scoring schemes that are graded indicators or dichotomous endorsement logos.

Some ten public and private FOP labelling schemes exist and are already implemented in several Member States and the United Kingdom (UK).[1] There are currently six FOP schemes developed or endorsed by the public sector: the Keyhole logo (used in Sweden, Denmark, Lithuania and also in Iceland, Norway, and North Macedonia), the Nutri-Score (used in France and Belgium and adoption announced by Spain, Germany, the Netherlands and Luxembourg), the Finnish Heart Symbol, the Slovenian 'Little Heart' sign, the Croatian 'Healthy Living' logo, and the Multiple Traffic Light combined with Reference Intakes (UK). Italy has developed a scheme based on Reference Intakes, called 'NutrInform Battery', which has not been implemented yet. Some other EU countries are exploring the possibility to recommend a FOP label.

Major private-sector FOP schemes in use are the Reference Intakes label (found throughout the EU) and the Choices logo (Czech Republic, Poland). Additionally, retailers in Estonia, Portugal and Spain have implemented FOP schemes on their own-brand products based on Multiple-Traffic-Lights colour coding, and another retailer uses a consumption frequency label on its own brand in Poland. A proposal by a group of multinational food manufacturers on a combination of Multiple Traffic Lights and Reference Intakes (Evolved Nutrition Label, ENL) that used portions as a reference base for products consumed in small quantities was put on hold in November 2018.

Outside of Europe, various nutrition schemes used on the front of pack exist that resemble Reference Intakes, traffic-light coding, or endorsement logos. Additional formats include star-based rating schemes and warning signs.

The impact of FOP schemes is usually measured in terms of consumers' attention, acceptance, and understanding. Furthermore, experimental studies, sales data, and shopping basket checks are used to assess any impact on intention to purchase or actual purchases in more or less controlled or real-life settings. Modelling studies indicate potential effects on diet and health.

1. The United Kingdom withdrew from the European Union and became a third country as of 1 February 2020.

Self-reported consumer attention to familiar labels is usually high (60% or higher), whereas the few objective assessments available indicate lower rates (<30%) of consumers really looking at FOP labels when shopping.

Using sufficient contrast and size to stand out on food packages can help attract consumer attention to FOP labelling. Attention is also higher when the type of label and its location on the package do not change.

Consumers tend to appreciate the provision of FOP nutrition labelling as indicated by their self-reported interest in and willingness to pay more for products showing such FOP schemes (positive ones, in particular). The observed variability in preference for a particular FOP scheme appears to be affected by familiarity and potentially identification with that scheme. Overall, evaluative FOP schemes with colour coding tend to do well in assessments of consumer liking.

As regards measured understanding, studies show that most FOP labels have a positive effect on the ability of consumers to identify the healthier option compared to a no-label situation, but that short, simple labels achieve the best objective understanding. The majority of laboratory and field studies suggest that evaluative schemes that use colour coding with or without a graded indicator help consumers of various ages, socio-economic status, and cultural background the most in identifying nutritious products.

As regards impact on purchasing behaviour, experimental studies looking at the intention to purchase show that FOP nutrition labelling, especially colour-coded labels with or without a graded indicator, can facilitate health-conscious food choices and improve the nutritional quality of shopping baskets.

The limited real-life evidence on shopping behaviour suggests a small beneficial effect of FOP nutrition labelling on 'on-the-spot' purchasing. Real-time purchasing decisions are influenced by a multitude of factors (beyond FOP labels), which makes it hard to isolate the effects specific to FOP nutrition labelling. Some real-life studies confirm that evaluative FOP schemes can guide consumers towards more health-conscious food choices, and schemes with colour coding with or without a grading indicator appear most promising.

Several studies note that education and awareness campaigns should accompany FOP nutrition labelling to optimise attention and understanding and to have an impact on purchases. FOP labels that make the health goal more salient in consumers' minds when shopping might help improve food choices.

There are data, mostly self-reported by industry, to indicate a potential beneficial impact of evaluative FOP schemes on product reformulation and innovation towards a more nutritious food supply. More data that are objective would be needed to understand the true effect size.

There is no empirical evidence to link any particular FOP scheme directly with concrete changes in food intake, overall diet, and health; this is largely owing to the difficulty to set up such studies and prove causality. Modelling studies are used in an attempt to fill the knowledge gap regarding the effects of FOP nutrition labelling on diet and health; these suggest that consistently and extensively shifting towards products with more favourable nutrient profiles (as indicated by better FOP label scores or the presence of endorsement logos) would reduce intakes of energy and nutrients of public health concern whilst potentially increasing intakes of dietary fibre and whole grain products. At the same time, other studies suggest that diet quality (as evaluated by the dietary index underlying the Nutri-Score scheme) is associated with lower risk of overweight, cardiovascular disease, and cancer.

The presence of different competing FOP schemes may impair consumer understanding. Among the main risks, consumers may confuse the meanings of different FOP schemes, feel overloaded by the information, or struggle to compare products across schemes.

Knowledge gaps

The major knowledge gaps around FOP nutrition labelling are a) the magnitude of the effect of FOP schemes on purchasing behaviour; and b) to what extent FOP schemes improve overall diets and health. More analyses of empirical nature (*e.g.* based on real-life retail data) would be helpful to corroborate the current findings. As demonstrated by the Nutri-Score system in France, the rollout of new FOP

schemes provides a window of opportunity for evaluating any effects on food sales, product reformulation and innovation, and people's diet and health.

The lack of strong evidence for a beneficial effect of FOP nutrition labelling schemes on diet and health should not be mistaken as evidence for a lack of effectiveness of FOP schemes. Certainly, more research and better data are needed to fill the remaining knowledge gaps. In addition, researchers need to develop better tools, including systems approaches, to evaluate the impact of interventions such as FOP nutrition labelling towards promoting healthier food preferences and, more generally, in supporting and enabling individuals to manage and improve their own health

No studies were found on the potential impact of FOP nutrition labelling on intra-EU trade of food products.

1. Background and aim of the report

Regulation (EU) No 1169/2011 [EU, 2011] on the provision of food information to consumers (hereafter FIC Regulation) governs the general mandatory and voluntary aspects of food labelling in the EU. Article 35(5) of the FIC Regulation required the Commission to submit by 13 December 2017 a report to the European Parliament and the Council on additional forms of expression and presentation of the nutrition declaration (front-of-pack, FOP, nutrition labelling), including the use of FOP nutrition labelling schemes, their effect on the EU internal market and on the advisability of further harmonisation in the area. This requirement for a report was the result of a lack of agreement on a single EU FOP nutrition labelling scheme during the negotiations of the FIC Regulation; its aim was to gather experiences on the functioning of the various schemes in the EU Member States in order to take a more informed decision on possible further harmonisation at a later stage.

At the time of finalisation of this literature review (July 2019), the only implemented European FOP schemes that fall under Article 35 of the FIC Regulation are the public-sector UK Multiple-Traffic-Light hybrid scheme (hereafter UK MTL scheme) and the private-sector Reference Intakes scheme (formerly Guideline Daily Amounts, GDA).

Other public- and private-sector schemes exist in Europe that, strictly speaking, do not fall under Article 35 as they do not repeat the information provided in the nutrition declaration (a qualifying criterion for falling under Article 35). The most well-known among these schemes, which should legally be considered as voluntary information under Article 36 of the FIC Regulation and/or nutrition claims (under the Claims Regulation (EC) No 1924/2006 [EU, 2006]), are:

- Keyhole, developed by the Swedish National Food Agency and later adopted by the Nordic Council.
- Choices logo, developed by Unilever and now managed by the Choices International Foundation.

- 'Nutri-Score' scheme, developed by French researchers and endorsed by the French government first and later by other EU governments (BE, ES, DE, NL, LU).

The European Commission decided to expand the scope (beyond schemes falling under Art. 35 of the FIC Regulation) and the evidence basis for its report to the European Parliament and the Council since any differentiation on the basis of a scheme's legal status would not be pertinent from a consumer perspective. The comprehensive literature review here presented has the following objectives:

1. gather information on FOP labelling schemes, including all schemes mentioned above that are available or are in the preparatory phase in the EU, even if they do not fall under the legal scope of Article 35, and also including schemes in other parts of the world;
2. provide a comparison of different FOP labelling schemes and their elements or characteristics (for example the characteristic of providing evaluative information versus reductive information, or classifying foods on information per portion versus per 100 g);
3. include and explore the evidence on both 1) and 2) with regard to:
   a. consumers' awareness, acceptance, understanding, and use;
   b. food purchases;
   c. diet and health;
   d. food reformulation and innovation;
   e. other potential intended or unintended effects or impacts of introducing FOP schemes; and
4. identify knowledge gaps.

2. Introduction

Nutrition labelling aims to inform consumers about the nutritional contribution that specific foods and drinks make to the overall diet. It is defined as 'a description intended to inform the consumer of nutritional properties of a food' [Codex Alimentarius, 2017][2] and consists of two components: 1) the nutrient declaration; and 2) supplementary nutrition information. Nutrient declaration is further defined as 'a standardized statement or listing of the nutrient content of a food'.[2]

Consumers have been reported to perceive classical nutrition declaration tables, commonly found on the back of food packages, as inaccessible and hard to understand. Several attempts have therefore been made at making nutrition information simpler, more practical, and easily accessible. For example, the Keyhole symbol was introduced as a FOP signposting scheme in Sweden as early as 1989 to identify nutritionally favourable options within certain product categories. Many other schemes have been developed and implemented since then (see *Annex*). Worldwide, some 40 countries are using government-endorsed FOP schemes [ANVISA, 2018] and in Europe[3] this holds for 15 countries [Kelly & Jewell, 2018]. Recent reports on the matter by national authorities [ANVISA, 2018; Max Rubner Institut, 2019] and international organisations [Kelly & Jewell, 2018; World Cancer Research Fund International, 2019], as well as the ongoing work by the Codex Alimentarius Committee on Food Labelling[4] highlight the continued interest in and relevance of FOP nutrition labelling as a public health policy tool.

2. The Codex Alimentarius is a set of international food standards, guidelines, and codes of practice agreed by Codex members and covering areas such as food hygiene, methods of analysis and sampling, and food labelling. Whilst these standards are not legally binding, they find wide application and serve as important reference points for global trade. http://www.fao.org/fao-who-codexalimentarius/home/en/

3. WHO European Region.

4. Codex Committee on Food Labelling (CCFL) Meeting 45, 13-17 May 2019, Ottawa, Canada. http://www.fao.org/fao-who-codexalimentarius/meetings/detail/en/?meeting=CCFL&session=45

FOP schemes can vary in a number of ways. Some highlight subsets of the numerical energy and nutrient information, and the percentage this represents of the daily reference intake for a 2000 kcal diet. Others provide an evaluative element indicating low, medium, or high levels of a certain nutrient, and yet others compute summary indicators of the overall nutritional value of a given product. Some FOP schemes employ a common reference base such as 100 g or 100 ml, others operate on a 'per portion' or 'per serving' basis.

Figure 1 summarises FOP nutrition labelling developments from the introduction of the Swedish Keyhole in 1989 up to plans of some countries for the year 2019 [Kanter *et al.*, 2018].

There are currently over ten different FOP labelling schemes in the EU (implemented or proposed), several of these in use in multiple countries. *Chapter 3* describes the most relevant schemes in Europe in detail. A more comprehensive overview of FOP labels encountered around the globe can be found in the *Annex*.

2.1. Regulatory situation in the EU

The FIC Regulation [EU, 2011] governs the provision of food information to consumers in the EU. Among others, the FIC Regulation requires the declaration of the content of energy and selected nutrients (fat, saturates, carbohydrate, sugars, protein, and salt), expressed per 100 g or per 100 ml (and optionally per portion). This information is typically found in tabular or linear format on the back of food and drinks packaging.

The FIC Regulation allows, on a voluntary basis, to repeat the main elements of the mandatory nutrition declaration on the front of food packaging, in order to help consumers to see at a glance the essential nutrition information when purchasing foods. For this repetition, Article 35 of the FIC Regulation allows using other forms of expression (*e.g.* per 200 g) and/or presentation (*e.g.* graphical forms or symbols) on the front of the pack, in addition to those contained in the nutrition declaration (*e.g.* words or numbers), provided that these additional forms comply with the criteria of the FIC Regulation. Some of the FOP schemes referred to above are examples of such additional forms of expression, repeating the main

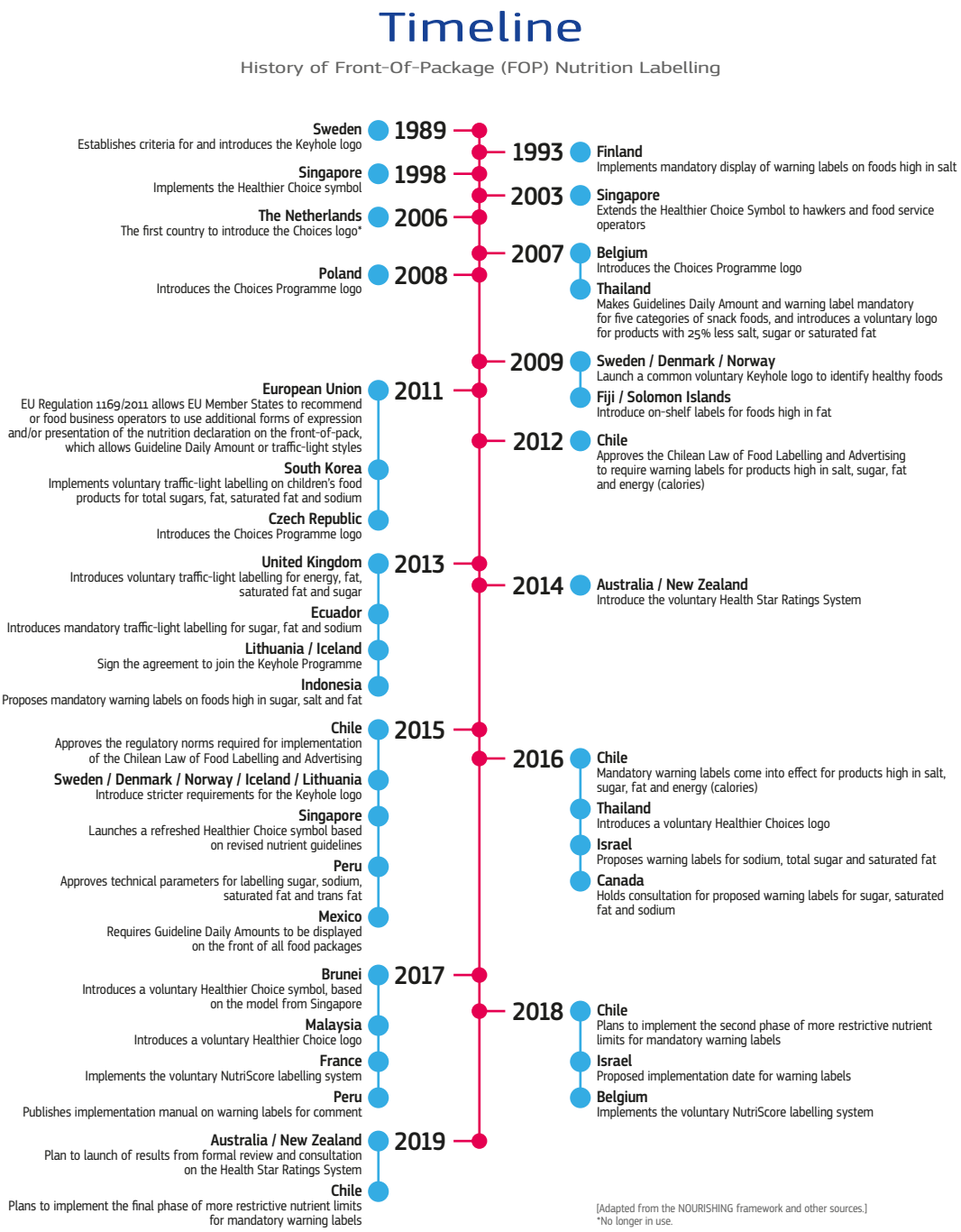


Figure 1. *Timeline of FOP nutrition labelling developments globally between 1989 and 2019.*
Reproduced in revised form with permission from Kanter *et al.* (2018).

nutritional characteristics of the mandatory nutrition declaration. Several other FOP systems developed by Member States or food business operators do not fall under Article 35 of the FIC Regulation since they do not repeat information provided in the nutrition declaration, but provide information on the overall nutritional quality of the food. Such schemes are considered as 'voluntary information' under Article 36 of the FIC Regulation and/or nutrition claims under Regulation (EC) No 1924/2006 on nutrition and health claims made on foods [EU, 2006].

2.2. Defining front-of-pack nutrition labelling

In relation to FOP nutrition labelling, the FIC Regulation [EU, 2011] speaks of the 'principal field of vision' as the package area 'commonly known as front of pack'. Some other relevant terms and their definitions as per the FIC Regulation are summarised in *Table 1*.

For the purpose of this report, FOP nutrition labelling is defined as nutrition information in the principal field of vision on food and drinks packaging that:

a) either repeats some or all of the numerical information from the mandatory nutrition declaration in a neutral way (so called reductive systems, *e.g.* Reference Intakes label or the NutrInform Battery label proposed by Italy) or in an evaluative way (*e.g.* by using traffic-light colours or wording 'high, medium, low');
b) or expresses the overall nutritional value of a food, by using some or all of the information from the nutrition declaration and/or other nutritional elements, to be applied on all products (*e.g.* graded score, such as Nutri-Score or the Australian Health Star Rating scheme) or only on products complying with certain nutritional criteria (*e.g.* positive/endorsement logos/symbols).

Warning signs are mandatory labels that do not repeat numerical information from the nutrition declaration nor express the overall nutritional value of a food. However, they are also covered in this report where relevant (*e.g.* when describing comparative studies that tested different FOP schemes including warning signs). Text-based nutrition and health claims are excluded from this definition given the purpose of the report but may be referred to if studied in conjunction with FOP labelling schemes as per the above definition.

Table 1. *Relevant terminology to the concept of front-of-pack nutrition labelling (from Regulation (EU) No 1169/2011).*

Term	Definition
Food information	Information concerning a food that is made available to the final consumer by means of a label, other accompanying material, or any other means including modern technology tools or verbal communication.
Label	Any tag, brand, mark, pictorial or other descriptive matter, written, printed, stencilled, marked, embossed or impressed on, or attached to the packaging or container of food.
Labelling	Any words, particulars, trademarks, brand name, pictorial matter or symbol relating to a food and placed on any packaging, document, notice, label, ring or collar accompanying or referring to such food.
Principal field of vision	The field of vision of a package which is most likely to be seen at first glance by the consumer at the time of purchase and that enables the consumer to immediately identify a product in terms of its character or nature and, if applicable, its brand name. If a package has several identical principal fields of vision, the principal field of vision is the one chosen by the food business operator. The principal field of vision is commonly known as 'front of pack' (recital (41) of the Regulation).
Nutrients	Protein, carbohydrate, fat, fibre, sodium, vitamins and minerals listed in point 1 of Part A of Annex XIII to Regulation (EU) No 1169/2011, and substances which belong to or are components of one of those categories.

3. Description of FOP nutrition labelling schemes in Europe and beyond

It is worth reviewing the range of FOP nutrition labelling schemes developed so far, together with their main features, to reveal the similarities and the differences between schemes and to allow for a better understanding of the evidence presented in the following chapters. In turn, this should shed light on the reasons why some schemes may be more effective than others in particular contexts and for specific groups of consumers.

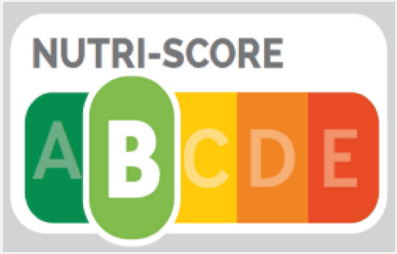
3.1. Nutrition schemes currently used on the front of pack

Table 2 shows selected FOP nutrition labelling schemes currently in use (or proposed) as well as their visuals and key features. A more comprehensive overview with additional details on such FOP schemes around the globe can be found in the *Annex*.

Table 2. *Examples of nutrition schemes used on the front-of-pack in use (or proposed) in and outside Europe, including visuals and key features.* These schemes were chosen because they were encountered repeatedly (as such or in modified/similar forms) in the studies reviewed.

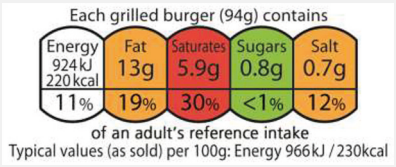
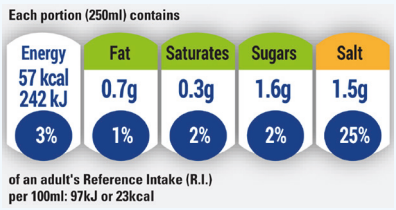
FOP labelling scheme	Country	Examples of visuals	Key features
Reference Intakes label, previously referred to as Guideline Daily Amounts (GDA)	EU-wide		• Nutrition information (energy plus four nutrients: fat, saturated fat, sugars, and salt) in grams and as percentage of daily reference intake. • Portion as main reference base; 100 g or 100 ml as reference base for additional energy info. • Typically monochrome.

Table 2. *(cont.)*

FOP labelling scheme	Country	Examples of visuals	Key features
Nutri-Score (previously called 5-Colour Nutrition Label (5-CNL))	France, Belgium (Spain, Germany, the Netherlands Luxembourg)		• Graphic scale that divides the nutritional score into 5 classes (expressed by a colour and a letter), based on the food's content of energy, sugars, saturated fat, sodium, 'fruit, vegetables, and nuts', fibre, and protein. • Algorithm based on UK Food Standards Agency (FSA) Nutrient Profiling system; minor modifications to FSA score algorithm for cheese, added fats, and beverages to improve consistency between Nutri-Score classification and French nutritional recommendations.[5] • Reference base for the nutritional score calculation is 100 g or 100 ml.
Keyhole	Sweden, Norway, Denmark, Iceland, Lithuania, North Macedonia		• Endorsement scheme ('positive logo') based on threshold levels for energy and various nutrients depending on product category. • Foods labelled with the Keyhole contain less sugars and salt, more fibre and wholegrain and healthier or less fat than food products of the same type not carrying the symbol. • Some food categories are not permitted to carry the logo (*e.g.* sweet and savoury snacks). • Reference base typically is 100 g or 100 ml.
Choices Logo	Poland, Czech Republic		• Endorsement scheme ('positive logo') based on threshold levels for saturated and trans fatty acids, added sugar, salt, dietary fibre, and/or energy, with category-specific cut-offs. • Foods are generally subdivided into core and non-core foods, and the logo is meant to identify the healthiest options in a given category. • Applicable to most foods and beverages.[6] • Reference base typically is 100 g or 100 ml.

5. Julia C., & Hercberg S. (2017).
6. Except alcoholic beverages, supplements, food products prescribed under medical supervision, and food for infants (<1 year-old).

Table 2. *(cont.)*

FOP labelling scheme	Country	Examples of visuals	Key features
Finnish Heart Symbol	Finland		• Endorsement scheme ('positive logo') based on threshold levels for energy and various nutrients depending on product category. • The logo identifies options with a better nutrient profile in a given category regarding fat (quantity and quality) and salt; in some product groups, also sugar and fibre contents are taken into account. • Reference base is 100 g.
UK Multiple Traffic Lights (MTL) (hybrid scheme)	UK		• Nutrition information (energy plus four nutrients fat, saturated fat, sugars, and salt) in grams and as percentage of daily reference intake. • Traffic light colour coding indicating low (green), medium (amber, and high (red) levels of the nutrients stated. • Portion as reference base for numerical information; 100 g or 100 ml as reference base for colour coding[7] and additional energy info. • Separate colour thresholds for solid foods and beverages.
Evolved Nutrition Label (ENL)	Not in use, put on hold		• Nutrition information (energy plus 4 nutrients) as percentage of daily reference intake, similar to the UK MTL scheme. • Portion as reference base for both numerical information and colour coding (except for green colour where 100 g/ml is used as basis), plus energy per 100 g or 100 ml.
Pick the Tick	Australia (no longer in use)		• Endorsement scheme ('positive logo') based on threshold levels for energy and various nutrients depending on product category. • Reference base is 100 g.

7. Except where the food portion is >100 g (*e.g.* a 400 g ready meal) or the drinks portion is >150 ml (*e.g.* a 250 ml can of cola), in which case the colour red is assigned based on a portion threshold.

Table 2. *(cont.)*

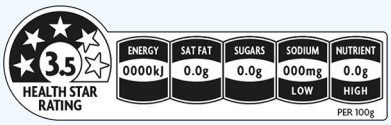
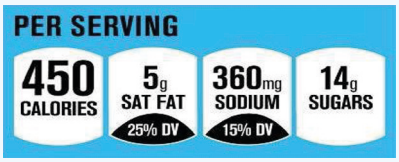
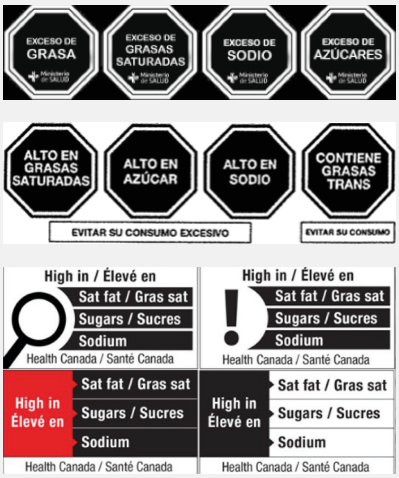
FOP labelling scheme	Country	Examples of visuals	Key features
Health Star Rating	Australia & New Zealand		• Points-based scheme that attributes a summary score between 0.5 and 5 stars, from poorest to best nutrient profile. • Contents of the food in qualifying and disqualifying nutrients are computed to calculate a raw score, using 100 g or 100 ml as the reference base. • This raw score is converted into the Health Star Rating using food group-specific conversion keys. • May be complemented with quantitative energy and nutrient content information, per 100 g, 100 ml, or pack.
Daily Intake Guide	Australia		• Nutrition information (energy in kilojoules plus four nutrients fat, saturated fat, sugars, and sodium) in (milli)grams and as percentage of daily reference intake. Additional nutrients permitted for display are protein, carbohydrates, vitamins and minerals. • Portion as reference base. • Typically monochrome.
Facts-Up-Front	USA		• Nutrition information (energy in calories alone or together with saturated fat, sugars, and sodium) in (milli)grams; it can also include information on up to two nutrients to encourage. • Portion as reference base. • Typically monochrome.
Smart Choices	USA (no longer in use)		• Endorsement scheme ('positive logo') based on threshold levels for energy and various nutrients and food components depending on product category. • Adaptations concerning one or more of several nutrients (total fat, saturated fat, trans fat, cholesterol, sodium, added sugars) for various categories. • Portion as reference base. .../...

Table 2. *(cont.)*

FOP labelling scheme	Country	Examples of visuals	Key features
Smart Choices *(cont.)*			• The programme also allows calorie information per serving as a separate FOP label; this label has to include the number of servings per pack.
Warning signs	Chile, Uruguay, Peru, Canada (under discussion)		• Warning label on foods high in energy, sugar, sodium, saturated fat or potentially other nutrients that should be consumed less. • Depending on the country/scheme, the reference base is 100 g or 100 ml, or portion/serving. • Everywhere these schemes have been implemented, they are mandatory.

3.1.1. Reference Intakes and similar schemes

The Reference Intakes label, developed by members of the European food and drink industry and in use throughout Europe, provides numerical information on the amount of energy and the nutrients present in a portion of a food and how much this represents as a percentage of the daily reference intake. In its simplest form, only the energy content (in kcal and kJ) is provided, whereas in the more comprehensive form the caloric content is accompanied by values in grams for fat, saturated fat, sugars, and salt content, together with the percentages of how much this contributes to daily reference intakes for energy and the nutrients. The FIC Regulation requires that the energy content always be expressed per 100 g or 100 ml on the front of pack; the amounts of nutrients can be expressed per portion only. For the calculation of the percentage of the daily reference intake, the refer-

ence intakes specified in Annex 13 of the FIC Regulation are used as the reference point. Theoretically, the Reference Intakes label can be used on all pre-packaged foods and drinks with a mandatory back-of-pack nutrition declaration.

In January 2020, Italy notified to the Commission a draft Decree recommending the use of the voluntary front-of-pack scheme 'NutrInform Battery'. The scheme is based on the Reference Intakes label with an added battery symbol indicating the amounts of energy and nutrients in a single serving as percentage of the daily intake. The scheme is not yet present on the EU market.

Variants of the Reference Intakes scheme are in place outside Europe, *e.g.* as mandatory FOP labelling in Mexico and Thailand, but also more widely through voluntary use by food business operators; a portion is commonly used as the reference base. A US equivalent to the European Reference Intakes scheme, jointly managed by the Grocery Manufacturers Association and the Food Marketing Institute, is called Facts Up Front.[8] In Australia, the equivalent scheme is called Daily Intake Guide[9] and is managed by the Australian Food and Grocery Council.

3.1.2. Colour-coded nutrient-based schemes

The UK Food Standards Agency (FSA) has developed the UK MTL scheme, which hybridises the Reference Intakes scheme information with traffic-light colours (and optionally wording). For each of the nutrients displayed, the colours indicate low (green), medium (amber), or high (red) levels. Green colour thresholds comply with the requirements for a 'low in' nutrition claim as defined in Regulation (EC) No 1924/2006. Nutrients are labelled red if the amount of the nutrient per 100 g or 100 ml of the food represents more than 25% (for food) and 12.5% (for

8. The Facts-Up-Front scheme presents per-portion information on energy alone or energy plus saturated fat, sugars, and sodium; it can also include information on up to two nutrients to encourage. For details on the scheme, see the dedicated website at http://www.factsupfront.org/.

9. The Daily Intake Guide provides per-portion information on energy (in kilojoules) and one or more of the following nutrients: fat, saturated fat, sugars, sodium (salt). Additional nutrients permitted for display are protein, carbohydrates, vitamins and minerals. For details on the scheme and common nutrient combinations, see the Daily Intake Guide website at http://www.mydailyintake.net/.

drinks) of an adult's recommended daily maximum intake for that particular nutrient. Colour coding is thus determined on a 100 g or 100 ml basis. In the case of products with a portion size larger than 100 g or 150 ml, for example a 300 g ready meal or a 250 ml can of soda, per-portion thresholds apply for assigning the colour red. These additional criteria ensure that products which contribute more than 30% (for food) and 15% (for drinks) of an adult's recommended maximum daily intake for a particular nutrient in a single portion or serving are labelled red for the respective nutrient, regardless of their content per 100 g or 100 ml. A Portuguese retailer also uses this system.

The Evolved Nutrition Label (ENL) scheme was initiated in 2017 by a group of multinational food companies.[10] The approach builds on the Reference Intakes label and adds colours similar to the UK MTL scheme. However, the ENL uses less than 100 g as the reference base for assigning the colours amber and red for products considered to be consumed in small portions (*e.g.* sweet spreads, cookies). For the green colour, a per 100 g basis is applied to align with the 'low in' nutrition claims as per Regulation (EC) No 1924/2006. In November 2018, the companies involved communicated their decision to suspend/cease label trials for food.

Another portion-based FOP traffic-lights scheme has been put in place by a Spanish retailer (see *Annex*). It applies a green colour when calories/nutrients per portion represent less than 7.5% of the maximum daily intake, a yellow colour when they represent between 7.5 and 20%, and a red colour when they represent more than 20% of the maximum daily intake.

3.1.3. Overall rating schemes

A different approach to FOP labelling consists in attributing an overall rating for a product's nutritional quality/healthfulness. Rating can be expressed by various means. For example, the Nutri-Score, a scheme developed under the aegis of the French Ministry of Health and implemented in France in 2017 and in Belgium in 2019, displays five letters (A, B, C, D, and E), which correspond to a nutritional rating of the food from best to worst. The A is coloured in dark green, the B in light

10. The Coca-Cola Company, Mondelez International, Nestlé, Pepsico, and Unilever (Mars left the ENL Initiative in 2018).

green, the C in light orange, the D in orange, and the E in dark orange (see *Table 2*); the letter corresponding to the rating of the food is made larger than the four remaining letters. The general algorithm to calculate the score considers a food's content of energy, sugars, saturated fat, sodium, fruit, vegetables, legumes and nuts, fibre, and protein. Three updated algorithms apply for cheeses, beverages, and added oils/fats to improve alignment with French dietary recommendations for these food groups. The FOP scheme SENS (Système d'Etiquetage Nutritionnel Simplifié) was developed by French researchers and used for some time by a major retailer. It is described here as it was used as well in a number of studies reviewed in this report. SENS classifies foods into four categories on the basis of their nutritional composition and indicates the recommended consumption frequency: (1) very often; (2) often; (3) regularly in small quantities; or (4) occasionally or in small quantities. It displays a triangle assorted with a ribbon of the following colour: respectively (1) green, (2) blue, (3) orange and (4) purple. A monochrome type of graded rating system called Health Star Rating is in place in Australia and New Zealand. It displays a semi-circle with five stars and a numerical rating. The rating ranges between 0.5 and 5 by increments of 0.5, a rating of 0.5 denoting a poor nutrient profile and 5 an excellent nutrient profile. A strip with nutritional values for several nutrients can be added at the right of the star rating.

3.1.4. Endorsement schemes ('positive logos')

Other forms of expression of nutrition information consist in attributing a 'positive logo' (also referred to as 'endorsement logo' or 'health logo') to foods with favourable nutrient profiles compared to same-category alternatives. Several schemes of this type are currently used in Europe. The oldest is the Nordic Keyhole, a trademark owned by the Swedish National Food Agency. It was first introduced in Sweden in 1989, followed by Denmark and Norway in 2009. Iceland and Lithuania adopted the scheme in 2013 and North Macedonia did so in 2015. The specific criteria, *i.e.* the choice of nutrients and thresholds, vary by category.

The Choices logo is another endorsement scheme, managed in this case by the Choices International Foundation. Within a product category, food products with healthier nutrient profiles (category-specific thresholds for energy and some nutrients) can qualify for bearing this FOP logo. The scheme is in operation in

the Czech Republic and in Poland. It was once implemented and endorsed by the government in the Netherlands but was withdrawn in 2017. Products from nine basic and five non-basic product groups[11] are eligible to bear the logo, provided that they meet the nutrient content criteria. The international Choices criteria have been used to inform the FOP nutrition logos of several countries within and outside the European Union, such as Croatia, Malaysia, Nigeria and Singapore, but designs can differ from the Choices logo. For example, the Croatian 'Healthy Living' guarantee mark is represented by a green cloud. Within the category of health logos, there are also heart symbols, such as the Finnish Heart sign and the Slovenian 'Little Heart' represented by a multicolour heart.

3.1.5. Warning signs

Finally, some countries outside Europe require the use of warning signs on the front of the package for foods containing high amounts of energy or nutrients to limit, such as saturated fat, sugars, or salt. Mandatory black warning signs are already in use in Chile and have been approved in Peru[12] and Uruguay.[13] Red circles alerting to high levels of sugar, sodium, or saturated fat are being implemented in Israel, and Canada has coined four health warning designs but has yet to select one for implementation. The decision will be informed by focus groups and public consultations. All warning schemes, still in development or already in place, are (to be) mandatory and are developed by the public authorities of these countries.

11. Basic products are defined by Choices as those that contribute significantly to the daily intakes of essential nutrients. The nine basic product groups are: fruits and vegetables; beans and legumes; sources of carbohydrates; meat, fish, poultry, eggs, and meat substitutes; dairy products; oils, fats and fat-containing spreads; nuts & seeds; water, tea, coffee; main meals, mixed salads, sandwiches, lunch meals. Non-basic products, in turn, generally do not contribute substantially to the intake of essential nutrients, but provide a great innovation potential. They comprise: soups; sauces; snacks (including pastry, ice cream, and sweet and savoury snacks); beverages (excluding water) and fruit juices; bread toppings; fruit juices. Products that do not fall under any of the basic or non-basic product groups are accommodated in a group labelled 'all other products'.
12. Decree available at https://www.gob.pe/institucion/produce/normas-legales/185544-012-2018-sa (last accessed 04/12/2018).
13. Signed decree available at https://medios.presidencia.gub.uy/legal/2018/decretos/08/cons_min_705.pdf (last accessed 30/11/2018).

3.2. Label typologies – definitions

Different taxonomies have been put forward in the literature to group FOP labelling schemes by type, some based on label features, others based on how consumers perceive them. These are described below and illustrated in *Table 3*.

A simple binary taxonomy can be based on the amount of detail provided in the FOP label and whether it provides a judgement about the total product (as in simple schemes) or provides a judgement per nutrients (complex schemes) [Feunekes *et al.*, 2008]. The dimension of 'directiveness', has also been proposed to distinguish between FOP labelling schemes [Hodgkins *et al.*, 2012]. Directive schemes are those including the least amount of information, often aggregated in one symbol or icon (*e.g.* the Swedish keyhole). Semi-directive schemes include labels where not only the nutritional information is provided, but where this is complemented by evaluative elements such as specific colours according to nutrient levels (*e.g.* the UK MTL). Non-directive labels, instead, include information elements only, such as nutrient names, grams, percentages.

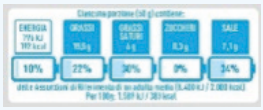
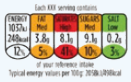
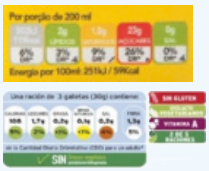
These distinctions are similar to those proposed by others. Newman *et al.* (2014) qualify FOP schemes as 'reductive' if they only convey a simplified version of the information contained on the back of the pack or as 'evaluative' if they somehow suggest to shoppers an evaluation of a product's healthfulness). Savoie *et al.* (2013) propose distinguishing between 'nutrient-specific' and 'summary indicator' schemes.

Julia & Hercberg (2017) subdivide the nutrient-specific format further into numerical (*e.g.* Reference Intakes label) and colour-coded (*e.g.* traffic-lights label) schemes and refer to endorsement schemes such as Keyhole and Choices on one hand, and graded summary schemes such as Nutri-Score on the other.

Overall, in the existing landscape of FOP schemes, several main features can be identified:

- shape (circle, box, triangle, octagon, etc.);
- use of symbols (*e.g.* keyhole, check mark, heart);

Table 3. *Proposed FOP labelling typologies and examples of corresponding FOP schemes (implemented or proposed) in EU Member States and the UK.*

FOP label studies and their proposed terminology						
Feunekes *et al.* (2008)	**Hodgkins *et al.* (2012)**	**Newman *et al.* (2014)**	**Savoie *et al.* (2013)**	**Julia & Hercberg (2017)**	**Examples**	
More complex schemes	Non-directive	Reductive (non-interpretative)	Nutrient-specific labels	Numerical	Reference Intakes label	
					NutrInform Battery (Italy)	
	Semi-directive	Evaluative (interpretative)		Colour-coded	UK MTL label	
					Traffic-light label	
Simple schemes	Directive	Evaluative (interpretative)	Summary indicator labels	Endorsement schemes ('positive logos')	Keyhole	
					Heart/ Health logos	
					Healthy Choice	
				Graded indicators	Nutri-Score	

Abbreviations: MTL, Multiple Traffic Lights; SENS, Système d'Etiquetage Nutritionnel Simplifié.

- colour (black & white, monochrome, polychrome, including semantic use as in traffic lights);
- rating (*e.g.* from 0.5 to 5 stars, from letter A to E);
- reference base (*e.g.* per 100 g, per portion, per 100 kcal);
- message tone (positive, negative, neutral); and
- applicability of the scheme across all food products or only to those that qualify for it.

Many of these aspects are related to considerations regarding the definition of nutrient or energy thresholds or nutrient profiling systems. The following *subchapter 3.3* provides an overview of nutrient profiling concepts and considerations.

3.3. Nutrient profile models used for FOP schemes providing nutrition information

Nutrient profiling is the categorisation of foods according to their nutritional composition using predefined criteria. These criteria may be simple nutrient thresholds or more complex algorithms that result in a summary score, and they can either apply to all food groups across the board, or be specific to different product groups. All evaluative FOP nutrition labelling schemes, be they nutrient-specific or summary indicators, are based on nutrient profile models. *Table 4* summarises the design elements of nutrient profile models and the various options within these.

Table 4. *Components of nutrient-profiling models* (adapted with permission from Sacks *et al.* (2011*a*)).

Component of nutrient-profiling model	Options available	Suitability	Implications	Other considerations
Number of categories	One ('all foods') or two ('foods and beverages'), often referred to as 'across-the-board'.	When the purpose requires comparing foods across the full range of products, for example, for overall nutrition education and for supporting a shift in consumption from, say, higher fat biscuits to fruit.	• No need to define categories. • Some foods that are healthier options within their category may be categorised as less healthy overall.	

Table 4. *(cont.)*

Component of nutrient-profiling model	Options available	Suitability	Implications	Other considerations
Number of categories *(cont.)*	More than two categories, often referred to as 'food category specific'.	When the purpose requires comparing foods within categories, for example, shifting consumption from higher fat to lower fat biscuits.	• Need to define categories. • Some foods that are unhealthy overall may be categorised as healthy because they are healthier options within their category (for example, meat pies). • A greater number of categories is likely to stimulate more product reformulation.	• No consensus on how food categories should be defined. • Can be difficult to allocate foods to food categories, for example, chocolate-coated biscuits could be regarded as confectionery.
Nutrients and other food components included	A short list of nutrients and/or other food components.	When aiming for a simple, practical model.	• Likely to be simpler to use. • A short list of nutrients may not reflect all public health concerns. • Can be useful for targeting specific nutrient deficiencies, for example, iron.	• There are problems in defining some nutrients (for example, if fibre is to be used, the analytical method needs to be specified; and for fruits and vegetables to be used it is necessary to consider what degree of processing is acceptable).
	A long list of nutrients and/or other food components.	When aiming for a model which reflects all nutritional concerns.	• Applying a model with a long list of nutrients is likely to be more difficult to use. • Has the potential to reflect all nutritional concerns.	• Increasing the number of nutrients does not necessarily increase the sensitivity or specificity of models. • Food composition data may not be available for all nutrients.
Reference base used	Per 100 g or per 100 ml.	When using a model to categorise foods solely on the basis of the nutrient quality of the food.	• Does not take into account the wide variation in water content of foods and drinks and so different criteria are needed for foods and drinks. • Facilitates comparison. • Does not take into account the amount of food usually consumed. Foods with very small or very large serving .../...	• The choice of base is connected with other choices such as the choice of the number of product categories. For example, if a 'per 100 g or ml' base is selected there needs to be at least two categories: 'foods' and 'beverages'.

Table 4. *(cont.)*

Component of nutrient-profiling model	Options available	Suitability	Implications	Other considerations
Reference base used *(cont.)*	Per 100 g or per 100 ml. *(cont.)*		sizes can be categorised in ways which appear anomalous (for example, mustard can be high in a particular nutrient but is eaten in very small quantities).	
	Per 100 kJ.	When using a model to categorise foods solely on the basis of the nutrient quality of the foods.	• Is not affected by water content and so does not need different criteria for foods and drinks. • Does not take into account the amount of food usually consumed. Food with very low or very high energy contents on a per 100 g basis can be categorised in ways which appear anomalous (for example, lettuce may appear high in some nutrients on an energy basis, but a lot of lettuce needs to be eaten to provide those nutrients).	
	Per serving/ portion.	When using a model to categorise foods on the basis of the nutrient quality of the foods and taking some account of how foods deliver their nutrients.	• Need to define serving/ portion size. • Does not take account of all the ways foods deliver their nutrients, for example, frequency of consumption.	• Little consensus on how to define serving/portion sizes with no agreed international standards. Where no standards exist, serving/portion sizes are open to manipulation. • Difficult to define a standard serving/portion size when serving/portion varies considerably (for example, milk).
Method for categorising/ ranking products	Thresholds.	For simple models designed for a single purpose.	• Less suited to differentiating between product,s for example, there is no discernible differ- …/…	

Table 4. *(cont.)*

Component of nutrient-profiling model	Options available	Suitability	Implications	Other considerations
Method for categorising/ ranking products *(cont.)*	.		ence between products that narrowly fail to meet a threshold and those that are a long way from the threshold. • Likely to be most applicable to category-specific models, in which different thresholds can be set for different food categories.	
	Scoring.	For more complex models that can be tailored for different purposes.	• More flexible in models that can be used for different purposes using different scoring levels depending on the application. • Model may be harder for users to understand.	
Cut-off numbers	On the basis of dietary recommendations.	When there is a need to be consistent with dietary recommendations.	• Maintains consistency across applications, for example, the 'amber'/'red' threshold numbers for the UK MTL scheme are based on Guideline Daily Amounts.	• Algorithms can be developed to combine numbers into a single output, for example, an overall score, index or a ratio.
	On the basis of existing legislation.	When there is a need to be consistent with legislation already in place.	• Maintains consistency across applications, for example, the 'green'/'amber' threshold numbers for the UK MTL scheme boundaries are based on the European Union nutrition claims legislation.	

3.4. Market penetration of FOP nutrition labelling schemes

Data on the current market penetration of FOP schemes providing nutrition information is limited and not reported in a standardised manner (*Table 5*), and

therefore solid estimates are difficult to provide. The most systematic and comprehensive assessment in Europe, from 2008-09 [Storcksdieck genannt Bonsmann *et al.*, 2010], showed that on average 48% of products from five categories[14] carried some form of FOP nutrition information (although this also included claims and other types of information not considered here).

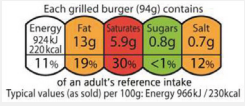
Table 5. *Data on market penetration of various EU and international FOP schemes providing nutrition information.* It should be noted that FOP schemes using eligibility criteria to identify a healthier option (here Choices, Keyhole, Heart Symbols) are likely never to reach 100% penetration.

FOP scheme	Country	FOP labelling scheme penetration	Data source
Choices*	Poland, Czech Republic	• The Choices logo is currently found on approximately 7000 food and beverage products of more than 120 companies.	Choices Programme website (last accessed 06/08/2018). https://www.choicesprogramme.org/industry/industry/
Heart Symbol*	Finland	• In 2018, about 1300 different products are carrying the logo. • About 120 food industry companies are using Heart Symbol in their products.	Slide deck shared by Heart Symbol staff.
Keyhole*	Norway	• There are now 2000 Keyhole food products in Norwegian grocery stores.	Nordic Co-operation website, Keyhole section (last accessed 06/08/2018). https://www.norden.org/en/news-and-events/news/keyhole-milestone http://norden.diva-portal.org/smash/get/diva2:700822/FULLTEXT01.pdf
	Sweden	• 'A total of approximately 2500 unique pre-packaged, Keyhole-labelled food products are available in shops' (data from 2009).	
Nutri-Score	France	• In November 2019, a total of 236 brands or >35% of the market share.	Slide deck shared by French Ministry of Health.

* Scheme restricted to healthier options in a given food product category, hence unlikely to ever reach 100% penetration.

14. More than 37000 products within the following five food and beverage categories were audited across the EU-27 plus Turkey: sweet biscuits, breakfast cereals, pre-packed chilled ready meals, carbonated soft drinks and yogurts. Audits were carried out in a total of 84 retail stores.

Table 5. *(cont.)*

FOP scheme	Country	FOP labelling scheme penetration	Data source
Slovenian 'Little Heart'* 	Slovenia	• Across 6341 products from 24 product categories, average penetration of 2% in the Slovenian market (yogurt and fermented milk drinks highest at 14%) (data from 2011).	[Pravst & Kušar (2015)].
UK Multiple Traffic Lights (MTL) 	UK	• Scheme adopted by two-thirds of the packaged food and drink market in the UK.	Slide deck presented by UK Dept of Health staff at 23 April 2018 joint Member States & stakeholder FOP labelling meeting.
Daily Intake (DI) label 	Australia	• 'The number of products with DI labelling increased from 58 in February 2007 to 1939 in August 2009 and appears to be growing strongly.'	[Williams *et al.* (2010)].
Health Star Rating (HSR) 	Australia & New Zealand	• As at April 2017, over 7500 products displaying the HSR scheme graphic in Australia. This represents over 150 companies. • As at March 2017, over 2700 products displaying the HSR scheme graphic in New Zealand. • In Australia, 'HSR appeared on 4348 /15767 (28%) of eligible products in 2017 and has now appeared on 7922 products since implementation'.	Slide deck from Codex Committee on Food Labelling meeting 44, Oct 2017. http://www.fao.org/fao-who-codexalimentarius/meetings/detail/en/?meeting=CCFL&session=44 [Jones *et al.* (2018*b*)].

* Scheme restricted to healthier options in a given food product category, hence unlikely to ever reach 100% penetration.

In addition, a small-scale analysis[15] of the occurrence of nutrition- and health-related claims and symbols [Hieke *et al.*, 2016], not FOP labelling in general, reported the following percentages for symbolic claims (which include FOP health logos such as Choices) on food products: 12% in the Netherlands, followed by Spain (4%), Slovenia (2%), the UK (1%), and Germany (0.3%).

15. Five countries (Germany, Netherlands, Slovenia, Spain, and UK), ca. 400 products per country, from three types of retailers: approximately 250 foods were sampled from a supermarket/national retailer, 75 foods were sampled from a discounter and 75 from a neighbourhood store.

3.5. Stated aims of FOP nutrition labelling

Before addressing if and how FOP nutrition labels affect consumers (or other target audiences), it is worthwhile looking at the stated aims of the various schemes encountered in the studies reviewed (*Table 6*). A key point is to help consumers, be it to better understand the nutritional composition of foods, compare foods with one another, or make more nutritious or healthier food choices. Additionally, some FOP schemes also intend to drive healthier product development and reformulation by food manufacturers.

Table 6. *Examples of the stated aims of different FOP nutrition labelling schemes encountered in the studies reviewed.*

FOP labelling scheme (in alphabetical order)	Stated aim	Source
Choices logo 	'helps consumers make healthy food choices and stimulates producers to develop healthier products'	Choices programme website. https://www.choicesprogramme.org/
Daily Intake Guide 	'make healthy eating easier by providing a better view of what's in your food and drinks' 'quick and easy information about the energy (kilojoule) and nutrient content of your food and drink per serve' 'empowering consumers so that they can make an informed choice'	Daily Intake Guide website: http://www.mydailyintake.net/
Facts-Up-Front 	'to quickly compare products and choose the one that is best for [consumers]'	Facts-Up-Front website. http://www.factsupfront.org/HowToUse.html
Health Star Rating 	'to compare similar packaged food and help [consumers] make healthier choices'	Health Star Rating website. http://healthstarrating.gov.au/internet/healthstarrating/publishing.nsf/Content/About-health-stars
Heart symbol 	'tells the consumer at a glance that the product marked with this symbol is a better choice in its product group'	Finnish Heart symbol website. https://www.sydanmerkki.fi/en

Table 6. *(cont.)*

FOP labelling scheme (in alphabetical order)	Stated aim	Source
Keyhole	'to help consumers identify the healthier options when buying food' 'to stimulate manufactures to product reformulation and development of healthier products'	Swedish National Food Agency website, Keyhole section. https://www.livsmedelsverket.se/en/food-and-content/labelling/nyckelhalet
Nutri-Score	'to help consumers assess the nutritional quality of the products they are buying'	Usage regulation for the 'Nutri-Score' logo. https://www.santepubliquefrance.fr/content/download/3544/27772/file/Nutriscore_reglement_usage_EN_200218.pdf
Reference Intakes	'better [consumer] understanding of how much of the energy and key nutrients exist in a portion and how much this represents in relation to the daily dietary intake of an average person'	Reference Intakes website. https://referenceintakes.eu/
UK Multiple Traffic Lights	'to help [consumers] eat a healthy diet'	UK Government Website, FOP labelling section. https://www.gov.uk/government/publications/front-of-pack-nutrition-labelling-guidance

These stated aims are important when evaluating the effectiveness of FOP labelling schemes, as reviewed in the following sections of this report.

4. Impact of FOP nutrition labelling – a review of the evidence

4.1. Literature search methodology

For this review, two separate literature searches were carried out, one on nutritional aspects of FOP labelling and the other on consumer behaviour aspects of FOP labelling.

For the first search, the online databases PubMed, Web of Science, Google Scholar, and OpenGrey were searched with the search strings defined below (*Table 7*):

Table 7. *Databases and search strings used for literature search on nutritional aspects of front-of-pack nutrition labelling.* The search covered the period from database inception to 31 May 2018.

Database	Search string
PubMed	"nutrition*[Title/Abstract] AND label*[Title/Abstract] AND front[Title/Abstract] AND pack*[Title/Abstract]"
Web of Science, Google Scholar, and OpenGrey	"food AND nutrition AND labelling OR label AND front-of-pack OR front of pack OR FOP AND health"

For the part related to consumer behaviour, the online databases of ScienceDirect, JSTOR[16] and Google Scholar were searched with the search strings defined below (*Table 8*). Earlier articles were considered when they were mentioned as key references in articles published after the year 2000; two such earlier articles were included in the review.

Table 8. *Databases and search strings used for literature search on consumer behaviour aspects of front-of-pack nutrition labelling.* The search covered the period from 1st January 2000[17] onwards.

Database	Search string
ScienceDirect, JSTOR, Google Scholar	"Front-of-pack OR Front-of-package OR FOP AND behaviour OR purchase OR purchasing"

16. JSTOR (Journal STORage, www.jstor.org) is a digital library of academic journals, books, and primary sources.
17. This cut-off date was chosen as most research specific to front-of-pack labelling emerged well after that date and any earlier studies would most likely be picked up through reviews on the subject.

Only English language studies and reports were considered, with an emphasis on qualitative and quantitative research (focus groups, online and in-store experiments and observations, impact modelling, questionnaire surveys). Using the PICO[18] question approach, studies were included without any limitation on the population (P) that assessed the provision or application of FOP nutrition labelling in any form (I) against other schemes or no FOP nutrition information as a comparator (C), with one or more of the following reported outcomes (O):

- O-1: Consumer awareness of FOP nutrition labelling.
- O-2: Consumer preferences for FOP nutrition labelling.
- O-3: Consumer understanding of FOP nutrition labelling.
- O-4: Consumer use of FOP nutrition labelling.
- O-5: Impact of FOP nutrition labelling on purchasing.
- O-6: Impact of FOP nutrition labelling on diet and health.
- O-7: Impact of FOP nutrition labelling on food reformulation/innovation.

As secondary outcomes, the impact of FOP labelling schemes on aspects such as nutritionally undesirable changes in consumption patterns, price changes that might promote poorer food choices, stifling of food reformulation/innovation, or trade impact was also considered.

The below PRISMA[19] flowcharts (*Figure 2* and *Figure 3*) show the study selection process from the number of initial hits to the number of full-text studies included in the review. The literature reviews were carried out in parallel by two different teams of, respectively, nutritional and behavioural experts. The two sets of scientific articles identified by both teams partially overlapped.

18. PICO = Population, Intervention, Comparator, Outcome.
19. PRISMA = Preferred Reporting Items for Systematic reviews and Meta-Analysis.

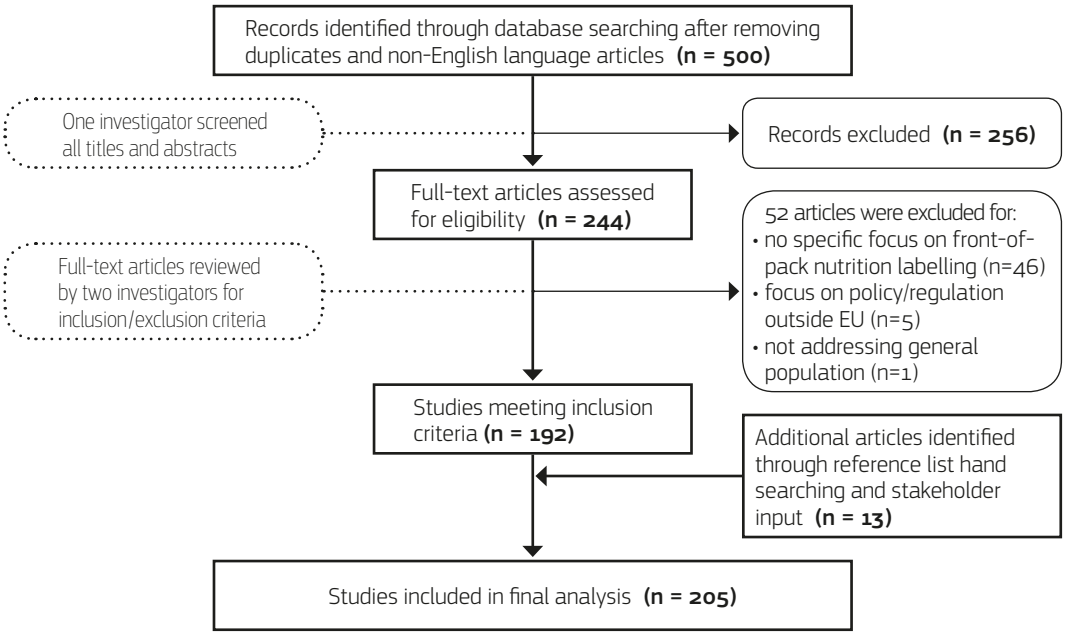


Figure 2. *PRISMA flowchart for the screening and selection process of studies included in the final analysis concerning nutritional aspects.* Databases searched: PubMed, Google Scholar, and Web of Science.

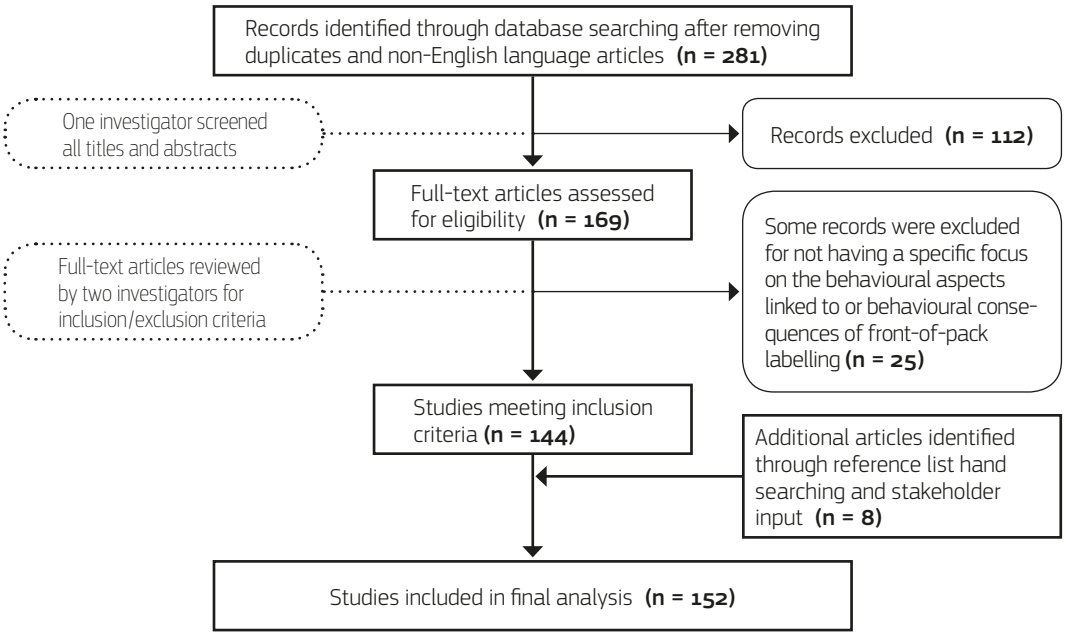


Figure 3. *PRISMA flowchart for the screening and selection process of studies included in the final analysis concerning consumer behaviour aspects.* Databases searched: ScienceDirect, Google Scholar, and JSTOR.

Both *methodological elements* and *behavioural arguments* help interpret the evidence collected and should be borne in mind when reading the following chapters.

As to the *methodological elements*, there are four issues that should be considered: 1) the robustness of the study generating the evidence; 2) its nature and how well it reflects reality (level of realism); 3) the comparability of results; and 4) the independence of the authors. Below follows a brief discussion of each of these issues.

1. Study type and robustness

This report highlights, where applicable, the type of study that produced the evidence, essentially distinguishing between five types: focus groups, surveys, online experiments, lab experiments, and field experiments. A description of the advantages and disadvantages of each approach goes beyond the scope of this document. However, it is worth noting that some approaches can generate more reliable and sound results than others:

- *Focus groups* provide qualitative information on people's perceptions about a given issue. Such evidence can be used to generate hypotheses for subsequent quantitative research but does not offer any population-level information.
- *Surveys* may provide statistically significant results but are knowingly based on self-reported replies, and therefore subject to a number of biases such as the 'hypothetical bias'[20] or the 'idealised persona bias'.[21]
- *Experiments* differ from the former approaches insofar as they are inherently designed to compare results between groups, ideally one or more intervention groups and a control group. In this sense, well-designed experiments constitute a more robust approach, able to identify a causal relationship between a given FOP label (and even elements within this) and a respondent's reaction.
  - *Online experiments* are less costly and can therefore be carried out with larger samples, with consequential larger statistical power.

20. Hypothetical bias refers to the issue that stated choices or preferences in a hypothetical setting may not reflect actual choices or preferences in real-life settings.
21. Idealised persona bias occurs when stated choices or preferences reflect those of an idealised self rather than the true self.

- *Laboratory experiments* are carried out in a controlled environment with rigorous design protocols. They are based on relatively smaller samples, though usually large enough to provide statistically significant results.
- *Field experiments* are carried out in a less controlled environment, *i.e.* where confounding factors that cannot be controlled for may affect results. However, they have the advantage of being performed with real incentives in a natural choice context, providing maximum ecological validity.

2. Level of realism

In assessing consumers' reactions to FOP labels, the vast majority of studies adopt a *piecemeal approach*, as opposed to a holistic one. In a *piecemeal approach*, consumer responses are investigated in an artificially simplified choice context (*e.g.* with less information to be assessed, more time to decide, larger and more readable labels/logos, etc.), with subjects usually primed to focus on a specific piece of information. Moreover, in comparisons between FOP labels and the mandatory nutrition declaration in tabular format, the nutrition labels may be presented without any notion of whether they would be found on the front or the back of a package. In contrast, in a *holistic approach* (which would translate into a more comprehensive and robust protocol design) the impact of various FOP labels is gauged in a choice context with other pieces of information also present – as it would be in real life.

3. Comparability of results

Familiarity of the participants in a study with a FOP scheme promoted in that country may be a key explanation for the observed better performance of that very FOP scheme. Whenever possible, this report stresses such points to contextualise the relevance of such evidence and relativise its implications.

4. Independence of the authors

Researchers working for commercial entities author some of the studies reviewed, and their independence may be compromised. Commercial affiliation is indicated where this information was reported or easily derived.

Besides these methodological caveats, *behavioural arguments* can also help interpret and structure the evidence presented here. Behavioural evidence challenges the very existence of an *average consumer*[22] – 'reasonably well-informed and reasonably attentive and circumspect' – and even more directly the assumption of a *rational consumer*, with fixed, independent, and consistent preferences, perfect information, and effectively pursuing their own maximum utility. The most relevant *behavioural biases* (*i.e.* behavioural 'anomalies' with respect to the typical rational assumptions) are presented below.

1. System 1 vs. System 2 thinking

In the large majority of real-life cases people take decisions based on system 1 thinking (effortless, quick, impulsive), as opposed to system 2 thinking (effortful, slow, Cartesian) [Kahneman, 2011]. Artificially prompting people's attention to FOP labels in a context devoid of real-life complexity may activate system 2 thinking and generate biased results with respect to what would be observed in real life.

2. Myopia (also known as present bias)

In real life, people tend to underestimate long-term benefits, and rather focus on immediate gratification. Such tension is not present in a *hypothetical* choice context, where therefore a preference for the more nutritious food item could more likely be elicited, regardless of the presence of a FOP label.

3. Loss aversion

People attribute more weight to losses than to gains of equal magnitude. To use an example related to FOP nutrition labelling, consumers might make more of an effort to avoid products bearing red traffic lights than they would to increase the number of products with green traffic lights in their shopping baskets [Scarborough *et al.*, 2015].

22. European Court of Justice (C-210/96 Gut Springenheide and Tusky (1998)).

4. Scarcity (in particular time scarcity)

It has been suggested that scarcity – of both of money and time – can lead to poorer choices [Mullanaithan & Shafir, 2013]. These same authors also discuss the concept of *bandwidth*, that is the lack of time and attention that prevents people from learning about a specific option and exploring its merits. Bandwidth puts people in a 'cognitive tunnel', limiting what they are able to see and evaluate, and encouraging impulsive and heuristic-based decision-making. In the context of FOP labelling, it follows that the failure to reproduce a realistic choice context may result in an overestimation of the impact of FOP labels.

5. Information overload

When it comes to information disclosure, 'more is not necessarily better' or, in other words, 'too much information may harm'.[23] This may partly explain an inherently contradictory finding, namely the relative attractiveness of directive (or evaluative, or simpler) FOP schemes, and the respondents' concomitant *self-reported* preference for more information (see Hodgkins *et al.*, 2012).

6. Overconfidence

This bias describes people's tendency to overestimate their own abilities; respondents often rate their competences (knowledge, performance) above the median. For example, 93% of U.S. and 69% of Swedish drivers rated themselves as more skilful than the median driver (a contradiction in terms).[24] Illustrations of overconfidence were found in a number of studies on FOP labelling, with respondents disregarding FOP labels claiming they know better, or claiming to have understood a FOP scheme and then being unable to use it correctly (see, for example, the *Shopper-internal reasons for not using FOP labels*, in Malam *et al.* (2009)).

23. See the UK Better Regulation and National Consumer Council report *Warning: Too much information may harm* (2007).
24. Svenson O. Are we all less risky and more skillful than our fellow drivers? *Acta Psychologica*, 2018; 47:143-148. A number of studies have since corroborated such results on overconfidence, in a variety of fields (from teaching capacities to financial knowledge and abilities).

7. Defaults

This bias refers to people's inclination to let the default rule dictate their decisions. Although awareness about the default bias has led to some important policy initiatives,[25] it is not immediately clear how this could be applied to encourage the choice of more nutritious food items. Still, this is inherently related to *choice-editing*, consumers' tendency to entrust retailers to suggest the best products for them (on various grounds, such as environmental, ethical or nutritional). Defaults could perhaps apply in online purchases, where food products could be ranked by their nutritional features, instead of by price or popularity.

8. Rebound effect (also known as take-back effect*)*

This concept is widely used in conservation and energy economics, but is of application for other types of consumption, too. In the case of FOP labelling, it refers to customers increasing the consumption of a food item with a positive FOP label to an extent that offsets the objective of the label itself.

9. Relativity and social norms

Individuals often evaluate their preferred option against a benchmark instead of in relative terms. It is uncommon for consumers to make evaluations in absolute terms. One possible distinguishing feature of FOP labels – although this is not found in the literature – is their ability to provide relative *vs.* absolute information. In this sense, it is not clear how much of the popularity of evaluative schemes (as opposed to non-evaluative ones) is due to their potential ability to distinguish easily between more and less nutritious products. Relativity matters not only across products, but also across consumers. In consumer decisions concerning energy consumption, for example, relative billing information (that is, showing a given household's consumption pattern both in absolute terms and relative to that of similar households) has shown to generate small albeit statistically significant savings. If social norms can be tapped into to encourage virtuous consumption,

25. For example, the US Save-More-Tomorrow intervention to increase pension contributions, or the 2014 EU ban on pre-checked boxes for ancillary paid-for services in online contracts.

supermarket chains may well use fidelity cards personal information for this purpose in the future. For example, they may apply internal algorithms to display the main nutritional features of a shopping basket compared to the average shopping basket of a similar consumer. Such relative information may be accompanied (as in the case of the energy billing) by specific suggestions on how to make healthier choices in the future.

Furthermore, when studying the behavioural literature on FOP nutrition labelling, it is useful to make the distinction between consumers' immediate reactions to such labelling and their purchasing behaviour. While in principle there should be a link between these two phases of the decision-making process, in this analysis they are kept conceptually separate since they address different questions. From a policy-making perspective, whether people alter their purchasing behaviour (and thus their diets) in response to the presence of FOP nutrition labelling is likely the main question. However, a given FOP scheme will not have an effect on behaviour unless it is noticed, understood, and ultimately accepted as reliable information and potentially guidance.

To gauge the effectiveness of FOP nutrition labelling in shaping healthier diets it is important to consider the following steps: a) consumers' attention and reading of labels; b) determinants of consumer liking and attractiveness of labels; c) understanding and health inferences from labels; d) in-store use of labels; and e) effects of labels on dietary intake. Many external and personal factors can affect each of these steps such as consumer attention and motivation, design, format and placement of the label scheme and their consistency.

4.2. Evidence on consumer attention to FOP nutrition labels

Attention to FOP nutrition labels is difficult to define and measure. Available studies are commonly based on self-reports or think-aloud protocols [Cowburn & Stockley, 2005; Higginson *et al.*, 2002; Kelly *et al.*, 2009], which are likely to be biased measures of attention [Bialkova & van Trijp, 2010]. Nonetheless, *Table 9* lists related studies and their results.

Table 9. *Studies of consumer attention to or awareness of FOP nutrition information.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Diekman *et al.* (2016)	1363 female adults (25-49 years) US non-Hispanic whites, Hispanics, African Americans.	Survey designed to measure shopper awareness, understanding, and engagement with the Facts-Up-Front nutrition labelling scheme, as well as some usage questions related to Facts-Up-Front and the Nutrition Facts label.	Self-reported awareness of the Facts-Up-Front scheme was 62% among US whites, 75% among Hispanics, and 60% among African Americans; awareness rates tended to increase with education level.
Leek *et al.* (2015)	30 adults (18 female, 12 male), average age 31 years (female) and 32 years (male) in the UK.	Semi-structured face-to-face interviews within which three ready meal comparisons were performed using a think aloud technique. FOP labels comprised Multiple Traffic Lights (with and without GDA), polychrome GDA, and black & white GDA.	70% reported looking at FOP labels when purchasing food.
Williams & Mummery (2013)	1446 adults (18+ years) in Australia.	Cross-sectional survey to explore use of the Australian Heart Foundation's Tick logo.	76% declared looking for the Heart Foundation Tick at least occasionally (19% regularly, 21% often, and 35% occasionally).
Möser *et al.* (2010)	128 consumers (53% women, 17-80 years) in Belgium.	Self-administered, anonymous quantitative questionnaire on consumer perceptions of simplified FOP nutrition information, namely Guideline Daily Amount (GDA) and Traffic Light (TL), in Germany and Belgium. Only Belgian respondents were asked about FOP label reading frequency.	Some 60% of respondents in Belgium reported reading FOP nutrition information always, often, or sometimes.

Consumers over-report their use of nutrition information by an estimated 50%, regardless of nutrition label placement front of pack or back of pack [Grunert *et al.*, 2010*b*].

Table 9. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Grunert *et al.* (2010*a*)	Adult shoppers in the UK (n = 2019), Sweden (n = 1858), France (n = 2337), Germany (n = 1963), Poland (n = 1800) and Hungary (n = 1804).	In-store observations and face-to-face interviews in six product category aisles (breakfast cereals, ready meals, soft drinks, salty snacks, yogurts, and confectionery) in major retailers. FOP labels comprised GDA, Traffic Lights, Nordic and Keyhole as encountered in the supermarkets.	Less than one-third of consumers were found to pay attention to nutrition information (not limited to FOP) while shopping (from 9% in France to 27% in the UK).
Kim & Kim (2009)	1019 Korean adults in their 20s-40s.	Face-to-face interview survey on nutrition labelling (degree of checking, understanding, utilizing nutrition labelling when purchasing products, and reasons for not checking).	68% reported to always or sometimes look for FOP nutrition labels.
Malam *et al.* (2009)	UK survey with 2932 shoppers. 113 accompanied shops. 56 in-store and 56 in-home bag audits.	In a nationally representative survey, consumers were asked to self-report their use of FOP labels. Accompanied shops and in-store and in-home bag audits were used to assess actual FOP label use.	Self-reported use of FOP labels was considerably higher (58% of shoppers) than observed use in the accompanied shops and bag audits.
Choinière & Lando (2008)	2575 non-institutionalized adults (18+) in the USA.	Random-digit-dialling telephone survey, including a question on awareness and use of FOP healthier option symbols.	72% reported having seen FOP healthier option symbols.

Several studies have shown however that FOP labels receive more attention than the classic back-of-pack Nutrition Facts Panel [Becker *et al.*, 2016; Becker *et al.*, 2015; Graham *et al.*, 2017], and that FOP labels are also noticed earlier [Becker *et al.*, 2015;[26] Becker *et al.*, 2016]. As concerns specific FOP schemes, studies show good attention-grabbing potential of Nutri-Score, Multiple Traffic Lights, and warning labels [Ares *et al.*, 2018; Vidal *et al.*, 2013].

26. These authors also tested some facial icons, but these had no impact on attention.

Several main characteristics can increase attention to FOP nutrition labels; these include label size, colour, contrast, and placement as well as overall package context. *Table 10* summarises the studies concerning FOP label size, which together show that larger label size aids attention capture.

Table 10. *Studies on label size as a determinant for consumer attention to FOP nutrition information.*

Study (most recent first)	**Population**	**Intervention/Comparator**	**Outcome**
Cabrera *et al.* (2017)	61 adults in Uruguay.	Visual search task to evaluate the influence of size and position of a FOP label on attentional capture. Two package front sizes were considered: 45 cm^2 and 152 cm^2, and three proportional warning label sizes tested: 1 × 1 cm, 1.5 × 1·5 cm and 2 × 2 cm for 45 cm^2 surface and 2 cm × 2 cm, 2.5 cm × 2.5 cm and 3 cm × 3 cm for 152 cm^2 surface.	The biggest FOP label in each pack size condition was noticed significantly faster than the smallest.
Bialkova *et al.* (2013)	24 academics at a Dutch university.	Visual search task on yogurt packages manipulated for number and type of nutrition labels (directive-, semi-, and non-directive), chromaticity (monochrome *vs.* traffic-light color-coded scheme); number and type of additional design elements; and distance between label and additional design elements.	Displaying a combination of two FOP label schemes, which together occupied a larger surface, increased attention over just one scheme.
Corvalán *et al.* (2013)	Convenience sample of 1300 head-of-the-household women (18-59 years) of low-middle socio-economic status of the Metropolitan Region of Chile.	Different warning labels were evaluated for visibility, comprehension and change of the intention to buy. 15 alternative warning messages that combined colours, figures, and types of messages, were tested on a yogurt container.	A label size of at least 10% of the surface of the package front was necessary for a FOP nutrition label to have some impact.

Table 10. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Bialkova & van Trijp (2010)	18 students at a Dutch university.	Two visual search tasks: FOP label detection (present *vs.* absent) and FOP label detection and identification (one *vs.* two FOP labels, namely monochrome or polychrome GDA with or without Choices logo).	Attention capture was faster and more accurate when the label was double the standard display size.

Regarding the impact of colour on attention to FOP labels, the evidence is mixed, partly owing to variations in the contrast between the FOP scheme and the package background across studies (*Table 11*).

Table 11. *Studies on the impact of label colour on consumer attention to FOP nutrition information.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Acton *et al.* (2018)	Convenience sample of 234 shoppers aged 16+ years in Canada.	Visual search task to test ease of noticing and legibility of FOP label varied on five design characteristics: (i) border *vs.* no border; (ii) white background *vs.* no background; (iii) white background *vs.* yellow background; (iv) 'caution' symbol *vs.* no 'caution' symbol; (v) government attribution *vs.* no government attribution.	FOP labels with a yellow background were noted more easily but compromised legibility compared to a white background. Separating the nutrition label from other label information with a black border helped attract consumers' attention.
Cabrera *et al.* (2017)	Five studies with a total of 496 participants aged 18-63 years in Uruguay.	Visual search task to test the impact of colour (and shape, textual information, size, position) on speed of noticing a FOP nutrition label.	Black visual noticed faster than a red one.

Table 11. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Becker *et al.* (2016, 2015)	Several studies with 45-80 participants aged 18-74 in the USA.	Change detection task with twelve FOP labels that resulted from a factorial combination of 3 (text, facial icons, checkmarks) × 2 (traffic-lights colour/no colour) × 2 (healthy/unhealthy) design elements. The FOP labels contained nutrition information for calories, fat, saturated fat, sugar, and salt.	Participants noticed multi-colour images of the traffic-lights scheme faster than black-and-white versions thereof; importantly, subjects were not primed to look for nutrition labelling.
Bix *et al.* (2015)	55 participants, aged 18-72 in the USA.	Eye-tracking study to detect attentional patterns when people without explicit, nutrition-related goals interacted with actual packages with and without FOP labels (Multiple Traffic Lights paired with smiling, neutral or frowning face icons according to colour).	Colour-coded FOP labels on food packages attracted attention to nutrition information more rapidly than the BOP Nutrition Facts Panel and increased people's total time spent attending to any nutrition information.
Antúnez *et al.* (2015)	10 (visual search) and 54 (eye-tracking) participants (58% females), aged 18+, in Uruguay.	Visual search task and eye-tracking study of consumer attention to monochrome and colour-coded GDA labels on mayonnaise packages. Two independent variables were considered for mayonnaise label design: fat content and type of FOP label. Two levels (medium and high) were considered for fat content, which was reflected in the relevant values, percentages, and colour coding (yellow *vs.* red) of the FOP labels.	People responded more quickly to colour-coded than to monochrome GDA labels.
Antunez *et al.* (2013)	52 adults (18+; 58% females) in Uruguay.	Consumer attention (and understanding) regarding sodium content of packaged breads, varying the package as follows: label background (Background A *vs.* .../...	People processed nutrition information faster in the presence of a traffic-lights label compared to standard nutrition declaration.

Table 11. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Antunez *et al.* (2013) *(cont.)*		Background B); type of product (regular *vs.* low salt); nutrition information format (panel *vs.* linear); and traffic-lights scheme (absence *vs.* presence)	
Bialkova *et al.* (2013) Bialkova & van Trijp (2010)	18 and 24 participants, aged 19-35, students or academic staff at a Dutch university.	Change detection study asking participants whether a specific label (Choices logo, traffic-light colour-coded GDAs, or monochrome GDAs) is present or absent on the picture of a yogurt pack, and to identify which label it was.	Attention capture was faster and more accurate with monochrome rather than polychrome colouring, irrespective of the ways in which polychrome labels affect consumer understanding and use of nutrition information.

Colour increases attention to FOP schemes, as long as contrast between the label and the package is achieved and the label is clear and big enough to be easily legible. Overall, these findings are in line with studies from outside the FOP nutrition labelling literature which suggest that colour increases the salience of stimuli and reduces the time necessary to detect them [Green & Anderson, 1956; Williams, 1966].

Notably, there are characteristics that do not refer to the label itself, but rather to the interplay between a label and the specific environment in which it is placed. For example, Bialkova & van Trijp (2010) showed that **attention was greater when the type of label and its location on the package did not change**, suggesting that FOP labelling should be uniform and printed in a consistent location on food packages. Also, Bialkova *et al.* (2013) showed that a combination of labels had superior attention-grabbing ability compared to a single label. It remains to be shown whether this is because of the resulting larger label or rather because of the specific combination of different label formats. Finally, the information density on the package where the label is found is also relevant. Bialkova *et al.* (2013) showed that **attention to the nutritional information is higher if there is less other information on the food package**.

In addition to specific label features, attention to FOP labelling also appears to depend on consumer characteristics such as age, education level, and health motivation (*Table 12*).

Table 12. *Studies on consumer characteristics related to attention to FOP labelling.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Soederberg Miller *et al.* (2015)	392 and 358 US residents, respectively, for the self-reported and the objectively measured attention to FOP labels.	Survey and eye-tracking study using a mock shopping task in which participants viewed food labels (including Facts-Up-Front FOP scheme) and decided which foods to purchase.	Self-reported and objective attention to FOP nutrition labelling increased with higher dietary quality.
Grunert *et al.* (2010a)	Adult shoppers in the UK (n = 2019), Sweden (n = 1858), France (n = 2337), Germany (n = 1963), Poland (n = 1800) and Hungary (n = 1804).	In-store observations and face-to-face interviews in six product category aisles (breakfast cereals, ready meals, soft drinks, salty snacks, yogurts, and confectionery) in major retailers. FOP labels comprised GDA, Traffic Lights, Nordic and Keyhole as encountered in the supermarkets.	Consumers were more likely to look for nutrition information when they focussed on health and nutrition. Having a high level of nutritional knowledge also increased attention for nutrition information in five out of the six countries.
Vyth *et al.* (2009)	Quantitative survey with over 1000 participants in the Netherlands (>80% female), mean age 46.4+/-13.2 years, mean BMI 25.6+/-5.1 kg/m². Focus group with 41 consumers (16 men, 25 women), mean age 46 years (range 20–83), mean BMI 23 kg/m² (range 17.7–27.7).	Online questionnaire sent to adult consumers 4 months after the introduction of the Choices logo and 1 year later. Respondents had to rate on a 5-point scale their need for the logo as well as how much they liked it and how credible it was.	Elderly and obese respondents reported to be more in need of a logo than younger and normal-weight individuals. People with low education reported more often to pay attention to the Choices logo than did highly educated people. Women perceived the logo as more attractive and credible than men did. Further qualitative analyses indicated that logo credibility would improve if it became known that

.../...

Table 12. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Vyth *et al.* (2009) *(cont.)*			governmental and scientific authorities supported it. Elderly respondents indicated that they needed a logo due to health concerns. Consumers interested in health reported that they used the logo.
Malam *et al.* (2009)	Nationally representative survey in the UK with 2932 shoppers; 113 accompanied shops; 56 in-store and 56 in-home bag audits.	Survey, accompanied shops, and in-store and in-home bag audits to identify consumer characteristics and reasons for FOP label use.	When FOP labels were used, this tended to be because of medical conditions, weight loss, or being generally health conscious (including buying food for children), with shoppers using the labels to evaluate the healthfulness of individual products, and (more commonly) to compare the healthfulness of two or more different products.

It is worth noting that several studies question the validity of self-reported attention data. For example eye-tracking data suggests that nutrition information is not processed further and little attention is actually paid to it [Cowburn & Stockley, 2005; Graham & Jeffery, 2012; Storcksdieck genannt Bonsmann & Wills, 2012]. Instead, consumers may base judgements of the healthfulness of food products on food categories, brand, or familiarity with the product [Orquin, 2014] as well as on package (bottle) design [Reis *et al.*, 2016].

However, in-aisle signposting or the provision of an information leaflet to highlight the presence of FOP labelling and explain how it works can greatly improve attention [Graham *et al.*, 2015; Julia *et al.*, 2016*a*].

4.3. Evidence on consumer preferences and acceptance regarding FOP nutrition labels

Whether a FOP nutrition label gets the attention of consumers and manages to convey information adequately is partly determined by consumer preferences for and acceptance of FOP nutrition labels. If consumers are sceptical of food labels, they will be negatively affected by them. *Table 13* lists studies on consumer appreciation of FOP nutrition labelling. Measures typically include self-reported liking of, need for, or willingness to pay for FOP labelling.

Table 13. *Studies of consumer appreciation of FOP nutrition labelling.*

Study (most recent first)	**Population**	**Intervention/Comparator**	**Outcome**
Talati *et al.* (2017*a*)	2069 adults and children aged 10+ years in Australia.	Online discrete choice task involving mock food packages. A 4 food type (cookies, corn flakes, pizza, yogurt) × 2 front-of-pack label presence (present, absent) × 3 FOP label type (Daily Intake Guide, Multiple Traffic Lights, Health Star Rating) × 3 price (cheap, moderate, expensive) × 3 healthfulness (less healthful, moderately healthful, more healthful) design was used. A 30 s time limit was imposed for each choice.	Health Star Rating increased willingness to pay for more healthful foods while decreasing it for less healthful foods. The Multiple Traffic Lights had some impact on willingness to pay (specifically for foods at either end of the healthfulness spectrum), while the Daily Intake Guide had no impact on this variable.
Fenko *et al.* (2016)	209 Dutch students aged 18-29 years (134 female).	Laboratory experiment with two between-subject factors (labels and presentation conditions) and one within-subject factor (a product). The label manipulation included: (1) Smart Choice health label; (2) hedonic label; and (3) control condition without a label.	Participants were more sceptical of 'hedonic labels' by producers (*i.e.* labels that highlight some attributes of the product like taste) than of health labels by third-party organisations.

Table 13. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Leek *et al.* (2015)	30 adults (18 female, 12 male), average age 31 years (female) and 32 years (male) in the UK.	Face-to-face, semi-structured interviews within which three ready meal comparisons were performed using a think aloud technique.	Almost all (93%) participants mentioned the importance of FOP labels in conveying simpler information and allowing better informed dietary choices.
Gregori *et al.* (2015) Gregori *et al.* (2014)	7550 adults (18+, 71.2% females) in 16 European countries: Austria, Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Poland, Portugal, Czech Republic, Slovenia, Spain, Sweden, United Kingdom and Hungary.	Phone-assisted survey to gather people's opinion on nutritional information provided at different levels, from the media to public institutions, and their commitment to healthy behaviour. The value of food package labelling was estimated using a willingness-to-pay elicitation technique.	Higher willingness to pay for products providing food labelling (not specific to FOP labelling) was noted across all countries. Such labelling was particularly valued by older age groups (>45 years old), members of a larger family, people of low income or low education, and those who perceived themselves to be obese. However, on a scale of 1 (low) to 5 (high), respondents expressed their preference for FOP nutrition labelling to be rather low (2.09).
Clare & Burghardt (2014)	Convenience sample of twenty 18-29 year old female US college students.	Focus group study to determine what food label designs are most appealing to consumers and label modifications that would be most effective in encouraging better nutritional choices.	Having FOP labels was not as important as improving the information on the current nutrition facts panel.
Vyth *et al.* (2009)	Quantitative survey with over 1000 participants in the Netherlands (>80% female), mean age 46.4+/-13.2 years, mean BMI 25.6+/-5.1 kg/m². Focus group with 41 consumers (16 men, 25 women), mean age 46 years (range .../...	Online questionnaire 4 months after introduction of the Choices logo and 1 year later. Respondents were asked if they were familiar with the logo or not and had to indicate the following on 5-point scales: perceived need for a logo; attention paid to or products bought with the logo; .../...	The mean score for self-reported need for a logo was 3.67 after 4 months and 3.44 after one year (which is above the indifference score of 2.5). Older adults reported a higher need for the logo than did younger respondents in the quantitative study. Respondents with obesity (BMI ≥30 kg/m²) agreed more strongly to be in need of a logo than respond- .../...

Table 13. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Vyth *et al.* (2009) *(cont.)*	20-83), mean BMI 23 kg/m² (range 17.7–27.7).	agreement that the logo was attractive, eye-catching, useful, and credible. Same concepts that were measured in the quantitative study were discussed in the focus groups, with the addition of comprehension.	ents of normal weight (BMI <25 kg/m²). In the focus group, participants said they needed a nutrition logo because of diet-related health problems. The explanation given against a nutrition logo was the overwhelming number of quality logos already in use, such as health, safety, organic, and ecological logos.
Kelly *et al.* (2009)	790 adults (≥18 years, 68% female) living in New South Wales, Australia, who had the primary or shared responsibility for grocery purchases for their household.	Survey to assess consumers' preferences and ability to compare the healthfulness of mock food products using four different FOP labelling schemes: % Daily Intake (monochrome and colour-coded versions), Multiple-Traffic-Lights scheme with and without summary Traffic Light.	Strong support for the inclusion of nutrient information on total fat, saturated fat, sugar, and sodium on the front of packages, and a consistent labelling format across all products.
Drichoutis *et al.* (2009)	Groups of 12-17 graduate and undergraduate students at the Agricultural University of Athens in Greece.	Experimental auction to elicit students' willingness to pay for products with different types of nutrition labelling (European Union-endorsed nutrition declaration, traffic-lights label, US government-endorsed nutrition facts panel).	Students were willing to pay more for products with a European Union-endorsed label or a traffic-lights label than a US government-endorsed label or products that were unlabelled.
van Kleef *et al.* (2008)	12 groups of 8-10 participants each in Germany, the Netherlands, France, and the UK.	Focus group discussions on the appeal and information value of eight variants of FOP calorie flags.	Participants were generally positive about FOP labels, especially when labels are uniform across products.

Just because a label is accepted, does not mean it will be effective. For example, in the studies by Ducrot *et al.* (2015*a*) and Gregori *et al.* (2014) (see *Table 16* and *Table 17*, respectively) the label that was most accepted differed from the one that led to the best understanding. However, if labels are not accepted, their message may be ignored even though they are noticed. Therefore, FOP scheme acceptance is a very relevant dimension to consider. The literature can be divided into those studies that examine isolated characteristics of individual FOP schemes and those that make comparisons between specific FOP schemes.

4.3.1. FOP label characteristics related to consumer preference

This section reports evidence of how specific characteristics of FOP schemes, such as the use of colours or wording, or the degree of directiveness may be linked to consumer preferences for a given scheme. For example, consumers tend to prefer FOP schemes that use colours, typically indicating nutrient levels or overall nutritional quality (referred to as semantic colours) (*Table 14*).

Table 14. *Studies of consumer preferences regarding the use of (semantic) colours in FOP nutrition labelling schemes.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
De la Cruz-Góngora *et al.* (2017)	135 adults (96% females) in Mexico, divided into 18 groups.	Focus group discussions to assess understanding and acceptability of four FOP schemes: Health logos (heart, tick, human figure, wind spinner), Rating Stars, GDA, and Multiple Traffic Lights. 16 generic breakfast cereal boxes designed for this study (four for each FOP scheme), varying in their nutritional value, were shown and participants asked to choose out of the four cereal boxes the one that best communicated the product healthfulness.	Participants liked and appreciated the use of traffic-light colours (yet showed some confusion, especially in relation to the colour amber and when faced with healthfulness assessments based on mixed traffic lights).

Table 14. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Babio *et al.* (2014)	81 adolescents (14-16 years) from a secondary school in Spain.	Randomized crossover study designed to compare two simplified FOP nutrition labels, namely monochrome and colour-coded GDA.	Around 90% of respondents preferred a Multiple traffic-lights GDA label to monochrome GDA because it was perceived as more friendly and understandable; less than 3% preferred the monochrome scheme.
Savoie *et al.* (2013)	2200 adults (65% females) in Canada.	Nationally representative questionnaire survey to assess how visually appealing participants rated the Nutrition Facts table and four FOP labelling schemes (GDA, Multiple Traffic Lights, NuVal®[27] and My-5®[28]).	FOP schemes using colour were considered more visually appealing than black-and-white schemes.
Malam *et al.* (2009)	Nationally representative survey in the UK with 2932 shoppers; 113 accompanied shops; 56 in-store and 56 in-home bag audits.	Nationally representative questionnaire survey to identify the characteristics of a FOP scheme that enables consumers to make informed choices in relation to fat, saturated fat, salt, sugars and calories (where provided). Colour coding, text, and % daily intake information as well as different label shapes/designs were tested.	For shoppers who were familiar with FOP labels, the traffic-lights labels were thought to be particularly useful as a 'quick guide' to nutrient levels in products, as the colours gave an instant indication of the healthfulness of items even whilst they were on the supermarket shelves.
Kim & Kim (2009)	1019 participants aged 20-49 years in Korea.	Nationwide survey with face-to-face interviews including questions on FOP nutrition labelling such as: necessity for FOP nutrition labelling; number and type of nutrients .../...	Around 90% of survey respondents thought it important or necessary to include Traffic Lights colour coding in the FOP nutrition information.

27. NuVal is a shelf-labelling scheme in the US, which rates foods on their nutritional composition from 1 (worst) to 100 (best), considering both positive and negative nutrients.
28. My-5 is an experimental FOP scheme that rates foods on their nutritional composition from 1 (worst) to 5 (best), considering both positive and negative nutrients.

Table 14. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Kim & Kim (2009) *(cont.)*		appropriate for FOP labelling; necessity for labelling % daily value; unit for FOP nutrition labelling; necessity for colour difference according to nutrient contents; and labelling method.	
Gorton *et al.* (2009)	1525 ethnically diverse consumers (mean age 41; 72% females) in New Zealand.	Face-to-face survey with questions to assess nutrition label use, understanding of the mandatory Nutrition Information Panel, and preference for and understanding of three FOP schemes (Multiple Traffic Lights, Simple Traffic Lights, % Daily Intake) and the nutrition information panel.	Of the four label formats tested, Multiple Traffic Lights were most frequently preferred (and best understood together with Simple Traffic Lights).

Another characteristic is the level of directiveness of FOP schemes, *i.e.* to what extent the label already evaluates for the consumer whether the product is nutritious or not. Some consumers might like directive labels because they allow for a quick decision. Others may react negatively to being told something is 'healthful' in the absence of any nutritional information [Grunert & Wills, 2007]. Hodgkins *et al.* (2012) argue that classifying FOP schemes according to their directiveness leads to a better understanding of why some labels might be more effective than others in particular situations or for particular consumers; they propose that schemes combining both directive and non-directive elements can be an effective format. Studies of consumer preferences for FOP schemes differing in directiveness and complexity are listed in *Table 15*. The very limited evidence, mostly from focus group discussions, supports the notion that consumers prefer (simple) evaluative over reductive FOP schemes.

Table 15. *Studies of consumer preferences regarding directiveness and complexity of FOP nutrition labelling schemes.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
De la Cruz-Góngora *et al.* (2017)	135 adults in Mexico, divided into 18 groups.	Focus group discussions to assess understanding and acceptability of four FOP schemes: Health logos (heart, tick, human figure, wind spinner), Rating Stars, GDA, and Multiple Traffic Lights. 16 generic breakfast cereal boxes designed for this study (four for each FOP scheme), varying in their nutritional value, were shown and participants asked to choose out of the four cereal boxes the one that best communicated the product healthfulness.	Participants liked and appreciated the health logos and Multiple Traffic Lights, whereas Ratings Stars and particularly the GDA label were not liked. Rating Stars were considered commercial and overused, and the GDA scheme as technical and complicated.
Talati *et al.* (2016c)	50 adults and 35 children aged 10-17 years in Australia, divided into ten groups.	Focus group discussions in which participants were shown the three FOP schemes Daily Intake Guide, Multiple Traffic Lights, and Health Star Rating. The FOP schemes were projected onscreen and distributed on large printouts in the order that reflected likely levels of prior exposure.	The two evaluative FOP schemes Multiple Traffic Lights and Health Star Rating were preferred over the reductive Daily Intake Guide.[8] The two main considerations were trust and ease of interpretation. The FOP schemes were also more likely to be considered in the product evaluation than health claims (this was especially true of the Health Star Rating and Multiple-Traffic-Lights labels). Of the two evaluative FOP schemes, participants preferred the one with the summary indicator (namely the Health Star Rating).

Table 15. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Miklavec *et al.* (2016)	1050 adults (49% women) in Slovenia.	Online questionnaire with incorporated word-association tasks and conjoint analysis to examine familiarity with and perception of the Protective Food symbol ('Little Heart' sign) in Slovenia and to investigate consumers' associations related to the symbol, and the influence of symbol appearance on their preferences.	Inclusion of a clear, short statement about the meaning of the FOP health logo substantially helped consumers appreciate the logo.
van Kleef *et al.* (2008)	12 groups of 8-10 participants each, in Germany, the Netherlands, France, and the UK.	Focus group discussions on the appeal and information value of eight variants of FOP calorie flags.	Participants preferred simple FOP nutrition information that is substantiated and detailed on the back of the pack. Calorie labelling was well understood and participants were generally positive about FOP labelling, especially when it is uniform across products. The most liked FOP schemes were the simpler ones, depicting only the number of calories per serving or per 100 g. The more complex FOP schemes including references to daily needs or exercise and a phrase referring to balanced lifestyle were the least preferred.

Temple & Fraser (2014) are among those pointing out that for FOP labels to be effective they should be simple and use colour coding, complemented with an accessibly structured nutrition declaration on the back of the pack for those wishing to obtain detailed numerical information. Furthermore, they recommend adding a summary traffic light for an overall evaluation of a product's nutritional value.

4.3.2. Consumer acceptance of specific FOP labelling schemes

When comparing the different FOP schemes with regard to acceptance, different studies show a preference for different schemes, due perhaps to the specific characteristics of the labels being studied or to cultural differences (*Table 16*). This variance highlights the need to test the FOP schemes in different countries and cultural groups.

Table 16. *Studies of consumer preferences for specific FOP nutrition labelling schemes.*

Study (most recent first)	**Population**	**Intervention/Comparator**	**Outcome**
Julia *et al.* (2017)	Subset of 21702 adults from the French NutriNet-Santé cohort.	Questionnaire on the perceptions of the four FOP schemes Nutri-Score, SENS, UK MTL, and modified Reference Intakes.[29]	The Nutri-Score was the most preferred FOP scheme, followed by Multiple Traffic Lights and the SENS scheme. Conversely, the modified Reference Intakes yielded the highest number of responses on negative dimensions of perception (complexity and time processing).
De la Cruz-Góngora *et al.* (2017)	135 adults in Mexico, divided into 18 groups.	Focus group discussions to assess understanding and acceptability of four FOP schemes: Health logos (heart, tick, human figure, wind spinner), Rating Stars, GDA, and Multiple Traffic Lights. 16 generic breakfast cereal boxes designed for this study (four for each FOP scheme), varying in their nutritional value, were shown and participants asked to choose out of the four cereal boxes the one that best communicated the product healthfulness.	Results showed that health logos were easy to understand, highly accepted, and useful for making decisions. Moreover, the logo was designed as endorsed by a credible institution, which gave the consumers greater confidence. GDA and Rating Stars came out as the least accepted FOP schemes.

29. In the modified Reference Intakes scheme, percentages are visualised with columns of proportional height.

Table 16. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Pettigrew *et al.* (2017)	2058 consumers (1558 adults and 500 children) in Australia.	Survey asking consumers to self-nominate the evaluation criteria they considered to be most important in choosing between FOP schemes Daily Intake Guide, Multiple Traffic Lights, and Health Star Rating.	Across the whole sample and among all respondent subgroups (males *vs.* females; adults *vs.* children; lower socio-economic status *vs.* medium-high socio-economic status; normal weight *vs.*overweight/obese), the Health Star Rating was the most preferred FOP scheme (44%) and the Daily Intake Guide was the least preferred (20%). Reasons related to ease of use, evaluative content, and salience.
Ducrot *et al.* (2015*a*)	Subset of 13578 participants from the French NutriNet-Santé cohort.	Survey to test consumer acceptance of four FOP labels: GDA, Multiple Traffic Lights, an early version of the Nutri-Score, the Green Tick, and a 'no label' condition. Acceptability was evaluated by several indicators: attractiveness, liking and perceived cognitive workload.	The GDA label was rated as the most attractive and liked label (yet it was rated not easy to identify and understand). The Nutri-Score label, in turn, was rated as the easiest to identify and to understand rapidly.
Mejean *et al.* (2013)	Subset of 39370 participants from the French NutriNet-Santé cohort.	Survey to test acceptance of the Green Tick, the logo of the French Nutrition and Health Programme (PNNS logo), Multiple Traffic Lights, a Simple Traffic Light[30] label, and a 'colour range' logo.	The Multiple Traffic Lights fared best in terms of self-reported liking, acceptance, and attractiveness, although Simple Traffic Light and Green Tick (and to some extent the PNNS logo) also scored well on liking and several dimensions of attractiveness.

30. Whereas Multiple-Traffic-Lights labels show a combination of colour codes for different nutrients, the Simple-Traffic-Light label provides an overall rating of the food in the form of a single traffic light.

Table 16. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Savoie *et al.* (2013)	2200 subjects in Canada.	Questionnaire to assess how participants rated the Nutrition Facts table and four FOP labelling schemes (GDA, Multiple Traffic Lights, NuVal®[27] and My-5®[28]) on: i) ease of understanding; ii) level of detail; iii) ease of finding info; iv) trustworthiness; and v) visual appeal. The control condition was a nutrition facts table.	Respondents preferred the two nutrient-specific schemes (Multiple Traffic Lights and GDA) to the two summary indicator schemes. The Multiple-Traffic-Lights and GDA labels were rated similar to the nutrition facts table in terms of level of detail and ease of finding information, but they were considered more visually appealing and tended to be preferred by most consumers. Respondents indicated that all four systems did not provide enough information, and this was especially so with the two summary indicator systems.
Hieke & Wilczynski (2012)	2002 undergraduate students (69% females; 70% 18-34 years) in Germany.	In an online survey, respondents rated the understandability of the Multiple-Traffic-Lights signposting scheme.	Participants rated the understandability of the traffic-lights scheme as high (5.9 out of 7).
Feunekes *et al.* (2008)	1630 adults from the UK, Germany, Italy and the Netherlands for study 1 and 776 in Italy and the UK for study 2.	Two industry-funded surveys to evaluate different FOP labels (Healthier choice tick, Health Protection Factor, Stars, Smileys; Multiple Traffic Lights, Wheel of health) for 'consumer-friendliness' (measured as understanding, liking, and credibility).	No large differences between the different formats, with the exception of the Health Protection Factor (a numerical summary score), which scored lowest.

Summing up the evidence on consumer preferences regarding FOP labelling, **a majority of people seem to appreciate the provision of FOP information** over and above the mandatory nutrition declaration. **Evaluative FOP schemes tend to do well in assessments of consumer liking.** Earlier reviews concluded that

consumers find traditional nutrition information on the back or side of the package difficult to interpret, especially when many numerical and technical details are included, and prefer labels with minimal numerical content and using graphics and symbols [Campos *et al.*, 2011; Cowburn & Stockley, 2005; Health Council of the Netherlands, 2008]. Mandle *et al.* (2015) reviewed the evidence on nutritional labelling research in 20 countries in Asia, Africa, the Middle East, and Latin America, and they also concluded that consumers preferred clear, easily visible, standardised labels which used symbols or pictures. However, as noted by Malam *et al.* (2009), self-reported preference is poorly related to actual, objectively measured understanding of a specific FOP scheme.

4.4. Evidence on consumer understanding of FOP nutrition labels

An essential condition for nutrition labels to have any effect is that consumers must be exposed to and aware of them. Exposure, however, does not imply effectiveness as the effect will be mediated by consumer understanding which, in turn, will be affected by consumers' nutrition knowledge [Grunert *et al.*, 2010*b*]. Usually authors differentiate between conceptual and substantive understanding. The former refers to consumers' ability to understand the general concept behind a specific FOP scheme and the meaning of specific codes and/or colours, while the latter refers to whether respondents interpret the information on the label correctly.

Substantial research efforts have been dedicated to testing people's comprehension of different FOP schemes. This is typically done by asking people to rank a given set of products by overall healthfulness or to identify the product highest or lowest in a given nutrient. Some of the studies focus on specific characteristics of FOP labels (see *section 4.4.1*) whereas others make direct comparisons between FOP labelling schemes (see *section 4.4.2*).

4.4.1. Effects of different FOP label characteristics on consumer understanding

In addition to affecting people's attention to and liking of FOP schemes, specific labelling scheme characteristics may also influence how well people objectively understand and are able to use a given type of FOP scheme correctly. The refer-

ence unit on which the nutritional information is based (*e.g.* 'per 100 g', 'per portion', 'per 100 kcal') is one such characteristic and its impact usually depends on the task to be completed (*Table 17*).

Table 17. *Studies of the impact of specific reference bases on consumer understanding of FOP nutrition labelling.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Raats *et al.* (2015)	13 117 participants (online panels) from six European countries: Germany, UK, Spain, France, Poland, and Sweden.	Online survey of how different reference amounts ('per 100 g', 'typical portion', 'half of typical portion') influenced evaluation of product healthfulness across three product categories (biscuits, sandwiches, yogurts). Following a review of the 'typical' portion sizes on the market for each of the three chosen food categories, a standardised 'typical portion' was set for each of the three food categories: biscuits 18 g, sandwiches 250 g and yogurts 150 g. The 'per 100 g' label was included as a comparator between the foods. Additionally, the impact of including GDA percentages was tested.	Overall, people correctly ranked foods according to their objective healthfulness as defined by nutrients to limit alone and could distinguish between more and less healthful variants of foods. This was the case both when seeing the nutrition label in absolute values and with additional GDA labelling. In other words, participants did factor the reference amount for which the nutritional information was being presented into their judgements of healthfulness. However, when the reference amount of 'per 100 g' was very different from the 'typical' portion size, products with a 'per 100 g' label were rated significantly less healthful than the 'typical' or 'half typical' portions.
Gregori *et al.* (2014)	7550 adults (18+, 71.2% females) in 16 European Countries: Austria, Belgium, Denmark, France, .../...	Telephone survey of understanding of nutrition labels, specifically the GDA scheme and the BOP nutrition declaration. Consumers were asked about their opinion .../...	When assessing the energy per quantity of the product, participants understood best when the indication was given 'per 100 g'. .../...

Table 17. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Gregori *et al.* (2014) *(cont.)*	Germany, Greece, Italy, the Netherlands, Poland, Portugal, Czech Republic, Slovenia, Spain, Sweden, United Kingdom and Hungary.	on nutrition information, assessing habitual use and understanding of labels, giving moreover a judgement on their perceived usefulness.	However, when it came to their preferences, in 70% of the cases they opted for the 'per portion' indications (even though there is currently a lack of a standardised definition of what a portion is).
Vanderlee *et al.* (2012)	National sample of 687 Canadian adults.	Online survey in which participants had to indicate the calories contained in a bottle of soft drink in one of four labelling conditions: 1) a 591 ml bottle with FOP calorie information *per serving*; 2) a 591 ml bottle with FOP calorie information *per container*; 3) a 591 ml bottle with the Nutrition Facts Table *per serving*; and 4) a 591 ml bottle with the Nutrition Facts Table *per container*.	Consumers were better able to indicate correctly the calories in a bottle of soft drink when the label provided that information per container rather than per serving. The authors surmise that poor numeracy skills may partly explain why consumers struggled when mental maths were needed to get to the correct answer.

The way in which the benefits of nutritious foods (or the risks of foods of poor nutritional value) are framed has also been tested in FOP nutrition labelling research. Health messages can be framed in a way that highlights either the benefits of some actions (a gain frame) or negative consequences of not taking that action (a loss frame). For example, informing consumers of the health benefits of consuming food that is more nutritious would be a gain-framed message, while informing consumers of the negative health consequences of failing to consume nutritious food would be a loss-framed message. Lundeberg *et al.* (2018) examined whether information provided in a gain frame, a loss frame, or in a frame combining both, allowed consumers to better distinguish between more and less nutritious choices than when no framing was present. Any frame was better than none, but no particular frame was better than the others were.

Colour coding seems to help consumers understand labels (*Table 18*), although there are indications that consumers can get confused when they have to integrate a mix of greens, ambers, and reds on the same label.

Table 18. *Studies of the impact of colour coding on consumer understanding of FOP nutrition labelling.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Enax, Krajbich, & Weber (2016)	44 subjects, mean age = 23.72, SD = 4.4) in Germany.	Binary decision task between healthful and unhealthful products along with two different nutrition labels, monochrome and colour-coded GDA. A set of 50 healthy and 50 unhealthy packaged products were obtained from the internet and presented on a black background. Nutrition labels were taken from the producer's nutrition information for the product and included sugar, fat, saturated fat, salt, and calories.	The percentage of healthful food choices increased when a product was labelled with a colour-coded label instead of a purely numeric label.
Siegrist *et al.* (2015)	98 participants (aged 16-74; 69% females) in Switzerland.	Eye tracking study in which participants were asked to evaluate the healthfulness of five single foods from different food categories (pretzels, cereals, hazelnut yogurt, milk chocolate, soft drinks) in the presence of the standard nutrition declaration, the GDA scheme, or the Multiple-Traffic-Lights scheme.	Participants needed more time to process the GDA label in comparison to the traffic-light label and the nutrition table. Moreover, participants processed the Multiple Traffic Lights more efficiently than the nutrition table.
Antúnez *et al.* (2015)	Visual search task: 10 people (70% females; aged 23-48 years) in Uruguay. Eye-tracking study: 54 people (53% females; aged 18-60 years) in Uruguay.	Visual search task and eye-tracking study of consumer attention and understanding regarding monochrome and colour-coded GDA labels on mayonnaise packages. Two independent variables .../...	When the labels had no colour and no text descriptors, participants spent more time looking at the labels. When the nutrient level was indicated using .../...

Table 18. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Antúnez *et al.* (2015) *(cont.)*		were considered for mayonnaise label design: fat content and type of FOP label. Two levels (medium and high) were considered for fat content, which was reflected in the relevant values, percentages, and colour coding (yellow *vs.* red) of the FOP labels.	colour coding and text descriptors, people got the least amount of incorrect answers. Colour codes and text descriptors used in combination were the most effective option to increase (attention and) understanding of nutritional information. The findings are similar to those of Malam *et al.* (2009).
Hieke & Wilczynski (2012)	2002 undergraduate students (69% females; 70% 18-34 years) in Germany.	In a conjoint experiment, respondents had to indicate which products they would select as the most healthful of the presented products, based on the nutritive information provided by the Multiple-Traffic-Lights scheme.	40% of respondents indicated Traffic Lights colour coding as the most important element in their product evaluation. Interestingly, participants placed greater emphasis on a change in a product's nutrient characteristic from 'amber' to 'red' compared with a change from 'green' to 'amber', a finding also observed by others [Balcombe *et al.*, 2010; Scarborough *et al.*, 2015].
Malam *et al.* (2009)	Nationally representative survey in the UK with 2932 shoppers, 113 accompanied shops, 56 in-store, and 56 in-home bag audits.	Questionnaire to identify the characteristics of a FOP scheme that enables consumers to make informed choices in relation to fat, saturated fat, salt, sugars and calories (where provided). Colour coding, text, and % daily intake information as well as different label shapes/designs were tested.	Traffic Lights colour coding significantly improved FOP label comprehension, especially when paired with text (high, medium, low) or text + GDA.

Another characteristic that has been explored is the simplicity of labels, and the general conclusion is that **short, simple labels achieve the best objective understanding**. Feunekes *et al.* (2008) found that consumers could evaluate the simpler labels much faster than the complex labels; they concluded that simpler labels are more appropriate in a shopping environment where quick decisions are made. Recent studies on the Nutri-Score, Health Star Rating, warning labels, and SENS lend further support to the benefit of simplified evaluative schemes [Arrúa *et al.*, 2017*b*; Ducrot *et al.*, 2015*a*; Ducrot *et al.*, 2015*b*; Egnell *et al.*, 2018*a*; Ni Mhurchu *et al.*, 2017*b*; Talati *et al.*, 2017*b*] (see *section 4.4.2*).

4.4.2. Consumer understanding of specific FOP labelling schemes

A number of studies have sought to compare directly specific FOP labelling schemes, usually including a traffic-lights scheme. The results have been mixed in terms of comprehension of the labels, although there is significant support for colour-coded schemes. Recent studies [Egnell *et al.*, 2018*a*; Egnell *et al.*, 2018*c*] further show that the combination of a colour-coded format with a graded indicator seems also effective in improving consumers' objective understanding of the nutritional quality of food.

The traffic-lights scheme and the Nutri-Score generally seem to lead to a high level of understanding and this is probably because the colour coding and grading reduce the complexity of decision-making.

Table 19. *Studies of consumer understanding of FOP nutrition labelling schemes.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Egnell, *et al.* (2018*c*)	12 015 consumers from twelve countries.[31]	Product healthfulness ranking study to test participants' objective understanding of Multiple Traffic Lights, Reference Intakes, octagonal black warning …/…	All five FOP schemes improved the number of correct responses over the 'no label' condition. Improvements were most pronounced for the Nutri-Score, followed by Multiple Traffic …/…

31. Nationally representative samples recruited in Argentina, Australia, Bulgaria, Canada, Denmark, France, Germany, Mexico, Singapore, Spain, USA, and UK.

Table 19. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Egnell, *et al.* (2018*c*) *(cont.)*		labels, Nutri-Score, and Health Star Rating compared to a no label situation. Participants had to rank three products from the three categories of breakfast cereals, cakes, and pizzas.	Lights, then Health Star Rating and warning signs with almost equal effect, and finally the Reference Intakes. When analyses included only participants reporting to have seen the label during the survey, the Nutri-Score and the warning sign resulted in the highest level of improvement compared to the Reference Intakes label. Trends were similar for individual product categories and all products together.
Egnell *et al.* (2018*a*)	Subset of 3751 adults from the French NutriNet-Santé cohort.	Product healthfulness ranking exercise to test objective understanding of the Nutri-Score, Multiple Traffic Lights, a modified Reference Intakes scheme,[28] and the SENS scheme.	The Nutri-Score performed best, increasing the odds for ranking three products correctly by their nutritional quality by a factor of 20.33 compared to a 'no label' control. SENS was the next best scheme (9.57), followed by Multiple Traffic Lights (3.55), and finally the modified Reference Intakes (1.53).
Talati *et al.* (2017*b*)	2058 subjects (50% females; 25% children 10-17 years) in Australia.	Survey in which consumers rated product healthfulness from mock food pack images that varied according to: nutritional profile (healthful, moderately healthful, unhealthful); FOP scheme (Daily Intake Guide, Multiple Traffic Lights, Health Star Rating, or control); and food type (cookies, cornflakes, pizza, yogurt).	Only the Health Star Rating helped discriminate healthful and moderately healthful from unhealthful products in the four categories. The Multiple-Traffic-Lights scheme was only marginally effective (P=0.052), and only for distinguishing healthful from unhealthful products, whereas the Daily Intake Guide label did not differ from the 'no FOP label' control.
Arrúa *et al.* (2017*b*)	387 participants in Uruguay.	Comparative analysis of the impact of nutritional respect to two alternative .../...	Compared to the GDA scheme, warning signs and traffic lights improved consumers' ability to .../...

Table 19. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Arrúa *et al.* (2017*b*) *(cont.)*		FOP nutritional labelling schemes (GDA and Traffic Lights), with a focus on attention, perceived healthfulness and users' ability to differentiate products.	correctly identify a product with high content of a key nutrient to limit.
Defago *et al.* (2017)	60 university students in Peru.	Theoretical choice experiment to identify the impact of Multiple-Traffic-Lights labels on consumers' ability to identify the most healthful option each out of four soft drinks and four packs of crackers. First only images of the products were shown, then only nutrition labels (standard table or standard table plus Multiple Traffic Lights). Both categories comprised products with similar prices but different nutritional quality.	Multiple-Traffic-Lights labelling, notably with four instead of three colour levels, more than doubled the accuracy of choosing the most healthful product when compared to the standard nutrition table.
Crosetto *et al.* (2016)	Study 1: 86 subjects (47 students and 39 participants from the general public) in Grenoble, France. Study 2: 174 participants from the general public in Grenoble, France.	Lab-based menu-building task with the aim to satisfy 1, 4, or 7 predetermined nutritional criteria, comparing GDA, Traffic Lights, and traffic-lights-coded GDA with and without a time constraint. Participants received a show-up fee of €10. On top of this amount, participants could earn additional money by cor rectly performing the tasks. Par ticipants were faced with up to 15 choice screens. For each task that they completed successfully, subjects earned €1.5-2.5.	The GDA scheme performed best compared to Traffic Lights and a GDA-Traffic-Lights combination when there was no time constraint and study participants were allowed pen and paper to make the necessary calculations. However, upon applying a 2-minute time constraint and not allowing pen and paper, the traffic-lights-coded schemes gained in performance to the extent that GDA was no longer better. The absence of a benefit of GDA over traffic-lights-based schemes in a task playing to the strengths of the GDA scheme in .../...

Table 19. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Crosetto *et al.* (2016) *(cont.)*			dicates that GDA labelling 'might only do worse in the case of real purchases, in which consumers are severely bounded in time, attention, focus, and budget'.
Ducrot *et al.* (2015*b*)	Subset of 14 230 adult respondents from the French NutriNet-Santé cohort.	Online survey to compare consumers' healthfulness ranking accuracy using one of four FOP schemes compared to a 'no label' control: GDA, Multiple Traffic Lights, an early version of the Nutri-Score, and a Green Tick logo.	All labels were found to be effective in allowing consumers to identify more healthful products compared to a 'no label' situation. The Nutri-Score performed best (Odds Ratio (OR) 12.61), followed by Multiple Traffic Lights (OR 8.71), GDA (OR 7.74), and the Green Tick (OR 2.36). These findings did not vary across socio-demographic characteristics.
Ducrot *et al.* (2015*a*)	Subset of 13 578 participants from the French NutriNet-Santé cohort.	Survey to test consumers' objective understanding of four FOP labels: GDA, Multiple Traffic Lights, an early version of the Nutri-Score, the Green Tick, and a 'no-label' condition. Objective understanding was assessed by the percentage of correct answers when ranking three products according to their nutritional quality. Five different product categories were tested: prepared fish dishes, pizzas, dairy products, breakfast cereals, and appetizers.	Compared to the 'no-label" control", all FOP schemes produced significantly higher percentages of correct product rankings (except the Tick, which was not differed from control in two product categories). The Nutri-Score yielded the highest percentages of correctly ranked products across all five categories (jointly with Multiple Traffic Lights in two categories, and with GDA in another). The Nutri-Score fared best across gender, age groups, occupational category and education levels, and it took participants the least time and effort to understand.
Soederberg Miller *et al.* (2015)	345 (eye-tracking) and 387 (healthfulness judgement accuracy) .../...	Laboratory experimental study to assess participants' healthfulness judge- .../...	The Facts-Up-Front scheme resulted in poor healthfulness judgement accuracy of pairs of .../...

Table 19. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Soederberg Miller *et al.* (2015) *(cont.)*	participants (60% females) in the USA.	ment accuracy of pairs of more and less healthful cereals or frozen entrees using a Facts-Up-Front label. For breakfast cereals, the FOP label included calories, saturated fat, sugars, sodium, fibre, and vitamin D, and provided % Daily Value for some of them. For frozen entrees the label included calories, fat, and fibre quantities without % Daily Value information.	more and less healthful cereals but better accuracy regarding pairs of frozen entrees (relative to chance). Better nutrition knowledge was associated with greater healthfulness judgement accuracy, even when less attention was paid to FOP labels. Attention to some specific nutrients (calories, fat, and sodium) was negatively correlated with healthfulness judgement accuracy, with this effect being more marked for individuals with less nutrition knowledge. Of note, the less complex FOP label (for entrees) performed better than the more complex one (for breakfast cereals).
Kees, Royne, & Cho (2014)	Study 1: 177 adult parents (aged 19-60, 56% females) residing in the USA with at least one child under the age of 18 living in the household. Study 2: 238 adults (aged 18-72, 46% females) residing in the USA.	Participants rated different types of nutrition labelling on a four-colour mock picture of the front panel of a granola bar package. The label conditions were: i) BOP nutrition facts as control; ii) Facts-Up-Front long version; iii) Facts-Up-Front with Traffic Lights long version; iv) Facts-Up-Front short version; and v) Facts-Up-Front with Traffic Lights short version. Study 2 was similar to study 1 but included giving half the participants background information about the specific FOP scheme to evaluate (educational prime).	Higher ratings of attention, ease of use, nutrition information engagement, product evaluation, and purchase intention with Facts-Up-Front and traffic-lights-coded Facts-Up-Front compared to a no FOP label control (only offering BOP nutrition information). However, the traffic-lights-coding did not seem to provide any additional benefit, potentially due to lack of familiarity with traffic-lights labelling in the US. Educational priming helped equalise the results across all FOP label conditions and showed a particular beneficial effect for the traffic-lights-coded labels. It is also worth noting here that Hoefkens *et al.* (2011) reported a …/…

Table 19. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Kees, Royne, & Cho (2014) *(cont.)*			somewhat higher preference by European consumers for qualifying rather than disqualifying nutrients.
van Herpen, Hieke & van Trijp (2014)	Study 1: 533 participants (53% females; age range 15-70 years) in Germany. Study 2: 87 undergraduate and graduate students (77% females; average age 21 years) in The Netherlands.	Product healthfulness evaluation using different FOP schemes (Multiple Traffic Lights, GDA, and Smart Choices logo) and a nutrition declaration table. Assessments were made across different product categories and healthfulness levels, between products in the same category, and with or without comparison with another product.	The Multiple Traffic Lights helped respondents better distinguish more and less healthful products. Labelling schemes without reference point information (*e.g.* nutrition table) were found less easy to interpret when no comparison product was available, and the Smart Choices logo could reduce consumers' ability to compare categories, leading to a potential misinterpretation of product healthfulness. None of the labels affected food preferences.
Smith Edge *et al.* (2014)	Representative sample of 7363 men and women aged 18-70 years in the USA.	Online survey in which consumers were presented with either no FOP nutrition information or one of three versions of the Facts-Up-Front scheme: 1) only calories on the front of package; 2) calories and three nutrients to limit; and 3) calories and three nutrients to encourage.	The versions of the Facts-Up-Front scheme with more information generally enabled participants to better understand nutrient content of food products tested. These versions also enabled better interpretation of nutrition information on the products included in the survey.
Roberto *et al.* (2012*b*)	703 adults (53% females; mean age 46 years) in the USA.	In an online study, consumer understanding of the Facts-Up-Front scheme and the Multiple-Traffic-Lights scheme was compared. The study included a 'plus' (+) version of each scheme: the Multiple Traffic Lights+ version had additional …/…	All FOP scheme groups outperformed the control group on nearly all of the measures of understanding regarding a product's nutritional information. However, when compared with each other, those in the Multiple Traffic Lights+ condition performed better than those in the …/…

Table 19. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Roberto *et al.* (2012*b*) *(cont.)*		information about protein and fibre; the Facts-Up-Front+ version had information about which nutrients to encourage.	Facts-Up-Front conditions on measures of nutrition knowledge and label perceptions.
Roberto *et al.* (2012*c*)	480 adults (64% females; 18-76 years) in the USA.	Healthfulness ranking study in which participants had to identify the more healthful of 2 products and indicate calorie and nutrient contents. Prior to this task, participants viewed a public service advertisement on-line for one of five nutrition labelling conditions: Choices logo; Multiple Traffic Lights; Multiple Traffic Lights + daily calorie reference; Traffic Lights for excess nutrients; 'no label' control. Ads for participants in the 4 FOP label groups included instructions on how to interpret the labelling system.	Multiple Traffic Lights, Multiple Traffic Lights + daily calorie reference and the Choices symbol led to more correct healthfulness ratings than 'no label' control and Traffic Lights for excess nutrients. For calorie/nutrient-specific questions, all traffic-light schemes performed substantially better than the Choices logo and the 'no label' control.
Borgmeier & Westenhoefer (2009)	420 adults in Hamburg, Germany.	Healthfulness rating test in which participants had to identify the more healthful food items in 28 pair-wise comparisons of foods from different food groups. Subjects were exposed to one of five experimental conditions: 1) a simple 'healthy choice' tick; 2) a Multiple-Traffic-Lights label; 3) a monochrome GDA label; 4) a traffic-lights-coded GDA label; and 5) a 'no label' control.	Multiple Traffic Lights allowed consumers to better identify more healthful foods, compared to a simple 'healthy choice' tick, a monochrome and a traffic-lights-coded GDA label, and a 'no label' condition.

Table 19. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Gorton *et al.* (2009)	1525 ethnically diverse consumers in New Zealand.	Face-to-face survey with questions to assess nutrition label use, understanding of the mandatory Nutrition Information Panel, and preference for and understanding of three FOP schemes (Multiple Traffic Lights, Simple Traffic Lights, % Daily Intake) and the nutrition information panel.	The traffic-lights schemes were the best understood across all ethnic and income groups, compared to % Daily Intake labelling and the BOP nutrition information panel.
Kelly *et al.* (2009)	790 adults (≥18 years, 68% female) living in New South Wales, Australia, who had the primary or shared responsibility for grocery purchases for their household.	Consumers' preferences and ability to compare the healthfulness of mock food products were assessed for four FOP schemes: a monochrome Daily Intake Guide scheme; a colour coded Daily Intake Guide; and two variations of traffic-lights schemes (Traffic Light and Traffic Light + overall rating).	The variants of the traffic-lights labels increased the likelihood of consumers correctly identifying the more healthful food option (five-fold more than monochrome Daily Intake Guide label, and three-fold more than colour-coded Daily Intake Guide label). There were no differences in the number of correct responses between the monochrome and polychrome Daily Intake Guide labels. The traffic-lights scheme was particularly effective in identifying the more healthful option among consumers of lower socio-economic status.
Jones & Richardson (2007)	92 participants (73% females; mean age 31.5 years) in the UK.	Healthfulness rating paired with eye-tracking, comparing the following two label types: 1) standard nutrition declaration per 100 g and per serving; and 2) standard nutrition declaration plus fat, saturates, sugars and salt also being displayed as high/medium/low traffic-light symbols.	Traffic-lights labelling helped guide consumers' attention to the important nutrients and improved the accuracy of healthfulness ratings.

Close to the issue of comprehension is the issue of perceived healthfulness of food products, and it appears FOP schemes can modulate healthfulness perceptions (*Table 20*). The observations are difficult to interpret because not all studies include an objective measure of product healthfulness. Consequently, it is not always clear whether consumer inferences about product healthfulness improved or worsened in the presence of a FOP scheme.

Table 20. *Studies of (change in) perceived product healthfulness with different FOP nutrition labelling schemes.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Lundeberg *et al.* (2018)	306 undergraduate students enrolled in an introductory psychology course at a large western university in the USA.	Perceived healthfulness study that employed a 2 (FOP label) x 5 (message framing) design. Participants first read a public service announcement and then viewed ten food products displaying either star rating or calorie traffic-lights FOP labels.	Compared to the traffic-lights scheme, a star-based scheme led respondents to perceive healthful foods as even more healthful and unhealthful foods as even less healthful.
Ares *et al.* (2018)	112 participants (visual search task) and 892 participants (online survey) in Uruguay.	A between-subjects design was implemented to compare a control condition (without FOP nutrition information) and the three evaluative FOP schemes (warning label, Health Star Rating, Nutri-Score). In the visual search task, attention to and processing time for interpreting the FOP labels was assessed. The online survey tested the influence of the FOP labels on purchase intention and perceived healthfulness of a series of products.	Octagonal black warning labels significantly reduced the perceived healthfulness for five out of seven products, all objectively ranked as medium healthful (based on the nutrient profile model of the Pan-American Health Organization), with no impact on most or least healthful products. The Nutri-Score reduced perceived healthfulness for three products, and no impact was observed for the Health Star Rating scheme.

Table 20. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Carter & González-Vallejo (2018)	297 students (57% females; aged 18-25 years) in the USA.	Evaluation of nutrition labels of varying complexity in relation to nutrition judgment accuracy. Accuracy was assessed by comparing nutrition judgments to a nutrition expert criterion (NuVal®[26]) in three package labelling conditions: no nutritional information highlighted; nutrients highly related to nutritional quality highlighted using a Facts-Up-Front FOP label; and nutrients unrelated to nutritional quality highlighted using Facts-Up-Front.	No benefit of providing the Facts-Up-Front scheme over the classic nutrition facts panel in this student sample in terms of judgment accuracy, consistency of nutritional information usage, and food choice.
Machín *et al.* (2018)	1228 adults in Uruguay.	Healthfulness rating study of packaged bread, yogurt, and ham products labelled with Multiple Traffic Lights, Simple Traffic Lights, or black octagonal warning signs. None of the FOP labels contained any numerical information.	Respondents perceived products as rather unhealthful in the presence of the warning sign and a Simple-Traffic-Lights label only showing red for a single nutrient in excess (sodium for bread, fat for ham, and sugar for yogurt). When green colours were added to the Traffic Lights for one or two low-content nutrients, healthfulness ratings increased significantly.
Arrúa *et al.* (2017*b*)	387 participants in Uruguay.	Comparative analysis of the impact of nutritional warnings, with respect to two alternative FOP nutritional labelling schemes (GDA and Traffic Lights), with a focus on attention, perceived healthfulness and users' ability to differentiate products.	Significantly lower perceived healthfulness ratings were observed with the warning label compared to GDA and Traffic Lights across products.

Table 20. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Wang *et al.* (2016)	566 Norwegian adolescents.	Offline survey to assess whether information provided by the Keyhole symbol, a widely used FOP symbol in Nordic countries to indicate nutritional content, and % Daily Values affected Norwegian adolescents' perception of the healthfulness of snacks.	Keyhole labelling increased perceived healthfulness of snacks relative to % Daily Value and plain labels.
Siegrist *et al.* (2015)	98 participants (16-74 years; 69% females) in Switzerland.	Eye tracking study in which participants were asked to evaluate the healthfulness of five single foods from different food categories (pretzels, cereals, hazelnut yogurt, milk chocolate, soft drinks) in the presence of the standard nutrition declaration, the GDA scheme, or the Multiple traffic-lights scheme.	Whilst there was no overall difference in perceived healthfulness ratings between the different schemes, the GDA scheme resulted in significantly higher perceived healthfulness of cereals compared to Traffic Lights and the nutrition declaration. The eye-tracking data suggest that the participants needed more time to process the GDA label in comparison to the traffic-light label and the nutrition table. Moreover, participants processed the Multiple Traffic Lights more efficiently than the nutrition table.
Costanigro *et al.* (2015)	148 and 96 participants (72% females) in the USA.	Two computer-based choice experiments in which respondents were asked to choose what they believed to be the best and worst out of ten branded milk products[32] according …/…	The FOP summary score further increased participants' negative beliefs about whole fat and chocolate-flavoured milks and reduced the healthfulness belief about milks labelled as organic. Overall the effect of this FOP …/…

32. Additional nutritional information concerned the content of various nutrients, provided in the back-of-pack nutrition facts panel and as FOP nutrition claims. Additional environmental information concerned soy *vs.* cow's milk, organic *vs.* conventional production, local *vs.* non-local, and cardboard *vs.* plastic packaging.

Table 20. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Costanigro *et al.* (2015) *(cont.)*		to their nutritional and environmental quality. A FOP summary score (ranging from 0 (worst) to 10 (best)) based on the ratio of recommended to risk nutrients was provided in the context of various additional pieces of information concerning nutritional and environmental attributes of the different milks.	scoring scheme was limited as the four products with the highest nutritional score were selected as the best option, in varying order, regardless of the presence of the FOP label.
Wąsowicz *et al.* (2015)	Study 1 (qualitative): 8 mothers, aged 25-45 years, in Poland; Study 2 (quantitative): 90 mothers, aged 25-45 years, in Poland.	In qualitative and quantitative studies, explored the effect of a health logo and the UK MTL on the perceived healthfulness of yogurt and frozen pizza products.	Consumers were found to associate certain colours with product healthfulness. Yellow, blue, green, and red were found to be related to health. Heather, pink, and celadon were associated with artificial, thus unhealthful products. The impact of labels on healthfulness assessment was observed only in the unhealthful category. Malam *et al.* (2009) found similar results.
Emrich *et al.* (2014)	3029 adults (65% females; 20-69 years) in Canada.	Healthfulness rating study evaluating four FOP schemes (Heart & Stroke Foundation Check logo, Smart Pick logo, Multiple Traffic Lights, GDA) relative to Canada's nutrition facts panel. The FOP labels were presented with and without the nutrition facts panel.	When the nutrition facts panel was absent, the ratings of the healthfulness and calorie and nutrient content varied according to FOP scheme. However, with the nutrition facts panel present, these ratings were more consistent (except for participants exposed to the traffic-lights scheme, who were influenced by the traffic-lights colours).

Table 20. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Schuldt (2013)	93 students (47% females) from a large Midwestern university in the USA.	Computer-based calorie content and healthfulness rating of a candy bar where the main field of the calorie label was either green or red (candy bars were identical otherwise).	Potentially detrimental effect on perceived healthfulness. Whilst the candy bars had the same amount of calories (260 kcal), the bar with the green label was rated significantly more healthful than the bar with the red label. Of note, traffic-lights-type labels currently in use do not assign a colour code to energy content.

Taken together, the studies suggest that evaluative FOP schemes help consumers to gauge the nutritional value of products better than reductive schemes. Of note, Graham & Mohr (2014) showed a simple summary score should avoid the zero (*e.g.* better to have a scale of 1-4 than 0-3) because products receiving zero nutritional points may be misidentified as nutritious.

The above notwithstanding, a few studies reported no major differences between FOP schemes in terms of consumer understanding (*Table 21*).

Table 21. *Studies showing no major differences between FOP nutrition labelling schemes in terms of consumer understanding.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Khandpur *et al.* (2018)	1607 adults in Brazil.	Online RCT to test warning signs and Traffic Lights with regard to consumer understanding, perceptions, and purchase intentions.	Warning labels performed better than the Traffic Lights, but both FOP schemes resulted in improvements on all dimensions. In particular, the warning labels – with respect to a no-label control condition – had a more positive impact on the

.../...

Table 21. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Khandpur *et al.* (2018) *(cont.)*			on the understanding of excess nutrient content, the ability to identify more healthful products, and the decreased perception of product healthfulness.
Hodgkins *et al.* (2015)	2068 participants from four European countries: 513 in the UK, 525 in Germany, 500 in Poland and 530 in Turkey.	Online survey to test the extent to which inclusion of the most prevalent FOP systems – GDA, Traffic Lights, GDA-Traffic-Lights hybrid, and health logos – impact consumer perceptions of healthfulness over and above the provision of a FOP basic label containing numerical nutritional information alone.	The FOP schemes tested resulted in small improvements for objective understanding under some conditions. However, there was not much difference from a FOP scheme containing basic numerical nutritional information alone.
Watson *et al.* (2014)	4357 Australian grocery shoppers.	Online survey to test seven different variants of the traffic-lights scheme, some monochrome, some polychrome, some with Daily Intake Guide information, evaluative text, overall star rating, and combinations thereof.	Participants were able to identify the more healthful product in each comparison over 80% of the time using any of the five schemes that provided information on multiple nutrients. However, no individual FOP scheme performed significantly better in terms of shoppers' ability to determine the healthier product, shopper reliance on the BOP nutrition information panel, and speed of use.

Since studies on consumer understanding rarely emulate the busy shopping context, they provide only partial information about the performance of FOP schemes in a natural store environment. Nonetheless, such studies can indicate which FOP schemes or specific characteristics are most likely to aid quick and accurate decisions about the nutritional quality of products.

4.5. Different socio-economic groups' attention, preferences and understanding of FOP labelling

Behavioural evidence challenges the very existence of an average consumer, who would be 'reasonably well-informed and reasonably attentive and circumspect'.[22] Much rather, there are various types of consumers, differing by level of education, environmental awareness, health-consciousness, wealth, age, gender, etc. It follows that the same intervention is likely not to generate the same impact across different categories of consumers. Indeed, the evidence in a number of policy areas shows that the same policy intervention may be effective in a specific group of consumers or citizens and have less, no, or even a detrimental effect in another. For example, warning messages and pictures on cigarette packages seem to be more effective in non-smokers than smokers [White, *et al.*, 2015; Woelbert & D'Hombres, 2018]. In other policy areas, such as consumer protection, there is even evidence of some cross-subsidisation taking place, with arguably more vulnerable consumers exerting less self-control and buying products or services that indirectly subsidise wealthier consumers, as is the case with hotel mini-bars [Gabaix & Laibson, 2006].

Nutrition label use is associated with certain consumer characteristics. Women are more likely to read nutrition labels compared to men, and higher income and higher education level are positively associated with understanding and use of nutritional information [Campos *et al.*, 2011; Cowburn & Stockley, 2005; Grunert & Wills, 2007; Health Council of the Netherlands, 2008; Storcksdieck genannt Bonsmann & Wills, 2012]. Furthermore, better nutrition knowledge and understanding of diet-disease relationships, as well as general interest in healthier eating habits are positively related with label use [Campos *et al.*, 2011; Cowburn & Stockley, 2005; Drichoutis *et al.*, 2006; Hersey *et al.*, 2013; Soederberg, Miller & Cassady, 2015; Storcksdieck genannt Bonsmann & Wills, 2012]. On the other hand, there is no clear evidence about the association of age and nutrition label use [Campos *et al.*, 2011; Cowburn & Stockley, 2005; Drichoutis *et al.*, 2006]. Despite the fact that older adults might be more interested in nutritional information due to stronger health concerns, they have more difficulties in interpreting the information.

The subsequent sections (*4.5.1* to *4.5.3*) provide information on whether FOP nutrition labelling affects different age and socio-economic groups differently and, if so, how. Of note, taking this perspective of different population groups, the evidence could no longer be meaningfully divided into sections on attention, preferences, and understanding.

4.5.1. FOP label effectiveness in children

Some studies have focused on the effectiveness of FOP schemes on specific socio-economic groups. Children are one of the groups that attract special attention as they usually face difficulties in the evaluation of a product's nutritional value based on the content of several nutrients [Neeley & Petricone, 2006]. Research has shown that emolabels can positively influence children's perception and food choices [Privitera *et al.*, 2015]. A small positive effect on the food choices of children aged 5-7 years has been reported in an uncontrolled pre-post evaluation of nutrition education and signpost labelling of canteen menu items in a UK school [Ellis & Ellis, 2007]. Children's food choices appear to be influenced by their parents' choices and purchases for their children [Elbel *et al.*, 2011; Tandon *et al.*, 2010; Tandon *et al.*, 2011]. However, the evidence is far from being conclusive on this aspect. *Table 22* lists studies of children's responses to FOP nutrition labels.

Table 22. *Studies of children's responses to FOP nutrition labelling schemes.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Lima *et al.* (2018)	318 Brazilian children aged between 6 and 12 years, and 278 parents with different socio-economic status.	Perceived healthfulness rating of different food products targeted at children in the presence of GDA, Traffic Lights, or black octagonal warning signs.	Among children, only the 9-12-years-old from middle/high socio-economic status were influenced by FOP labels in that warning signs and Traffic Lights reduced perceived healthfulness relative to GDA. Across the three schemes, the warning signs and the traffic-lights scheme reduced perceived healthfulness more.
Pettigrew *et al.* (2017)	2058 Australian consumers (including 500 .../...	Cross-sectional online survey (Daily Intake Guide, .../...	Out of the different FOP schemes, the Health Star Rating .../...

Table 22. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Pettigrew *et al.* (2017) *(cont.)*	children aged 10-18 years) of different socio-economic status.	Multiple Traffic Lights, and Health Star Rating).	scheme was the most preferred labelling scheme across the whole sample and in the various subpopulations, and significantly more so among the children compared to the adults. As at the time of the study, the Health Star Rating had recently been introduced both in Australia and in New Zealand, this may have driven the preference for this scheme over the longer-standing Daily Intake Guide scheme.
Arrúa *et al.* (2017*a*)	442 children in grades 4 to 6 from 12 primary schools in Montevideo, Uruguay.	Choice conjoint task to evaluate the relative influence of two FOP nutrition labelling schemes – the traffic-lights scheme and Chilean warning sign – and label design on children's choice of two popular snack foods in Uruguay: wafer cookies and orange juice.	Children's choices of wafer cookies and juice labels were significantly influenced by both package design and FOP nutritional labels. The relative impact of FOP nutritional labelling on children's choices was higher for the warning scheme compared to the traffic-lights scheme.
Arrúa *et al.* (2017*c*)	221 primary school children in Uruguay.	Choice preference study comparing Traffic Lights and GDA labels on sponge cake and yogurt packages. Labels were designed using a fractional factorial design with 3 two-level variables: cartoon character, nutrition claims, and FOP nutrition information.	Traffic-lights labelling had no effect on children's perceived liking of yogurt and sponge cake when compared to a control GDA label without percentage nutrient information.
Yoo *et al.* (2017)	321 children in Uruguay.	Study to assess children's attitudes towards sugar reduction in three dairy products and to assess if these attitudes were .../...	Small, yet significant desirable effects of traffic-lights labelling on children's expected liking and perceived healthfulness of three dairy products, especially among .../...

Table 22. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Yoo *et al.* (2017) *(cont.)*		modulated by the inclusion of the traffic-light system on labels.	those from low(er)-income families.
Graham *et al.* (2017)	153 parent-child pairs in the USA.	In a laboratory grocery aisle, investigated the effectiveness of different FOP labels (including Multiple Traffic Lights and Facts up Front) on the healthfulness of food choice.	The presence of FOP labels did little to improve the healthfulness of selected foods, with few exceptions (participants with *vs.* without access to FOP labels selected lower-calorie cereals, participants with access to both FOP labels and in-aisle explanatory signage selected products with less saturated fat *vs.* participants without explanatory signage).
Ares *et al.* (2016)	238 children from a primary school (grades 1 to 6) in Uruguay.	Rating and choice-based conjoint study to test the influence of three design variables (cartoon characters, nutrition claims and FOP traffic-lights scheme) on the hedonic reaction of school-aged children towards labels of two popular snack foods: yogurt and sponge cake.	Inclusion of cartoon characters and nutrition claims positively influenced children's preferences, whereas the FOP nutrition label had no impact.

4.5.2. FOP label effectiveness in adolescents

Understanding the effect of FOP schemes in adolescents may be of central importance because the habits developed in childhood are generally maintained and reinforced in adolescence and will also be observed in adulthood [Dain, 2012]. Moreover, adolescents constitute a relevant group as they are often very sensitive about their diet and body image [Friederich *et al.*, 2007; Verri *et al.*, 1997] and, at the same time, very responsive to social food marketing [Bryant *et al.*, 2011]. There is in fact strong evidence that marketing can influence young people's preferences and purchases, especially in Western countries [Institute of Medicine, 2006].

Table 23. *Studies of adolescents' responses to FOP nutrition labelling schemes.*

Study (most recent first)	**Population**	**Intervention/Comparator**	**Outcome**
Yoo *et al.* (2017)	325 adolescents in Uruguay.	Study to assess adolescents' attitudes towards sugar reduction in three dairy products and to assess if these attitudes were modulated by the inclusion of the traffic-light system on labels.	No significant effects of traffic-lights labelling on adolescents' expected liking and perceived healthfulness of three dairy products.
Wang *et al.* (2016)	Adolescents aged 15-20 years in Norway.	Offline rating task in which the adolescents had to state how tasty and healthful they considered ten types of snacks: lemon soda, ice cream, chips, teacake, milk flower candy, dark chocolate, fruit, yogurt, nuts, and baby carrots, *i.e.* a mix of healthful and unhealthful snacks. 4 snacks contained plain nutrition information, 3 showed a Keyhole symbol and 3 showed % Daily Values. Participants also indicated their intention to buy the snacks (yes or no), and pairwise yogurt comparisons were used to assess ability to identify the more healthful option.	The Keyhole symbol increased healthfulness perception without influencing taste perception of the snacks. Participants had limited abilities to use information from the % Daily Values correctly to identify the more healthful yogurts. The nutrition labels did not affect intention to buy, liking of labels, or liking of snacks. However, asked to make a purchase from among ice cream, chips, and yogurt, 47.2% of adolescents chose snacks with the Keyhole symbols, 25.8% adolescents chose snacks with the % Daily Values, and 27% chose plain-label snacks. Adolescents who chose a snack for its healthfulness were more likely to choose a Keyhole symbol snack than a snack with one of the other two kinds of labels.
Babio *et al.* (2014)	81 adolescents, aged between 14 and 16 and attending a Spanish high school.	In a non-real food-choice condition study, tested Multiple Traffic Lights and monochrome nutritional labels, both including GDA.	When participants used the Multiple Traffic Lights-GDA scheme they chose significantly less total energy, sugar, fat, saturated fat, and salt than when they used the monochrome GDA scheme. Moreover, in this specific study, the differences between the …/…

Table 23. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Babio *et al.* (2014) *(cont.)*			energy and nutrients chosen using both label schemes were independent of socio-economic status and gender.

The very limited evidence concerning adolescents' responses to FOP nutrition labelling suggests some minor support for FOP schemes using Traffic Lights and argues against purely numerical schemes.

4.5.3. FOP label effects across socio-economic groups

Evidence concerning the effects of FOP nutrition labelling among different socio-economic groups spans a large diversity of subpopulations, including those differing in ethnicity, occupation, education level, and nutrition knowledge.

Table 24. *Studies of the impact of FOP nutrition labelling schemes on different socio-economic groups.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Machín *et al.* (2017)	300 Uruguayan consumers (18-70 y, 25% males).	Perceived healthfulness of a range of ultra-processed foods[33] assessed in the presence and absence of GDA, regular Traffic Lights, and black-and-white traffic-lights labelling.	Low-income participants perceived ultra-processed foods as significantly more healthful than middle- and high-income participants. Furthermore, the low-income group were the only group to display reductions in perceived healthfulness in the presence of FOP labels, and this effect was limited to the two traffic-lights schemes tested.

33. Defined as 'industrial formulations manufactured from substances derived from foods or synthesized from organic sources'. Products included breakfast cereals, crackers, instant soup, and yogurt, among others.

Table 24. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Ni Mhurchu *et al.* (2017*b*)	1357 New Zealand consumers.	Randomised controlled trial to evaluate the effects of two evaluative nutrition labels (Multiple Traffic Lights and Health Star Rating) compared with the nutrition information panel (NIP) on food purchases.	The Multiple Traffic Lights and Health Star Rating were found effective only in intensive users (who scanned ≥34 products), while there was no evidence that effects varied by age, ethnicity, education, frequency of grocery shopping, household size, and self-reported diet rating, interest in healthy eating, nutrition knowledge, or usual label use. Interestingly, there were significant interactions by sex and income with NIPs (the control) being more effective than Health Star Rating or Multiple Traffic Lights for low-income participants and men. Finally, subjects who scanned ≥34 products were older and had a slightly larger household size compared with subjects who scanned less frequently.
Ducrot *et al.* (2015*a*)	13578 participants from the French NutriNet-Santé cohort.	Survey to evaluate the understanding of four labels: GDA, Multiple Traffic Lights, an early version of the Nutri-Score, Green Tick (Tick), along with a reference without label.	Overall, the Nutri-Score yielded the highest rate of correct responses, followed by Multiple Traffic Lights, GDA, and Tick. The strongest impact of the Nutri-Score was observed among individuals with no nutritional knowledge. Older adults and those with a lower educational level, income, nutritional knowledge, and likelihood of reading nutrition facts were less skilled at ranking food products according to nutritional quality. Compared with individual characteristics, nutrition labels had a larger impact on food product ranking ability.

Table 24. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Thorndike *et al.* (2014)	Longitudinal cohort of 2285 hospital employees who used the hospital cafeteria regularly.	Point-of-purchase intervention to assess the impact of traffic-lights labelling on beverage purchases in a hospital cafeteria.	No racial, age, or gender differences. Purchases of green-labelled beverages increased and red-labelled beverages decreased compared to baseline for employees from all racial/ethnic backgrounds and from all job types.
Méjean *et al.* (2013)	Subset of 38763 adults from the French NutriNet-Santé cohort.	Cross-sectional survey to test the perception of different FOP labels, using indicators of understanding and acceptability. Schemes assessed were three simple FOP labels (a 'Green Tick', the logo of the French Nutrition and Health Programme (PNNS logo) and a Simple-Traffic-Lights label) and two detailed formats (Multiple Traffic Lights and a 'Colour Range' logo).	Poorly educated individuals were most often found in groups favouring simple formats. The 'favourable to Colour Range' group had a high rate of men and older adults. Poor nutritional knowledge was more frequent in the 'favourable to Simple Traffic Lights' group, whilst individuals with substantial knowledge were proportionally more numerous in the 'favourable to Multiple Traffic Lights' group. Overall, the majority of participants fell into the 'favourable to Multiple Traffic Lights' cluster. Moreover, the Multiple Traffic Lights fared best in terms of self-reported liking, attractiveness, and utility, yet Green Tick, PNNS logo, and the Simple-Traffic-Lights label scored slightly higher on objective understanding.
Levy *et al.* (2012)	Longitudinal cohort of 4642 employees of a large hospital in Boston MA who were regular cafeteria patrons.	Point-of-purchase intervention to assess the impact of traffic-lights labelling on food purchases in a hospital cafeteria.	Latino and black employees bought more red and fewer green items at baseline but labelling (along with choice architecture) decreased all employees' red item purchases and increased green-labelled purchases. Intervention effects were .../...

Table 24. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Levy *et al.* (2012) *(con.)*			similar across all race/ethnicity and job types. Mean calories per beverage decreased similarly over the study period for all racial groups and job types, with no increase in per-beverage spending.
Gorton *et al.* (2009)	1525 ethnically diverse shoppers[34] in New Zealand.	Survey to assess consumer understanding and preferences regarding nutrition labels (Multiple Traffic Lights, Simple Traffic Lights, nutrition information panel, and Daily Intake Guide).	Reported use of nutrition labels (always, regularly, sometimes) ranged from 66% (Maori) to 87% (NZEO). There was little difference in ability to obtain information from the nutrition information panel according to ethnicity or income. However, there were marked ethnic differences in ability to use the nutrition information panel to determine if a food was healthful, with lesser differences by income. Of the four label formats tested, Simple-Traffic-Lights and Multiple-Traffic-Lights labels were best understood across all ethnic and income groups, and Multiple-Traffic-Lights labels were most frequently preferred.
Lahti-Koski *et al.* (2012)	29378 consumers participating in annual surveys in 2000-2009.	Self-report data on consumers' use of the Finnish Heart Symbol.	Men and women with the highest education were best aware of the Heart symbol and more likely to use products bearing such a label in the early 2000s. The educational differences diminished or disappeared during the study period.

34. 401 Maori, 347 Pacific, 372 Asian and 395 New Zealand European and Other (NZEO) ethnicities (ten did not state ethnicity).

Overall, it appears fair to conclude that where FOP labelling had a (beneficial) effect, simple evaluative schemes using traffic-light coding performed best across socio-economic strata in terms of consumer understanding and product healthfulness assessment.

4.6. Effects of FOP labelling on purchasing

Notwithstanding the extensive evidence on consumers' perceptions and understanding of different FOP labelling schemes (see *sections 4.2*, *4.3*, *4.4*, and *4.5* above), scientific studies that actually test whether FOP labels have any impact on consumers' choice are much rarer. In a meta-analysis, Cecchini & Warin (2016) computed, on the basis of six relevant scientific studies[35] mainly looking at hypothetical food selection and intention to purchasee, that FOP labelling could increase the number of people choosing a more nutritious food option by about 18%. traffic-lights labelling showed the highest percentage at around 29%, followed by 'other food labels'[36] at 15%, and finally the Reference Intakes label at 12%. Despite these seemingly concrete numbers provided by Cecchini & Warin (2016), overall the evidence on real-life purchasing behaviour remains limited [Andrews *et al.* 2014; Crockett *et al.* 2018; Health Council of the Netherlands 2008; Hersey *et al.* 2013; Van Kleef & Dagevos 2015].

The literature on FOP labels and consumers' food choices developed along two distinct paths that differ in terms of methodology and outcome measures. Many studies, mainly surveys or laboratory experiments, focused on intention to purchase in response to the introduction of FOP labels on *ad hoc* or existing products [Acton & Hammond, 2018; Egnell *et al.*, 2018*c*; Feunekes *et al.*, 2008; Gorski Findling *et al.*, 2018; Graham *et al.*, 2017; Hamlin & McNeill, 2016; Julia *et al.*, 2016*a*; Waterlander *et al.*, 2013]. Other studies used empirical data from retailers or other facilities to evaluate the impact of the introduction of FOP labels on consumers' actual purchases in real shopping situations [Boztuğ *et al.*, 2015; Cawley *et al.*, 2015; Elshiewy & Boztuğ, 2018; Inbox, 2018; Julia & Hercberg, 2017; Machín *et al.*,

35. Randomised controlled trials as well as experimental studies in controlled and real-world settings.

36. Not specified further in the paper, but including healthy choice logos, star-rating systems, health claims; the Nutri-Score was not included.

2018*a*; Neal *et al.*, 2017; Sacks *et al.*, 2009; Sacks *et al.*, 2011*b*; Sonnenberg *et al.*, 2013; Thorndike *et al.*, 2014; Vyth *et al.*, 2010*b*]. Both approaches have pros and cons, and the following subsections describe the relevant studies in more detail.

4.6.1. Effects of FOP labelling on purchasing – experimental studies

The advantage of laboratory experiments is that the artificial environment, the *ad hoc* selection of the products under analysis, and the randomisation of subjects makes it possible to control for confounding factors that may influence the choice. The use of a laboratory setting also has the advantage of being easily replicable and highly standardised. These studies, however, examined intention to purchase rather than actual purchasing behaviour, thus focusing on a hypothetical non-incentivised choice that has limited external validity. Among the studies reviewed for this section, there are only three laboratory experiments for which the outcome measure is not hypothetical but incentivised [Acton & Hammond, 2018; Crosetto *et al.*, 2018; Koenigstorfer *et al.*, 2014]. Taken together, the experimental evidence suggests that colour-coded FOP schemes (Multiple Traffic Lights, Nutri-Score) serve consumers best in making more nutritious food purchases (*Table 25*).

Table 25. *Experimental studies of the impact of FOP nutrition labelling schemes on food purchases.*

Study (most recent first)	**Population**	**Intervention/Comparator**	**Outcome**
Crosetto *et al.* (2018)	691 subjects from Grenoble metropolitan area, France.	Lab experiment to assess the impact of the Nutri-Score, UK MTL, the SENS scheme, Health Star Rating, and modified Reference Intakes on food selection from a paper catalogue of 290 products. Participants had to select a full two days' food supply, and purchases made were real. First, they were given the catalogue without labels .../...	The Nutri-Score achieved the largest improvement in the FSA Nutrient Profile Score (-2.65) compared to a no label control, followed by the Health Star Rating (-1.86), then Multiple Traffic Lights (-1.40), modified Reference Intakes (-1.02), and SENS (-0.81). On average, all FOP labels performed better than the no label control, reducing the FSA Nutrient Profile Score by 1.56. Notably, nutritional .../...

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Crosetto *et al.* (2018) *(cont.)*		and then, unannounced, a second time but with FOP labelling included.	improvements were least costly for lowest income households with the Nutri-Score and Health Star Rating schemes. In terms of nutrient content of shopping baskets, Nutri-Score, Health Star Rating, and the UK MTL scheme helped reduce fat and saturated fat whereas modified Reference Intakes and the SENS scheme did not (no impact on sugar or sodium with any of the FOP labels).
FOP-ICE Consortium (2018)[37]	Nationally representative samples of approx. 1 000 adults each recruited in Argentina, Australia, Bulgaria, Canada, Denmark, France, Germany, Mexico, Singapore, Spain, USA, and UK.	Choice task in which participants were asked to indicate their preferred choice from a selection of three products in the categories breakfast cereals, cakes, and pizza. FOP schemes compared against a 'no label' condition were: Health Star Rating, UK MTL, Nutri-Score, Reference Intakes, and black octagonal warning symbol.	Choice healthfulness improved in the label *vs.* no label condition. The Nutri-Score and the UK MTL performed best, producing significant improvements in seven countries each. This was followed by the octagonal black warning sign with six countries, the Health Star Rating with three countries, and the Reference Intakes with two countries.
Lundeberg *et al.* (2018)	306 undergraduate students enrolled in an introductory psychology course at a large western university in the USA.	Purchase likelihood rating task in which participants viewed ten food products with either star rating or Simple-Traffic-Lights FOP labels on the packaging. Prior to rating, participants read a public service announcement with or without information on the FOP scheme.	For both label types participants were more likely to indicate they would purchase the most healthful foods (*i.e.* 3-star/green light foods) compared to all other food options (*i.e.* 0, 1, and 2-star/red and amber traffic-light foods).

37. FOP-ICE study (Front-Of-Pack International Comparative Experimental) conducted by a scientific consortium from Paris 13 University (France) and Curtin University (Australia). The findings reported here are unpublished observations courtesy of the study consortium.

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Ares *et al.* (2018)	892 people (ages ranging between 18 and 84, 67% females) in Uruguay.	Online assessment of consumers' purchase intention, comparing the impact of three evaluative schemes (Nutri-Score, Health Star Rating, and nutritional warnings) relative to a 'no label' control. Products differed in nutritional profile (lentils, canned green beans, breakfast cereals, yogurt, orange juice, bread, mayonnaise and potato chips).	Relative to the 'no label' control, the two FOP schemes Nutri-Score and warning labels reduced purchase intentions for some of the less healthful products (both FOP schemes: breakfast cereals, mayonnaise; warning signs only: bread, yogurt). The Health Star Rating had no significant effect.
Khandpur *et al.* (2018)	1607 adults in Brazil.	Online RCT on consumer purchase intentions in the presence of warning labels or Traffic Lights relative to a 'no label' control.	Compared to Traffic Lights, warning labels resulted in a higher increase in the percentage of people: i) expressing an intention to purchase the relatively more healthful option (16.1% *vs.* 9.8%); and ii) choosing not to buy either product (13.0% *vs.* 2.9%), relative to the control condition.
Machín *et al.* (2018*a*)	437 adults in Uruguay.	Simulated online grocery store setting, to compare the impact of the traffic-lights scheme with the Chilean warning scheme. Participants were randomly assigned to one of three experimental conditions: a control condition with no nutrition information; a traffic-lights scheme; or the Chilean warning scheme.	The warning label decreased purchasing intentions for sweets and desserts, but the overall results showed no significant differences between the experimental conditions.
Machín *et al.* (2018*b*)	1182 adults in Uruguay.	Online grocery store, where participants were asked to purchase food in order to prepare a healthful dinner for themselves and their …/…	Modified Traffic Lights and the warning label scheme improved the healthfulness of participants' choices, compared to the control condition, with no difference …/…

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Machín *et al.* (2018*b*) *(cont.)*		family. Participants were recruited and randomly allocated to one of three between-subjects experimental conditions: i) no FOP nutrition information; ii) modified version of the traffic-lights scheme including information about calorie, saturated fat, sugars and sodium content per portion; and iii) Chilean warning scheme.	of impact between both FOP schemes.
Tórtora & Ares (2018)	155 adults (18-60 y, 16% men) in Uruguay.	Impact of FOP labelling on food choice and its relation with people's time orientation as measured by their consideration of future consequences (CFC) of current eating behaviours. Participants had to choose between two types of cookie packages (granola and chocolate), which carried either a modified Facts Up Front scheme (with fat instead of saturated fat, and without percentage values for fat and sodium) or black octagonal warning sign labels on the front. Granola cookies served as the perceived healthier option whereas the chocolate cookie had a more hedonic connotation.	Two clusters emerged from the CFC assessment, one with a focus on the future (CFC-F) and characterised by health concerns, the other focusing on the immediate present (CFC-I) and giving higher importance to hedonic aspects of eating. Overall, participants were more likely to choose chocolate cookies than granola. Presence of the warning signs significantly discouraged the choice of the respective package compared to the Facts-Up-Front label, and the CFC-F cluster was significantly more likely to choose the granola cookies compared to the CFC-I cluster. The novelty of this study consisted in the prompting of participants to time consistency, shifting their attention away from immediate gratification. The authors concluded that strategies designed to stimulate a less myopic stance on eating habits could contribute to more healthful food choices.

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Acton & Hammond (2018)	675 respondents aged 16 years and older in Canada.	Experimental marketplace study in which participants were randomised to one of four labelling conditions (no label; star rating; high sugar symbol; health warning) and completed five within-subject purchase tasks. In each task, participants selected from 20 commercially available beverages at varying price/tax levels (0, 10, 20, and 30% sugar tax); upon conclusion, one of five selections was randomly chosen for purchase.	The overall effect of FOP labelling was not statistically significant, although there was a trend for the 'high sugar' label to reduce the likelihood of selecting a sugary drink and encouraging participants to select drinks with less free sugar.
Talati *et al.* (2017*a*)	2069 adults and children aged 10+ years in Australia.	Online discrete choice task involving mock food packages. A 4 food type (cookies, corn flakes, pizza, yogurt) × 2 front-of-pack label presence (present, absent) × 3 FOP label type (Daily Intake Guide, Multiple Traffic Light, Health Star Rating) × 3 price (cheap, moderate, expensive) × 3 healthfulness (less healthful, moderately healthful, more healthful) design was used. A 30 s time limit was imposed for each choice.	Health Star Rating increased choice probability and willingness to pay for more healthful foods while decreasing these for less healthful foods. The Multiple Traffic Lights had some impact on choice and willingness to pay (specifically for foods at either end of the healthfulness spectrum), while the Daily Intake Guide had no impact on either outcome variable.
Russell *et al.* (2017)	520 parents in Australia.	Discrete choice experiment to test the role of the Health Star Rating scheme relative to product visuals,[38] .../...	Whilst product visuals emerged as the most important driver of product choice (contributing 58% to the model), the Health .../...

38. The four product visuals tested were an 'artificial-looking' (multi-coloured) cereal, a chocolate-coloured cereal, a 'healthy-looking' (bran-coloured) cereal, and a 'neutral-looking' (yellow creamy colour) cereal.

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Russell *et al.* (2017) *(cont.)*		written claims, numerical FOP nutrition information, and additional visuals[39] on participants' decision to purchase breakfast cereals for their children.	Star Rating came second at 19%, followed by additional numerical nutrition information (16%), written claims (5%), and finally additional visuals (2%). Whereas an absent and a 2-star Health Star Rating had a significant negative impact on product choice, the 5-star Health Star Rating formats tested had a significant positive impact. Notably, the Health Star Rating also was a more important driver of product choice than price (different levels above and below average price tested), although this seemed to depend on the magnitude of deviation of the actual price from the average price. Since the study used mock packages of fake brands, it remains unknown to what extent real and liked brands might qualify the findings.
Ducrot *et al.* (2016)	A subset of 11 981 participants, from the French Nutri-Net-Santé cohort.	In an online experimental supermarket study, the impact of an early version of the Nutri-Score, the UK MTL, a Green Tick logo, a GDA label, or a 'no label' control on the overall nutritional quality of participants' shopping basket was tested. Participants were asked to shop a week's worth of food, and the FSA Nutrient Profile Score (the lower, the better) served …/…	The Nutri-Score achieved the shopping basket with the highest nutritional quality (FSA score of 8.72), followed by UK MTL (8.97) and Green Tick (8.99), compared with the control (9.34). The GDA results (9.18) were not different from the control. As the authors noted, the Nutri-Score was the only FOP scheme that led to a lower content in fat, saturated fat, and sodium of the shopping cart.

39. The four additional visuals tested were a cartoon puppy, a cartoon sports kid, various fresh fruits, and a bundle of wholegrain wheat.

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Ducrot *et al.* (2016) *(cont.)*		to assess the nutritional quality of participants' shopping baskets.	
Julia *et al.* (2016*a*)	901 adults in France.	In a physical experimental supermarket study, the impact of an early version of the Nutri-Score alone and in combination with an explanatory leaflet on choice healthfulness was tested in the three product categories sweet biscuits, appetizers, and breakfast cereals.	Only when accompanied by the leaflet, the Nutri-Score resulted in an improved food choice, and only for sweet biscuits (not for appetizers, breakfast cereals, or across all products). Although statistically significant, the differences were small.
Carrad *et al.* (2015)	120 students from a university and 120 employees, patients and visitors (58% females) of a hospital in regional New South Wales, Australia.	Assessed the potential impact of Traffic Lights and star rating schemes on consumers' vending machine purchases in a university and a hospital setting. Product pairs tested were (less healthful *vs.* more healthful): chocolate *vs.* fruit strap; lollies *vs.* sultanas; cereal bar high fat/sugar *vs.* cereal bar low fat/sugar; potato crisps *vs.* roasted chickpeas; cola *vs.* fruit juice.	Both schemes helped the participants identify the more healthful of two options for three of the five product pairs[40] tested. In the case of lollies *vs.* sultanas, most participants already chose the more healthful option without the FOP label, so there was little room for improvement. However, in the case of cola *vs.* fruit juice, the traffic-lights label resulted in a significant drop in the percentage of respondents choosing fruit juice (the more healthful option), whereas the star rating produced no change. The observed decrease in the proportion of participants correctly identifying the healthier drink may have resulted from misunderstanding how added sugars are assessed and presented on the traffic-lights label.

40. Choice pairs tested (less healthful *vs.* more healthful): Chocolate *vs.* fruit strap; Lollies *vs.* sultanas; Cereal bar high fat/sugar *vs.* cereal bar low fat/sugar; Potato crisps *vs.* roasted chickpeas; Cola *vs.* fruit juice.

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Koenigstorfer *et al.* (2014)	Study 1: 184 consumers (79% females; 16-70 years) Study 2: 152 consumers (81% females; 16-71 years).	Two in-store lab studies to assess the effects of traffic light colour coding of GDA labels on food purchase behaviour. The colour coding was implemented on nutrition labelling schemes shown on the front of actual food packages (six types of pasta meals in Study 1; eight types of cereal bars in Study 2). The food options differed in objective healthfulness as assessed by nutrient profiling. The consumer sample was not informed about the goals of the research.	Food purchase behaviour within a given category was affected by the traffic-light-coded GDA label. However, this effect was contingent on consumer self-control. Consumers with low self-control, but not consumers with high self-control, made more healthful food decisions in response to the colour coding on GDA labels (*vs.* GDA labels without colour coding). The colour primes helped low self-control consumers control their food purchasing behaviour.
Maubach *et al.* (2014)	768 adults (70% females; 18-83 years) in New Zealand.	Forced choice online survey to estimate how labels featuring a new Star rating (0-7 stars), the Multiple Traffic Light, Daily Intake Guide, or a no-FOP control affected consumers' self-reported likelihood to buy from a selection of muesli products differing in nutrient profile from good to moderate to poor. Each participant evaluated nine sets of four products, stating which product they were most and least likely to buy.	While respondents made broadly similar choices with respect to the Multiple Traffic Lights and Star labels, the Multiple Traffic Lights format had a significantly greater impact on depressing self-reported likelihood to buy as a food's nutritional profile became less healthful. On the other hand, the Daily Intake Guide label increased the probability that respondents would select any option as best, independent of the food's nutritional profile.
Balcombe *et al.* (2010)	477 respondents (48.3±13.3 years; 81% females) from UK households.	Assessed willingness to purchase different shopping baskets, which contained a week's food .../...	The survey respondents showed a strong willingness to pay for baskets that did not have any red nutrient labels, with most .../...

Table 25. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Balcombe *et al.* (2010) *(cont.)*		supply and indicated with traffic-lights labelling the levels of salt, sugar, fat, and saturated fat.	emphasis being given to salt levels and least to fat levels.

4.6.2. Effects of FOP labelling on purchasing – empirical studies

Studies that focus on purchasing in real shopping situations are more realistic and potentially include a large variety of products, thus presenting higher generalisability. It should be borne in mind though that the results may be affected by confounding factors that are difficult to isolate, such as brands, habits, self-selection, and seasonality.

Table 26. *Empirical studies of the impact of FOP nutrition labelling schemes on actual food purchases.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Elshiewy & Boztuğ (2018)	4131570 purchase transactions from 188062 loyalty card members from a major retailer located in the UK with approximately 2000 supermarkets nationwide.	Scanner data from a random sample of loyalty card members for one year before and one year after the GDA label introduction on store brands (2006 and 2007). Analysis done for three food categories of the retailer's store brands: biscuits, breakfast cereals, and soft drinks. The average share of store brands available in the supermarkets during the time span of the study exceeded 50% and generated almost the same proportion of total sales.	9.5% reduction in calories purchased and overall sales of the retailer's own brand cereals, biscuits, and soft drinks after the introduction of GDA labelling. However, it is unknown whether sales of equivalent branded products increased, or whether this change was compensated for in some other way, healthy or not.

Table 26. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Inbox (2018)	Close to 300 000 customers roughly equally divided between 33 E. Leclerc stores.	Survey to test the impact of the Nutri-Score and the Health Star Rating on consumers' actual purchases in E. Leclerc online stores (with product pick-up in drive-through stores). The study ran over a 3-month period comparing the Nutri-Score, the Health Star Rating, and the 'no label' control. Study commissioned by the retailer E. Leclerc and conducted by a market research agency.	A small, yet statistically significant overall improvement of the shopping basket was observed with the Nutri-Score relative to the Health Star Rating (-0.18 points in the FSA Nutrient Profile Score) and the no label control (-0.21 points). The effect of the Nutri-Score was slightly more pronounced in shoppers of lower socio-economic status, and it differed by product category and age group, yet with no clear pattern. The FSA Nutrient Profile Score for the overall shopping basket was found not to differ between the Health Star Rating and the control.
Julia & Hercberg (2017)	Sales in 60 supermarkets in four regions of France.	In a large-scale supermarket trial – involving ten stores each for the four FOP schemes Nutri-Score, UK MTL, SENS, and modified Reference Intakes[28] – shoppers' receipts were collected over a ten-week period to check for changes in food purchases upon introduction of the FOP schemes. In total, 1 298 products from four different categories were labelled: fresh deli; bread; pastries; and canned prepared meals, with a labelling rate of 63-86%.	Compared to purchases in twenty control supermarkets, small, yet statistically significant improvements in the FSA Nutrient Profile Score of shopping baskets were seen for Nutri-Score (0.267 points less than the score average of 6 in the control sample), UK MTL (-0.233), and SENS (-0.198), whereas the modified Reference Intakes scheme had no impact. When only shoppers of discount brands were considered, the beneficial impact of the Nutri-Score became more pronounced (-0.312) whereas the UK MTL effect did not differ from the general analysis (-0.223) and the effect of the SENS scheme was no longer beneficial.

Table 26. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Neal *et al.* (2017)	1578 participants (38±11 years; 84% females) in Australia.	In-store RCT in which participants were equipped with a bar code scanner app and randomly exposed to Health Star Rating, Multiple Traffic Lights, Daily Intake Guide, a Nutrition Information Panel with a warning statement to avoid products qualifying as unhealthy choice, or just the Nutrition Information Panel. The study participants had to use the app to see the FOP labels.	Only the warning statement resulted in significantly fewer unhealthy choices compared to the Nutrition Information Panel, as judged by a nutrient profile score computed on the totality of purchased packaged products over a 4-week period. Concerning the other schemes, the Health Star Rating was rated as easier to understand and more useful if found on products than the Daily Intake Guide and the Multiple Traffic Lights. Furthermore, the Multiple Traffic Lights resulted in small, yet statistically significant reductions in mean total sugar per 100 g purchased.
Zhu *et al.* (2016)	Ca. 129000 actual household purchases of ready-to-eat breakfast cereals, from 5844 households in the USA over 152 weeks.	Empirical analysis to test whether a decrease in information cost has a positive impact on the probability that heterogeneous consumers choose healthier ready-to-eat cereals. The introduction of FOP labelling (Facts-Up-Front) is a proxy variable for the reduction of information cost.	Only about 15% of the observations had a FOP label. On average, FOP labels increased the probability of consumers choosing foods that are more healthful. Consequently, the consumption of sugar, saturated fats, and sodium would decrease, and the consumption of fibre would increase. Less-educated consumers from small households who purchase groceries less frequently were more sensitive to FOP labels.
Cawley *et al.* (2015)	Aggregate sales data for 102 categories of food (over 60000 brands) on a weekly basis for 2005-2007 in all 168 stores of the US supermarket chain Hannaford.	Assessed the impact of the introduction of the Guiding Stars scheme on actual food purchases. Of note, the Guiding Stars scheme is applied to shelves, not food packages.	Sales of products receiving 0 stars declined by 8.3%, whereas sales of more nutritious products (1-3 stars) remained unchanged. Category sales dropped by between 10% (cookies and crackers) and 36% (canned fish

.../...

Table 26. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Cawley *et al.* (2015) *(cont.)*			and meat). Since fewer products were bought in total (-5%), the overall impact was a small, yet statistically significant increase of 1.4% in the sales of more nutritious products. Unfortunately, the study did not include a control group and thus gives room for a range of confounders. The authors surmised that if the change in sales compromised profits, for which no data were available, the labelling might not be sustainable.
Mørk *et al.* (2014)	1411 adults (18+) in Denmark.	Commissioned by the Danish Food Agency, this study assessed whether a Keyhole logo promotion campaign had a real effect on consumers' food purchases. Comparisons were made between the behaviour of consumers before, during, and immediately after the campaign. The evaluation was carried out in two main parts: 1) observation and interviews with customers in selected stores within two product categories to analyse how the campaign affected the behaviour at the shelf; and 2) analysis of sales data for selected stores. The researchers analysed how the campaign affected the sale of Keyhole- *vs.* non-Keyhole-labelled products.	As the main result, approx. 10% more Keyhole-labelled products were sold during the campaign. However, the effect varied widely between product categories and was greatest in product categories such as fresh fish and fresh fruit and vegetables where all products could in principle carry the Keyhole. The effect could be detected in retail stores where the proportion of Keyhole-labelled products was relatively lower, while no effect could be detected in the retail chain where this share was already high.

Table 26. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Rahkovsky *et al.* (2013)	Data for this study came from two proprietary sources: the Guiding Stars database provided by the Guiding Stars Licensing Company and Scantrack StoreView data of RTE cereal sales in 13175 stores across the continental United States (US) provided by Nielsen.	Analysis of sales data from US retailers with and without the Guiding Stars programme.	Sales of ready-to-eat cereals shifted towards choices that were more healthful (indicated by a higher star rating) in stores with the Guiding Stars. However, lower socio-economic status and income were associated with poorer food choices, potentially promoting inequality.
Aachmann *et al.* (2013)	In-store observation: 30 consumers. In-store interviews: 18 consumers. Two online surveys: 1048 and 1009 consumers. Denmark.	Commissioned by the Danish Veterinary and Food Administration, this study gauged consumers' use and understanding of nutrition and health claims, with a particular focus on the Keyhole logo (a nutrition claim) and whether it affected purchases. Additionally, two web surveys were completed by 1048 and 1009 consumers, respectively.	Awareness of nutrition and health claims during shopping appeared limited, and claims were generally not used on a conscious level in the purchasing decision process. The Keyhole label was among the best-understood claims; it was most often used in the evaluation of products, but only by few consumers. No substantial connection was found between consumers' understanding of the Keyhole scheme and choice of Keyhole-labelled products.
Sacks *et al.* (2011*b*)	66869 units sold of 53 products (33904 units pre-trial; 32965 units during trial). Australia.	2 x 10-week sales data (pre-trial and trial) for 53 products from the five categories milk, bread, breakfast cereals, biscuits, and frozen meals in online supermarkets in Australia. traffic-lights labelling was included in product information in the intervention store and sales compared to a control store without traffic-lights labelling.	Sales data indicated that traffic-lights labelling had practically no effect on food purchases. Since only a minority of products bore a traffic-lights label, the value of these studies is very limited.

Table 26. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Sacks *et al.* (2009)	n/a. UK.	This study examined changes to consumer food purchases after the introduction of traffic-light labels in physical supermarkets in the UK with the aim of assessing the impact of the labels on the healthfulness of foods purchased. Sales data were from a major UK retailer, for products in two categories (ready meals (n = 6) and sandwiches (n = 12)), investigating the percentage change in sales 4 weeks before and after traffic-lights labels were introduced (taking into account seasonality, product promotions and product lifecycle).	For the selected ready meals, sales increased (by 2.4% of category sales) in the 4 weeks after the introduction of traffic-lights labelling, whereas sales of the selected sandwiches did not change significantly. Critically, there was no association between changes in product sales and the healthfulness of the products.

Taken together, the evidence from real-life supermarket studies and sales data analyses suggests that the impact of FOP nutrition labelling on the healthfulness of food purchases is small, even if statistically significant at times. However, more pronounced effects might become apparent if challenges such as incomplete FOP scheme roll-out or mixed levels of familiarity with different FOP schemes are addressed. Evaluative FOP schemes that use colour coding with or without a graded indicator appear most promising for improving the nutritional value of consumers' shopping baskets.

Although FOP labels increase the understanding of nutrition information [Cecchini & Warin, 2016; Roseman *et al.*, 2018] they do not necessarily affect consumers' willingness to purchase and eat more nutritious food [Gorski Findling *et al.*, 2018; Vasiljevic *et al.*, 2015]. One explanation is that food selection is driven by expected tastiness and that higher tastiness is negatively correlated with healthfulness for

many consumers [Bialkova *et al.*, 2016; Koenigstorfer *et al.*, 2014; Lähteenmäki *et al.*, 2010; Raghunathan *et al.*, 2006; Vyth *et al.*, 2010*b*], although not all studies find this [Wang *et al.*, 2016]. Another possible reason for the limited nudging effects of FOP labels observed so far is that purchases are driven by factors that are more salient. For example, Waterlander *et al.* (2013) found that price discounts, rather than the Choices logo or a 'special offer' label, significantly encouraged the purchase of nutritious products. It should be noted, though, that out of the three discount levels tested – 10, 25, and 50% – only the 50% option had a significant effect. Furthermore, whilst more foods that are nutritious were purchased in this condition, the number of unhealthful products remained steady, thus resulting in a higher amount of total energy purchased. Other authors [for example, Acton & Hammond, 2018; Boztuğ *et al.*, 2015; Grunert *et al.*, 2010*a*; Grunert & Wills, 2007] have also noted that price and habit are more relevant than FOP labels. Acton & Hammond (2018) found that increasing price was associated with fewer sugary drink purchases, whereas the FOP labels tested (Simple-Traffic-Lights-like and Health Star Rating) essentially had no effect. Cognitive depletion may have a strong effect on food choice [Cohen & Babey, 2012]. Fatigue, hunger, and high number of alternatives increase the cognitive effort and thus reduce consumers' ability to interpret the information. As a result, consumers often apply heuristic-based food choices. Riley *et al.* (2016), using survey data in Australia, found that for unfamiliar food, country of origin was considered the most important information on food packaging by more than a third of responders.

Any FOP scheme introduction should be combined with awareness and/or communication campaigns for optimal effectiveness. To illustrate this point: participants with access to FOP labels and in-aisle explanatory signage selected products with less saturated fat compared to participants without explanatory signage [Graham *et al.*, 2017]. A significantly higher mean nutritional quality of the shopping basket was observed in one out of three product categories in the condition that combined a FOP label with an explanatory leaflet [Julia *et al.*, 2016*a*]. Furthermore, in a US supermarket study of consumers' food and beverage purchases, sales data revealed significant and lasting changes in food purchasing following the implementation of a three star shelf-label with accompanying educational materials [Cawley *et al.*, 2015; Sutherland *et al.*, 2010]. After the introduction of the labels on the shelves, together with informational material in the form

of brochures, kiosks, and signage, sales of less nutritious foods fell by 8.31%. As a result, the percentage of food purchases rated as nutritious rose by 8.39%. One of the strongest supporting studies from consumer attention research showed that the provision of an in-aisle explanation of a FOP scheme made 94-97% of participants look at the FOP label, compared to 23-31% of participants without in-aisle signage [Graham *et al.*, 2015]. In the latter case, there was no significant difference from the percentage of participants viewing the back-of-pack nutrition facts table.

A true impact of FOP labels on consumer behaviour requires two steps: greater understanding and ability to compare the healthfulness of products, and the willingness to buy products that are more nutritious. Using eye-tracking, Turner *et al.* (2014) found that people with motivation to purchase healthful products spent significantly more time on nutrition information compared to people with taste motivation. Rawson *et al.* (2008) used eye tracking in a supermarket to conclude that there is very low attention for nutrition information (no distinction made between front and back of pack), unless consumers have a dietary goal. This claim has been extensively tested in the literature with studies that compare behaviour under preference goals with behaviour under health goals [Aschemann-Witzel *et al.*, 2013; Bialkova & van Trijp, 2011]. With very few exceptions the evidence suggests that FOP schemes can be effective in modifying consumer behaviour only if there is an 'induced' inclination of the consumer towards healthy choices [Bialkova *et al.*, 2016; Machín *et al.*, 2017, 2018*a*; van Herpen & van Trijp, 2011]. In the real world, this translates into FOP labels being effective: a) mainly with consumers who already pay attention to the healthfulness of the food they buy [Finkelstein *et al.*, 2018; Ni Mhurchu *et al.*, 2017*a*; Vyth *et al.*, 2010]; or b) if FOP labels are introduced in combination with other interventions such as information campaigns about the FOP labelling scheme in question [Graham *et al.*, 2017; Thanavutwatthana & Chiaravutthi, 2014]. Consumers who may be inherently more sensitive to health issues, such as hospital personnel in a hospital cafeteria [Sonnenberg *et al.*, 2013; Thorndike *et al.*, 2014] or customers of a sport facility [Olstad *et al.*, 2015] were found to react to FOP labels. Finally, the food category also seems to affect the effectiveness of FOP labels [Ni Mhurchu *et al.*, 2018; Nikolova & Inman, 2015]. For example, consumers are less likely to read the nutrition information on unhealthful foods than on healthful foods because when buying unhealthful foods they want to indulge and avoid discouraging information [Talati *et al.*, 2016*c*].

The large variety of the existing labelling schemes adds further need to test and compare them. Indeed, reductive FOP schemes may have significantly different effects on behaviour compared to evaluative ones [Hamlin, 2015]. In their review, Sanjari *et al.* (2017) concluded that health-motivated consumers make cognitive efforts to understand and follow the nutrition information, while hedonically motivated consumers disregard the available nutrition information. Therefore, hedonically motivated consumers may be more interested in brand names and simple, graphic information [Visschers *et al.*, 2010]. They are more likely to follow nutrition information that is easy to recall and simple, such as evaluative labels. Moreover, evaluative labels seem to produce more nutritionally desirable purchase intentions than reductive labels when consumers need to compare products that are difficult to compare [Newman *et al.*, 2018]. On the other hand, traffic-lights labelling had little impact in forced choice experiments using yogurt labels, with only small differences between participants with a rational or an intuitive thinking style [Ares *et al.*, 2014; Mawad *et al.*, 2015]. However, presenting all package information on the same plane may have created more distraction from the traffic-light label than would be encountered on 3D packaging in a real shopping situation. Finally, Crosetto *et al.* (2018) observed that consumers tended to turn the information they get from the labels into binary (good–bad) or ternary (good–average–bad) information. This tendency resulted in shopping baskets that contained more products that are labelled 'green' or 'five star' and less products that are labelled 'red' or 'zero stars' but do not differ much for all the in-between categories. The study further observed that when consumers face information on more than one nutrient, they focus on one. This needs to be investigated further.

As shown so far, it is difficult to make general conclusions on the effectiveness of FOP labels on consumers' choices. Habits, price, expected tastiness, and various other factors strongly interact with the effect of FOP labels, which also makes it hard to isolate the effects specific to FOP nutrition labelling. Some real-life studies confirm the findings of experimental studies as regards impact on purchasing behaviour, although it has to be noted that some of these real-life studies focus on specific categories of products, or on specific categories of consumers or facilities. FOP labels may also have unintended effects on purchases. Further research is needed to systematically identify the circumstances under which FOP labels may affect consumers' behaviour towards making healthier food choices.

4.7. Effects of FOP labelling on diet and health

Studies on the impact of FOP nutrition labelling on people's diets and consequently their health are limited because such links are difficult to measure. It would be necessary to observe consumers' dietary choices daily over the long term (months to years), integrate this with information on FOP label-driven food purchases, and assess the eventual effect of FOP labels on health against the counterfactual of no FOP label exposure. Notably, the contribution of FOP-labelled products to the diet may differ widely between people.

Even assuming that consumers always use FOP labelling schemes to inform their dietary choices, assessing the effects of FOP nutrition labelling on health is challenging given the existing differences between schemes. Foods classified as healthful in one scheme may be considered unhealthful in another [Foltran *et al.*, 2010; Garsetti *et al.*, 2007]; *Table 27* lists studies that exemplify related issues.

Table 27. *Studies of different FOP nutrition labelling schemes in relation to the healthfulness of the food supply.*

Study	Sample	Intervention/Comparator	Outcome
Roberto *et al.* (2012*a*)	100 packaged products that qualified for a 'Smart Choices' designation were sampled from eight food and beverage categories in the USA.	A list of approved 'Smart Choices' products across 19 food and beverage categories was compiled from the 'Smart Choices' website (as of 17 October 2009). The following eight food categories were selected: sauces, dressings and condiments; fats, oils and spreads; cereals; snack foods and sweets; desserts; .../...	64% of the products carrying the industry-developed 'Smart Choices' label did not meet the nutrient profile model criteria for a healthful product.[41]

41. The Smart Choices programme has been put on hold in response to a warning letter by the US Food and Drug Administration implying that the programme criteria '[…] were not stringent enough to protect consumers against misleading claims; were inconsistent with the Dietary Guidelines for Americans; or had the effect of encouraging consumers to choose highly processed foods and refined grains instead of fruits, vegetables, and whole grains'. http://wayback.archive-it.org/7993/20171115001625/https://www.fda.gov/Food/IngredientsPackagingLabeling/LabelingNutrition/ucm180146.htm

Table 27. *(cont.)*

Study	Sample	Intervention/Comparator	Outcome
Roberto *et al.* (2012*a*) *(cont.)*		soups, meal sauces and mixed side dishes; beverages; and bread, grains, pasta and flour. All products were evaluated using the nutrient profile model of the UK Food Standards Agency.	
Lawrence *et al.* (2018)	1269 products carrying a Health Star Rating label (out of 12 108 new products in the database) in Australia.	This study aimed to investigate whether the Australian Health Star Rating (HSR) system aligns with the Australian Dietary Guidelines (ADGs). The Mintel Global New Products Database was searched for every new food product displaying a HSR entering the Australian marketplace from 27 June 2014 (HSR system endorsement) until 30 June 2017. Foods were categorised as either a 'five food group' (FFG) food or 'discretionary' food in accordance with ADG recommendations.	Over half of the discretionary foods[42] had a Health Star Rating of ≥2.5 stars, thus potentially undermining national dietary guidelines.
Pettigrew *et al.* (2016)	85 Western Australians aged 10 years and older.	Using a qualitative, exploratory approach involving 10 focus groups with adults and children, this study investigated consumers' attitudes to the Tick and its relevance to their purchase decisions.	Credibility issues with the Australian Heart Foundation's Tick logo regarding its use on some products sold in fast food outlets and deemed of questionable nutritional value.
Yang *et al.* (2016)	31 non-alcoholic pre-packaged beverages representing eight subcategories in Australia.	Focussing on beverages, this study compared how Traffic Lights, Daily Intake Guide, and Health Star Rating rated the healthfulness of drinks as di- …/…	Whereas water came out on top with the Traffic Lights and Daily Intake Guide schemes, the Health Star Rating rated various …/…

42. 'Discretionary' foods are described in that study as non-nutritious and high in kilojoules, saturated fat, added sugars, added salt, or alcohol. These foods are opposed by nutritious foods, *i.e.* those belonging to the Five Food Groups defined in the Australian Dietary Guidelines (fruit; vegetables; grain foods; meat/eggs/tofu/nuts/seeds/legumes; milk/yogurt/cheese/alternatives).

Table 27. *(cont.)*

Study	Sample	Intervention/Comparator	Outcome
Yang *et al.* (2016) *(cont.)*		verse as water, ginger beer, cola, and tomato juice.	vegetable and fruit juices higher than water. Despite a certain arbitrariness of the comparative rating approach,[43] the study showed how different FOP schemes might send very different messages to the consumer about the healthfulness of a given product.

On the other hand, there are several studies that show reasonable agreement between FOP scheme ratings and dietary recommendations (*Table 28*).

Table 28. *Agreement between FOP scheme ratings and dietary recommendations.*

Study (most recent first, but grouping related studies)	**Outcome**
Jones *et al.* (2018*a*) Carrad *et al.* (2016)	Ratings assigned by the Guiding Stars and Australian Health Star Rating schemes to packaged foods and drinks were broadly in line with Australian Dietary Guidelines; discrepancies in median score between the two schemes for edible oils, convenience foods, and dairy.
Maillot *et al.* (2018) Julia *et al.* (2015*b*)	Nutri-Score and SENS scheme ratings found to align with French national dietary recommendations.
Cooper *et al.* (2017)	Health Star Rating correctly classified dairy beverages according to healthfulness, but found poorer performance regarding yogurt, cheeses, and other dairy products.
Menday *et al.* (2017) Peters *et al.* (2017)	Substitution of added sugars for total sugars would better align the Health Star Rating with the Australian Dietary Guidelines.
Wellard *et al.* (2016)	Looking specifically at dairy products, fair to very good agreement between the Health Star Rating scheme and nutrient profile criteria for health claims, and overall alignment with Australian Dietary Guidelines for this food group.

43. Traffic Lights ranking based on colour, followed by nutrient contents; % daily intake ranking based on energy content; Health Star Rating ranking based on number of stars, followed by energy content.

Common criteria and guidelines to classify food in terms of nutritional value and the adoption of these standards when assigning evaluative FOP schemes may be useful for consumers. Emrich *et al.* (2013) checked an extensive Canadian national food database against the criteria of the Canadian Heart and Stroke Foundation's Health Check and the Sensible Solutions FOP scheme developed by Kraft and concluded that many products that would qualify for the symbols did not bear them. No reason is provided why this is so, yet for the Sensible Solutions scheme, an important reason may be that this was developed by a single food manufacturer; hence interest by other food business operators in adopting it would likely be limited. Likewise, Edenbrandt *et al.* (2018) noted that the Choices logo in the Netherlands and the Keyhole logo in Denmark did not appear on many eligible products. This observation raises at least two issues, namely incomplete penetration of FOP schemes, and lack of clarity as to reasons for label absence (product ineligibility or manufacturer non-participation).

Incomplete, or selective, penetration may also occur in another sense. For example, the Reference Intakes scheme comes in the two main formats of energy-only or energy plus fat, saturates, sugars, and salt. Manufacturers may choose to use the energy-only format for products that are particularly high in one or more of these nutrients, as suggested by Carter *et al.* (2013). Van Camp *et al.* (2012), in turn, noted decreased odds for the presence of a FOP label for some product categories with increasing levels of sugar or sodium content (albeit with limited significance).

A couple of other studies [Christoforou *et al.*, 2018; Devi *et al.*, 2014] highlighted the use of FOP nutrition information (in a wide sense, including claims but also health logos and the Daily Intake Guide scheme) as marketing tools. If applied to products with poor nutrient profiles, such nutrition information has the potential to mislead about the healthfulness of food products. In an assessment of 10 487 products from a Canadian food database, Emrich *et al.* (2015) observed that products bearing FOP schemes[44] on average did not differ

44. The analysis included FOP schemes that provided nutrition information beyond what is required by the nutrition facts table (*i.e.* nutrition marketing): nutrient-specific systems based on claim criteria, summary indicator systems, and food group information systems. Nutrient-specific systems that displayed the amount of calories and select nutrients on the FOP were excluded as they simply repeated nutrition facts table required information.

nutritionally from similar products without a FOP label. On these grounds, they recommend that comprehensive minimum nutritional standards be developed to ensure products with such FOP labels are indeed compatible with health-promoting diets. Along the same lines, the Dutch consumer organisation Consumentenbond criticised the Choices logo[45] as unduly promoting discretionary and nutritionally unbalanced core foods [Polderman, 2016]. It may also be warranted to study if and how much a given FOP scheme incentivises product reformulation and innovation.

To date, there is no available empirical evidence to link FOP labelling in general or any FOP scheme in particular directly with concrete changes in food intake. As mentioned earlier, proving this causal link is a daunting task. In the absence of evidence – which is not evidence of absence – concerning the actual impact of FOP labelling on diet and health [Cecchini & Warin, 2016; Crockett *et al.*, 2018; Hersey *et al.*, 2013; Health Council of the Netherlands, 2008], the following subchapters consider studies that give an idea of the potential impact of FOP labelling.

4.7.1. Associations between diet quality and health

A slightly modified version of the UK FSA Nutrient Profiling System is used to categorise foods in the Nutri-Score labelling scheme. The FSA Nutrient Profiling System has also been used to assess the overall nutritional quality of diets. The Diet Index thus created theoretically can span from -15 to +40 points [Julia *et al.*, 2014], with a higher index indicating poorer nutritional quality. Associations have been studied between the quality of diets of volunteers of prospective cohorts and the risk of cardiovascular disease (CVD) [Adriouch *et al.*, 2017; Adriouch *et al.*, 2016], cancer [Deschasaux *et al.*, 2018; Donnenfeld *et al.*, 2015], and overweight and obesity [Julia *et al.*, 2015*a*].

45. A green logo bearing the words 'healthier choice within this product group' applied to core foods found in the Dutch Dietary Recommendations 'Schijf van Vijf', whereas a blue logo bearing the words 'conscious choice within this product group' applied to non-core foods (including discretionary foods).

Table 29. *Studies using the Diet Index based on the UK Food Standards Agency (FSA) Nutrient Profiling System to examine associations between diet quality and disease risk.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Deschasaux *et al.* (2018)	Subset of 471595 adults from the European Prospective Investigation into Cancer (EPIC) cohort.	The Diet Index score based on the FSA Nutrient Profiling System was used to assess the healthfulness of participants' diets and correlate this with their risk of cancer.	The HR for total cancer was 1.07 in the quintile with the highest compared to that with the lowest Diet Index score ($p<0.0001$). Significant associations with different cancer types were found for: colorectal, upper aero-digestive tract, and stomach cancers; for lung cancer in men; and for liver and post-menopausal breast cancers in women.
Adriouch *et al.* (2017)	Subset of 75801 individuals from the French NutriNet Santé cohort.	The Diet Index score based on the FSA Nutrient Profiling System was used to assess the healthfulness of participants' diets and correlate this with their risk of CVD.	The Diet Index score was positively associated with CVD risk in the NutriNet cohort. The Hazard Ratio (HR) for CVD associated with an increment of 1 point of the score was 1.08 ($p<0.001$). The HR for CVD in volunteers with the poorest diet quality (lowest quartile) was 1.4 compared with those with the highest diet quality.
Adriouch *et al.* (2016)	Subset of 6515 adults from the French SU.VI.MAX cohort.	The Diet Index score based on the FSA Nutrient Profiling System was used to assess the healthfulness of participants' diets and correlate this with their risk of CVD.	The HR for CVD in volunteers with the poorest diet quality (lowest quartile) was 1.61 compared with those with the highest diet quality. The HR for CVD associated with an increment of 1 point in the Diet Index score was 1.14 ($p=0.01$).
Donnenfeld *et al.* (2015)	Subset of 6435 adults from the French SU.VI.MAX cohort.	The Diet Index score based on the FSA Nutrient Profiling System was used to assess the healthfulness of participants' diets and correlate this with their risk of cancer.	The HR for cancer in volunteers with the poorest diet quality (lowest quintile) was 1.34 compared with those with the highest diet quality. The HR for cancer associated with an increment of 1 point in the Diet Index score was 1.08 ($p=0.02$).

Table 29. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Julia *et al.* (2015*a*)	Subset of 4344 middle-aged participants in the French SU.VI.MAX cohorts 1 and 2.	The Diet Index score based on the FSA Nutrient Profiling System was used to assess the healthfulness of participants' diets and correlate this with their risk of becoming overweight/obese.	A higher baseline Diet Index score (=poorer diet) was associated with an increased risk of becoming overweight or obese. However, only in men was this shown to result in a significantly higher risk (12% for overweight, 16% for obesity) per 1-point increase in the Diet Index score ($p \leq 0.02$).

Taken together, the results from these five studies suggest that better diet quality is associated with lower risk of CVD, cancer, and weight gain (in men). Given that the study cohorts tended to be more health conscious and represented only few European countries, one might expect more pronounced effects in more deprived population. The study authors conclude that FOP labelling schemes based on the FSA Nutrient Profiling System could help consumers shift their diets towards lower Diet Index scores and with it reduced risk of said conditions.

4.7.2. Effects of FOP labels on diet and health – food perception experiments

FOP labelling can affect consumers' perception of the tastiness of foods, which in turn may influence purchasing and consumption decisions. The few studies encountered on the subject (*Table 30*) suggest that FOP labels have the potential to guide consumers towards healthier products, but attention should be paid to label features and socio-cultural context in order to achieve the desired impact.

Table 30. *Studies highlighting the impact of FOP nutrition labelling on consumers' tastiness evaluations of foods.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Wang *et al.* (2016)	566 Norwegian adolescents.	Assessment of whether information provided by the Keyhole symbol, a widely .../...	Keyhole labelling did not affect perceived tastiness of snacks compared to snacks without the Keyhole label.

Table 30. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Wang *et al.* (2016) *(cont.)*		used FOP symbol in Nordic countries to indicate nutritional content, and % Daily Values affect Norwegian adolescents' perception of the tastiness of snacks.	
Liem *et al.* (2012*a*)	46 Dutch adults.	Effect of different labels, one being the Healthy Choice FOP logo, on taste perception of an instant chicken soup. The exact same soup was served to each volunteer four times on the same day, yet each time with a different label. The four different labels were: i) a control label saying 'chicken soup'; ii) a label saying 'now with reduced salt'; iii) a label displaying a 'Healthy Choice' tick logo; and iv) a label with both the 'now with reduced salt' statement and the Healthy Choice logo.	Expected liking of the soup was lower for the three experimental conditions than for the control label. Actual liking, as reported after tasting, was not affected by the label. In conclusion, highlighting reduced salt content may have a detrimental effect on salt intake (and potentially health) if consumers decide against purchasing products labelled in such a way.
Liem *et al.* (2012*b*)	50 Australian adults.	Assessment of expected and actual liking of instant chicken soup with three different salt levels (regular, 15% reduced salt, 30% reduced salt) served on three separate days. On each day, the three labelling conditions studied were: i) a control label saying 'Chicken Noodle'; ii) 'now reduced salt – great taste' label; and iii) Australian Heart Foundation 'Pick the Tick' label.	Overall, the results were mixed for expected and actual liking under the different labelling conditions, but it is worth noting that the 15% salt-reduced soup scored closest to the ideal on the scale indicating the 'just about right salt level for me'. The authors concluded that the Tick logo was a viable option for indicating salt-reduced foods without saying so and thus lowering potential consumers' taste expectations. Soups labelled as …/…

Table 30. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Liem *et al.* (2012*b*) *(cont.)*			30% reduced in salt resulted in participants adding salt beyond the levels in the standard soup without salt reduction.

4.7.3. Effects of FOP labels on diet and health – food selection in online choice tasks

Several experimental studies have looked at the potential impact of one or more FOP nutrition labelling schemes on consumers' food choices and nutrient intakes in an online setting (*Table 31*). This approach allows for maximum control of the label exposure and surrounding environment, which however limits its transferability to the real world. Taken together, the evidence suggests that, in a highly controlled environment, evaluative schemes (*e.g.* colour-coded schemes, positive logos) may help steer consumer choices in nutritionally desirable directions. A reference base of 100 g seems to be favourable over per portion labelling in this experimental setting.

Table 31. *Studies assessing the impact of FOP labelling schemes on food/portion selection in online choice tasks.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Egnell *et al.* (2018*b*)	Subset of 25 772 adults (mean age 56 ± 14.5 y, 27% men) from the French NutriNet-Santé cohort.	Assessed the impact of Nutri-Score, UK MTL, Evolved Nutrition Label (ENL), and a 'no label' control on consumers' portion selection in the categories of sweet biscuits, cheese, and sweet spreads. These categories were chosen because they are typically consumed by the French study population at various mealtimes, .../...	Participants consistently chose smaller portions in the Nutri-Score compared to the 'no label' control, both in individual food categories and across all products. The UK MTL produced very similar results except for sweet spreads, where the reduction was not significant. In contrast, portions selected in the ENL condition were smaller than in the control group only for cheese, .../...

Table 31. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Egnell *et al.* (2018*b*) *(cont.)*		reductions in portion size (= consumption) would be desirable, and the small portion criteria of the ENL applied. This latter aspect allowed discerning the impact of this specific feature from the colour coding in the UK MTL.	and significantly larger than the control for sweet spreads. There was no difference between ENL and control for sweet biscuits and across all products. The authors conclude that per portion FOP nutrition information might not help consumers choose healthier portion sizes and that instead 100 grams would be a more suitable reference base.
Talati *et al.* (2018)	1505 Australian adults (50% men, skewed towards lower socio-economic status).	Tested the impact of the Health Star Rating, Daily Intake Guide, Multiple Traffic Lights, and a 'no FOP label' control on portion size selection. With the intention to focus on unhealthful foods, the authors chose pizza, cookies, cornflakes, and yogurt (none of which rated higher than 1.5 stars in the Health Star Rating scheme). Eight different portion sizes were offered for the former two foods, four for the latter two. Participants were asked to indicate the amount they should eat at one time and had the option to choose 'no amount'.	Out of the individual FOP schemes, the Health Star Rating resulted in smaller portion sizes selected for pizza and cornflakes, and the Multiple Traffic Lights produced lower portions for pizza. The Daily Intake Guide showed no significant impact in any of the food options. Interestingly, in the presence of any FOP label, 'no amount' was chosen more often than in the 'no FOP label' control (12-15% *vs.* 9%, $P \leq 0.04$), with slightly more pronounced effects observed for the evaluative Health Star Rating and Multiple-Traffic-Lights labels compared to the reductive Daily Intake Guide.
Tórtora & Ares (2018)	155 adults in Uruguay.	A choice conjoint task was designed using labels differing in type of cookie (chocolate chips *vs.* granola), FOP nutrition information (warning sign *vs.* Facts-Up-Front system) .../...	FOP black octagonal warning signs discouraged choice of cookies when compared to the Facts-Up-Front scheme. This was regardless of whether participants sought instant gratification (*i.e.* less consideration for .../...

Table 31. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Tórtora & Ares (2018) *(cont.)*		and nutritional claim (no claim *vs.* '0% cholesterol. 0% trans fat'). Participants evaluated eight pairs of cookie labels and selected the one they would buy if they were in the supermarket. Then, they were asked to complete a consideration of future consequences scale adapted to eating habits.	future consequences) or had a rather long-term, health-minded perspective (*i.e.* more consideration for future consequences).
Masic *et al.* (2017)	458 adults (87 men), aged 18-64 years in the UK.	Food and beverage choice task to investigate the effect of different FOP nutrition labels in four different labelling conditions: a) no label; b) kcal label; c) physical activity (PA) label;[46] and d) kcal + PA labels.	All experimental conditions led to choices lower in calories than in the no label condition, ranging from -87 kcal with the kcal label to -166 kcal in the PA label condition. The authors noted that the observed energy intake reduction would match the 100 kcal daily deficit computed to address weight gain in 90% of the adult population [Hill *et al.* 2003]; for children and adolescents, a 150 kcal reduction in excess energy intake has been reported to be necessary [Wang *et al.* 2006].
Defago *et al.* (2017)	100 university students in Peru.	Choice experiment to identify the impact of Multiple-Traffic-Lights labels on consumers' actual food choices. Participants were asked to pick a beverage and a pack of crackers among three options, re- .../...	Multiple-Traffic-Lights labelling, notably with four instead of three colour levels, resulted in significantly more healthful beverage but not cracker choices when compared to standard nutrition labelling. In both categories, subjects could choose .../...

46. Duration of walking necessary to burn off the calories contained in the food or drink product.

Table 31. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Defago *et al.* (2017) *(cont.)*		spectively. Both categories comprised products with similar prices but different nutritional quality.	between three levels of healthfulness, and they were more likely to choose the most healthful and less likely to choose the least healthful option in the Multiple-Traffic-Lights condition. The authors speculate that a slightly larger sample size might have rendered the results significant for both categories.
Onozaka *et al.* (2014)	108 adults (52% females; 20-64 years) in Norway.	Small laboratory experiment testing food choice behaviour in the presence of the Keyhole logo and a Multiple Traffic Lights.	Products with the Keyhole label were chosen more often when participants had to select any product. However, when they were nudged into a 'choose healthy' state of mind before product choice, neither of the two FOP schemes affected the choice. Interestingly, this health priming revealed to be beneficial for overweight, but not for obese subjects.
Bui *et al.* (2013)	220 parents with at least one or more children the age of 15 or younger in the USA.	Participants were asked to choose a breakfast cereal for their child out of a selection of three products varying from unhealthful, to moderately healthful, to healthful. The moderately healthful cereal and a wholegrain logo served as the reference condition to test the impact of a 'Smart choices made easy' FOP logo and a claim saying 'Whole Grain Guaranteed' on choice healthfulness.	The Smart Choices logo more than tripled the likelihood of selecting the healthier product over the reference condition. However, combining the wholegrain logo with the claim increased that likelihood by a factor of about 5.5.
McLean *et al.* (2012)	500 hypertensive and 191 normotensive .../...	Examined the effect of nutrition label format on .../...	Providing FOP labels significantly increased the respondents' ability .../...

Table 31. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
McLean *et al.* (2012) *(cont.)*	adult online panellists in New Zealand.	forced choice of high and low-sodium baked beans (fictitious brand cans). The three labelling options tested were: (i) BOP nutrition declaration only; (ii) BOP + % daily intake; and iii) BOP + Multiple Traffic Lights (only colours, no numbers or text).	to discriminate between canned beans with high and low sodium content, and especially the traffic-lights format helped consumers identify the high-sodium product as the less healthful option. Notably, the hypertensive participants were significantly more likely to choose the low-sodium option when compared to normotensive respondents, and this was further aided by the presence of a FOP label. However, the % Daily Intake label rendered the high-sodium product more attractive among hypertensives, whereas the Traffic Lights did not, and the Traffic Lights decreased the attractiveness of this option among normotensives.
Roberto *et al.* (2012*d*)	216 adults in the USA.	Influence of the Smart Choices symbol tested on the serving and consumption of cereal, and the impact of providing calorie and serving size information on a FOP label. Participants were exposed to high-sugar breakfast cereals that had i) no label; ii) the Smart Choices symbol; or iii) a modified Smart Choices symbol with serving size information. Participants rated healthfulness, taste, and purchase intent. They also estimated calories per serving, and chose and ate a portion of the cereals.	Participants in the Smart Choices label conditions were better able to indicate calories per serving, but there were no differences across groups on ratings of healthfulness, taste, purchase intent, and amount of cereal consumed.

4.7.4. Effects of FOP labels on diet and health – food selection in offline choice tasks

Similar to online choice tasks, choice experiments in offline settings provide a great deal of control over the experimental setting. Furthermore, they add a more or less pronounced haptic or even sensory element depending on whether study participants are asked to prepare and taste a food/meal (see *section 4.7.5*), are being shown real food packages, or just get to handle show cards of products or food baskets. The offline food choice studies listed in *Table 32* suggest that FOP nutrition labelling can have a positive, albeit small effect on the nutritional composition of food choices and nutrient/energy intakes. Amongst the labels tested in the studies listed below, traffic-lights-based schemes tended to be most effective, although this may differ depending on food category and cultural context. Measures that increase familiarity with and awareness of a given FOP scheme are likely to enhance the implied beneficial impact on diets.

Table 32. *Studies assessing the impact of FOP labelling schemes on food selection in offline choice tasks.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Graham *et al.* (2017)	153 parent/child pairs in the USA.	Tested the impact of a monochrome and a Traffic Lights-coded[47] Facts-Up-Front label, with or without in-aisle explanation of these labels, on the nutritional composition of food choices against a 'no label' control. The food choice task was carried out in a laboratory grocery aisle set-up with 90 products, 30 each from the categories of: i) crackers/cookies; ii) breakfast cereals; and iii) chips/snacks. FOP labels were affixed in the top right corner of real packages positioned on the shelves similarly to what would be found in an actual .../...	Food choices turned out to remain unaffected by the presence of FOP labels. Only when FOP labels were accompanied by in-aisle explanation, a few marginally significant improvements occurred. Importantly, higher self-reported motivation to purchase healthful foods was significantly linked with healthier food choices. Higher parent BMI and child body weight also led to some improvements for certain nutrients depending on the food cat- .../...

47. Using UK MTL criteria.

Table 32. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Graham *et al.* (2017) *(cont.)*	153 parent/child pairs in the USA.	supermarket, including price tags. Participants were asked to choose two products in each category, resulting in a total of six products to take home. Attention to FOP labels was measured using eye-tracking methodology.	egory. The authors speculate that lack of familiarity with the traffic-lights concept on food labels may have resulted in the failure of the traffic-lights-coloured Facts-Up-Front scheme to perform better than the monochrome Facts-Up-Front. Having had to choose healthier options from within generically rather unhealthful categories (cookies, chips) may also have presented a constraint that in real life could be circumvented by skipping such categories altogether.
Goodman *et al.* (2013)	430 adults in Canada.	Lab experimental study to examine the efficacy of four types of FOP sodium labels at influencing consumers' selection of products low *vs.* high in sodium. Sodium-specific reductive (% Daily Intake) and evaluative (traffic-lights-coded) FOP labels on packaged crackers were compared to nutrition facts panel on the side of the pack as control.	Significantly more participants chose the low-sodium option compared to the control group. The FOP label combining colour coding and wording high/low sodium was the most effective, and including numerical information rendered the FOP label more believable than offering only traffic-lights labelling.
Vermeer *et al.* (2011)	89 participants (74% females; mean age 50 years) in the Netherlands.	Field experiment in a Dutch cinema. Participants were asked to select one of five different portion sizes of a soft drink. Consumers were provided with portion size and caloric GDA labelling (experimental condition) or with millilitre information (control condition).	GDA labels were found to have no effect on soft drink intake.

Table 32. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Balcombe *et al.* (2010)	477 UK households.	Consumers were asked to choose from a range of shopping baskets containing foods for one week and labelled with traffic-lights colours for their content of salt, sugar, fat, and saturated fat. Employing various price levels and traffic-lights colour combinations, the aim was to assess consumers' willingness to pay for a nutritionally more favourable shopping basket.	Consumers were eager to move away from baskets with any red labels (for all nutrients), but showed substantially less concern for switching from amber to green. The effect was most pronounced for salt, which the authors explain by the heavy salt reduction campaigning present in the UK at the time. In terms of socio-demographics, women, households with children, and people of higher education level were more willing to pay for shopping baskets with lower negative nutrient levels; age did not play a major role.
Borgmeier & Westenhoefer (2009)	420 adults in Hamburg, Germany.	In a simulated shopping situation, participants were asked to compose one day's consumption from food show cards. The FOP schemes compared were: i) Multiple Traffic Lights (without RI); ii) a simple 'healthy choice' tick (applied to all products that scored a green traffic light on all nutrients considered); iii) monochrome GDA; iv) traffic-lights-coded GDA; and v) a 'no label' control condition. The 78 foods available allowed participants to select a day's diet in line with dietary recommendations.	No significant differences emerged between the various FOP labels in terms of energy and nutrient intakes. The authors note, though, that different labelling schemes may work differently depending on the food group. They observed that Traffic Lights yielded the most correct choices for dairy products, whereas the healthy choice tick performed best on breakfast cereals. This latter result may have been influenced by the different number of products available for comparison: 8 dairy products *vs.* 3 breakfast cereals.

4.7.5. Effects of FOP labels on diet and health – meal selection/preparation studies

A few studies investigated whether FOP schemes have an impact on people's selection or preparation of meals (*Table 33*).

Table 33. *Studies assessing the impact of FOP labelling schemes on people's selection or preparation of meals.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Brown *et al.* (2017)	117 adults aged 18-30 from the University of Newcastle Callaghan campus and via social media, radio and newspaper advertisements in the UK.	Meal selection study with a fake food buffet, focussing on FOP labels and portion sizes. Participants were randomly assigned to a control group, to a kJ/100 g food label or to a Health Star Rating label. They were then asked to serve themselves an adequate portion of breakfast cereal, fruit salad, and chocolate, and a three-component meal (chicken, fries, and mixed vegetables) from a fake food buffet.	Neither the kilojoule nor Health Star Rating information influenced negatively (positively) the self-served portion size of unhealthful (healthful) foods or meal components.
Babio *et al.* (2014)	81 adolescents (14-16 years) from a Spanish secondary school.	Participants had to choose breakfast, lunch, snack, and dinner options for a period of five days from a closed menu based on monochrome or Multiple traffic-lights-coded GDA labelling.	When participants used the Multiple traffic-lights-GDA scheme, they chose significantly less total energy, sugar, fat, saturated fat, and salt than when they used the monochrome GDA scheme.
Gregori *et al.* (2013)	114 Chilean mothers and close relatives.	Participants were asked to prepare meals from foods labelled with (monochrome) numerical nutrition information, either per portion or per 100 g.	Participants prepared meals with a higher energy content when provided with numerical nutrition information per 100 g (rather than per portion) on the labels of the foods they used. This suggests that displaying the numerical nutrition information per

.../...

Table 33. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Gregori *et al.* (2013) *(cont.)*			portion may be more effective than displaying it per 100 g. However, the result contradicts other studies, including a pan-European survey by the same research group [Gregori *et al.*, 2014], and would first need to be confirmed in larger samples differing in factors such as age, gender, socio-economic status, ethnicity, and cultural background. Furthermore, it remains unclear if, and how, any addition of evaluative elements might change the observed outcome.

Complementing the above evidence, a recent systematic review [Brown *et al.*, 2018] on food information and portion size selection identified six studies reporting a total of eight effects of various traffic-lights-coded labelling schemes[48] on food consumption; not all studies were specific to FOP labelling. Three effects were nil and four were positive (two meant higher intakes of nutrient-dense foods, and two meant lower intakes of energy-dense, nutrient-poor foods). The one negative effect, namely higher intakes of energy-dense, nutrient-poor foods, was observed in the study by McCann *et al.* (2013). Brown *et al.* (2018) also reported on the impact of GDA on food consumption, finding four of a total of six effects to be nil, one positive (lower intake of energy-dense, nutrient-poor foods), and one negative (again from McCann *et al.*, 2013). For health logos (Smart Choices, Choices,

48. The five papers reporting the six studies used the following traffic-light formats: calorie and multiple traffic-light menu labelling; traffic-light diet (TLD) labels which divide all foods into three categories (green, yellow, and red) based on fat and sugar content; labelling with high fat (red) or low fat (green) traffic lights based on UK FSA criteria; multiple traffic-light labelling of meals based on UK FSA criteria.

Keyhole, and a brand health logo), they found four studies reporting four effects. Only one of these, testing the Keyhole logo in a worksite canteen, showed a beneficial increase in the consumption of nutrient-dense foods. The studies considered on Smart Choices and Choices showed no effects whereas the brand health logo resulted in increased consumption of energy-dense, nutrient-poor foods.

4.7.6. Effects of FOP labels on diet and health – theoretical modelling studies

Several studies have investigated the impact of FOP nutrition labelling on consumer purchases and as a possible incentive towards product reformulation efforts by industry. Typically, these studies estimate the subsequent impact on nutrient intakes, specifically salt, (saturated) fat, and sugar. However, evidence demonstrating that any such impact is ultimately translated into a public health benefit is sparse, partly owing to the difficulty of setting up such studies and proving causality.

Whereas Cecchini & Warin (2016) calculated that FOP labelling could increase the number of people choosing a more nutritious food option by about 18% (see *4.6*), their findings show a less clear picture in terms of whether food labelling schemes reduced calorie consumption (on the basis of four relevant scientific studies identified). This may be explained in part by the fact that consuming a product with reduced salt content is healthier but does not reduce calorie intake.

In the absence of available real-life evidence on the impact of FOP labelling on diet, modelling studies serve to explore 'what if' scenarios (*e.g.* by extrapolating the effects on purchasing behaviour to overall diet and diet-related health outcomes). Using existing data from diet surveys, researchers have modelled the potential improvement in the whole diet that could be achieved by substituting foods non-compliant with FOP labelling criteria with compliant foods.

Modelling can offer valuable insights and facilitate the comparison and quantification of the impact of FOP labelling initiatives, by evaluating policy scenarios and health outcomes, while giving due care to the underlying uncertainty in this domain. Herein, some modelling endeavours have been identified, in which FOP labelling has been specifically considered.

One modelling approach considers potential improvements in nutrient intakes due to FOP labelling schemes (*Table 34*). Most of the studies report relevant reductions in the theoretical consumption of energy and nutrients to limit, occasionally also considering increases in nutrients (fibre) or food components (whole grain) to encourage. However, the scenarios are often more ambitious than what current food purchasing studies suggest to be realistic levels of FOP labelling impact. They may thus rather be seen as indicators of what dietary improvements could be achieved under ideal circumstances.

Table 34. *Studies modelling the impact of FOP labelling schemes on people's energy or nutrient intake.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Mendoza *et al.* (2018)	General population in Mexico.	Calculated the potential changes in energy and nutrient composition of Mexican diets using two sets of nutrient profile criteria for FOP labelling schemes. One set of criteria, developed by an independent expert committee from the National Institute of Public Health, was named MCNE criteria[49] and not linked to a specific FOP label. The other set, called COFEPRIS criteria[50] and based on the EU Pledge nutrition criteria developed by the food industry, forms the basis for the voluntary 'Sello Nutrimental' FOP logo currently in use in .../...	A total of 76% (n = 268) of processed foods were classified as not meeting the MCNE nutrition criteria. From these, 44% (n = 118) could be replaced by a food that met the criteria, and thus formed the basis for calculating the nutrient intakes. In contrast, 46% (n = 167) were classified as not meeting the COFEPRIS nutrition criteria, and 32% (n = 54) of these could be replaced by a food that met the COFEPRIS criteria. Using the MCNE criteria, intake reductions were observed in energy (-5.4%), saturated fatty acids (-18.9%), trans-fatty acids (-20%), total .../...

49. Foods were divided in 19 categories; cut-offs were set for energy, saturated fat, trans fat, added sugar, sodium and fibre content per 100 g, 100 ml, or in % of total fat or energy of food. Cut-off points are different for each category.
50. Foods were divided into 26 categories, and limits were set for energy, saturated fat, total sugar and sodium content per 100 g or 100 ml, per serving or in % of total fat or energy per product. Cut-off points are different for each category. These criteria excluded sugar-based products, like chocolate products, jam, jelly, syrup, honey and soft drinks, which are not considered healthy.

Table 34. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Mendoza *et al.* (2018) *(cont.)*		Mexico (see *Annex*). Commonly consumed processed foods identified from the national survey were replaced wherever possible by processed foods meeting the respective nutrient profile criteria and the resulting changes in nutrients and energy computed.	sugar (-36.8%) and sodium (-10.7%), combined with a significant increase in fibre intake (+15.5%). In comparison, applying the COFEPRIS criteria only resulted in significant changes for trans fat (-20%) and sodium (-9.7%).
Emrich *et al.* (2017)	General population in Canada.	Evaluated all foods reported in the national Canadian diet survey using UK MTL criteria and replaced any products with one or more red lights by similar foods not bearing any red lights, where available, or otherwise by the healthiest option.	In this scenario, caloric intake could be reduced by 5%, total fat intake by 13%, saturated fat intake by 14% and sodium intake by 6%. Sugar intake would not be reduced significantly under this scenario.
Raulio *et al.* (2017)	General population in Finland.	Assessed potential to reduce the intake of hard fats (saturated and trans fat) and sodium by using products bearing the Heart Symbol. Based on 48-h diet recall data of, the researchers replaced foods from four food groups[51] majorly contributing to intakes of hard fat, sodium, and fibre with products complying with Heart Symbol criteria.	In this scenario, hard fat intake was reduced by 34.6% (from 14.3 to 9.9 en%), and salt intake by 11% (from 7.6 to 6.8 g/day). Other effects were less pronounced.
Julia *et al.* (2016*b*)	95 942 volunteers (22% men) from the French NutriNet-Santé diet survey.	Classified foods consumed according to their Nutri-Score rating. Based on how much energy individuals obtained .../...	The substitution scenarios resulted in lower intakes in fat, sugars and added sugars and an increase in fibre intake, .../...

51. Milk and dairy products (milk, buttermilk, vegetable milks, cream, yogurt, fermented milk, curd, pudding, soft cheese, cheese spread, hard cheese), meat products (cold cuts, sausages), fats and oils (fat spreads) and bread and cereal products (bread, biscuit and pastry items).

Table 34. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Julia *et al.* (2016*b*) *(cont.)*		from each of the five categories of the Nutri-Score, the researchers identified three mutually exclusive clusters of diet patterns: Healthy, Western, and Traditional. Next, three potential substitution scenarios were designed. In the first scenario, all products in a given category not labelled green were substituted by foods with the mean nutritional value of all higher rated products in that category. For example, the nutritional value of a breakfast cereal rated lowest (letter E, colour red in the Nutri-Score) was replaced by the mean of all breakfast cereals rated A-D. In the second scenario, all products not scoring green (A) were replaced by same category products falling into the next higher 5-CNL scoring bracket (products rated B were replaced by products scoring A, those rated C by products scoring B, and so on). In the last scenario, the same approach as for the second scenario was applied, but only for a random selection of 30% of all products consumed, to simulate an incomplete and thus more realistic substitution pattern.	with pronounced effects observed in the more ambitious scenarios (1 and 2) only. Not surprisingly, people with a Western or Traditional diet pattern benefitted relatively more than those with an already healthy pattern. In the Western diet pattern, the fraction of people achieving the dietary recommendations for total and saturated fat was 16.2% and 13.5%, respectively. These figures increased to 22.0% and 17.8% in scenario 3 and peaked in scenario 1 at 60.6% and 85.7%, respectively.
Amcoff *et al.* (2015)	General population in Sweden.	Effects on nutrient intake in the Swedish population by replacing unlabelled foods with Keyhole-labelled foods where .../...	If consumers consistently opted for Keyhole foods, intake reductions would be observed for total calories (-11%), fat .../...

Table 34. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Amcoff *et al.* (2015) *(cont.)*		feasible based on food intakes in the national dietary survey Riksmaten adults 2010-11.	(-29%), saturated fat (-40%), and added sugar (-9%). At the same time, dietary fibre intake would increase by 30% and wholegrain by 754%. Of note, the switch to Keyhole-labelled products would cause a drop in mono- and polyunsaturated fat intake by 25% and 7%, respectively. This is largely owing to a reduction in animal fat intake, and the substantially larger drop in saturated fat results in an improved fat quality overall.
Biltoft-Jensen *et al.* (2015)	General population in Denmark.	Effects on nutrient intake in the Danish population by replacing unlabelled foods with Keyhole-labelled foods where feasible based on food intake data for 2011-13.	Danes replacing non-Keyhole foods with corresponding products featuring the label would consume less energy (-1000 kJ), saturated fat (-27%), and salt (-1 g) per day, and increase their intakes of wholegrain (76%) and dietary fibre (18%).
Astrup *et al.* (2015)	General population in Norway.	Effects on nutrient intake in the Norwegian population by replacing unlabelled foods with Keyhole-labelled foods where feasible based on food intake data from the NORKOST 3 survey.	In Norway, replacing the usual non-keyhole foods from a national food survey with keyhole-labelled foods resulted in lower daily intakes of total fat (-11.4 g; -13%), saturated fat (-8.9 g; -26.5%), and energy (-403 kJ; -4.3%), while dietary fibre intake increased (4.7 g; 19.3%). Milk and cheese variants marked with a keyhole contributed most to the reduction in total fat and energy intake and helped as much as replacing margarine and but- .../...

Table 34. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Astrup *et al.* (2015) *(cont.)*			ter in reducing saturated fat intake. The exchange of grain products contributed most to the fibre increase. Switching to keyhole foods helped move the saturated fat intake close to the recommendation of less than 10% of daily energy. Notably, men benefitted more than women did from switching to keyhole foods in terms of total fat, saturated fat, dietary fibre, and energy intakes. Younger men and men with lower education experienced the greatest nutritional benefit of switching to keyhole foods. For women, there were small differences between age groups and education levels.
Ahlin (2015)	General population in Sweden.	Thesis project based on national food consumption survey Riksmaten 2010-2011. Modelled shift in nutrient intakes in the Swedish population from switching to Keyhole- or Finnish Heart Symbol-labelled or 'best-in-class' products where feasible. 'Best-in-class' products were those that within a given category differed maximally from the original product in the specific nutrient considered.	Whilst nutrient intakes could be improved by using products labelled with the Keyhole or the Finnish Heart Symbol, the most substantial effect was achieved with 'best-in-class' products. However, it is unlikely that such products would achieve 'best-in-class' status for all nutrients concomitantly. As an example, choosing the lowest salt level product in a given category might not result in an optimal saturated fat reduction for that category.
Wilson *et al.* (2014)	General population in New Zealand.	Compared nutrient intakes in the Tick FOP label programme to the counterfactual case of no programme, using nutrition …/…	There were 448 of the 8 440 (5.3%) packaged food items in NutriTrack that displayed the Tick. Reductions in saturated …/…

Table 34. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Wilson *et al.* (2014) *(cont.)*		survey and food composition data (NutriTrack).	fat (-1 g/day, -3.2%), sodium (-38 mg/day, -1.1%), and energy (-72 kJ/day; -0.8%) have resulted from the existence of the Tick labelling scheme.
Roodenburg *et al.* (2013)	Dutch young adults aged 19-30.	Used food consumption survey data from 2003 to compare three nutrient intake scenarios for young adults: 1) actual nutrient intakes; 2) hypothetical nutrient intakes if products not compliant with Choices logo criteria would be replaced by compliant products where possible; and 3) scenario 2 corrected for differences in energy content between original and replacement foods.	Median intake reductions for energy (-16%) and nutrients to limit (from -23% for sodium to -62% for TFA). Intakes of beneficial nutrients varied from an unintentional reduction in fat-soluble vitamin intakes (-15 to -28%) to an increase of 28% for fibre and 17% for calcium. Stratification by gender, age, BMI, and education level revealed only small differences.
Roodenburg *et al.* (2009)	750 Dutch adults aged 19-30 from the Dutch National Food Consumption Survey 2003.	Used food consumption survey data from 2003 to compare three nutrient intake scenarios for the Dutch population: 1) actual nutrient intakes; 2) hypothetical nutrient intakes if products not compliant with Choices logo criteria would be replaced by compliant products where possible; and 3) scenario 2 corrected for differences in energy content between original and replacement foods.	In scenario 2, reductions were found for energy (-15%), sodium (-23%), and trans fats (-63%), with other nutrients to limit (total fat, total sugar, saturated fat) falling between the sodium and trans fat reduction levels. At the same time, nutrients with minimum intake levels increased between 5% (folic acid) and 28% (fibre). However, decreases were also observed for mono-unsaturated fatty acids (-28%) and polyunsaturated fatty acids (-1%) as well as total carbohydrates (-16%). Similar to Amcoff *et al.* (2015), the drop in unsaturated fats may be largely owing to a reduction in animal fat intake, .../...

Table 34. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Roodenburg *et al.* (2009) *(cont.)*			which leads to an overall desirable improvement in fat quality. Changes remained in scenario 3, but were smaller for nutrients to limit and more pronounced for most of the nutrients with lower intake limits.

Going beyond modelling the changes in nutrient intakes, three studies estimated the impact of FOP labelling schemes on health (*Table 35*). Again, whilst the scenarios show the evaluative FOP schemes to be a cost-effective measure to improve health, the underlying assumptions may be very optimistic.

Table 35. *Studies modelling the impact of FOP labelling schemes on people's health.*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Egnell *et al.* (2019)	Purchase data from a framed-field experiment with 691 participants and dietary intake data from 81421 participants in the NutriNet Santé observational cohort.	Investigated the effects of five different FOP labelling schemes (Nutri-Score, Health Star Rating system, Multiple Traffic lights, Reference intakes and SENS on the nutritional quality of household purchases. Relative differences in nutrient content and composition of food purchases were then applied to dietary intakes using data from an observational study. A macro-simulation study was then conducted to estimate the impact of the modification in dietary intake as a result of FOP scheme use on mortality from diet-related non-communicable diseases.	The use of FOP labelling schemes led to a substantial reduction in mortality from chronic diseases. Approximately 3.4% of all deaths from diet-related non-communicable diseases was estimated to be avoidable when the Nutri-Score scheme was used. The remaining FOP labelling schemes likewise resulted in mortality reductions, although to a lesser extent: Health Star Rating system (2.8%), Reference Intakes (1.9%), Multiple Traffic Lights (1.6%), and SENS (1.1%).

Table 35. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Mantilla Herrera *et al.* (2018)	General Australian population.	Cost-effectiveness analysis of the potential of the Australian Health Star Rating scheme to motivate product reformulation and thus impact health.	Reductions in energy intakes resulting from food reformulation could lead to weight and BMI reductions, which in turn affects the incidence and prevalence of many obesity-related diseases and would be cost-effective in both voluntary and mandatory scenarios.
Vyth *et al.* (2012)	General Dutch population.	Investigated the impact of replacing foods that do not comply with the Dutch choices labelling criteria with compliant foods in 24% (minimum scenario), 48% (medium scenario), and 100% (maximum scenario) of the population. Of note, 36% of all non-compliant products could not be replaced by a similar compliant product.	In the maximum scenario, the resultant median reductions in saturated fatty acids (from 14.5 to 9.8 en%) and trans-fatty acids (from 0.95 to 0.57 en%) were predicted to reduce both low-density-lipoprotein and total cholesterol, with a slight increase in the ratio of total cholesterol to high-density-lipoprotein (HDL) cholesterol owing to a concomitant drop in HDL cholesterol. Based on epidemiological findings, the authors computed a 1.59% reduced risk of myocardial infarction in the maximum scenario, but they also point out that even the minimum scenario may be too optimistic.
Sacks *et al.* (2011)	General Australian population.	Cost-effectiveness analysis of FOP Traffic Lights labelling in Australia.	Mandatory inclusion of labelling on selected food products yielded a change in energy intake (-154 kJ/day in men, -88 kJ/d in women) with subsequent reductions in weight (-1.6 kg for men, 0.9 kg for women). Under the assumption that this energy intake reduction would occur in 10% of the population, the authors report that 45 100 disa-

.../...

Table 35. *(cont.)*

Study (most recent first)	Population	Intervention/Comparator	Outcome
Sacks *et al.* (2011) *(cont.)*			bility-adjusted life years (DALYs) could be averted. In economic terms, the intervention would be effective and cost saving.

A common feature in the studies cited above – both on nutrient intakes and health – is the somewhat *ad hoc* manner in which consumer behaviour and choice is incorporated in the modelling framework. This becomes most evident in studies that assume a 100% shift towards products with a (positive) FOP label without considering consumer preferences or likely purchasing behaviour. There is conflicting evidence in the literature on the drivers of consumer preferences, which includes not only health but also factors such as cost, taste, and convenience. The acceptance of consumers regarding reformulated or newly innovated foods is uncertain and highly variable across consumer groups. Emrich *et al.* (2017) assumed that all consumers would choose the more nutritious option if available. Sacks *et al.* (2011*c*) adopted a more conservative approach with an assumption that only 10% of the population would respond to the labelling and alter their purchasing behaviours. None of the studies consider inequalities amongst consumers, and the accessibility and influence of the labelling schemes are assumed uniform. Adjustments could be made to consider different incomes, education levels, and ethnicities. Another feature which may strengthen existing modelling endeavours could be the stratification of populations by nutrient intake levels. All studies neglect the presence of energy-dense food consumers, a population subgroup that could potentially experience the largest benefits from lower energy intakes.

Another issue identified with several of the studies is an underlying steady state assumption, whereby consumers effectively remain as static populations changing neither other dietary nor any lifestyle factors. This allows for the quantification of a labelling scheme in isolation, uninfluenced by external factors. However, it potentially overestimates benefits by neglecting possible confounding factors such as compensatory eating, increases in physical activity, or consuming larger quantities of foods perceived as more nutritious.

While some studies took a broad view of the packaged food markets, others (*e.g.* Sacks *et al.* 2011*c*) focused on specific food groups, thus underestimating potential benefits obtainable from a market-wide labelling initiative. A further limitation of the studies was the grouping of products, often a consequence of the data available. Consumer purchases were restricted to a like-for-like food replacement, thus limiting the potential of the intervention for maximum impact. Examples include the missing option to replace a sugar-sweetened beverage with water rather than with a lower sugar variant, or switching to slightly lower-fat milk rather than from whole to fat-free. Also, a lack of data availability on nutrient intakes often necessitated the use of outdated consumption surveys, which raises questions as to the representativeness of the model populations. For example, Sacks *et al.* (2011*c*) relied on a 1995 National Consumption survey, Vyth *et al.* (2012) used 1997-98 national consumption data, and Wilson *et al.* (2014) used data from 1997 to estimate food category contributions to sodium intakes.

More research would be helpful to better understand and calculate the potential impact of FOP labelling schemes on the diet of European populations. Data scarcity is a limiting factor for modelling studies, which would benefit from longitudinal studies assessing consumer responses to labelling schemes. Such gaps in data and evidence necessitate undertaking a thorough sensitivity analysis to assess uncertainty in the model inputs, a feature that is lacking in the existing modelling efforts.

Notably, the modelling approaches rest on strong assumptions on how much consumers' eating behaviour is affected by FOP labels and in which direction. Beyond the effect of FOP labels on purchases, their effect on eating behaviour is hard to qualify and quantify. For example, some studies have shown that perceiving a food as healthful increases intake of that food [Chandon & Wansink, 2007]. Moreover, consumers have been shown to wrongly associate different nutritional features, for example Wansink & Chandon (2006) show that energy content of food may be underestimated in the presence of a low-fat label. Provencher *et al.* (2009) observed that foods perceived as healthful were considered more appropriate to eat and less likely to lead to weight gain. The authors found that participants consumed 35% more cookies that were perceived as healthful compared with the same cookies when their healthfulness was not made salient. The result is in line with research claiming that norms can influence eating [Herman & Polivy, 2008]. More specifical-

ly, people generally find it more acceptable to eat larger portions of healthful than of unhealthful foods. Similarly, Faulkner *et al.* (2014) showed that foods labelled 'reduced fat', yet without actual fat reduction, were eaten in larger portions because they were perceived as less energy dense and caused less guilt in indulging. Wansink & Chandon (2006) also find lower anticipated consumption guilt for foods labelled as healthful. FOP labels may have unintended consequences on portions eaten if they signal the healthfulness of food. More research is needed on this.

Considering the lack of available real-life evidence, and given the difficulty to set up such studies, no definitive conclusions can be drawn at this point regarding the effect of FOP nutrition labels on diet and health. Modelling studies, used in an attempt to fill this knowledge gap, suggest a positive effect of evaluative labels. More research on the health effects of FOP labels is needed. The impact on eating behaviour of labelling food as healthful or unhealthful should be explored further. In any case, compliance with dietary recommendations is the overarching goal to which FOP schemes should be contributing.

4.8. Effects of FOP labelling on reformulation/innovation, and on the European internal market

In addition to helping consumers make healthier dietary choices, FOP labels could lead food business operators to reformulate existing products and develop new ones that are more healthful. In this regard it is noteworthy that a comprehensive assessment in the USA [Dunford *et al.*, 2017*a*] and a much smaller study in New Zealand [Rosentreter *et al.*, 2013] indicate that more than half of the packaged food supply (selected categories in New Zealand) would score a red traffic light for at least one of the nutrients to limit. As long as FOP labels may affect consumers' choices, producers have an incentive to adapt the content of their products to the requirements needed to obtain a good nutritional rating. Firms strategically evaluate the benefits of nutrition-based product differentiation when they reformulate or introduce new products [Van Camp *et al.*, 2012]. From a policy perspective, it is essential to assess how industry uses FOP labels. The goal of the regulator to foster the consumption of healthier diets may be achieved also through the food supply side. However, studies on food manufacturers' responses to FOP labels are limited in both number and strength of evidence.

The evidence suggests that evaluative FOP labels actually influence food product composition. Adoption of the Choices nutrition logo in the Netherlands [Vyth *et al.*, 2010*a*], the Health Check symbol in Canada [Dummer, 2012], and the Health Star Rating [Ni Mhurchu *et al.*, 2017*a*] and Pick the Tick in New Zealand [Ning *et al.*, 2017; Thomson *et al.*, 2016; Young & Swinburn, 2002] and Australia [Williams *et al.*, 2003] brought about improvements in the nutrient profile of food products on the market. *Table 36* provides a more detailed description of the relevant studies. It is also interesting to note that the only study on a reductive FOP scheme (Australian Daily Intake Guide) found no impact on the nutritional composition of breakfast cereals [Louie *et al.*, 2012].

Table 36. *Studies assessing the impact of FOP labelling schemes on food reformulation.*

Study (most recent first)	**Intervention**	**Outcome**
Ni Mhurchu *et al.* (2017*a*)	Compared the nutritional composition of Health Star Rating-labelled products in New Zealand in 2016 against their composition in 2014 (within-product change) and looked at how the changes fared against any reformulation of products not carrying the Health Star Rating label.	In line with the introduction timeline for the Health Star Rating, no products carried this FOP label in 2014, 0.3% (39/14,415) bore it in 2015, and 5.3% (807/15,358) displayed it in 2016. In 2016, Health Star Rating products were found to be higher in energy and protein but lower in saturated fat, total sugars, and sodium when compared to non-Health Star Rating products. The authors noted that differences might have resulted from both the selective application of the Health Star Rating scheme on healthier products and reformulation. Relative to Health Star Rating-labelled products in 2015, products carrying the Health Star Rating label in 2016 were higher in saturated fat, total sugars, and sodium. According to the authors, this latter observation might have been due to a broadening out of the Health Star Rating scheme to product categories with overall less healthful composition over time. As for within-product change[52] from 2014 to 2016, 356 Health Star Rating-labelled products had been reformu-

.../...

52. Defined as a minimum 5% change in at least one key nutrient.

Table 36. *(cont.)*

Study (most recent first)	Intervention	Outcome
Ni Mhurchu *et al.* (2017*a*) *(cont.)*		lated. The categories contributing the highest share of reformulated products were cereals and cereal products (26%), and sauces and spreads (20%). Remaining food groups each accounted for <10% reformulated products. Significant changes were observed for overall mean energy (-29 kJ/100 g), sodium (-49 mg/100 g), and fibre (+0.5 g/100 g).
Ning *et al.* (2017)	Survey on the impact of the Pick the Tick programme on salt reduction across 52 products from the categories of breakfast cereals (20 products), edible oil spreads such as margarine (7 products), cooking sauces (14 products), and processed poultry (11 products) in New Zealand.	Reduction in salt of 16 tonnes across all products. Importantly, the authors point out environmental factors other than the Tick programme may have (additionally) driven the reformulation efforts undertaken by industry. Such factors include the availability and price of raw ingredients, food technological advances, and the taste of the final product.
Freire *et al.* (2017)	Key informant interviews with industry representatives in Ecuador on the impact of traffic-lights labelling on reformulation and innovation.	Traffic-lights labelling resulted in efforts to reduce red labels on existing products and the creation of new products without any red labels from the start.
Thomson *et al.* (2016)	Reported reformulation results under the Pick the Tick programme for 45 products from the five categories of edible oil spreads, yogurt & dairy desserts, frozen desserts, ready meals, and processed poultry in the period 2011-2013 in New Zealand.	In this sample, which represents 31% of all Tick-labelled products in these five categories, the following reductions were achieved: -4.1 million MJ of energy, -156 tonnes of saturated fat, -15.4 tonnes of trans-fat, and -4 tonnes of sodium.
Dummer (2012)	Survey of 14 Health Check programme licensees in Canada representing 371 products (approx. 23% of the total number of products in the programme at that time). These were from 12 food categories in four groups, including grains, vegetables and fruits, meat and alternatives, and combination foods. The primary research question involved …/…	150 products had been reformulated to meet the sodium criteria, equating to over 322 tonnes of sodium removed from the food supply.

Table 36. *(cont.)*

Study (most recent first)	Intervention	Outcome
Dummer (2012) *(cont.)*	determining the impact of the Health Check criteria in prompting sodium reduction in products made by Health Check licensees, from 2004 to 2008.	
Louie *et al.* (2012)	UK MTL scheme as a rating mechanism to assess healthfulness of breakfast cereals (n = 164) on the Australian market before and after introduction of the Daily Intake Guide FOP scheme in 2006. Supermarket surveys were conducted in 2004 and 2010 using the same methodology to collect information from the nutrition information panels of Australian breakfast cereals and the nutrient content of cereals was compared by year. Breakfast cereals with and without Daily Intake Guide labelling in 2010 were also compared.	No significant difference was detected in nutritional composition of breakfast cereals between 2004 and 2010. There was no notable improvement in nutritional composition of breakfast cereals marketed as the same product in both years. Overall, the introduction of Daily Intake Guide labelling does not appear to have promoted product reformulation, and breakfast cereals carrying Daily Intake Guide labels were not consistently more healthful.
Vyth *et al.* (2010*a*)	Assessed 821 products (23.5% of all Choices-labelled products on the market at the time of study, August 2009) in the Netherlands.	168 products had been reformulated to meet the Choices criteria. The most frequently affected product category was soups (n = 68), followed by sandwiches (n = 16), other products (n = 15), and processed meat (n = 11). Additionally, 236 products were newly developed in line with the Choices criteria, namely snacks (n = 50), processed fruits and vegetables (n = 32), fruit juices (n = 32), drinks (n = 21), and soups (n = 21). The most substantial reformulation changes per 100 g of product were seen for sodium and fibre in the sandwich category.
Williams *et al.* (2003)	Survey on the impact of the Pick the Tick programme on sodium reduction in 12 breakfast cereal products in Australia in 1997. Sales volume data for these products for the year 1997 were obtained from the manufacturer. To estimate the impact over 1 year, the …/…	Removal of 235 tonnes of salt annually from twelve breakfast cereal products made by one of the largest food companies. Reductions ranged from 85 to 479 mg sodium per 100 g, with an average reduction of 40% (12-88%).

Table 36. *(cont.)*

Study (most recent first)	Intervention	Outcome
Williams *et al.* (2003) *(cont.)*	reduction in sodium content was multiplied by the volume of product sold in the 12-month period.	
Young & Swinburn (2002)	Survey on the impact of the Pick the Tick programme on salt content in 23 food products (7 breads, 4 breakfast cereals, and 12 margarines) in the period 1 July 1998 to 30 June 1999 in New Zealand.	Food companies excluded 33 tonnes of salt over the course of a year (mid-1998 to mid-1999) through reformulation (10 products) and innovation (13 products). Average sodium reduction was largest for breakfast cereals (-378 mg/100 g), followed by bread (-123 mg/100 g), and then margarine (-53 mg/100 g).

Furthermore, for 2016 the Chilean Ministry of Health reported that 18% out of a total of 5343 products had been reformulated [Ministry of Health, 2017], possibly in response to the FOP warning label introduced around that time. Of the affected product categories, milks & dairy drinks and processed meats & hamburgers showed the highest proportion of reformulated products – 65% and 48%, respectively.

The evidence of reformulation is largely based on self-reported data, on a limited number of food groups and from few food producers. One potential risk associated with producers' response to FOP labels is that reformulation occurs only for the nutrients that are included in the FOP label. Another risk lies in the substituting ingredients used. For example, if the trans fat content of foods is being reduced by using saturated fat instead, public health benefits are likely to be small. Likewise, if saturated fat is taken out and plain starch put in, the impact on health would probably be neutral at best. *Table 37* lists studies identifying potential risks related to FOP schemes, product composition, and reformulation.

Manufacturers can use labels as cues to highlight good attributes of their products to consumers without the need to reformulate them. For example, firms that are more transparent about the nutritional features of products may be perceived as caring more about their customers' well-being and needs. FOP labelling may be a marketing strategy also for retailers [Machleit & Mantel, 2001]. Newman *et al.* (2014) showed how FOP labels could positively affect customer perceptions of a

Table 37. *Studies highlighting potential risks from FOP labelling schemes related to food composition or reformulation.*

Study (most recent first)	**Outcome**
Carter *et al.* (2013)	The Daily Intake Guide may show different combinations of nutrients, including only energy for small packages. The Daily Intake Guide label was present on 66% of products analysed but most of them (75%) only reported energy (excluding saturated fat and sugar content). Products with Daily Intake Guide labels that did not include fat and sugar content contained on average ten times more saturated fat and almost twice the level of sugar.
Vyth *et al.* (2010*a*)	Reported that energy content was unchanged across all new product groups after the introduction of the Choices Logo. The Choices logo used in the Netherlands at the time of the study did not integrate energy information.
Van Camp *et al.* (2010)	Suggested that food producers prefer Reference Intakes to traffic-lights labelling because the latter imposes additional pressure to reformulate a product, especially in terms of sugar, salt, fat, or saturates, with uncertainty about the potential benefits on marketing. A prepared meal with 5 g of saturates and another with 15 g of saturates per 100 g would both be labelled red, and may not be easily differentiated by consumers. Producers should reduce negative nutrients in large amounts to move from high to medium or low level, but this may influence taste and other features of the products, which could lead to a decrease in demand.

retailers' attention to their welfare, which in turn can lead to higher patronage intentions. Shoppers preferred retailers that voluntarily offer FOP labelling instead of retailers that do not. Firms may see FOP labelling as an opportunity in the market, as a tool to anticipate future consumer demand for more information, or as a reaction to their competitors' actions. Van Camp *et al.* (2012) provide one of the first comprehensive studies of the factors that may explain FOP labelling by the private sector. The analysis included products sold in the UK from 2007 to 2009. The main finding was that FOP labels were more likely to be present on private label products (in line with Vyth *et al.*, 2010*a*) and that FOP label provision increased over time; better nutrient composition of food was not correlated with more frequent use of FOP labelling overall.

The above notwithstanding, to date there has been no systematic and comprehensive assessment of the effects of FOP labels on food reformulation and supply

strategic behaviour. The available evidence suggests that **evaluative FOP schemes can incentivise reformulation, although more data that are objective would be needed to understand the true effect size**.

As to the impact of FOP schemes on the European internal market, no literature was found on research that has explicitly tackled this aspect.[53] Therefore, **it remains unclear whether the existence of multiple FOP schemes would constitute an obstacle to the free circulation of food products within the European internal market**.

4.9. Unintended consequences of FOP nutrition labelling

There are very few studies in the literature that focus on the unintended effects of FOP labelling. Such schemes may have negative effects on hedonists or negative effects on selected portions due to less guilt. Studies on the association that consumers make between different nutrients, different types of nutrition information, and different products, are also almost non-existent. Many studies focus on specific products, while very few studies look at shopping baskets and their composition. The evidence suggests that various types of misinterpretations may occur with nutrition labels.

Notably, some studies find a change in purchasing behaviour that is correlated with the presence of FOP labels but that has no association with the healthfulness of the products as indicated by the respective scheme [Hamlin *et al.*, 2015; Hamlin & McNeill, 2016; Hamlin, 2015; Sacks *et al.*, 2009]. For example, Hamlin, (2015) observed that consumers chose significantly more products with a FOP scheme label irrespective of the indicated healthfulness of the products. This is described as a 'malfunctioning of FOP labels' by Hamlin & McNeill (2016) because FOP labels were used by people, but not in the intended way. Voluntary guidelines or schemes do not require labels on all packages, which may bias consumer perceptions towards products with labels that are equally, or potentially less, nutritious than products with no labels, as has been demonstrated in previous research

53. Based on an online search using combinations of the keywords 'FoP schemes' or 'FoP labels' and 'European Market' or 'Internal Market' or 'European Internal Market'.

[Maubach *et al.*, 2009; Talati *et al.*, 2016*a*]. Gomez *et al.* (2017) reported this effect to be stronger among participants with lower nutrition knowledge. Similarly, Bialkova *et al.* (2014) found that the colour-coded FOP label affected choice not because it was better in communicating the fat level, but because it was better in attracting attention. In the opposite direction, in an experiment on food with and without 5-star labels, Hamlin & McNeill (2016) found that the presence of the 5-star label reduced preferences for the product, irrespective of the indicated healthfulness. In the same direction, Trudel *et al.* (2015) showed that non-dieters followed the stop and go message of traffic lights (green and red). However, for dieters, the presence of the label made consumers eat less of the product and consider it less healthful irrespective of the colour. The processing of nutrition information requires cognitive effort. For this reason, consumers may process nutrition information only partially or use heuristic cues to simplify the choice task [Sanjari *et al.*, 2017].

As alluded to above (see *Table 34*), relying substantially on the Choices or Keyhole logo in the selection of foods may lead to compromised intakes of certain beneficial nutrients [Amcoff *et al.*, 2015; Roodenburg *et al.*, 2009; Roodenburg *et al.*, 2013]. Furthermore, consumers may inadvertently increase their intakes of one or more nutrients to limit due to a too narrow focus on reducing the intake of another [Graham *et al.*, 2017].

The warning message of red traffic-light colours might be diluted or lost completely by the concomitant presence of one or more green traffic lights [Machín *et al.*, 2018*c*]. Similarly undesirable, consumers may choose larger portion sizes if the FOP label fails to signal limited healthfulness [Egnell *et al.*, 2018*b*].

Other important misconceptions about FOP labels tend to relate to whether the food producer makes use of the label or not, and whether the information refers to a single portion or 100 grams of the product [Grunert *et al.*, 2010*a*; van Kleef *et al.*, 2008]. Mohr *et al.* (2012) suggested that adopting a smaller serving size allows producers to reduce the reported calories, fat, sugar, and carbohydrates in a product serving, which in turn can influence the anticipated consequences of consumption. Manipulating the serving size, and thus calories per serving, for equivalent food consumption influenced the anticipated guilt of consumption, purchase intentions, and choice behaviour. Consumers were found to focus atten-

tion on calorie information but not serving size. This leads to the counterintuitive finding that more nutritionally careful consumers are more heavily influenced by serving size manipulations. Elshiewy *et al.* (2016) also noted that smaller portions highlighted on FOP labels might result in increased purchases. Although this effect was only noted in the supposedly healthful category of yogurts but not with cookies, an overall higher resulting energy intake would counteract the intended guidance by FOP schemes towards needs-matched calorie intake.

4.9.1. Consumer confusion and loss of trust

The presence of different types of FOP labels in the marketplace could cause problems such as confusion and misunderstanding [Andrews *et al.*, 2011; Cowburn & Stockley, 2005; Draper *et al.*, 2013; Grunert & Wills, 2007; Harbaugh *et al.*, 2011; Malam *et al.*, 2009; Wąsowicz *et al.*, 2015]. Loss of trust shines through, for example in the focus group statements from Ecuador reported by Freire *et al.* (2017). Participants were suspicious of relevant nutrition information being hidden on the back of packs or provided as black and white GDA labels instead of traffic-lights labels noted as more informative and helpful. Future work needs to explore the different dimensions of any issues, their sources and their effects.

Mitchell *et al.* (2005) propose a conceptual model of consumer confusion:

- *Similarity:* if FOP labels look very similar but have different meaning, this could cause inaccurate comparison due to misinterpretation of one or the other FOP label. Some qualitative studies suggest evidence of this misallocated meaning to some FOP labels, for example monochrome labels interpreted as having a traffic-light meaning [Malam *et al.*, 2009].
- *Information overload:* the simultaneous presence of many FOP label types could result in too much information and difficulty in interpreting it. Malam *et al.* (2009) show that some shoppers were unable to compare two products with different FOP labels, declaring it was too difficult. Using in-depth qualitative interviews, Draper *et al.* (2013) noted that consumers struggled with making sense of numerical information, particularly percentages.
- *Ambiguous/unclear information*: two products may seem not to be comparable due to the differences in their FOP labels. For example, Malam *et al.* (2009)

find that when comparing two products with different FOP label types, some shoppers did not realise that there was some common information to both labels that could have helped them with the comparison. Some shoppers just chose the label they understood better rather than attempting the comparison. Having to trade off nutrient-specific information (*e.g.* a product is low in salt but high in saturated fat) on FOP labels might also cause consumer confusion [Malam *et al.*, 2009].

Purely numerical, reductive FOP schemes can be confusing in cases where the nutritional information is equivocal. For example, 100% fresh orange juice might be richer in nutrients, but also higher in calories, compared to diet soft drinks. What should the consumer conclude? Kim *et al.* (2012) showed that reductive FOP labelling (Facts-Up-Front and Clear on Calories)[54] made consumers rate milk and 100% fresh juice as less healthful and soft drinks and fruit drinks as more healthful compared to a no-label condition. They suggest that the negative information in 100% fresh juice and milk, namely the high calorie content, may have outweighed the positive information on the FOP label. An evaluative FOP scheme would seek to avoid this misunderstanding.

Vanderlee *et al.* (2012) noted per portion labelling as a source of consumer confusion, considering that serving size may vary with different container/pack sizes of the same product. Using soft drinks as an example, a can of 330 ml may contain one serving whereas a bottle of 500 ml may contain two servings of 250 ml, in which case the calorie content for the same beverage may appear different. Furthermore, consumers may mistake the 'per serving' information to mean per pack. In this case, drinking the whole 500 ml bottle they would believe to be consuming half the actual calories.

Colours may be another source of confusion, especially where multiple schemes with different colour codes are used [Draper *et al.*, 2013; Malam *et al.*, 2009]. Finally, the diversity of product categories carrying the same logo appears to be confusing [Vyth *et al.*, 2009].

54. The Clear on Calories scheme presents the calories contained in a portion of the food/drink, in the same lozenge design as the Facts-Up-Front scheme (but without percentages).

4.10. Effects of FOP labelling on shopping costs

Crosetto *et al.* (2018) show that the nutritional improvements due to the labelling may come at an economic cost, as the average cost of a 2000-kcal diet increases when shopping for labelled products. However, the data show that labels do not have the regressive effects of other policies, such as taxes and subsidies [Muller *et al.*, 2017]. Lower income subjects were less affected in terms of cost of nutritional adjustment than medium and high-income subjects were, especially for the Nutri-Score and Health Star Rating. More research is needed on this.

5. Knowledge gaps and suggestions for further research in FOP nutrition labelling

Whilst research on FOP labelling has been growing substantially in the past decade, the evidence is largely fragmented owing to diversity in methodology and FOP labels (and elements thereof) tested. The majority of studies suggest that evaluative schemes that use colour coding or that use colour coding combined with a graded indicator, help consumers of various ages, socio-economic status and cultural background the most in identifying more nutritious products. Future research should focus on interactions between FOP labels and exogenous or complementary factors that may affect their effectiveness. A more systematic approach to comparing different FOP labelling schemes and to measuring their impact on purchasing behaviour would be advisable. In this section, a structured review of the knowledge gaps and future research needs is attempted.

5.1. Preference for and understanding of FOP labels – knowledge gaps and suggestions

Consumers' perception – covering aspects such as attention, attitudes, and liking – of FOP labels strongly depends on their socio-economic background and culture. Knowledge gaps in this area pertain to methodological and graphic design issues as well as challenges in the structured comparison of FOP schemes. Furthermore, observed mismatches between understanding and preferences for FOP labels should be investigated further.

5.1.1. Methodological issues and potential improvements

Most of the studies on the perception of FOP schemes are conducted in simulated choice contexts. This approach bears little resemblance with real-life conditions as it rarely includes the real-world incentives and often prompts consumers to pay attention to the FOP labelling. It is very insightful and useful in the process of designing and developing new FOP labels. However, when it comes to evaluating consumers' perception (liking, attention) of FOP labels in a real shopping situation, a different methodology may be more informative. Instead of prompting

attention to FOP schemes artificially, researchers should try more often to emulate key features of a typical shopping situation, such as time constraint, other attributes of the packages [Bialkova *et al.*, 2013], price, promotions, and claims [Talati *et al.*, 2016*b*]. More experimental studies with participants facing real product packages, where the focus on FOP labels is not revealed to them, and where they face a trade-off for their choices, would usefully complement the findings from existing experimental studies. Measuring intentions to purchase that bear no consequences can lead participants to answer as they think they should, instead of answering according to what they really would buy when shopping. Monetary incentives are a well-recognised tool used in behavioural economics in order to elicit real choices [Smith & Walker, 1993].

5.1.2. Graphic design-related issues

Another difficulty encountered in studies aiming to identify the most effective FOP label stems from the variability in the labels being tested. Whilst this is partly owing to the FOP schemes having evolved over time (*e.g.* from the 5-CNL design to the final Nutri-Score design), in various cases the reasons for label design modifications are not obvious. As a result, comparability between studies is hampered and may account for some of the inconsistencies observed. Given that the consumers' ability to see and read the label is important, studies should report information on the text size of the labels tested, and further research should seek to determine adequate label size and position across package formats and contexts [Hawley *et al.*, 2013].

5.1.3. Structured comparisons of different FOP nutrition labelling schemes

When comparing FOP label schemes, it is critically important to consider what exactly was measured in a given study, and how, because the research design might favour one FOP scheme over another, knowingly or unknowingly.

Comparisons between FOP labels in specific countries are often biased by the familiarity that participants have with the labelling schemes. Consequently, results tend to show that participants prefer the FOP scheme to which they are more accustomed (or that they perceive as their own). An interesting example is the study

by Van Herpen *et al.* (2012). It shows that both in the UK (where UK MTL and Reference Intakes labels prevail) and in the Netherlands (where the Choices logo and Reference Intakes were/are most widely used), all three schemes were effective in helping in the identification of the more healthful product in an experimental setting. However, familiarity with the labelling scheme affected consumers' self-reported evaluation and usage intention of the scheme.

Another gap regarding existing comparative studies is that more recent formats, such as summary graded FOP labels (*e.g.* Nutri-Score), have not yet been included in the scope of these studies. Therefore, more large studies that test attention, understanding, and acceptability of the existing FOP labels (not prototypes) on representative samples from different countries would be useful. A recent international study done in 12 countries [Egnell *et al.*, 2018*c*] is a step in the right direction. It is the first study comparing the perception, objective understanding and purchasing intention associated with various FOP nutrition labels that are currently implemented in various countries, with a comparison across countries exploring the effect of cultural differences.

5.2. Effects of FOP labelling on food choice and overall diet – knowledge gaps and suggestions

Challenging as it may be, more real-life research is needed on the effects of FOP nutrition labelling on consumers' actual shopping behaviours and dietary intakes. From a behavioural point of view, it would be important to study the interplay of food choice determinants and elucidate further the cognitive processes underlying people's food purchasing decisions in the presence of FOP labelling [Sanjari *et al.*, 2017].

5.2.1. Methodological issues and potential improvements

Laboratory experiments or simulated supermarkets are useful tools to understand behaviour, but the design of experiments in this field could be enriched with new features. New studies that involve monetary incentives and trade-offs could shed more light on the topic. For example, consumers may receive a monetary endowment and actually use the endowment to buy food products for the week.

In this context, by changing the (FOP) information on the products, the features of the products (brand, price, packaging), and the shopping environment (time constraint, quantity of products) it would be possible to compare the effect of FOP labels with higher external validity. The study by Crosetto *et al.* (2018) is an example of this approach, although in that study participants are asked to pay attention to FOP labels thus making these labels artificially salient.

Another issue that might merit further research concerns the finding that FOP labels are particularly effective on health-sensitive consumers. This may be the result of a simple correlation or due to reverse causality. For example, the studies that show that consumers who are more sensitive to health issues buy more products with FOP schemes (*e.g.* positive logos) do not control for reverse causality. Consumers may buy those products for their good nutritional profile, irrespective of the presence of the logo. Given that their better nutritional profiles make these products more likely to have the logo, the observer risks attributing the impact of one characteristic to the other. In this case, an experimental approach is ideal to assess the net impact of each characteristic.

In addition to experimental data, more empirical analyses that exploit natural experiments or field interventions would be helpful to better understand the role of FOP labels on purchasing behaviour. These research methods should be complemented by data provided by retailers and producers: loyalty cards, for example, could be a useful source of information. Analysis of retail data can help to understand the effect of FOP labels in real life. For example, data mining experts at the request of a French retailer analysed the effect of two FOP labels on consumers' food choices. A very large scale, real-world experiment under controlled conditions with consumer choice/purchase as a dependent variable is theoretically possible with total industry support and cooperation at all levels, and it would usefully complement existing studies.

5.2.2. Interaction of FOP nutrition labelling schemes and moderating conditions

Overall, the limited evidence on actual shopping behaviour suggests a small effect of FOP nutrition labelling on 'on-the-spot' purchasing. Real-life evidence on the nudging power of FOP labels on purchasing behaviour is sparse and difficult to

obtain since purchasing decisions are influenced by confounding factors that are hard to isolate. There is evidence that FOP schemes can be effective in consumers who already have a disposition towards healthy diets at the time of purchasing [Bialkova *et al.*, 2016; Machín *et al.*, 2017, 2018*a*; van Herpen & van Trijp, 2011]. More research would therefore be needed on how to activate health goals. Several studies also show that communication and awareness campaigns should support the introduction of FOP labels, and more studies looking at the joint effect of these activities would be useful.

Research on the interaction between FOP labels and other elements of the packages or shelves is needed. Likewise, more research is needed on how to balance the primary objectives of each FOP scheme (*i.e.* guiding consumers towards healthier food choices and incentivising food business operators to reformulate/innovate) on the one hand and how, on the other hand, a FOP label's effectiveness varies by the type of consumer. How are FOP schemes helping consumers with lower literacy and numeracy skills? Despite a wealth of available evidence, there are still some grey areas that would benefit from sound studies, notably on the interaction between socio-demographic factors and FOP schemes. It is also important to examine the interplay of variables such as nutrition knowledge and motivation, rather than only studying their effects independently. Whilst the differential effect of FOP labels along sociodemographic and nutrition literacy gradients has begun to be studied, more research would be welcome regarding the effect of FOP labels on existing health inequities. Finally, more research is needed to investigate the effect of personal variables such as time pressure, distraction, depletion, and fatigue on the consumer's use of nutrition labelling and food purchases.

5.3. Use of FOP nutrition labelling by producers, effects on reformulation and on product pricing – knowledge gaps and suggestions

More in-depth studies should be conducted on if and to what extent suppliers use FOP labels for marketing and competitive purposes. For example, trying to study better which kind of producers adopt which kind of FOP schemes more often; or why private brands are more likely to adopt FOP labels; or how FOP labels relate to prices. Newman *et al.* (2018) suggest that both manufacturers and retailers should further consider how the use of FOP labelling may affect other po-

sitioning strategies (*e.g.* those centred on taste or price). For example, will adding a FOP label on a product promoted as tasty increase its perceived healthfulness but compromise some consumers' taste expectations [Raghunathan *et al.*, 2006]? The study by Mohr *et al.* (2012), although not focusing on FOP labelling, shows that there can be an incentive to exploit the interaction between FOP labels and serving size. Indeed, reducing the serving size helps producers display lower levels of negative nutrients. Consumers who focus on calories but do not focus on the serving size may be influenced by this strategy toward higher intentions to purchase. More research is needed in this direction.

Additional insight could also be gleaned from studies on the cost-effectiveness of FOP labelling [Mantilla Herrera *et al.*, 2018; Sacks *et al.*, 2011*c*], if a broader perspective was adopted. The two studies reviewed here included healthcare costs and costs to industry; including other costs (*e.g.* potential productivity losses) could add further value.

In terms of the effects of FOP schemes on reformulation, more data are needed on two key aspects: 1) causal links between the presence of FOP schemes and changes in nutritional quality; and 2) comparisons of the impact of different FOP schemes on reformulation.

Some studies, mostly based on self-reported data by industry, find a correlation between the introduction of evaluative FOP schemes and changes in nutritional components, but more objective data would be needed to understand the true effect size and whether there is a causal effect of the former on the latter. We cannot be sure that the observed change in the nutritional component that followed the introduction of a FOP label was the direct consequence of this introduction instead of the effect of concomitant factors. Indeed, they may both be the consequence of producers' and retailers' willingness to adapt to new consumer needs or to expected changes in the market. Moreover, the adoption of FOP schemes may follow reformulation (rather than the opposite), as producers may choose whether to adopt or not a scheme based on the rating they are expecting to receive.

The effects of FOP schemes on reformulation may vary with the nature of the scheme and with the ex-ante nutritional value of the product. For example, Van

Camp *et al.* (2010) suggested that food producers prefer GDA to traffic-lights labelling since for the latter they may have to reduce negative nutrients in large amounts to move from high to medium or low level. This in turn may influence taste and other features of the products, which could lead to a decrease in demand. Producers of products that are very close to the threshold needed to obtain a better rate have larger incentives to reformulate, but the benefit for consumers is lower.

In addition, so far no studies are available on the issue of which FOP scheme(s) would be the most perceptive to reformulation and would be the most helpful to shift the food supply to healthier choices. One might argue that labels indicating only certain nutrients (or indicating certain nutrients only in case when specific thresholds are exceeded), might be less helpful to shift the food supply to healthier choices than *e.g.* graded summary labels that could have a more balanced reformulation potential, but no studies are available so far on this subject.

5.4. Effects of FOP labelling on the environment – knowledge gaps and suggestions

In case FOP labelling schemes affect consumers' dietary choices or influence production decisions, this may have knock-on effects on the environment. For example, if FOP labelling schemes would favour a decrease in the consumption of meat and animal products, this may have a positive impact on the environment. Moreover, FOP labelling schemes may interact with environmental labels (organic production, water footprint, etc.) concurrently present on the pack. If attention is diverted from one label to the other, their effectiveness may be lessened [Drescher *et al.*, 2014]. It would be useful to study the interaction of labels covering diverse aspects such as nutrition, environmental footprint, food quality, and origin labelling and the consequences for each individual label's effectiveness.

Very few studies try to quantify the indirect impact of FOP schemes on the environment, which is not surprising considering that the direct impact on health and diet is already hard to assess. Drescher *et al.* (2014), in a survey in Germany on pizza, showed that an organic production label was positively related to the choice probability for products without Traffic Lights labelling but the choice probability was reduced with the introduction of Traffic Lights.

5.5. Suggestions for future research on digital tools

More research can be done on FOP labels from a behavioural angle, but academia as well as the practitioners and the stakeholders with the capacity to conduct research should also try to explore more interactive ways to facilitate healthier choices. One idea could be developing an application that directly computes calories or other nutrient information on a basket of products to be scanned, or that ranks products within categories according to their healthiness. By making the application social, with the possibility to share your own shopping basket, and comment on others it would be possible to leverage on well-known behavioural aspects, such as social norms and peer pressure. Another way would be to highlight short-term rather than long-term benefits of consuming healthier diets, such as fidelity prizes or promotions. This would attract consumers and hopefully open the path to awareness and educational campaigns.

6. Conclusions

In Europe, nutrition labelling is mandatory. As a minimum, the nutrition declaration must include the energy value and the amounts of fat, saturates, carbohydrate, sugars, protein and salt. This declaration can be complemented by a voluntary repetition of its main elements in the principal field of vision, referred to as front-of-pack (FOP) labelling. Food labelling Regulation (EU) No 1169/2011 stipulates that the European Commission submit a report to the European Parliament and the Council on the use of FOP nutrition labelling schemes, on their effects on the internal market and on the advisability of further harmonisation of those forms. In conjunction with that report, and complementing a series of stakeholder consultations, the JRC was tasked with a review of the scientific literature on FOP nutrition labelling. Specifically, evidence of FOP labelling effects on consumers, food business operators, and the single market was considered, giving due concern to potential unintended consequences where reported.

The review of the literature points to a number of conclusions, covering the following aspects: consumer attention, preferences and acceptance, and understanding; food purchasing; diet and health; and food reformulation and innovation.

1. First, there is no *average consumer*. Not only do consumers differ by age, health status, education, cognitive skills, culture, and other attributes, but their behaviour is also – though somewhat predictably – biased by factors such as loss aversion, overconfidence, and present bias (myopia). This implies that any FOP scheme should be carefully tested on a large and varied sample.

ATTENTION

2. Most studies on consumer attention to FOP labels are based on self-reported measures and note high levels of attention to FOP labels (between 60% and 70%). Over-reporting by consumers is very common, and studies based on observational data in supermarkets show lower levels of attention.

3. FOP labels attract more attention than back-of-pack nutrition information. Various attributes (size, colour, position of the label, amount of complementary information on the package, the level of directiveness, the interaction between various elements of the packaging, etc.) exert an impact on consumer attention. The level of attention also depends on personal and environmental factors, the latter including FOP label information/awareness campaigns.

PREFERENCES AND ACCEPTANCE

4. Evidence from a variety of data collection approaches (*e.g.* focus groups, interviews, surveys) suggests that FOP labels fill an informational gap or an unmet consumer need, with older adults and overweight/obese people more likely to report a need for a FOP label.

5. Preference may be shaped by factors such as familiarity with a given FOP labelling scheme. Caution should therefore be paid to environmental circumstances when interpreting the relative acceptance of a given FOP label over another, namely whether or not that given label is close to the implementation stage in the country at stake.

6. Given the self-report nature of studies on FOP label preference, there may be a certain gap between FOP labels that consumers say they prefer and FOP labels that actually help consumers make informed food decisions for better nutrition (objective understanding of the label).

7. Consumer acceptance of a FOP scheme is a necessary rather than a sufficient condition for its effectiveness.

8. When comparing different FOP schemes, different studies show a preference for different schemes, where the most preferred label tends to be the one implemented in the country where the study is conducted (*e.g.* the Health Star Rating in Australia, the Nutri-Score in France).

9. Overall, evaluative FOP schemes with colour coding tend to do well in assessments of consumer liking.

UNDERSTANDING

10. Simpler labels are understood more easily than complex ones. Colour coding also significantly improves the ability of consumers to identify the healthier option. FOP schemes providing nutrition information 'per 100 g' seem to achieve better objective understanding than FOP schemes based on portions. These results should be borne in mind, as in the shopping environment consumers' decisions are made very quickly.

11. Comparative studies point to a traffic-light colour coding format as the one leading to a high level of understanding. Studies including formats that became recently available, also point to the combination of a colour-coded format with a graded indicator (Nutri-Score) as being effective across a wide range of consumers in improving understanding of the nutritional quality of food.

IMPACT ACROSS DIFFERENT SOCIO-ECONOMIC GROUPS

12. There is consistent evidence showing that label use is associated with certain consumer characteristics: women are more likely to read nutrition labels compared to men; higher income and higher education level are positively associated with understanding and use of nutritional information; and better nutrition knowledge and understanding of diet-disease relationships as well as general interest in healthier eating habits are positively related with label use. There is no clear evidence about the association of age and nutrition label use.

13. Generally, older adults and those with lower income and/or education and nutritional knowledge struggle the most to interpret FOP labels correctly.

14. Poorly educated consumers seem to favour simpler, evaluative FOP labels.

15. Evidence suggests that the traffic-lights and Nutri-Score schemes are particularly effective among consumers of lower socio-economic status in helping them identify the healthier option.

IMPACT ON PURCHASING

16. Experimental studies looking at the intention to purchase show that FOP nutrition labelling, especially colour-coded labels, can improve the nutritional quality of food choices and shopping baskets.

17. The limited evidence on actual shopping behaviour suggests a small effect of FOP nutrition labelling on 'on-the-spot' purchasing. A possible reason is that real-time purchasing decisions are influenced by a multitude of other factors (price, taste, habit, cognitive depletion, etc.) which may be difficult to isolate, making evidence on actual shopping behaviour difficult to obtain.

18. Some real-life studies confirm that evaluative FOP schemes can improve the nutritional quality of people's actual food choices; evaluative FOP schemes with colour coding and/or with colour coding in combination with a grading indicator appear most promising.

19. FOP labels are effective in supporting health-conscious consumers.

20. For optimal effectiveness, FOP labels should be combined with appropriate education and promotion campaigns.

21. The type of FOP labelling scheme may influence the effect on purchasing behaviour depending on the type of consumer. Evaluative and reductive labels may activate different cognitive processes: evaluative labels activate fast thinking and reductive labels influence more complex processes.

IMPACT ON DIET AND HEALTH

22. To date, there is no empirical evidence that unequivocally links the introduction of FOP nutrition labelling in general or a specific FOP scheme in particular to a healthier diet or better health. This is largely owing to the inherent difficulty of proving such causal links and the extensive research effort required.

23. Modelled scenarios of replacing commonly consumed foods with more nu-

tritious options, as identified by FOP labels that are based on nutrient profile models, indicate potential changes in nutrient intakes. These changes are largely beneficial and become more pronounced with more ambitious scenarios.

24. FOP labels that make the health goal more salient in consumers' minds when shopping might help improve food choices and overall diets. However, this may have to be balanced against the risk of decreasing consumers' liking of products perceived as healthy and thus of inferior taste.

IMPACT ON REFORMULATION, INNOVATION, AND OTHER SUPPLY CHAIN BEHAVIOUR

25. Most of the evidence that FOP labels actually influence food product composition is based on self-reported data. A few empirical studies support this evidence, but others fail to find any correlation between the nutritional composition of the food and the presence of FOP schemes. More objective data would be needed to conclude about a causal link between the presence of FOP nutrition labels and changes in the formulation of products.

26. Some studies highlight that although reformulation or product innovation may occur, it may only involve nutrients that appear on the FOP labels or which are considered in underlying nutrient criteria, while reducing the incentive to improve on the others.

27. FOP labels seem to influence consumers' perception of producers and retailers adopting them because these would be viewed as more transparent and caring. FOP labels seem to be present more on private label products than on branded ones.

UNINTENDED CONSEQUENCES

28. Modelling evidence suggests that some FOP labels could potentially cause nutritionally undesirable changes in food intake patterns (*e.g.* inappropriately large portion sizes, focus on one specific nutrient only).

29. FOP labels could potentially be used as heuristic cues generating consumers' choices not in line with the message that the scheme aimed to convey.

30. Voluntary FOP schemes can lead to a biased perception towards products with labels, which may be equally or less nutritious than some other products without labels.

31. Nutritional improvements of the shopping basket driven by FOP labelling may come at an economic cost although lower-income subjects seem less affected in terms of cost of nutritional adjustment.

32. If FOP labels look very similar but have different meaning, this could cause inaccurate comparison due to misinterpretation of one or the other FOP label.

33. The presence of many schemes may generate information overload.

34. It could be difficult to compare different products displaying different FOP labels.

All in all, FOP nutrition labelling has the potential to guide consumers towards healthy diets and incentivise food product reformulation and innovation. Evaluative (graded) FOP schemes seem to meet consumer information needs better in the busy shopping context, and their underlying nutrient profiling criteria can serve as targets for optimised food composition. Dedicated monitoring and evaluation efforts can help shed light on FOP labelling-related changes in food purchases and supply. To what extent any given scheme really achieves a more balanced food supply and healthier diets, will partly depend on the availability of the scheme on food packages and the empowerment of consumers to use the scheme correctly.

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Annex

JRC overview of Front-Of-Pack (FOP) schemes providing nutrition information.
Separate file:
https://data.jrc.ec.europa.eu/dataset/ee4aa355-2e2f-4419-a1ee-b2041eda1486.

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