Lead Article

NUTRITION REVIEWS

Effects of front-of-package and shelf nutrition labeling systems on consumers

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As standards are considered for nutrition front-of-package (FOP) and shelf-labeling systems in the United States, it is important to know what types of systems are most effective in conveying scientifically accurate and useful information to consumers. A systematic literature review identified 38 empirical studies on consumer response to FOP nutrition labeling and shelf labeling. Studies indicate that consumers can more easily interpret and select healthier products with nutrient-specific FOP nutrition labels that incorporate text and symbolic color to indicate nutrient levels rather than nutrient-specific labels that only emphasize numeric information, such as Guideline Daily Amounts expressed as percentages and/or grams. Summary systems may influence consumers to purchase healthier products. However, more research is needed to assess the influence of nutrient-specific labels on consumers' purchases. This review identified few studies that compared consumers' ability to select healthier products using nutrient-specific systems that incorporate text and color codes with multiple-level summary icons. More research is needed to determine the effects of FOP nutrition labeling on consumers' actual shopping behaviors and dietary intakes.

INTRODUCTION

Food manufacturers selling products in the United States are required under the federal Nutrition Labeling and Education Act of 1990 to provide nutrition information on the Nutrition Facts Panel in the information panel, typically located on the back or side of a package. There is interest in extending these requirements to allow front-of-package (FOP) nutrition labeling. In recent years, several food manufacturers and retailers have added simplified nutrition information or symbols on the front of food packages or on shopping aisle shelf tags, where the information is more visible to consumers. As different labeling schemes are appearing in the marketplace, there is concern that this multiplicity of systems could be confusing to consumers. One possible solution to this challenge is the development of a US federal standard for FOP labeling. To better inform such development, this article presents the results of a comprehensive literature review on consumer responses to FOP nutrition labeling and shelf-labeling systems.

Two general types of FOP or shelf-labeling systems are in use: nutrient specific and summary systems (Figure 1). Nutrient-specific FOP symbols display a few key nutrients; examples of these symbols include the percentage Guideline Daily Amounts (%GDA) and the traffic light (TL). %GDA schemes (also called GDA schemes) display nutrients per portion and include the amount in grams and as a percentage of a person's GDA for each nutrient. The Grocery Manufacturers' Association and Food Marketing Institute recently introduced the "Facts Up Front" label, which is a type of GDA scheme that displays a food's or beverage's calories, saturated fat, sodium, and sugar per serving.[1] Manufacturers who vol-

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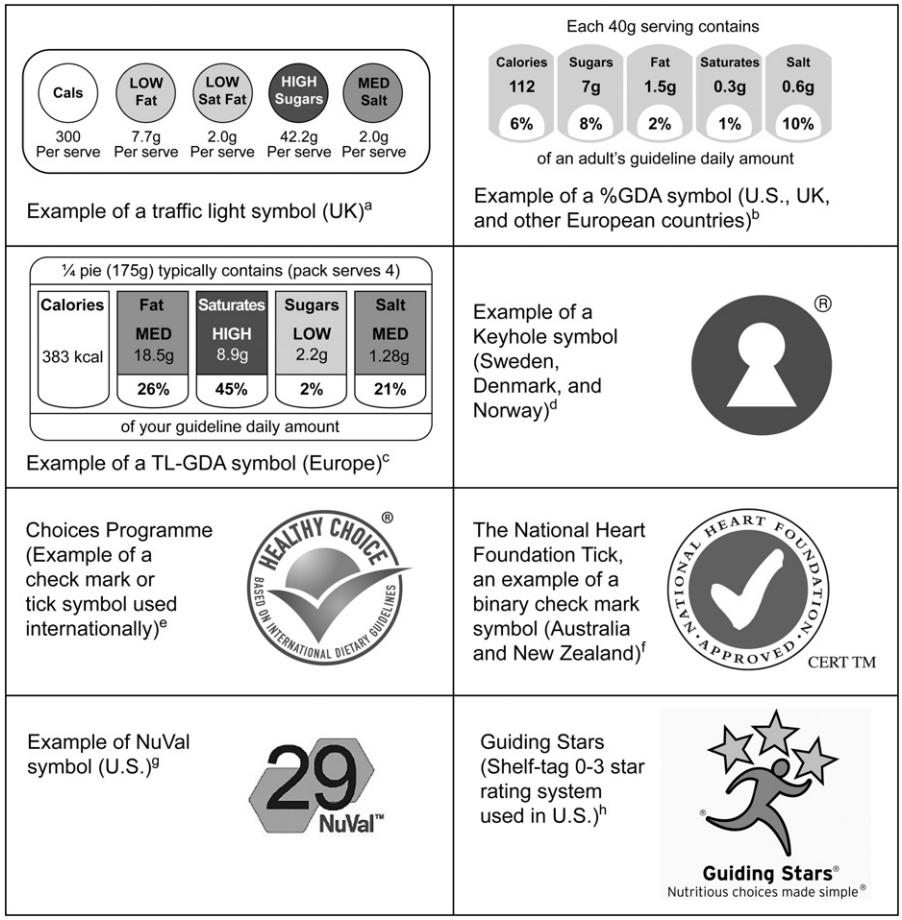
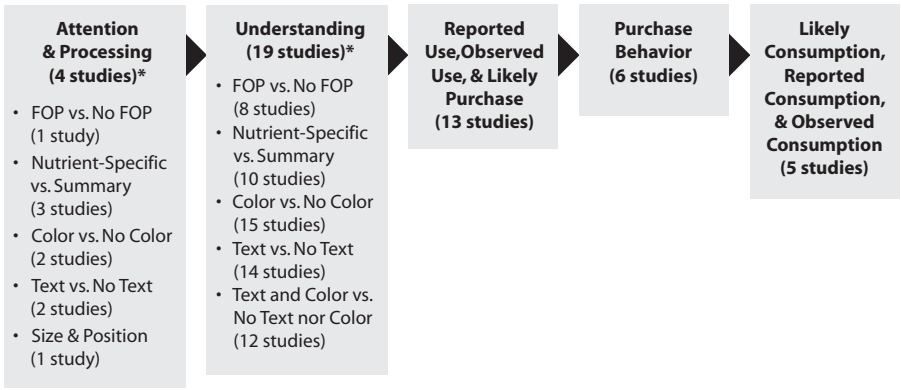


Figure 1 **Examples of front-of-package (FOP) nutrition labels and shelf tags.**
[a]Traffic light symbol reprinted with permission from the Food Standards Agency, United Kingdom.
[b]%GDA symbol reprinted with permission from the Food and Drink Federation, United Kingdom.
[c]TL-GDA symbol reprinted with permission from the Food Standards Agency, United Kingdom.
[d]Keyhole symbol reprinted with permission from the National Food Administration, Sweden.
[e]Choices logo reprinted with permission from the Choices International Foundation, Belgium.
[f]National Heart Foundation Tick symbol reprinted with permission from the National Heart Foundation of Australia.
[g]NuVal symbol reprinted with permission from NuVal, LLC, United States.
[h]Guiding Stars symbol reprinted with permission from Guiding Stars Licensing Company, United States.

untarily place this scheme on their products also have the option to display up to two "positive" nutrients that may include fiber, potassium, protein, vitamin A, vitamin C, vitamin D, calcium, or iron.[1] If a food or beverage package has limited space, a manufacturer who participates in the Facts Up Front program is only required to display calories per serving.[1]

TL labeling schemes are color coded and more interpretive than GDA schemes. They usually display a ranking (e.g., high, medium, or low) of total fat, saturated fat, sugar, sodium or salt, and sometimes energy. Levels are assigned color codes of red, amber, and green, respectively. In some instances, a food manufacturer may use a combination of the TL and the %GDA symbol, or the TL-GDA symbol (sometimes referred to as a colored GDA).

In contrast to nutrient-specific systems, summary systems use an algorithm to provide an overall nutritional score. Summary systems can be binary, such as the Choices Programme logo, which displays a check mark on a food package if the food meets specified nutrient criteria, or the Keyhole symbol, which is displayed on "healthier" products. Other summary systems are graded, such as the Guiding Stars system, which displays a ranking of zero to three stars, or provide a score, such as the NuVal system, which displays a food's nutritional score on a scale from 1 to 100. In October 2011, the Institute of Medicine's Committee on Examination of Front-of-Package Nutrition Rating Systems and Symbols recommended the adoption of a multiple-level summary icon that displays calories and a ranking of zero to three points for nutrients to limit,



* Each study falls into one or more categories shown below.

Figure 2 **Effects of front-of-package (FOP) and shelf nutrition labeling on consumers.**

including saturated fats, trans fats, sodium, and added sugars.[2]

FOP labeling has been an issue in many countries.[3–5] For example, in 2006, the United Kingdom's Food Standards Agency provided recommendations for a TL labeling scheme and urged food manufacturers and retailers to voluntarily use this scheme. However, a consortium of food companies disregarded Food Standard Agency's recommendation and continued using GDA or other FOP labels.[3] Today, a large number of companies in the United Kingdom use GDA labels.[6]

The synthesis of the literature review is organized in terms of health communication theory[7] and a conceptual framework adapted from Grunert and Wills.[8] Figure 2 provides the number of studies found to be related to each aspect of the theoretical framework. First, simplified nutrition labels affect consumers' decision-making and attitude formations, including attention/processing, understanding, use, and purchase behavior. Attention refers to the point in time when consumers are drawn toward a stimulus, and processing occurs when consumers begin to take in the information offered by the stimulus. Attention, processing, and perception can lead to understanding that might direct the consumers' decision-making process and prompt the consumer to make healthier food purchases and, thus, healthier consumption choices.

The purpose of this article is to inform policymakers in the United States about which types of labeling schemes or which specific features of labels have been scientifically tested on consumers and have been found to most quickly capture their attention, are easiest for them to understand, and prompt them to make healthier purchases and consumption choices. This study updates earlier reviews,[8–11] expands their geographic coverage,[8] and identifies knowledge gaps in the literature that could be addressed in future studies.

LITERATURE SEARCH METHODS

A systematic literature search was conducted for articles published between January 1990 and September 2010 in English from Europe, the Americas, Asia, Australia, and New Zealand.The databases searched included PubMed, Web of Science, ScienceDirect, CINAHL, Business Source Corporate, PsycINFO, AGRICOLA, Food Science and Technology Abstracts, New York Academy of Medicine Grey literature Report, NTIS, AgEcon, and CAB Abstracts. The following key words or phrases were used to search each database: "front-of-package nutrition label" OR "FOP label or front-of-package label" OR "shelf labeling" AND "consumer" OR "consumer response" OR "effective" OR "design" OR "nutrition" OR "producer" OR "retailer." Two researchers independently reviewed each of the 190 abstracts identified in the database searches and deemed 106 articles to be relevant and retrieved for review. Articles not retrieved for review discussed topics that were related to but not directly relevant to this study, such as labeling of organic foods or country-of-origin labeling.

To supplement the database searches and to retrieve additional grey literature, the US Food and Drug Administration docket solicitation on front-of-pack and shelf tag nutrition symbols[12] was reviewed. In total, the search yielded 111 articles that were reviewed for this article as well as a previous report written for the Department of Health and Human Services, Office of Assistant Secretary for Planning and Evaluation.[13]

Two researchers independently reviewed and rated each study according to the criteria provided in Table 1. A study could receive a score as high as 10.0 – one point for each of the following criteria: 1) clearly specified theoretical framework, 2) clearly specified population, 3) population-based sample, 4) experimental design, 5) stimuli clearly described, 6) measures clearly described, 7)

Table 1 **Criteria used to score quality of identified articles.**

Quality criteria	Operational criteria	Rating value	No. of studies satisfying criterion[(References)]
Theoretical framework			
Theoretical framework described	Description of theory or conceptual framework in article	1.0	6[(19,30,34,38,44)]
Sample selection			
Clearly specified population	Description in methods	1.0	30[(19–22,24–32,34,35,37–42,44,46–49,51)]
Representative sample	Random sample rather than convenience sample (note: opt-in internet surveys were considered to be nonrepresentative)	1.0	9[(19,20,24,33,35,36,46,51)]
Study design			
Experimental or crossover design with randomized assignment	Experimental design	1.0	20[(19,20,22–30,32,33,37,43,49,50)]
Measurement			
Test stimuli clearly described	Illustration or clear description of FOP labels tested	1.0	37[(19–41,43–51)]
Measures clearly described	Clear description of measures	1.0	37[(19–28,30–51)]
Established measures	Reference for source of outcome measures (note: objective measures such as processing time and sales were considered established measures)	1.0	16[(20,23–25,31,35,36,39,44–50)]
Statistical analysis and reporting			
Reported statistical tests for effects	Statistical tests for effects (e.g., provided *P* values)	1.0	32[(19–35,37–40,43,44,46–51)]
Statistical modeling to identify effects	Methods and analysis (e.g., logistic regression models)	1.0	3[(27,37,44)]
Reported subpopulation differences controlling for interaction effects	Statistical tests for effects in different subpopulations	1.0	7[(27,34,37–39,41,51)]
External credibility			
No peer review	Publication not subjected to a peer-review process	(0.5)	13[(20,26,29,30,32,33,36,42,45)]
Developer conducted study	Study conducted for or by same organization that developed the FOP or shelf nutrition labeling system studied	(0.5)	8[(29,32,36,44–46)]
Total		10.0	

established measures, 8) statistical tests of effects, 9) statistical modeling, and 10) reported subpopulation differences, controlled for interaction effects. However, one-half a point was deducted from a study's score if the publication was not peer reviewed or if the study was conducted for or by the same organization that developed the FOP or shelf nutrition labeling scheme evaluated. It should be noted that some studies had multiple components and therefore had outcomes relating to more than one aspect of the theoretical framework. In this situation, each study component was scored separately.

When synthesizing study findings, an attempt was made to concentrate on those that were more highly rated. This review emphasizes empirical studies that examine the effects of FOP and shelf labels on consumers' attention and processing time, identification of healthier food choices, use of labels, purchase behavior, and dietary intake. The literature search uncovered a number of studies that only measured consumers' preferences for different FOP or shelf nutrition labeling systems.[14–18] These articles were excluded from the review because evidence suggests that a preference for a particular FOP or shelf nutrition label does not necessarily indicate understanding of a scheme or lead consumers to make informed decisions about nutrition.[19]

After assessing the quality of the 111 studies reviewed for this report, 38 studies were identified as most focused on the topic of consumer response to FOP nutrition and shelf labeling, as set forth by the theoretical framework. These studies employed a variety of methodologies, including experiments, cross-sectional surveys, and a few in-store observations. Key information was abstracted from these studies, including their design, sample population, and results. This information, along

with each study's quality score(s) (ranging from 1.5 to 7.0), are provided in Table S1, which can be located in the Supporting Information for this article available online. Table 2 summarizes the type of FOP label assessed, summarizes how study outcomes relate to the theoretical framework, and provides each study's quality score(s).

Because authors sometimes refer to labeling systems with similar design features differently, a consistent set of terminology was employed to describe labeling schemes studied according to their design features. Nutrient-specific FOP systems discussed in this paper are described or referred to by key design features, including %GDA, grams, TLs (e.g., color codes for each nutrient, signifying high, medium, or low levels), and text (e.g., stating "high," "medium," or "low" levels of nutrients).

Summary systems examined in the studies included are referred to as a single-level summary icon, a multiple-level summary icon, or a summary TL. A single-level summary icon refers to a binary summary symbol, such as a check-mark symbol that is either present or absent on foods. A multiple-level summary icon is a symbol that displays a graphic rating or numerical score based on a nutritional algorithm. A summary TL is a specific type of single-level summary icon that displays a circular symbol in red, amber, or green, and the specific color displayed is determined by set nutritional criteria. A summary TL or multiple-level summary icon is sometimes displayed with text. This text communicates how much of the product should be eaten (e.g., "eat a little," "eat some," or "eat most") or the healthiness of the product choice (e.g., "Healthier choice," "Ok choice," or "Less healthy choice"). Synovate[20] and Gorton et al.[21] tested a summary TL concept that they referred to as a "simple TL." Kelly et al.[22] also tested a summary TL as a component of the TL+ scheme. The summary TL, however, is not an FOP symbol that is in use like nutrient-specific TL schemes that sometimes display text stating "high," "medium," or "low" based on nutrient amounts.

RESULTS

The sections that follow summarize study findings on consumer response to FOP and shelf nutrition labeling systems in terms of attention and processing; understanding; reported use/observed use/likely purchase; purchase behavior; and likely consumption/reported consumption/observed consumption.

Attention and processing of labels

Four empirical studies regarding consumer attention and processing of FOP labels were identified.

FOP labels versus a no-label condition. One study conducted in the United Kingdom[20] found that consumers' processing time or time to answer questions about the nutrient content in products was 40% faster when using a label displaying TLs + text; 36.5% faster when using a label that displayed %GDA, grams, TLs, and text; and 21.2% faster when using a label with %GDA, grams compared with the no-label condition ($P < 0.05$). However, although consumers' processing time was 3.5% faster when viewing the summary TL + text compared with the no-label condition, this difference was not statistically significant.[20] Results were similar in another task that asked respondents to rate which product of a product pair contained the higher level of negative nutrients. In this task, subjects' processing time was significantly faster for all FOP labels (e.g., TLs, text, %GDA, grams; %GDA, grams; TLs, text; summary TL + text) compared with the no-label condition ($P < 0.05$).[20]

Summary versus nutrient-specific systems. Two of three studies that examined processing time found that consumers' processing time was faster when they viewed summary labels versus nutrient-specific labels.[23,24] For example, consumers in the Netherlands more quickly responded to questions when they viewed a single-level summary icon (depicting a check mark) than when they viewed nutrient-specific schemes that displayed %GDA, grams ($P < 0.001$).[23]

A study conducted in the United Kingdom and Italy assessed the length of time needed to compare and identify which of two food product pairs was healthier. The study found that consumers' processing time was 16.8% faster using a multiple-level summary icon with 1–5 stars, 13.1% faster using a single-level summary icon depicting a check mark, and 8.9% faster using a multiple-level summary icon with a series of ticks compared with a nutrient-specific label that displayed %GDA, grams ($P < 0.01$).[24]

In contrast, a study conducted in the United Kingdom yielded mixed evidence. The study measured the time it took consumers to answer questions about levels of nutrients in foods and measured the time it took consumers to interpret which of two products contained more negative nutrients.[20] The study found that consumers' processing time when answering questions about levels of nutrients in foods was 37.8% faster using a label with TLs, text; 34.1% faster using a label with %GDA, grams, TLs, text; and 17.6% faster using a label with %GDA, grams compared with a summary label (summary TL + text) ($P < 0.05$).[20] However, consumers' processing time to determine which of two products contained more negative nutrients was 41% faster using a label with %GDA, grams, TLs, text; 36.8% faster using a label with %GDA, grams; and 33.7% faster using a label

Table 2 **Effects of front-of-package and shelf-labeling systems on consumers: attention and processing; understanding; reported use/observed use/likely purchase behavior; purchase behavior; and likely consumption/reported consumption/observed consumption.**

Study	Location(s)	Label types	Relation to theoretical framework (quality score)
Hunt et al. (1990)[40]	United States	Text (Brand-specific shelf labels of uniform color presenting messages: low fat; low sodium; low fat, low sodium; and fat ratio OK)	Reported use, observed use, and likely purchase behavior (4.0)
Schucker et al. (1992)[35]	United States	Text (Brand-specific nutrition shelf tags identifying brands that have low levels of sodium, calories, fat, and cholesterol. Nutrients were given prominence by placing on color background.)	Reported use, observed use, and likely purchase behavior (6.0) Purchase behavior (5.0)
Scott & Worsley (1994)[31]	New Zealand	Grams (not an FOP) Single-level summary icon Multiple-level summary icon + text Nutrition claim recommended by National Heart Foundation (e.g., low fat, low sodium)	Understanding (5.0)
Larsson et al. (1999)[51]	Sweden	Single-level summary icon (Keyhole symbol)	Likely consumption, reported consumption, and observed consumption (6.0)
Lang et al. (2000)[41]	United States	Symbolic color + text (M-Fit Supermarket Shelf-Labeling Program that uses color-coded shelf labels to identify foods as green "Best Choice" or as yellow "Acceptable Choice"; foods identified by labels were low in total fat, saturated fat, cholesterol, sodium, and high in fiber)	Reported use, observed use, and likely purchase behavior (4.0)
Reid et al. (2004)[44]	Canada	Single-level summary icon (Canada's Health Check logo)	Reported use, observed use, and likely purchase behavior (4.5) Likely consumption, reported consumption, and observed consumption (6.5)
Steenhuis et al. (2004)[50]	Netherlands	Shelf label indicating low-fat products (label consisted of logo, name of item, and indication that the product was a good low-fat choice)	Likely consumption, reported consumption, and observed consumption (6.0)
Synovate (2005)[20]	United Kingdom	Summary TL + text TLs, text %GDA, grams, TLs, text %GDA, grams No label	Attention and processing (6.5) Understanding (5.5)
Green (2006)[42]	United Kingdom	FOP labels in United Kingdom	Reported use, observed use, and likely purchase behavior (1.5)
Which? Consumers' Association (2006)[33]	United Kingdom	Grams, TLs, text %GDA, grams (Tesco's GDA scheme) %GDA, grams (other manufacturers' GDA scheme) %GDA, grams, TLs	Understanding (4.5)
Affinnova (2007) & NuVal (2010)[36]	United States	Multiple-level summary icon (NuVal shelf tags, overall score 1 to 100)	Reported use, observed use, and likely purchase behavior (2.0)
Jones & Richardson (2007)[25]	United Kingdom	Grams (not an FOP) Grams, TLs, text	Attention and processing (6.0) Understanding (6.0)
Feunekes et al. (2008)[24] (Study 1)	United Kingdom, Germany, Italy, Netherlands	Single-level summary icon Multiple-level summary icon (shield symbol with rating from 1 to 7) Multiple-level summary icon (1 to 5 stars) Multiple-level summary icon (1 to 5 smileys) TLs, text Grams, TLs	Understanding (6.0)
Feunekes et al. (2008)[24] (Study 2)	Italy, United Kingdom	Single-level summary icon Multiple-level summary icon (ticks) Multiple-level summary icon stars) %GDA, grams, TLs	Attention and Processing (7.0) Understanding (6.0)
Gorton et al. (2008)[21]	New Zealand	Grams (not an FOP) Summary TL + text TLs, text %GDA, grams	Understanding (4.0) Reported use, observed use, and likely purchase behavior (4.0)
Affinnova (2009) & NuVal (2010)[36]	United States	Multiple-level summary icon (NuVal shelf tags, overall score 1 to 100)	Reported use, observed use, and likely purchase behavior (2.0)
Borgmeier & Westenhoefer (2009)[27]	Germany	Single-level summary icon Grams, TLs, text %GDA, grams %GDA, grams, TLs No label	Understanding (7.0) Likely consumption, reported consumption, and observed consumption (7.0)
Drichoutis et al. (2009)[43]	Greece	Grams only (with and without price – not an FOP) Grams, %GDA (with and without price – not an FOP) TLs, text, grams (with and without price) No label	Reported use, observed use, and likely purchase behavior (4.0)
Kelly et al. (2009)[22]	Australia	%GDA, grams %GDA, TLs, grams TLs, text, grams TLs, text, grams + summary TL	Understanding (5.0)

Table 2 **Continued**

Study	Location(s)	Label types	Relation to theoretical framework (quality score)
Malam et al. (2009)[19]	United Kingdom	%GDA, grams, TLs, text Grams, TLs, text %GDA, grams, TLs Grams, TLs %GDA, grams, text Grams, text Grams, %GDA No label	Understanding (7.0)
Maubach et al. (2009)[30] (Study 1)	New Zealand	%GDA, grams TLs, text	Understanding (5.5)
Maubach et al. (2009)[30] (Study 2)	New Zealand	%GDA, grams TLs, text Grams (NIP; similar to US NFP)	Understanding (5.5)
National Heart Foundation of Australia (2009)[32]	Australia	%GDA, grams TLs, grams Single-level summary icon	Understanding (4.0)
Sacks et al. (2009)[47]	United Kingdom	TLs (details of this TL labeling scheme were not provided)	Purchase behavior (5.0)
Balcombe et al. (2010)[37]	United Kingdom	TLs	Reported use, observed use, and likely purchase behavior (7.0)
Bialkova & van Trijp (2010)[23]	Netherlands	Single-level summary icon %GDA, grams %GDA, grams (note: included polychromatic or decorative color rather than symbolic color)	Attention and processing (5.0)
Edge (2010)[29]	United States	No label FOP calories FOP calories + negative nutrients (saturated fat, sodium, total sugars) FOP calories + negative nutrients + positive nutrients	Understanding (3.0)
Freedman & Connors (2010)[48]	United States	Fuel Your Life shelf tag	Purchase behavior (5.0)
Grunert et al. (2010)[38]	United Kingdom, Sweden, France, Germany, Poland, Hungary	%GDA, grams Single-level summary icon (Sweden only)	Understanding (6.0) Reported use, observed use, and likely purchase behavior (6.0)
Grunert et al. (2010)[34]	United Kingdom	%GDA, grams Grams, TLs, text %GDA, grams, TLs, text	Understanding (6.0) Reported use, observed use, and likely purchase behavior (6.0)
Hannaford's 12-month sales trends (Guiding Stars Licensing Company, 2010)[45]	United States	Multiple-level summary icon (Guiding Stars)	Purchase behavior (2.0)
Information Resources, Inc. (2010) (NuVal, 2010)[36]	United States	Multiple-level summary icon (NuVal, overall score of 100)	Purchase behavior (2.0)
Lin & Levy (2010)[26] (Study 1)	United States	Nutrient-specific FOPs: %GDA, grams Grams, TLs, text Summary FOP: Single-level summary icon Controls: %GDA, grams (NFP) No label	Understanding (4.5)
Lin and Levy (2010)[26] (Study 2)	United States	Nutrient-specific FOPs: %GDA, text Grams, text Grams, TLs, text Grams, TLs, text Grams, TLs, text Summary FOPs: Single-level summary icon includes calories and servings per container) Multiple-level summary icon (includes calories per serving information) Calorie count symbols: Calories per serving and per package Calories per serving and servings per package Controls: NFP No FOP or NFP	Understanding (4.5)
Steenhuis et al. (2010)[49]	Netherlands	Single-level summary icon (Choices logo)	Likely consumption, reported consumption, and observed consumption (6.0)
Sutherland et al. (2010)[46]	United States	Multiple-level summary icon (Guiding Stars)	Purchase behavior (5.5)
Vyth et al. (2010)[39]	Netherlands	Single-level summary icon (Choices logo)	Reported use, observed use, and likely purchase behavior (6.0)
Andrews et al. (2011)[28]	United States	Single-level summary icon %GDA, grams, TLs No label	Understanding (5.0)

Abbreviations: FOP, front of package; GDA, Guideline Daily Amount; TL, traffic light; NFP, Nutrition Facts Panel; NIP, Nutrition Information Panel.

with TLs, text compared with the summary label (summary TL + text) ($P < 0.05$).[20]

Symbolic color versus no symbolic color/text versus no text. One study conducted in the United Kingdom found that consumers can more quickly process FOP labels with color compared with labels without color and FOP labels with text compared with labels without text.[25] Jones and Richardson[25] also used eye-tracking technology to measure the amount of time participants spent examining each amount of nutrient on each nutrition label (e.g., a typical label found in the United Kingdom displaying nutrient amounts in grams versus the typical label that included TLs, text) while they rated the healthiness of the label on a 1-to-10 scale. This study found that participants' eyes were drawn to the nutrients indicated by the TLs; thus, participants made fewer errors in their perceived healthiness ratings while they viewed a label with grams, TLs, text compared with a label that displayed only grams.[25]

A second study found mixed results on whether labels with color and text are easier to interpret than labels without color and text.[20] Synovate[20] measured the time it took for participants to evaluate the amount (e.g., high, medium, or low) of negative nutrients in a single product and found that the nutrient-specific labels with TLs (e.g., label with TLs, text and label with %GDA, grams, TLs, text) took the least amount of time to interpret: participants were 29.3% faster than with other labeling schemes studied (e.g., summary TL + text; %GDA, grams) ($P < 0.05$). However, there was no significant difference in the time it took for study participants to evaluate the amount of negative nutrients in a single product when using a summary TL + text. This same study measured the time it took for consumers to interpret which of two products contained more negative nutrients. Consumers interpreted a nutrient-specific label with %GDA, grams, TLs, text 6.7% faster than a label that displayed %GDA, grams; 11.1% faster than a label with TLs, text; and 41.1% faster than the summary TL + text ($P < 0.05$).

Size and position. One study measured consumers' attention as they completed two tasks while viewing different FOP labels, including a single-level summary icon; a monochromatic label with %GDA, grams; and a polychromatic label with %GDA, grams.[23] These tasks included indicating whether a logo was present or absent on the food package and, if present, whether there were one or two logos on a food package.[23] In addition to label type, a number of other factors were varied across the tasks, including logo display size (e.g., doubled versus standard), location on the package (e.g., top-left, top-right, down-left, or down-right), and familiarity with logo location (e.g., same or different than previous trial).[23] For the logo detection task, participants' performance was faster when the location of the FOP remained the same in two consecutive trials ($P < 0.0001$) and when the logo was present rather than absent ($P < 0.0001$).[23] For trials in which the logo was present, participants responded faster with doubled logo display size ($P < 0.01$) and when the FOP logo was presented on the top-right of label ($P < 0.001$).[23] In the task to indicate one versus two labels, participants' performance was significantly faster when they viewed an FOP label with doubled display size ($P > 0.0001$). For trials in which only one logo was present, performance was faster when FOP labels remained in a consistent location on the food package ($P > 0.0001$).[23]

Understanding of labels

The literature search identified 19 empirical studies that assessed the effects of different types of FOP labels on consumers' understanding. Among these studies, 8 studies compared consumers' understanding using different FOP schemes versus a no-FOP-label condition,[19,20,26–30] 10 studies compared consumers' understanding using nutrient-specific systems versus summary systems,[20,21,24,26–28,31,32] 15 studies compared consumers' understanding using schemes with symbolic color (e.g., color that has significance, such as levels of nutrients in products) versus schemes without symbolic color,[19–22,24–28,30,32–34] 14 studies compared consumers' understanding using FOP labels that included text to indicate nutrient levels versus labels without text to indicate nutrient levels,[19–22,24–27,31,33,34] and 12 studies compared consumers' understanding using labels that included both text and symbolic color with labels that did not have either of these features but instead displayed numeric information that included %GDA and/or grams.[19–22,25–27,30,33,34]

FOP labels versus a no-label condition. Three of seven studies reviewed found that consumers could more easily identify the healthier of two products using all FOP labels studied compared with the no-label condition.[26,27] It should also be noted that Maubach et al.[30] found that consumers could more easily identify the healthier of two products using FOP labels compared with the Nutrition Information Panel [NIP], a label similar to the US Nutrition Facts Panel. The other four studies found mixed results, depending on the particular FOP label that was compared with the no-label condition, the specific type of test that was conducted, or the specific product categories compared.[19,20,28,29] For example, Synovate[20] conducted an experimental study with consumers and found that, among four labels (e.g., summary TL + text; %GDA, grams; %GDA, grams, TLs, text; and TLs, text) compared with the no-label condition, consumers could more fre-

quently correctly assess the level of nutrients in foods as high, medium, and low and indicate which of two products contained more negative nutrients for all labels except for the summary TL + text ($P < 0.05$). Andrews et al.[28] found that consumers perceived the product with the single-level summary icon to be healthier than the same product with the %GDA, grams, TLs, and no FOP label ($P < 0.05$). Therefore, the single-level summary icon evaluated in this study led to less realistic healthiness perceptions.[28] Malam et al.[19] conducted an experimental study and found that consumers could more frequently correctly identify the healthiness of a single product (e.g., a small meal or snack) for all FOP labels compared with a no-label condition except for the label that displayed %GDA, grams ($P < 0.05$). However, this result changed when consumers were asked to compare the overall healthiness in two products. For all labels compared with the no-FOP-label condition, there were no significant differences in the percentage of consumers correctly identifying the healthier small meal or snack product.[19]

Finally, a study conducted by Edge[29] found that FOP labels increase consumers' ability to correctly identify a healthier product compared with the no-label condition. This was true for all product categories studied (e.g., cereal, savory snacks, frozen entrees, and salad dressing) as long as the nutrients tested were relevant to making a decision about the healthfulness of the product. For example, when determining which salad dressing was the healthiest option, it was more important for the consumer to see the level of sodium in the product and less important to see the level of vitamin A in a product.

Summary versus nutrient-specific systems. Six of ten studies found that consumers can more easily assess levels of nutrients or healthfulness of a single product or identify the healthier product among two products using nutrient-specific systems compared with summary systems.[20,26–28,32] Among the other four studies that compared consumers' understanding of nutrient-specific versus summary systems, three studies found that consumers could more easily rate the healthiness of foods using summary systems compared with nutrient-specific systems,[21,24,31] and the remaining study did not find a difference in consumers' understanding when rating the healthiness of foods with summary versus nutrient-specific labels.[24]

Symbolic color versus no symbolic color. Eight of 15 studies found that FOP labels with symbolic color (e.g., TL color codes) compared with labels without symbolic color more easily allow consumers to determine which of two products is healthier, to more accurately rate the healthfulness of an individual product, or to have more realistic attitudes about a product's healthfulness.[21,22,25,27,28,30,33]

Among the remaining seven studies with mixed results, five studies found no significant differences when viewing a label with color versus a label without color,[24,26,32,34] and two studies found different results depending on the specific test that was conducted with consumers or whether the label used symbolic color.[19,20] For example, Synovate[20] found that, when consumers were asked to indicate levels of nutrients in foods as high, medium, or low, a larger percentage of consumers provided correct responses when viewing labels with multiple TLs compared with labels without color (e.g., %GDA, grams) or a summary TL. Furthermore, a larger percentage of consumers could correctly identify which of two products contained more negative nutrients when viewing the label with %GDA, grams, TLs, and text (88%) compared with the other labels tested with participants ($P < 0.05$). However, there was no significant difference in the percentage of consumers who correctly identified which of two products contained more negative nutrients when they viewed a label with TLs and text compared with a label without color (e.g., %GDA, grams).[20]

Text versus no text. Eight of 14 studies found that consumers can more easily compare products in terms of their healthiness or can rate the healthiness of an individual product when an FOP label has text versus no text.[21,22,25,27,30,31,33] Of the other six studies, four studies did not find any significant differences in the percentage of consumers who chose or ranked products in terms of their healthfulness when using labels with text versus no text.[24,26,34] Finally, two studies found mixed results on whether consumers most clearly understood FOP nutrition labels with text versus no text.[19,20] For example, Synovate[20] conducted a study by asking consumers to indicate nutrients in foods as either "high," "medium," or "low" and found that a larger proportion of consumers could correctly identify nutrient levels when food products had a nutrient-specific FOP label with text compared with consumers who were not shown FOP labels with text ($P < 0.05$).[20] However, when consumers viewed the summary symbol with text (e.g., summary TL + text), only 37% of consumers correctly identified levels of nutrients in foods, a percentage that was not significantly different than the no-FOP-label condition (38%). It should be noted that the text corresponding to the TL color on the summary TL symbol was different text, stating either "eat a little," "eat some," or "eat most."[20]

Malam et al.[19] found mixed results regarding whether consumers more clearly understand labels with text versus no text, depending on the specific test that was conducted with consumers. For example, they concluded that consumers who were asked to indicate levels of two of four nutrients (fat, saturated fat, salt, and sugar) on a

label for a smaller portion/snack and a main meal could more easily complete this task using labels with text compared with labels without text.[19] However, when consumers were asked to indicate which of two products was healthier for a smaller portion/snack or main meal, there were no significant differences in the percentage of consumers who correctly identified the healthier product among all but one situation (a significantly larger portion of consumers could correctly identify the healthier product using a label with text only compared with a label that displayed TLs and text for the main meal [$P < 0.05$]).[19]

Text and color versus no text or no color. Seven of 12 studies found that consumers can more accurately interpret nutrient levels of an individual food, compare or rate products in terms of their healthiness, or be led to have more realistic attitudes/opinions about the healthiness of a product when they use nutrient-specific labels with both TLs and text compared with nutrient-specific labels that do not display these features but instead display only numeric information that included %GDA and/or grams.[21,22,25,27,30,33] Among the other five studies, two studies found mixed results, depending on the experimental task.[19,20] For example, Synovate[20] found that a larger percentage of subjects could correctly indicate nutrients in foods as high, medium, or low when using the label that displayed TLs and text (79%) and a label that displayed TLs, text, and grams (66%) compared with the label that displayed only %GDA, grams (43%) ($P < 0.05$). However, when subjects were asked to indicate which of two products contained more negative nutrients, there was not a significant difference in the percentage of consumers who could correctly complete this task using labels with TLs and text versus the label with only %GDA, grams.[20]

Among the other three studies, two studies found no significant differences or minimal differences between the percentage of subjects correctly indicating the healthier product or ranking products in terms of their healthiness using labels with TLs and text compared with labels that did not display both of these features.[26,34] One study found that a larger portion of subjects were able to select the healthier product using the Nutrition Facts Panel (0.68), a label that displays only %GDA, grams, compared with a label that displayed TLs, text, and grams (0.51) ($P < 0.05$).[26]

Reported use of labels, observed use of labels, and likely purchase behavior

Researchers found 13 empirical studies on consumers' reported use and likely purchase behavior related to FOP and shelf-labeling systems.[21,34–43] Not included in the count of 13 studies were several qualitative studies conducted by Malam et al., including a study that examined consumers' use of FOP labels by asking subjects to think out loud while they shopped.[19] Eleven studies measured – via consumer interviews or surveys – the number or percentage of consumers who reported using or were likely to purchase products indicated by FOP or shelf-labeling systems.[21,34–36,38–42,44] Two studies were choice experiments that specifically considered what labels for which consumers are willing to pay more.[37,38,43] Among the 13 studies, eight studies examined potential associations between consumers' demographic and/or other characteristics, such as whether they were health or weight conscious and their frequency of label use.[21,34–39] Additionally, among the 13 studies, only one study examined consumers' actual use of the label by examining their store purchases for presence of the Choices logo.[39]

Among the 13 studies reviewed in this section, five studies found that over 50% of study participants reported they use or are likely to use FOP and shelf nutrition labeling systems (labels with different features studied) at least some of the time and are likely to allow these labels to influence their purchases.[21,36,40,41] For example, Hunt et al.[40] found that, among US consumers who correctly identified the 4-Hearts label, a shelf tag that identifies foods that are low in fat, sodium, and/or calories using messages such as "low-fat," "low-sodium," and "fat ratio OK," those who reported being encouraged to purchase healthier foods over a 4-year period increased from 36% to 54% (95%CI of difference: 5–41). In a 2009 study conducted by Affinnova, 78% of respondents indicated they were "much more likely" or "somewhat likely" to purchase a product with a higher NuVal score (NuVal is a shelf-tag program in which a multiple-level summary icon displays a product's overall nutritional score from 1 to 100) (unpublished correspondence from NuVal to the FDA).[36]

On the contrary, six studies found different results regarding consumers' reported use of FOP labels.[34,35,38,42,44] A national survey conducted in the United Kingdom found that 44% of consumers believed that FOP labeling had no effect on their purchase decisions, whereas 43% of consumers believed that FOP labeling had changed many or some of their purchasing decisions.[42] After conducting observations of shoppers, Grunert et al.[38] found that only 16.8% of shoppers reported looking for nutrition information while shopping. After conducting observations of shoppers in a similar study, Grunert and Wills.[34] found that 27% of consumers reported looking for nutrition information. Although Schucker et al.[35] found that the percentage of respondents who reported they looked for the Special Diet Alert program shelf tags (shelf tags that displayed descriptor terms, such as "very low," "low," "reduced," and "OK" to indicate brands with low levels of sodium, calo-

ries, fat, and cholesterol) increased over a 12-month period, this percentage was still less than 50% of shoppers interviewed in Baltimore (45%) and Washington, DC (44%). Sixty-six percent of Canadian shoppers surveyed reported that they never look for the Health Check logo (a single-level summary icon) when grocery shopping.[44] Vyth et al.[39] examined consumers' grocery purchases and administered a questionnaire to determine consumers' food choice motives and found that 29% of consumers reported intentionally purchasing products with the Choices logo. Those who reported purchasing products with the logo actually purchased more products with the logo than those who reported not intentionally purchasing products with the logo ($P < 0.01$).

Two experimental studies examined whether consumers are willing to pay more for certain labels or label features.[37,43] A study conducted in Greece found that subjects valued products with nutrition information more than products without, and they generally bid more for the label with grams only or the label with TLs, text, grams compared with the label that displayed %GDA, grams.[43] Another study conducted in the United Kingdom found that, when subjects were asked to choose one of three hypothetical baskets of goods that differed in terms of price and nutrient content as indicated by a label that displayed TLs for salt, sugar, fat, and saturated fat, subjects had a strong preference to avoid a basket of goods with a label that displayed more "red lights."[37] In this study, the TL system was described to participants using simple language, and a basket of goods was defined as a selection of foods that might be offered in a store and relate to an individual's typical weekly "basket of goods." Some examples of these foods were provided to subjects.[37]

Among the studies that examined consumers' characteristics that might determine their use of nutrition labels, one study conducted in Canada found that awareness of the Health Check logo, a single-level summary icon, was associated with use and attitude toward healthy food purchases ($P < 0.05$).[44] The other seven studies found that some groups of consumers are less likely to use FOP labels than other groups. Groups less likely to use FOP labels include less nutrition-conscious individuals, those of low socioeconomic status, those with higher body mass indices, and those who have children living in their households.[34,38] Health-conscious consumers and consumers who have family members on special diets are more likely to purchase foods indicated as "healthy" by FOP and shelf-labeling systems than price-focused consumers.[35,36,39] As a result of examining consumers' food selections after grocery shopping, Vyth et al.[39] found that consumers in the Netherlands who purchased products with the Choices logo (a single-level summary icon) were more concerned about weight control ($P = 0.017$) and product information ($P = 0.002$); however, hedonism (e.g., pleasure seeking) was negatively associated with purchasing products with the logo ($P = 0.01$). Interestingly, this study also found that consumers with low and high education were more likely to purchase products with the Choices logo compared with consumers with medium education ($P < 0.01$). Balcombe et al.[37] found that, compared with individuals with less education, those with higher education were willing to pay more for lower levels of negative nutrients, as indicated by a label with TLs. Gorton et al.[21] found that, although label use was high for all ethnic groups (ranging from 66% to 87%), the odds of using labels was significantly lower for Maori compared with New Zealand Europeans. The odds were also 1.7 times greater for medium-income households to use nutrition labels compared with low-income households.

Purchase behavior

Four of six empirical studies suggest that consumers were influenced to purchase products indicated as "healthy" by shelf-labeling systems,[35,36,45,46] and among studies that analyzed consumers' purchase behavior after the introduction of multiple-level summary icon shelf tags in supermarkets ($n = 3$), all studies found that consumers were influenced to purchase healthier products as a result of these icons.[36,45,46] For example, a study assessing the effectiveness of the Guiding Stars program (a program that indicates participating products with a multiple-level summary icon depicting 0 to 3 stars) in one US supermarket chain found that, within the first year of the program, sales of starred frozen dinners and yogurts had increased (56% and 8%, respectively) and outsold frozen dinners and yogurts without stars.[45] Moreover, sales of lean ground beef increased (18%), whereas sales of fattier ground beef decreased (5%), and sales of skim milk (1%) increased, whereas sales of whole milk decreased (4%).[45] It should be noted that this study did not report statistical tests for effects.[45]After the introduction of the Guiding Stars program in 168 supermarkets located in the northeastern United States, another study found a 0.5 percentage point increase in sales of starred foods after 1 year ($P < 0.001$) and a 1.4 percentage point increase in sales of starred foods after 2 years ($P < 0.0001$).[46] The study reporting the results of analysis of sales data for the ready-to-eat cereal category found that the Guiding Stars program led to increased sales of highly rated cereals.[46]

In contrast, two studies found no effect of FOP and shelf nutrition labeling systems on sales of healthy foods.[47,48] A study assessing the introduction of TL labels in a major UK food retailers' stores found no effect on sales of healthy foods.[47] It should be noted that this study analyzed only two product categories (e.g., ready-to-eat meals and sandwiches). A study assessing the effects of

introducing Fuel Your Life shelf tags in one US college convenience store found no significant effect on sales of products tagged as nutritious.[48] Although not significant, Freedman and Connors[48] found sales of tagged items as a percentage of total sales increased as a result of the program by 3.6%.

Likely consumption, reported consumption, and observed consumption

Studies are limited and show mixed results regarding whether FOP and shelf-labeling systems influence consumers to select healthier foods and adopt healthier diets. Only one study that was reviewed analyzed consumers' actual dietary intake.[49] This Dutch study evaluated the Choices logo (a single-level summary icon that is present or absent on foods) and found no significant differences in participants' actual consumption and perceived tastefulness of chocolate mousse cake between the logo and nonlogo conditions.[49]

Another study examined subjects' food and drink selections, representing what they intended to consume the following day.[27] This simulated shopping study, conducted in Germany, found no difference among five FOP label schemes: a single-level summary icon; grams, TLs, text; %GDA, grams; %GDA, grams, TLs; and no label.[27]

Three studies examined consumers' awareness of FOP or shelf nutrition labeling systems and compared this information with consumers' reported dietary quality.[44,50,51] For example, a Dutch experimental study evaluating a shelf-labeling system that indicated low-fat products with text found no significant differences in consumers' reported fat intake among three conditions: an educational program without labeling, an educational program with labeling, and a control with no education or labeling.[50]

In contrast, two studies report that FOP and shelf-labeling systems can have a positive impact on consumers' reported diets, leading to reduced consumption of negative nutrients (e.g., fat and sugar).[44,45,51] For example, a Swedish study found that consumers (with the exception of the least-educated consumers) who had knowledge of the Keyhole symbol (a single-level summary icon) reported consuming more low-fat foods than consumers who did not have knowledge of this symbol.[51] A Canadian study found that consumers who purchased foods with the Health Check logo, a single-level summary icon, reported they had lower-fat diets than those who did not purchase products with the logo.[44]

DISCUSSION

In general, the findings of this review suggest that FOP and shelf nutrition labels can help consumers make better food choices. One study found that labels that are large and positioned in a consistent location on a food package more quickly capture attention.[23] Two of three studies conducted with European consumers found that consumers more quickly process simple summary icons compared with the more graphically complex nutrient-specific schemes.[23,24] However, this was not the case for the summary TL + text[20]: consumers more quickly processed symbolic color and text on a nutrient-specific label.[20] A limitation to these studies is that they did not examine the effects of background color or other nutrient claims surrounding the FOP label on the food package. Thus, it is recommended that future studies measure the effects of consumer attention on and processing of FOP labels while examining sources of information that may compete with consumers' attention in supermarket settings.

In considering the types of FOP and shelf nutrition labeling schemes that increase consumers' understanding of nutrition information, this review found that nutrient-specific FOP labels, rather than summary systems, more easily help consumers identify healthier products.[20,26–28,32] Furthermore, consumers can more easily interpret nutrition information using FOP schemes that incorporate text and color to indicate "high," "medium," or "low" levels of nutrients compared with FOP labels that only display numeric information, including %GDA and/or grams.[21,22,25,27,30,33]

There is some evidence that consumers use FOP and shelf nutrition labels[21,36,40,41] and, thus, may be influenced to purchase healthier food products. However, the percentage of consumers who use these schemes may be influenced by the level of education efforts and/or the particular communication strategy. To improve the nation's health, education and communication efforts for FOP and shelf nutrition labeling systems should target consumers who are at high risk for developing obesity-related illnesses and who are less likely to use FOP and shelf nutrition labeling schemes, including consumers with low socioeconomic status, with high body mass indices, or with children living in their households[34,38] rather than consumers who are nutrition conscious or have family members on special diets.[35,36,39]

Studies suggest that shelf tags, particularly those displaying multiple-level summary icons, can influence consumers to make healthier purchases.[35,36,45,46] However, this type of study has not been widely conducted with consumers using nutrient-specific FOP labels: in the present review, only one such study[47] was identified in the literature search. Although four studies were found that measured consumers' reported consumption as a result of FOP or shelf labels,[27,44,45,50,51] only one study measured consumers' actual dietary intake before and after the implementation of an FOP label.[49] Therefore, this review

found limited evidence regarding whether FOP and shelf tags actually change consumers' eating behaviors.

Although this review uncovered useful information on FOP and shelf nutrition labeling, it identified limitations in individual studies and considerable variability in outcome measures across the studies. In addition, many of the studies reported only statistically significant differences between groups rather than reporting means and variances; therefore, comparing findings across studies to easily identify the magnitude of effects was difficult. Another limitation was the range of studies that have been conducted in different settings. Although there is a growing body of evidence about consumer response to FOP labels in experimental situations (e.g., in-store intercept studies or Web-based panels), this review identified relatively few studies that assessed consumer use of FOP labels in a shopping environment.

This review and an earlier review conducted for the Department of Health and Human Services, Office of Assistant Secretary for Planning and Evaluation identified a number of knowledge gaps that will be important to address in future research.[13] First, although several of the shelf-labeling studies identified were conducted in the United States, the majority of studies on FOP labeling systems identified in this review were conducted in Europe, Australia, and New Zealand. Nutrition labeling requirements are different in the United States compared with other parts of the world. For example, although the US government mandates that all food packages contain the Nutrition Information Panel, nutrition labeling is optional in Europe. In addition to differences in regulations, differences in culture and in the availability of consumer educational campaigns are likely to exist among the different countries and regions where studies of this review were conducted, affecting the comparability of results with those found in US consumers. Therefore, it will be important for future studies to examine the effects of FOP labeling on the US population. Second, although this review identified several studies that have compared TL systems with %GDA systems or with systems using a single summary check or tick symbols, few studies have compared a TL system with multiple-level summary icons similar to the Institute of Medicine committee's recommendation for an FOP system. Third, as discussed earlier, existing studies provide limited information about the effects of other contextual information, such as nutritional claims on the front of packages or the interrelationship between the Nutrition Facts Panel and FOP symbols. This information will be especially important for understanding the efficacy of FOP labels in the US market. Fourth, few studies have provided evidence on the likelihood or existence of substitution effects, that is, whether and how much consumers may overconsume products displaying healthy symbols (e.g., green lights or high scores) because they perceive them as healthy. Finally, little is known about the effects of broader social marketing, in-store promotions, and consumer education to encourage the understanding and use of FOP labels.

CONCLUSION

In summary, this review found that consumers more easily identify healthier foods using nutrient-specific schemes compared with summary systems. More importantly, particular features of FOP labels, such as text and symbolic color to indicate nutrient levels, allow consumers to more easily select healthier products. On the contrary, studies have found that consumers have more difficulty comprehending FOP labels that display only numeric information such as %GDA and/or grams. For the largest public health impact, education efforts should target consumers with low socioeconomic status and high body mass indices rather than consumers who are nutrition focused. There is merit in using summary symbols such as a symbol recommended by the Institute of Medicine committee because studies have found that summary icons attract consumers' attention, and multiple-level summary icons may influence consumers to purchase healthier products. However, this review found relatively few studies that compared consumers' understanding using nutrient-specific systems, such as TL schemes, with multiple-level summary systems. More research is also needed to assess the influence of nutrient-specific labels on consumers' purchases. Additionally, more research should be conducted to examine the factors that surround the implementation of FOP and shelf-labeling systems – for example, how nutrition claims interact with consumers' understanding of FOP labeling schemes. More studies of US consumers in actual shopping situations are needed to characterize more accurately how FOP labeling systems affect consumer purchase decisions and dietary intakes.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1. Studies on Consumer Response to Front-of-Package and Shelf Nutrition Labeling Systems.