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Review Article

The science on front-of-package food labels

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Abstract

Objective: The US Food and Drug Administration and Institute of Medicine are currently investigating front-of-package (FOP) food labelling systems to provide science-based guidance to the food industry. The present paper reviews the literature on FOP labelling and supermarket shelf-labelling systems published or under review by February 2011 to inform current investigations and identify areas of future research.

Design: A structured search was undertaken of research studies on consumer use, understanding of, preference for, perception of and behaviours relating to FOP/shelf labelling published between January 2004 and February 2011.

Results: Twenty-eight studies from a structured search met inclusion criteria. Reviewed studies examined consumer preferences, understanding and use of different labelling systems as well as label impact on purchasing patterns and industry product reformulation.

Conclusions: The findings indicate that the Multiple Traffic Light system has most consistently helped consumers identify healthier products; however, additional research on different labelling systems' abilities to influence consumer behaviour is needed.

Keywords
Front-of-package food labelling
Nutrition labelling
Obesity

In May 2010 the White House Childhood Obesity Task Force highlighted the need to 'empower parents and caregivers to make healthy choices' with simple, practical information, including improved front-of-package (FOP) food labels[1]. Currently the US Food and Drug Administration (FDA) has undertaken a Front-of-Package Labeling Initiative[2] with the goal of reviewing available evidence on FOP labelling systems to determine whether one approach can be recommended over others. Congress also requested that the Institute of Medicine (IOM) examine this issue and in October 2010 the Committee on Examination of Front-of-Package Nutrition Ratings Systems and Symbols released its first of two consensus reports which reviewed the current FOP systems and examined the strengths and limitations of the nutrition criteria that underlie them[3].

A variety of FOP systems exist, including industry-initiated systems in the USA[4], a Traffic Light (TL) approach in the UK developed by the Food Standards Agency (UK FSA)[5] and the 'Choices' programme check mark system being used by food manufacturers around the world[6]. A number of major food manufacturers in the USA and the UK have also voluntarily agreed to post the number of calories per serving and the per cent daily calorie value on the front of their food products[7]. More recently, prior to the FDA and IOM's recommendations, the Food Marketing Institute and the Grocery Manufacturers Association, two of the industry's largest trade groups, announced the introduction of a new 'Nutrition Keys' labelling system[8]. The four basic icons on the symbol will provide information about calories, saturated fat, sodium and sugars per serving as well as per cent daily value (%DV)[9]. The label will also highlight up to two nutrients to encourage which include potassium, fibre, vitamin A, vitamin C, vitamin D, calcium, iron and/or protein[9].

Much is at stake regarding an FOP labelling system. An FDA survey found that 67 % of respondents reported using FOP symbols often or sometimes when making purchasing decisions[10], but the array of non-standardized labelling systems makes it difficult for consumers to evaluate and compare the nutritional profiles of foods. In addition, each labelling system is based on a different set of nutrition criteria, which are susceptible to industry manipulation. Furthermore, because people tend to use heuristic-based decision making when pressed for time, consumers are vulnerable to food manufacturers highlighting healthy

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aspects of an overall unhealthy product[11]. Therefore, it is critical that an informative, easily understood, science-based FOP labelling system be implemented.

The current paper aims to: (i) evaluate existing research to identify FOP/shelf labelling systems which hold the most promise; and (ii) identify key FOP/shelf labelling research needs.

Methods

A structured search of research studies published or under review by February 2011 on consumer use, understanding of, preference for, perception of and behaviours relating to FOP labelling and supermarket shelf-labelling systems was performed.

Inclusion and exclusion criteria

To be considered, a published, in press or under review research paper had to meet the following criteria: (i) must relate to FOP nutrition labelling and/or shelf-labelling systems and consumer use, understanding, preference, perception or behaviour related to that label; (ii) the labels examined must include symbols or nutrition information flags located on the front of the package or on the supermarket shelf; and (iii) must relate to original research or a review of research.

Studies were excluded if they: (i) discussed policy and legal strategies for obesity prevention and the FOP/shelf label was only mentioned; (ii) included general information on FOP/shelf labelling, but did not describe relevant research; (iii) described nutrition criteria for FOP/shelf labelling, but not consumer use; (iv) described research related to nutrition labels, but not FOP/shelf labels specifically; (v) described research on health claims; (vi) were not peer-reviewed research, except for government reports; or (vii) related to nutrition labelling on menus or *trans* fat labelling.

Search strategy

A search strategy using ('FOP' OR 'front-of-pack' OR 'shelf label') AND nutrition was run in Medline and adapted for other databases including Google Scholar, CINHAL, PsychINFO, CDSR and AGRICOLA. Titles and abstracts were screened for relevance; when in doubt, full papers were reviewed and/or authors were contacted for clarification. In addition, nutrition label researchers were contacted for any in press or under review publications. Twenty-eight studies were included in the current review (see Table 1).

Table 1 Studies included in the present review

1. Vyth EL, Steenhuis IH, Mallant SF *et al.* (2009)[6]
2. van Kleef E, van Trijp H, Paeps F *et al.* (2008)[12]
3. Malam S, Clegg S, Kirwin S *et al.* (2009)[13]
4. Lando AM & Labiner-Wolfe J (2007)[14]
5. Feunekes GI, Gortemaker IA, Willems AA *et al.* (2008)[15]
6. Kim WK & Kim J (2009)[18]
7. Kelly B, Hughes C, Chapman K *et al.* (2009)[19]
8. Gorton D, Ni Mhurchu C, Chen MH *et al.* (2009)[20]
9. Möser A, Hoefkens C, Van Camp J *et al.* (2010)[21]
10. Levy AS, Mathews O, Stephenson M *et al.* (1985)[22]
11. Borgmeier I & Westenhoefer J (2009)[23]
12. Maubach H & Hoek J (2008)[24]
13. Andrews JC, Burton S & Kees J (2011)[25]
14. Jones G & Richardson M (2007)[26]
15. Vyth EL, Steenhuis IH, Vlot JA *et al.* (2010)[27]
16. Sacks G, Rayner M & Swinburn B (2009)[28]
17. Steenhuis IH, Kroeze W, Vyth EL *et al.* (2010)[30]
18. Drichoutis AC, Lazaridis P & Nayga RM (2009)[31]
19. Bialkova S & van Trijp H (2010)[32]
20. Lang JE, Mercer N, Tran D *et al.* (2000)[33]
21. Jeffery RW, Pirie PL, Rosenthal BS *et al.* (1982)[34]
22. Katz DL, Njike VY, Rhee LQ *et al.* (2010)[35]
23. Berning JP, Chouinard HH, Manning KC *et al.* (2010)[37]
24. Sutherland LA, Kaley LA & Fischer L (2010)[38]
25. Grunert KG, Wills JM & Fernandez-Celemin L (2010)[39]
26. Drewnowski A, Moskowitz H, Reisner M *et al.* (2010)[40]
27. Young L & Swinburn B (2002)[41]
28. Vyth EL, Steenhuis IH, Roodenburg AJ *et al.* (2010)[44]

Results

Consumer preferences for label elements and systems

Front-of-package label simplicity

Consumer preferences for labelling systems were assessed via focus groups in Germany, France, the UK and the Netherlands. The study included young adults, families and individuals over 55 years old[12]. The participants reported that an FOP label with information about calories, exercise, %DV and daily caloric amounts provided too much information[12]. Overall, participants in these groups[12], as well as those participating in a large FOP study undertaken by the UK FSA[13], expressed a desire for a simple FOP label. The FDA also evaluated consumer preference for various FOP labelling systems by conducting eight focus groups across four US cities[14]. Sixty-eight adults from varying educational backgrounds responded most positively to a simple keyhole summary symbol that included the statement 'meets FDA Healthy Meal Guidelines'. In addition, a study conducted by Unilever found that individuals with low perceived nutritional knowledge reported difficulty understanding complex FOP labels, although no difference between education and comprehension level was observed[15].

How should front-of-package labels present calorie information?

Calorie information is one of the most frequently accessed pieces of information on nutrition labels[12,13,16]. In the UK FSA study, calorie information was the most understood element of FOP labels[13], and those trying to lose weight reported using calorie information most frequently[13].

One study recommended that calorie information be presented in a neutral, white box because when it was displayed inside a starburst shape consumers interpreted the attention-grabbing nature of the symbol as an indication that the calorie information was for the whole

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package[14]. Consumers also felt that calorie information alone was not enough for them to make an informed choice; however, that study did not identify what additional information consumers would want[14].

In addition, FOP labels that include information about daily caloric needs were viewed positively and could be an important educational tool, as few people in the USA can accurately identify such needs[14,16]. European focus group participants also favoured FOP labels that included daily caloric reference values for men and women[12]. Furthermore, research on restaurant menu labelling has shown that the statement 'The recommended daily caloric intake for an average adult is 2000 calories' enhanced the effect of menu labelling by staving off overeating at a subsequent meal[17]. One concern with a daily caloric requirement and per cent dietary intake (%DI) labels is that they are based on a recommended number of calories that is not suitable for everyone.

It is also important to consider how calorie information should be presented in relation to serving size. Individuals in the USA, Korea and the UK were confused by labels showing calories per serving for products often consumed in one sitting (i.e. a muffin, 20 ounce soda bottle)[13,14,18]. This suggests that calorie information should be listed per package for these types of foods. In addition, participants in Europe felt that information about calories per 100 g should be avoided because it makes it difficult to compare across products and does not provide serving size information[12]. More research on how the presentation of calorie information per serving or per package impacts purchasing behaviour and perception of product healthfulness is greatly needed.

Should front-of-package labels include percentages?

The purpose of including percentages on labels is to put the numbers in context of the overall diet. Research strongly suggests, however, that percentages on FOP labels are confusing and few people find them helpful. In FDA focus groups, some consumers did not understand %DV labels[14] and in European focus groups, symbols including a graphic expression of %DV were viewed by consumers as difficult to understand[12]. In an Australian study, individuals in socially disadvantaged areas were six times less likely to identify the healthier of two foods when using a monochrome %DI symbol in contrast to the TL symbol which resulted in equitable performance across socio-economic groups[19]. In that study two versions of the TL label also yielded more correct answers for the identification of nutrients in food products compared with two variants of the %DI system[19].

In a study of 1525 supermarket shoppers in New Zealand, the least preferred among four FOP labelling systems was the %DI label[20]. The UK FSA study also found that many people had a poor understanding of what information per cent guideline daily amount (%GDA) conveys and those over 65 years old found labels with %GDA information particularly difficult to comprehend[13]. These findings suggest avoiding percentages as a method of providing dietary context on labels.

Should front-of-package labels include text to indicate nutrient levels?

The UK FSA study found that the best predictor of successful label comprehension was the appearance of text indicating whether a product had 'high', 'medium' or 'low' levels of a specific nutrient[13]. The study used a factorial design for the presence and absence of %GDA, TL and interpretive text to examine consumers' evaluation of the level of individual nutrients and the overall healthfulness of a product. The inclusion of text increased the proportion of correct answers for both product types (main meal sized portion and snack) for both the evaluation of a single nutrient and overall healthfulness of the product. In addition, interviews with customers revealed that shoppers who did not understand that the TL colours were meaningful or had trouble comprehending percentages were assisted by the text. These findings suggest that such interpretive text can greatly improve label comprehension.

The UK FSA recommends the use of a label combining TL colours, text which specifies whether the product is high, medium or low in a specific nutrient, and %GDA because it was liked the best and had good comprehension[13]. When used alone %GDA was not found to be effective, but when combined with both text and TL colours, the percentage helped some shoppers to determine the level of individual nutrients[13]. These findings suggest that if percentages are to be used on a label, they should be accompanied by text to help with interpretation.

Should front-of-package labels include information statements about exercise or energy balance?

There is very little research on how exercise labels or statements about energy balance appearing on packaged foods may influence consumer perception and behaviour. In European focus groups[12], most participants disliked exercise labels which gave the calories per serving of the product plus the amount of exercise needed to burn these calories. While younger consumers liked the label because they found it easy to understand and motivating, most others argued that the exercise labels would be 'demotivating and patronizing' and induce guilt. The participants also indicated that FOP labels should avoid phrases about energy balance on labels. For example, a symbol including calories per serving and the phrase 'balance your energy' was least preferred and viewed with scepticism as a marketing tool, which was 'gimmicky and coercive'. Some respondents saw the label as meaningless because they did not understand what it was trying to convey. Larger studies using quantitative methods, rather than focus groups, are needed to draw more definitive conclusions about the impact of exercise and energy balance phrases on FOP labels.

What is the appropriate size for a front-of-package label?

Participants in the UK FSA study expressed concern that the labels were too small and difficult to read, especially for those requiring reading glasses[13]. Given that consumer ability to see 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.

Which front-of-package label do consumers prefer?

Only a handful of studies have asked consumers about their preferences regarding different FOP labels. In addition, there is a dearth of research comparing preferences for different industry and non-industry developed labels. However, existing research comparing the Multiple Traffic Light (MTL) label to other FOP labels suggests that consumers prefer a TL system.

A New Zealand study of 1525 supermarket shoppers found the MTL symbol was preferred most often[20]. An interview-based study of 1019 consumers in Korea[18] found that 58% of respondents believed colour differences based on nutrient content (as seen on the MTL label) convey important information, but 33% of respondents had difficulty understanding what the information was conveying.

Two surveys, one conducted in Germany and one in Belgium, investigated perceptions of their widely used GDA label compared with the MTL[21]. The GDA label provides average energy and macronutrient intake levels per serving that people should consume daily. This label has been criticized because the nutrient reference levels are not grounded in science, the nutrition requirements are based on those for an average adult and therefore not applicable to groups with different needs, and the portion sizes used are unrealistically small. Participants in Germany preferred the MTL label because it was easier to understand and seen as more appealing and trustworthy than the widely used GDA label. However, a similar study in Belgium found that Belgians preferred the GDA label to the MTL, although this was partly explained by Belgians' familiarity with the GDA symbol. However, older individuals and those with a higher BMI had less of a preference for the GDA label.

More studies on perceptions and use of the MTL label and other existing FOP symbols in US samples are needed. However, several studies have found that consumer preference for a label format is not indicative of label comprehension[13,19,22] or ability to use a label to choose a healthy product[22]. This suggests that less emphasis should be placed on studies examining preference alone.

Consumer understanding and use of labels

Which front-of-package label best helps consumers assess product healthfulness?

Existing literature suggests that consumers are better able to evaluate food products when using the MTL label compared with other approaches. A study of 790 respondents conducted in Australia[19] tested consumer perceptions and performance using four different FOP labels: (i) a TL system ranking levels of total fat, saturated fat, sugar and sodium; (ii) TL rankings plus an overall rating (TL+) for the product; (iii) a monochrome %DI label indicating the per cent dietary contribution of energy, protein, total fat, saturated fat, total carbohydrate, sugar, fibre and sodium; (iv) a colour-coded %DI system with the same nutrients ranked plus a colour code for total fat, saturated fat, sugar and sodium. Each respondent was exposed to one labelling format on two sets (a healthy product and less healthy product) of two different food products. A product was defined as healthy if it was eligible to carry a health claim based on the Australia and New Zealand 2007 Food Standards Agency Nutrient Profiling guidelines. The authors found that while people initially thought they would have the easiest time using a colour-coded %DI label, the TL label was most successful in assisting customers select the healthier food product.

In a two-part experimental study, 420 participants were randomized to one of five label formats: (i) a simple tick; (ii) an MTL format; (iii) a monochrome GDA; (iv) a colour-coded GDA; or (v) a no label control. Exposure to the MTL symbol yielded the highest percentage of correct choices when trying to decide which of two foods was healthier[23]. However, when participants completed a virtual supermarket task during which they were asked to select all the foods they would eat the next day, no differences in the energy content of the foods was found across the label conditions.

A study of 1525 ethnically diverse shoppers in New Zealand found that the Simple Traffic Light (STL) format led to increased ability to correctly determine if a food was healthy, followed very closely by the MTL label[20]. 'Not healthy' was defined as high in fat, saturated fat and sodium, and low in fibre, as assessed by a registered dietitian. The nutrition information panel and %DI label yielded fewer correct distinctions regarding food healthfulness.

In contrast, an Internet survey of 1630 participants from four European countries found that survey respondents viewed the MTL as the easiest to comprehend and most credible. However, when making selections between healthy and less healthy products in the food spreads category, the MTL label differentiated significantly less between products compared with a label with Smileys or with Stars[15]. This significant difference was not found between the other products studied (dairy drink and ice cream), which highlights the need for future research to examine more product categories when testing label formats.

In addition to helping consumers identify the healthier of two products, the TL system impacts perceptions of healthfulness. When 294 parents and caregivers in New Zealand evaluated pictures of cereals, those who saw the MTL label reported significantly lower health scores for cereals of poor nutritional quality compared with a control

condition, while those who viewed a %DI label gave lower, but not significantly different ratings from a control condition[24]. In contrast, a web-based study examining perceptions of healthfulness for a frozen chicken dinner with a 'Smart Choices' logo, a TL plus %GDA or no logo revealed that participants viewed an unhealthy product as being healthier and having lower levels of negative nutrients when it had a Smart Choices symbol on it relative to a no logo control. This was also true, although less strong, for the TL plus %GDA symbol compared with the no logo control. Furthermore, the Smart Choices icon, relative to the control, led to more favourable product attitudes and purchase intentions as well as reduced assumptions that regularly eating the food would lead to heart disease and weight gain. The TL plus %GDA also led to an increase in favourable product attitudes and purchase intentions, but did not impact perceptions of eating the food and developing heart disease or gaining weight[25].

An eye-movement study of ninety-two participants comparing a label with eight nutrients to a label with the same nutrients plus TL symbols for specific nutrients found that nutrients on the TL were examined most[26]. Unlike the colourless label format where testing found that the nutrients people examined had a limited impact on the nutrients they used when making a judgement, the TL guided people to important nutrients which they used when making healthfulness judgement. More research testing different FOP labels using eye-movement technology would be useful.

Which front-of-package labels impact food purchases?

Little research exists on the impact FOP labelling systems have on purchasing patterns. One study examined sales of products with the Choices logo[27]. Four hundred and four customers exiting nine different grocery stores in the Netherlands completed questionnaires while research staff counted the number of their purchased products that contained the Choices logo. The study found that most products purchased with the logo were in the dairy category, followed by oils and fats, vegetables and fruits, and finally soups. Out of the 246 participants who were familiar with the Choices label, seventy-two participants reported purchasing products with the logo and did indeed buy more products with the logo relative to those who did not report buying Choices products.

There are few studies examining the impact FOP labels have on actual sales of food products. One study conducted in the UK examined supermarket sales data for two types of food products (chilled pre-packaged meals and fresh pre-packaged sandwiches) sold by a major retailer four weeks before and after the implementation of the TL label[28]. The study investigators found that the TL labels did not substantially influence the sale of healthier products. However, only two categories of food were examined over a short period of time. Additionally, such before-and-after studies should be accompanied by informational campaigns to ensure consumers are educated about the change in label format and the meaning of the label.

Which front-of-package labels impact food consumption?

In addition to a lack of research on purchasing patterns, few studies have examined how FOP labels influence food consumption. One concern with placing an FOP label on food products is that people may eat even more of the product because they perceive it to be healthy. For example, this 'health halo' effect has been documented for products labelled as 'low fat'[29]. To test this possibility with the Choices logo, participants in a laboratory-based study using a cross-over design[30] were given a piece of chocolate mousse cake. In one condition, they were told the cake qualified for a Choices logo, which was further explained on an information card. In the other condition, they were not told the cake qualified for the Choices symbol. When the Choices logo appeared on the cake, it was perceived as 'less unhealthy', but there was no difference in taste perception or cake consumption relative to when the cake did not have the logo on it. This suggests that the logo does not promote overconsumption of unhealthy foods or cause people to think a food will taste worse because it is viewed as healthier. It is possible, however, that this would not be the case with other food products that are not as obviously unhealthy. More research on the impact FOP labelling systems have on purchasing and consumption of foods is greatly needed.

For which front-of-package labels are people willing to pay more?

A study in Greece found that students participating in a laboratory experiment were willing to pay more for products with nutrition labels *v.* without. However among the products with nutritional information, the students' willingness to pay differed across label formats[31]. The study participants were presented with different labelling schemes and were asked what they would pay for each product with a nutritional label via a second price Vickrey auction. Products with a European Union-endorsed label or a TL label were valued more than a US government-endorsed label and an unlabelled product. The authors noted that the US label provided much more information which might have overwhelmed participants and led to label indifference.

What are the potential problems of the Multiple Traffic Light symbol?

While the MTL symbol has a growing body of research support, several issues regarding this system arose during the UK FSA study. One concern is that some people did not realize that the red/amber/green colours had meaning[13]. Some assumed the colours were simply being used to make the labels stand out. In addition, some

individuals thought the colours were related to specific nutrients (i.e. fats were always in red). However, this problem was overcome when text was included on the FOP label to indicate high/medium/low levels of nutrients in food products. An additional problem uncovered by the UK FSA study was that some consumers did not know that different nutrients have different maximum daily amounts, which explained why 0·5 g of salt had an orange label, but 1·4 g of sugars had a green label.

What label characteristics increase attention to a front-of-package label?

A study using a visual search paradigm found that attentional performance was faster when a logo was: (i) present (instead of absent); (ii) doubled in size; and (iii) displayed on the top-right of the package[32]. Participants also responded faster when viewing a monochromatic *v.* polychromatic logo. Given the research described thus far indicating the utility of a polychromatic TL, more research is needed to understand the relationship between response time and label comprehension. Finally, attentional performance was improved when the logo location did not change in consecutive tasks, suggesting that a single location for the logo on each product may be most beneficial.

How often do consumers report using supermarket shelf-label systems?

In contrast to FOP food labels, another possible labelling scheme is supermarket shelf-label systems. These systems place nutrition information on the shelf underneath or above the product, rather than on the actual product packaging. A number of studies have evaluated consumers' preference for, awareness of and use of nutrition labels placed on grocery store shelves. One study conducted in eighteen Detroit supermarkets examined consumer awareness and use of colour-coded shelf labels that indicated varying levels of product healthfulness[33]. Exit surveys of 361 participants revealed that 28 % of the sample was aware of the shelf labels, and ethnic and racial minority groups were significantly more likely to report awareness than Caucasians. However, 37 % of participants reported they did not use the shelf-label system, with only 17 % of participants reporting use of the system 'often' or 'always'.

Another study of 400 participants involving eight supermarkets in Minnesota examined the effect of shelf labels using pre- and post-test surveys that assessed consumer nutrition knowledge[34]. Results indicated that there were no differences in consumer knowledge between the control and intervention supermarkets, although data were only collected over the course of 9 months and there were no intensive marketing efforts to promote the programme. In one study, a quasi-experimental repeated-measures design was used in twenty matched supermarkets in Washington, DC and Baltimore, MD to evaluate consumer use of shelf labels[22]. Two years after the shelf labels were implemented, 31 % of customers in the shelf label condition reported using the labels.

More recently, an interdisciplinary group of nutrition and public health researchers developed the Overall Nutritional Quality Index (ONQI), which served as the basis for NuVal, a shelf-labelling system that considers nutrient properties as well as associations between nutrients and health outcomes[35]. Katz *et al.* found that approximately 80 % of participants in one study (*n* 804) reported the ONQI would influence their purchase intentions. While there is a strong correlation between various food products' ONQI scores and the products' nutritional rankings according to expert panellists[36], the actual algorithm used as the basis for the labelling system has not been released to the public for evaluation.

Overall, consumers view shelf-labelling systems positively and health-conscious consumers are strongly in favour of them[35,37]. However, none of these studies directly compared whether consumers would prefer shelf-labelling systems more than FOP labels.

Which shelf labels have impacted food sales?

A few studies have evaluated consumer use of shelf labels through sales data, and have generally found a positive impact of shelf labels on the purchase of healthy options. A quasi-experimental repeated-measures design involving twenty grocery stores in the USA was used to examine the effect of the 'Special Diet Alert' (SDA) programme[22]. This shelf-labelling programme was implemented in ten of the twenty grocery stores, and sales data were compared across various food categories for a 2-year period. In each store 1600 food items were grouped into twenty-three food categories (e.g. butter/margarine) and then assigned to a product sector that described the amount of a given nutrient (e.g. low/reduced sodium sector). Valid comparisons between the intervention and control stores were made in sixteen instances (fourteen food categories): seven sodium sector comparisons and nine calorie/fat/cholesterol comparisons.

Eight of these sixteen instances showed a significant positive effect of the SDA programme. More specifically, five low calorie/low fat/low cholesterol sectors (canned fish, mayonnaise, butter, cottage cheese, fruit juice) and three low sodium sectors (soft drinks, frozen vegetables, tomato sauce) showed growth trends in market share between the intervention and control stores consistent with a positive programme effect. Significant market share differences between the intervention and control stores were not found in the following low fat/low calorie/low cholesterol sectors: canned fruit, fresh milk, soft drinks and cheese. A significant market share difference between intervention and control stores was not found in the following low sodium sectors: nuts and snacks, dry cereals, crackers and butter/margarine. Results also demonstrated that sales increased by 4 to 8 % in the SDA condition, indicating a positive effect of the programme.

A study comparing four supermarkets with shelf labels and four control supermarkets failed to observe sales differences based on the shelf-labelling system[34].

More recently, researchers investigating the impact of the 'Guiding Stars' shelf-labelling system found changes in sales of ready-to-eat cereals that translated into 2·9 million more items with stars being purchased monthly and an equivalent decrease in the products that did not receive stars[38]. Strengths of the study include the participation of 168 supermarkets and analyses of sales data eight months before the start of the programme as well as at 1- and 2-year follow-up periods. More sales data of this nature are clearly needed and future research should include comparisons across multiple food categories. In addition, the few studies which have examined the influence of demographic factors on shelf-label system use[22,38] have reported mixed results on the effect of income and education on preference for shelf-labelling systems[37] and/or used samples of primarily middle-aged women[34,37].

What nutrients should appear on front-of-package or shelf labels?

The decision regarding which nutrients to highlight on an FOP labelling system is complex and consumer preference is only a small piece. Respondents in the UK reported that they most frequently look for fat, then sugar, calories, salt, saturates and additives[39]. In the UK FSA study participants usually started with calorie information when determining product healthfulness because it was the most easily understood[13]. Participants felt the next most understood element was salt, and saturated fats were the least well understood and used. Individuals with medical conditions reported most frequently checking sugar content if diabetic and salt and fat content for those with heart disease. Those shopping for children most frequently checked salt and sugar. In a Korean survey, most people felt four or five nutrients should be displayed on the FOP label, including calories, *trans* fat, total fat, cholesterol and sodium[18]. In its first report, the IOM noted that 'Americans consume too many calories, saturated fats, trans fats, and added sugars; too much sodium; and too little vitamin D, calcium, potassium, and fiber'[3], suggesting that these nutrients should be the focus of FOP labels. However, in an online consumer study of 320 mostly female participants located in the USA, consumer perception of food healthfulness was most primarily driven by the presence of protein, fibre, calcium and vitamin C, and the absence of saturated fat and sodium[40]. The finding that the presence of positive nutrients can greatly influence health perceptions cautions against the inclusion of such nutrients on FOP labels appearing on nutritionally poor foods. One option is to highlight problem nutrients associated with the most prevalent health problems in the USA. In addition, it should be considered that those nutrients that appear on an FOP label will likely be the greatest focus of potential industry reformulation.

Industry product reformulation

Which labels will promote food product reformulation?

Few studies have examined industry reformulation of food products following the implementation of FOP labelling systems. It is possible to argue that even a system that produces little impact on consumer behaviour could have considerable public health benefit if companies feel compelled to reformulate their foods.

When a new logo system was introduced in New Zealand, food companies excluded 33 tonnes of salt over the course of a year by reformulating products[41]. In addition, following the FDA mandate to list *trans* fat content on packaged food labels[42], the amount of *trans* fats was reduced in many products[43], suggesting that similar effects would be seen based on the nutrients highlighted on FOP labels. In a larger study examining the impact of the Choices programme on product reformulation in the Netherlands, Vyth *et al.*[44] retrieved nutritional information for 821 products from food manufacturers participating in the programme. The authors found that 168 products were reformulated after the Choices logo was introduced and 236 newly developed products meeting the Choices criteria were introduced into the market. After reformulation, there was a significant increase in fibre for fruit juices and sandwiches. Sodium and SFA levels were reduced in processed meats as was sodium in sandwiches, sandwich fillings and soups. Dairy products saw a decrease in SFA, added sugar and energy, and added sugars were reduced in sauces. Finally, sandwich fillings also decreased in SFA, *trans* fat and energy. Products that were newly developed had increased fibre levels for fruit juice; less sodium and increased fibre for processed meats; lower SFA and added sugar and more fibre for dairy products; more fibre for sandwiches, although added sugar levels increased; and lower sodium and more fibre for soups. However, for newly developed products, energy was unchanged across all product groups. The Choices stamp used in the Netherlands at this time did not include calorie information on the logo. Displaying the calorie information with the logo may have encouraged manufacturers to decrease the energy in products.

Improving label awareness and trust

How do demographics impact label awareness and use?

In a study commissioned by the Choices Foundation[6], the elderly, obese and those with diet-related health problems expressed the need for an FOP logo, although respondents over 50 years old were less familiar with the Choices logo after it was launched. Interestingly, respondents with a lower education reported paying more attention to the logo. In the Netherlands, women liked the Choices logo more than men overall.

A study conducted in New Zealand[20], which recruited ethnically diverse shoppers in supermarkets, found that

those 18–24 years old were less likely to use labels. Individuals with special dietary requirements and from households with medium income compared to low income were more likely to use labels.

Should a uniform labelling system be used on all products?
Several studies have found that consumers desire uniform FOP systems across products[12,19]. However, participants in focus groups in the Netherlands expressed concern that a diversity of product categories such as vegetables and snacks carrying the same logo would be confusing[6].

Should front-of-package labels be government mandated or done voluntarily by industry?
A common theme throughout several studies was that FOP labels will be maximally effective if the label is perceived as credible. Focus group studies have found that individuals consistently desire a label where the definition of healthfulness is understood and comes from a trusted source[6,12,26]. European focus groups also found that an official endorsement from a national or international organization strongly increased the consumer perception of credibility, while endorsements by the European Union and European food manufacturers were perceived as less credible compared with the WHO or a national nutrition organization[12]. People were more sceptical if they thought the symbol was developed by the food industry[6]. The UK FSA study also found that some consumers were sceptical about FOP labels because they thought the food companies were using them to push certain products and therefore could not be trusted[13]. In contrast, others disliked the labels because they felt the government was trying to tell them what to eat.

The need for an information campaign
After the implementation of the Choices programme in the Netherlands, focus group participants generated a variety of explanations for the logo such as 'product health, safety or natural or organic product' and some people in the UK were confused about the meaning of the TL colours. Given concerns about the credibility of a system, misinterpretation of FOP label elements and overall label messages[6], it will be important to undertake a public health information campaign to inform consumers about what an FOP label means and how it should be interpreted. When the Nutrition Facts panel was first released, the Nutritional Labeling and Education Act funded a nationwide multi-lingual education campaign that attempted to reach every American household[45]. However, little research exists evaluating the marketing campaign's influence. This will likely be an important component of any FOP initiative.

Discussion

Research on FOP labelling systems in a variety of countries has produced mixed results. Existing studies have varied widely in the type of labelling systems tested, the methods used, the outcomes examined and the participants studied (see Table 2). A concerted research effort is necessary to discover which FOP or shelf labelling system is most beneficial to consumers. An ineffective labelling system could be misleading, deceptive, or at the very least represent a lost opportunity to improve public health.

Table 2 Summary of science on front-of-package (FOP)/shelf labelling systems

- The Multiple Traffic Light label is the FOP system with the greatest empirical support.
- FOP labels should convey calories per serving, daily caloric requirements and specific nutrient levels with high/medium/low text.
- Highlighted nutrients should be associated with the most prevalent health problems in the USA.
- Nutrients appearing on an FOP or shelf label will likely be the greatest focus of industry reformulation.
- Products consumed in one sitting should contain calorie information per package.
- Labels should be prominent in size and consistently displayed on the top-right of the package.
- Shelf-labelling systems such as 'Guiding Stars' and 'Special Diet Alert' hold promise.
- The labelling system should be viewed as a credible and trusted source of information.
- More research is needed to test potential FOP and shelf labelling systems among diverse US populations.

Based on current knowledge, the MTL label has the most consistent support. Research suggests that an effective MTL label should contain calorie information per serving, daily caloric requirement information and convey nutrient levels using high, medium or low text. The most prevalent health problems in the USA would indicate the need to highlight saturated fat, sodium and sugar. In addition, products consumed in one sitting should contain calorie information per package. A uniform labelling system that is prominent and consistently located in the top-right corner of the package should be implemented. It is also important that the labelling system be viewed as credible, which will most likely be achieved through endorsements from national and international agencies, rather than an industry-created system.

Such a label and its variants must be tested in diverse populations. In addition, different versions of the TL labels should be tested against possible alternatives that have not yet been compared with the TL symbol, including the Choices logo. Given that the Guiding Stars and the SDA shelf-label systems have had some impact on product sales, these should also be tested against the TL and Choices symbol as both a shelf-tag labelling system and a possible FOP graphic type. Furthermore, consumers' preference for and use of FOP labels should be compared more generally with preference for and use of supermarket shelf-labelling systems. Real-world studies that evaluate sales data as well as consumer behaviour in response to FOP and shelf labelling systems are greatly needed. Finally, more research is needed to understand

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Table 3 Research needs on front-of-package (FOP)/shelf labelling systems

- Study participants should be representative of the US population; therefore it is necessary to include participants from diverse socio-economic backgrounds and literacy levels.
- Eye-movement technology and virtual supermarket settings should be used to further investigate differences in FOP and shelf label comprehension.
- Supermarket sales data should be used in large-scale before-and-after studies to examine the impact new labelling formats have on consumers' purchasing behaviour.
- Studies examining the influence of FOP and shelf labels on food and beverage consumption are needed.
- Willingness-to-pay studies should be used to determine the kinds of labels consumers might be willing to pay extra money for to guarantee better nutrition information.
- Research on the most effective ways to educate the public about a new labelling system and how to interpret it is needed.

how best to inform and teach consumers to interpret a new labelling system (see Table 3).

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