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Research review

The effects of nutrition knowledge on food label use. A review of the literature ☆

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ABSTRACT

Nutrition information on food labels is an important source of nutrition information but is typically underutilized by consumers. This review examined whether consumer nutrition knowledge is important for communication of nutrition information through labels on packaged foods. A cognitive processing model posits that consumers with prior knowledge are more likely to use label information effectively, that is, focus on salient information, understand information, and make healthful decisions based on this information. Consistent with this model, the review found that nutrition knowledge provides support for food label use. However, nutrition knowledge measures varied widely in terms of the dimensions they included and the extensiveness of the assessment. Relatively few studies investigated knowledge effects on the use of ingredient lists and claims, compared to nutrition facts labels. We also found an overreliance on convenience samples relying on younger adults, limiting our understanding of how knowledge supports food label use in later life. Future research should 1) investigate which dimensions, or forms, of nutrition knowledge are most critical to food label use and dietary decision making and 2) determine whether increases in nutrition knowledge can promote great use of nutrition information on food labels.

Contents

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Introduction

Nutrition information on food labels could be a cost-effective method of communicating nutrition information to consumers because the information appears at the point of sale for most packaged foods (Campos, Doxey, & Hammond, 2011). Although consumers value nutrition when deciding which foods to buy (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998), nutrition information on food labels is complex and does not always live up to its potential to communicate effectively (Drichoutis, Nayga, & Lazaridis, 2009; Hieke & Taylor, 2012; Lin & Yen, 2010; Wills, Schmidt, Pillo-Blocka, & Cairns, 2009). Prior knowledge has been shown to support performance on complex tasks in the cognitive literature; however, its role in food label use is less clear. In this review, we examine the literature surrounding the effects of nutrition knowledge on food label use to examine the state of literature on whether knowledge is important for food label use.

We draw on the cognitive science literature to illustrate how knowledge could support food label use. In particular, we assume that food label use relies on a set of interrelated processes centered on comprehension: attention, comprehension and memory, and decision making (see shaded portion of Fig. 1). Consumers pay attention to information on a food label, comprehend it, and store the information at least long enough to apply it to a food-related decision.

Knowledge has been credited with providing the power to perform these key cognitive processes. The phrase "knowledge is power," often credited to Sir Francis Bacon, has been used widely to convey the centrality of knowledge to human and artificial intelligence (Feigenbaum, 1989). The Long-Term Working Memory model (Ericsson & Kintsch, 1995) describes how knowledge supports cognition. Specifically, the model states that knowledge facilitates cognition by providing retrieval structures which link information in working memory (a limited attention buffer) with long-term memory (stored knowledge), so that newly learned information can be integrated with existing knowledge stores for later use. This results in a long-term working memory system, which represents the speed of access, associated with working memory, with the durability and capacity associated with long-term memory. Knowledge is powerful because it renders attention, comprehension, memory, and decision making processes more efficient (Chiesi, Spilich, & Voss, 1979; Ericsson & Kintsch, 1995).

Based on this work, as well as findings surrounding the effects of knowledge on perceptual processes and information overload (Charness, Reingold, Pomplun, & Stampe, 2001; Jacoby, Speller, & Berning, 1974), nutrition knowledge could support the use of nutrition information on food label use in at least three ways. First, prior knowledge could enable consumers to pay attention to important information on a food label, and to ignore marketing features that do not reflect salient nutritional qualities, which in turn minimizes information overload. Second, prior nutrition knowledge can facilitate comprehension of, and memory for, food label nutrition information (e.g., determining whether 700 mg represents a little or a lot of sodium). Third, prior nutrition knowledge could support the application of the comprehended and remembered information to food choice.

Nutrition knowledge could be important for dietary choice in other ways, for example, by having direct effects on food choice, without food label information, or by impacting attitudes or beliefs. In addition, food label use could be a moderator of the association between nutrition knowledge and dietary behaviors (Fitzgerald, Damio, Segura-Pérez, & Pérez-Escamilla, 2008; Satia, Galanko, & Neuhouser, 2005). There have been excellent reviews conducted in the past 5 years addressing knowledge effects on dietary intake (Spronk, Kullen, Burdon, & O'Connor, 2014) as well as a broad range of consumer attributes and behaviors such as attitudes, perceptions, and food choice (Bonsmann & Wills, 2012; Campos et al., 2011; Hieke & Taylor, 2012; Lähteenmäki, 2013; Wills, Storcksdieck genannt Bonsmann, Kolka, & Grunert, 2012). However, in this review, we limit the focus of our inquiry to the effects of knowledge on food label use in an attempt to better understand whether and how knowledge supports food label use.

Food label use constructs and information type

We review the literature on food label use related to three types of food label information that are most central to conveying nutrition and health information: nutrition labels, ingredient lists, and claims. Typically, food label use studies focus on nutrition labels; however, ingredient lists and health/nutrient claims also play important roles in conveying the products' diet and health information to consumers and, for this reason, are regulated in the US by the Food and Drug Administration (FDA). The European Commission's regulation of food labels was limited to claims until very recently, although food producers voluntarily provided nutrition labels and ingredient lists on most packaged foods (Bonsmann & Wills, 2012). Drawing on past research (Campos et al., 2011; Mhurchu & Gorton, 2007), we adopt two broad categories to organize the literature on food label use: whether or how often food labels are used (frequency) and the ability to understand labels (comprehension).

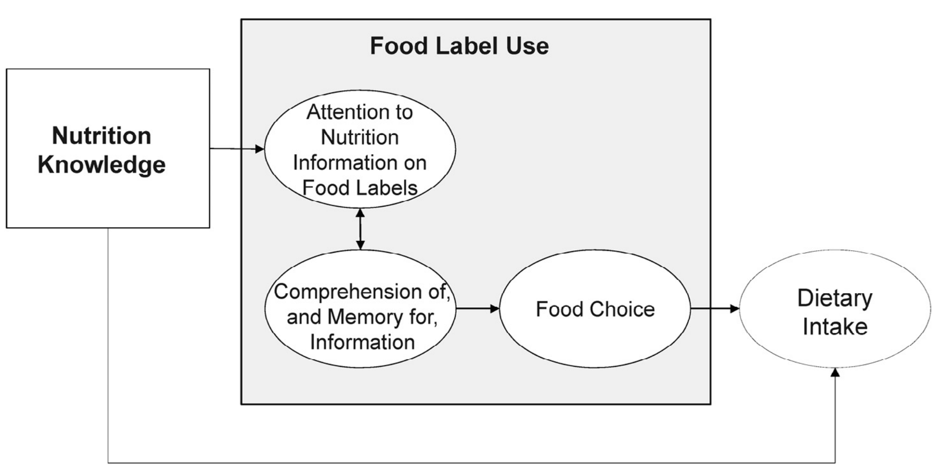

Fig. 1. Cognitive processes underlying use of food labels.

Frequency of use and comprehension measures can be further subdivided into subjective (e.g., self-reported assessment of frequency, self-ratings of ability to locate and/or apply information) and objective measures (e.g., experimenter's observation of consumer food label consultation or experimenter's assessment of comprehension using questions scored for accuracy).

Nutrition labels

Over 98% of FDA-regulated processed, packaged foods have Nutrition Facts panels (NFPs) in the US (Legault et al., 2004) and roughly 84% of products in Europe have nutrition labels (Bonsmann, Celemin, & Grunert, 2010). Nutrition labels typically contain information on calories, serving size, and amounts and/or daily values of several macronutrients, vitamins, and minerals (e.g., fats, carbohydrate, calcium). In the US, the content of NFPs is government regulated and must include serving size, calories, nutrients, and percent of daily values of each nutrient. Close to two-thirds of respondents in a survey report using NFPs to make purchasing decisions (Ollberding, Wolf, & Contento, 2010). Most individuals are able to understand at least some basic nutrition information on food labels (Graham & Jeffery, 2011; Grunert & Wills, 2007; Levy & Fein, 1998; Miller, Probart, & Achterberg, 1997). However, comprehension accuracy decreases for more complex tasks. For example, Levy and Fein (1998) found that most consumers (78%) accurately identified nutrient differences between two products; however, far fewer (20%) were able to calculate the contribution of a single food to a total daily intake.

Ingredient lists

In addition to non-nutrition information (e.g., additives), ingredient lists contain important nutrition information that can contribute to the consumer's assessment of a food's healthfulness. The US Dietary Guidelines 2010 states that: "The ingredients list can be used to find out whether a food or beverage contains synthetic trans fats, solid fats, added sugars, whole grains, and refined grains." Ingredient lists provide an account of ingredients within a product in descending order of proportion by weight (i.e., ingredients at the end of the list are present in smaller quantities). The FDA recommends that lists conform to a variety of specifications to enable consumers to be informed (Food and Drug Administration, 2014). For example, basic components of foods must be listed and products containing ingredients consisting of several components must list the components in parentheses. Font size and presentation should conform to federal regulations to maximize readability, but even when they do, font size is a frequent problem for consumers' use of ingredient lists (Mackey & Metz, 2009). Consumers frequently consult the ingredient list portion of food labels. For example, self-reported frequency of ingredient list use (as well as use of nutrition labels and claims) was 52% in one study (Ollberding et al., 2010) and even higher (78%) in another (Norazmir, Norazlanshah, Naqieyah, & Anuar, 2012).

Health and nutrient claims

Health claims are intended to communicate scientifically proven health benefits associated with consuming a particular food (Ippolito & Mathios, 1991; Williams, 2005), for example, "low fat diets rich in fiber may reduce the risk of some types of cancer." One goal of nutrient content claims is to communicate the value or relative amount of a specific nutrient within a food product (e.g., good source of fiber, fat free, low calorie). Claims have been shown to impact how other food label information is processed and to influence other dietary behaviors (Mathios & Ippolito, 1999; Williams, 2005). For example, consumers sometimes use claims in place of NFPs (Labiner-Wolfe, Jordan Lin, & Verrill, 2010). On the other hand, claims sometimes have little impact on product evaluations (Garretson & Burton, 2000) and may even be misleading and confusing (Hasler, 2008). However, claim comprehension is higher among those with greater experience and education (Dean, Lähteenmäki, & Shepherd, 2011; Verbeke, Scholderer, & Lähteenmäki, 2009).

Nutrition knowledge construct

Nutrition knowledge, broadly defined, refers to knowledge of concepts and processes related to nutrition and health including knowledge of diet and health, diet and disease, foods representing major sources of nutrients, and dietary guidelines and recommendations (Axelson & Brinberg, 1992; McKinnon, Giskes, & Turrell, 2014; Moorman, 1996; Parmenter & Wardle, 1999). Although some have argued that a narrower definition of nutrition knowledge may be desirable (Axelson & Brinberg, 1992; Li, Miniard, & Barone, 2000), Parmenter and Wardle (1999) suggest that a broad definition of nutrition knowledge is needed to capture the complex and wide-ranging nature of the information used to inform dietary choice. We make a similar argument that the ability to use food labels draws on a wide range of situations and behaviors that could potentially draw on many areas of nutrition knowledge. For example, knowledge of the relationship between diet and cancer may enable consumers to focus on fiber information presented on the nutrition label and whole grains in the ingredient list. Knowledge of dietary recommendations may support applying these pieces of nutrition information to decide whether the food product represents a healthful choice within the context of other foods the individual consumes that day. Consistent with the cognitive literature, the various dimensions of nutrition knowledge may be connected in such a way that they support each other, as an integrated semantic network. In this review, we categorize the literature in terms of the number of dimensions included in the nutrition knowledge assessment.

Materials and methods

The review was restricted to empirical, English-language, peer-reviewed studies examining knowledge effects on food label use. Searches were conducted in electronic databases (CINAHL, Cochrane, PubMed, Proquest, Psychinfo, ScienceDirect, Web of Science) and reference lists of relevant articles and reviews, that were published between June 1999 and June 2014 (including in online first print in 2015). The Nutrition Labeling and Education Act of 1990 mandated compliance with a new set of regulations by May of 1994. We used this time frame to allow a sufficient gap in time for consumers to become familiar with the new labels and researchers to examine consumers' familiarity with labels, which is an important factor for label use (Bialkova & van Trijp, 2010). Similarly, we omit studies investigating relatively new forms of nutrition information, namely, front-of-package symbols, which appear on some products (Hawley et al., 2013; Hersey, Wohlgenant, Arsenault, Kosa, & Muth, 2013; Vyth et al., 2012).

The following key word combinations to search each database: "knowledge" AND "consumer" OR "label use" OR "use of *labels" OR "attention" OR "comprehension" AND "nutrition * panel OR nutrition* label OR food label*" OR "ingredient list" OR "health claim" OR "nutrition claim" yielded 55 abstracts. Articles were screened for quality in terms of clarity of the descriptions of measures, methods, and findings. We excluded studies that did not include sufficient details of the nutrition knowledge measure to evaluate whether it assessed nutrition knowledge rather than another type of knowledge (e.g., functional foods, diabetes), did not differentiate between nutrition knowledge and constructs such as beliefs, confidence, or attitudes, did not describe in detail or provide examples of food label use questions, or did not differentiate between nutrition knowledge and food label use (n = 13). We also excluded studies with adequate measures of nutrition knowledge and food label use when associations between the two measures were not reported (n = 8). We coded food label use measures in terms of frequency of use and comprehension, and within that, self-reported and objective measures; we coded nutrition knowledge assessments in terms of self-reported and objective measures. These criteria were coded by the authors; agreement between raters was good (over 95%), and discrepancies were resolved through discussion.

Results

The final pool of articles (n = 34) is shown in Table 1. Each was coded in terms of the location, sampling method, food label area examined, and dimensions included in the nutrition knowledge assessment as well as the source of the measure. We found wide variation in sampling methods and thus representativeness of the samples, including convenience samples from college students, online panels, random samples of food shoppers in one or more stores, as well as random selections of households representing the entire country. We also found a variety of nutrition knowledge assessments, ranging from a single-nutrient focus to a multidimensional approach, most typically employing Parmenter and Wardle's (1999) measure. Table 2 summarizes the findings in terms of which studies reported a positive association between nutrition knowledge and food label use by type of measure. In the sections that follow, we present the findings for each food label area. Although we did not exclude studies based on age, none of the studies included individuals under the age of 17.

Nutrition labels

Our search of the literature identified 32 papers that examined nutrition label use and nutrition knowledge. The majority of these studies (n = 28) reported significant associations between nutrition knowledge and nutrition label use. For example, in a mail survey of 1162 Swiss adults, Hess, Visschers, and Siegrist (2012) found that both subjective and objective measures of nutrition knowledge were significantly associated with self-reported nutrition label use, even after accounting for demographic and health-related variables in a multivariate model. An online survey of a randomly selected group of 500 college students in the UK also found that prior nutrition knowledge was associated with self-reported food label use (Cooke & Papadaki, 2014).

However, four of the 32 studies reported no effects. For example, Norazlanshah et al. (2013) found that nutrition knowledge was unrelated to self-reported frequency of use that was assessed for specific areas within the nutrition label (e.g., serving size, fat). Another study reported only indirect effects of nutrition knowledge, showing that knowledge influenced self-reported nutrition label use through its influence on attitudes (Misra, 2007).

It could be that measures assessing self-reported frequency of label use are somewhat less able to detect the effects of nutrition knowledge, perhaps because they are assessed more remotely in terms of time, or do not include an indication of how well the information on the food label was understood. In support of this, two of the four studies showing null effects of nutrition knowledge on frequency of use also included nutrition label comprehension measures and in both cases, the associations between knowledge and comprehension were positive (Drichoutis, Lazaridis, Nayga, Kapsokefalou, & Chryssochoidis, 2008; Norazmir et al., 2012).

Although it could be that the type of knowledge assessment may also influence the relationship to self-reported frequency of use, this does not appear to be the case. One study using both subjective and objective measures of nutrition knowledge reported a significant relationship with food label use when the subjective – but not objective – measures were used (Petrovici & Ritson, 2006). However, the majority of studies that used self-reported knowledge measures found a positive association with frequency of nutrition label use (Burton, Garretson, & Velliquette, 1999; Hess et al., 2012; Jacobs, deBeer, & Larney, 2011; Orquin, 2014).

The literature reviewed here fairly consistently shows that knowledge is related to how *well* consumers are able to use food labels. In 18 studies, knowledgeable consumers were more likely to comprehend nutrition labels better than those with lower levels of knowledge (see Table 2). Some of the findings, however, are complex. For example, the effects of knowledge were found on a comprehension task requiring participants to use nutrition labels to determine which of two products was more healthful. However, knowledge effects were not evident on a task requiring participants to evaluate the healthfulness of a single label (Miller, 2014). These findings could suggest that knowledge is particularly useful when comparing two products in order to find nutrition differences between them.

Our search yielded only one, relatively small study, reporting no associations between nutrition knowledge and comprehension of nutrition labels (Block & Peracchio, 2006). In study 1 (studies 2 and 3 did not meet inclusion criteria), researchers provided a definition of dietary reference values to participants and then administered a brief exercise that asked, and then provided, the daily recommended intake of various vitamins and minerals, including calcium. Next, participants were asked, "How many milligrams of calcium are in the container?" based on the information provided in a nutrition label that provided the percent daily value of calcium per serving for a one-serving container. Very few (2 of 37) were able to answer the question correctly, and those with higher scores on the general nutrition knowledge test did not perform better. However, given the narrow range of label comprehension, the probability that the general knowledge test could provide support is low. Indeed, the initial assessment of calcium knowledge (recommended daily value) showed that most individuals did not have this prior knowledge and therefore would have to remember it from the subsequent task (because daily value of calcium in grams is not provided on the nutrition label). Thus, from this relatively small study, it is unclear whether consumers were unable to perform the calculation or failed to recall the required missing piece of information needed to perform the calculation.

The use of eye tracking to examine associations between food labels and food choice is becoming more common (Bialkova et al., 2014; Jones & Richardson, 2007; Miller, 2014; Miller & Cassady, 2012; Miller et al., 2015; Nelson, Graham, & Harnack, 2014). Within our conceptual framework, attention is a form of frequency of use (how much or how often food label information is consulted) that is objectively assessed. However, by itself, eye tracking data (or attention) do not indicate how well the information is understood or used to make decisions. That is, high levels of attention to information can indicate comprehension failure (e.g., confusion) as well as comprehension success (e.g., connecting the information to other information and integrating it so that it can be used to make a decision). To interpret the quality of attention devoted to food label information, eye tracking studies often include a comprehension task so that quality (i.e., accuracy) of understanding can be assessed. However, only one study assessed the association between nutrition knowledge and attention (Miller & Cassady, 2012). In this study, decision-making strategies were inferred from patterns of attention as individuals compared the two nutrition labels to determine which was more healthful. Researchers examined the relative frequency with which individuals engaged in compensatory strategies, in which one nutrient value compensates for another (lower amounts of fat may compensate for higher amounts of sodium) and non-compensatory strategies (e.g., amount of fat in one product versus another product). Results showed an effect of nutrition knowledge on attention (specifically, relatively greater use of

Table 1
Studies of nutrition knowledge and food label use for Nutrition Labels (NL), Claims (Cl), and Ingredient Lists (IL).

	Studies	Location	Sampling Method	Food Label Area			Knowledge Assessment Characteristics (for objective measures)			
				NL	Cl	IL	Dimensions	Number of items	Source of items (or dimensions)	Used some or all items from source
1	Ahmadi et al. (2013)	Iran	Convenience	x			Not defined	7	Parmenter and Wardle, 1999	Some
2	Barreiro-Hurlé et al. (2008)	Spain	Random	x	x		Not defined	2	None	NA
3	Barreiro-Hurlé et al. (2010)	Spain	Random	x	x		Not defined	2	None	NA
4	Block and Peracchio (2006), Study 1	USA	Convenience	x			Not defined; calcium only	1	Moorman, 1996	None
5	Burton et al. (1999)	USA	Representative of state	x			Not defined	12	None	NA
6	Cannoosamy, Pugo-Gunsam, and Jeewon (2014)	Mauritius	Random sample	x			Dietary recom, sources of nutrients, diet–disease	Not reported	Parmenter and Wardle, 1999	Not Reported
7	Carrillo, Varela, and Fiszman (2012)	Spain	Purposive convenience	x			Dietary recom, sources of nutrients	21 questions (multiple items)	Parmenter and Wardle, 1999	Some
8	Cooke and Papadaki (2014)	UK	Convenience	x			Dietary recom, sources of nutrients, choosing foods, diet-disease	110	Parmenter and Wardle, 1999	All
9	Drichoutis et al. (2005)	Greece	Random	x			Not defined	7	Parmenter and Wardle, 1999; Blaylock, Smallwood, Kassel, Variyam, and Aldrich, 1999	Some
10	Drichoutis et al. (2008)	Greece	Random	x			Dietary recom, sources of nutrients, choosing foods, diet-disease	9	Parmenter and Wardle, 1999; Blaylock et al., 1999	Some
11	Elbon, Johnson, Fischer, and Searcy (2000)	USA	Random	x			Not defined; dairy products only	10	Elbon, Johnson, and Fischer, 1996	Some
12	Fitzgerald et al. (2008)	USA	Convenience	x			Dietary recom, sources of nutrients, diet- disease	20	Sheard, 1984	Not Reported
13	Grimes, Riddell, and Nowson (2009)	Australia	Convenience	x			Not defined; sodium/salt only	2	None	NA
14	Hess et al. (2012)	Switzerland	Random	x			Not defined; 1 item on calories in food	1	Dickson-Spillmann and Siegrist, 2011	Some
15	Howlett et al. (2008)	USA	Convenience	x	x		Manipulated trans fat k; diet-disease, acceptable levels	na	None	NA
16	Jacobs et al. (2011)	South Africa	Random	x	x	x	Subj measures only	NA	NA	NA
17	Jasti and Kovacs (2010)	USA	Convenience	x			Not defined; trans fats only	6	None	NA
18	Li et al. (2000)	USA	Convenience	x			Positive/negative nutrients, DVs and %DVs,	NA	Moorman, 1996 (dimensions only)	None
19	Liu, Hoefkens, and Verbeke (2015)	China	Convenience	x			Dietary recom; sources of nutrients; salt and energy recom	59	Grunert, Wills, and Fernández-Celemín, 2010	Some
20	Macon, Oakland, Jensen, and Kissack (2004)	USA	Random	x			Not defined; fat only	15	CSFII and DHKS	Not Reported
21	Marietta, Welshimer, and Anderson (1999)	USA	Convenience	x			Not defined	9	None	NA
22	Miller and Cassady (2012)	USA	Convenience	x			Diet-health, sources of nutrients, procedural	38	Miller et al., 2011	Some
23	Miller (2014)	USA	Convenience	x			Diet-health, sources of nutrients, procedural	35	Miller et al., 2011	Some
24	Misra (2007)	USA	Random	x			Not defined; fat and cholesterol only	9	CSFII and DHKS	Not Reported
25	Nayga (2000)	USA	Convenience	x			Not defined	8	None	NA
26	Norazlanshah et al. (2013)	Malaysia	Convenience	x			Not defined	4	None	NA
27	Norazmir et al. (2012)	Malaysia	Convenience	x			Not defined	22	None	NA
28	Orquin (2014)	Denmark	Random	x	x		Not defined	6	Andrews, Netemeyer, and Burton, 2009	Not Reported
29	Pérez-Escamilla and Haldeman (2002)	USA	Random	x			Food fat content, food groups, obesity-health	20	CSFII and DHKS	Not Reported
30	Petrovici and Ritson (2006)	Romania	Random	x			Diet-disease, nutrition principles, food nutrient density	11	Blaylock et al., 1999 (dimensions only)	None
31	Petrovici et al. (2012)	UK	Convenience	x	x		Not defined	4	Drichoutis et al., 2005	Some
32	Pletzke et al. (2010)	USA	Random			x	Not defined; trans fats only	9	None	NA
33	Rasberry, Chaney, Housman, Misra, and Miller (2007)	USA	Convenience	x			Not defined	11	Marietta et al., 1999	Some
34	Walters and Long (2012)	USA	Convenience		x	x	Not defined	NA	None	NA

Notes: NL = nutrition label; Cl = claims; IL = ingredient list; NA = not applicable; NR = not reported; recom = recommendations; articles were coded with "not defined" when the no information was provided on the dimensions of nutrition knowledge included in the assessment.

Table 2
Nutrition knowledge and food label use assessment types.

Types of Assessment	Description	Identified studies	Knowledge-Food Label Use Association
Nutrition Knowledge			
Self-reported	Self-rated nutrition knowledge	5, 14, 16, 28, 30, 32	YES: 5, 14, 16, 28, 29–31; NO: none
Objective	Accuracy of responses on nutrition knowledge test	1–15, 17–34	YES: 1–3, 5–15, 17–23, 27, 28 31–34 NO: 4, 10, 24–27, 29, 30
Food Label Use Frequency			
Self-reported	Self-reported frequency of use (e.g., how often do you use food labels?)	1, 3, 6–17, 19–21, 24–27, 29–33	YES: 1, 3, 6–9, 11–17, 19–21, 29, 30 (subj K), 31–33 NO: 10, 24–27, 29, 30 (obj K)
Objective	Observation of label use via a coding or tracking system	22	YES: 22
Comprehension			
Self-reported	Self-rated comprehension of food label information	6, 16, 19, 20, 31	YES: 19
Objective	Accuracy of responses on comprehension test (e.g., identifying presence or levels of nutrients)	2, 4, 5, 7, 10, 13, 15, 16, 18–20, 22, 23, 27, 28, 32, 34	YES: 2, 5, 7, 10, 13, 15, 16, 18–20, 22, 23, 27, 28, 30–32, 34 NO: 4

Notes. Subj = subjective; obj = objective; K = knowledge; articles could receive a YES and a NO rating if one measure showed knowledge-food label use association and another did not.

noncompensatory strategies) but only among those who reported having dietary goals. Food label use was also objectively assessed in terms of comprehension (accuracy of the healthfulness decision). Across all individuals, comprehension was positively related to nutrition knowledge.

Ingredient lists

Three studies included an investigation of this area of the food label. Given their importance in communicating nutrition and health information, it is surprising how little attention ingredient lists have received in the literature. In a notable exception, Walters and Long (2012) examined the effects of expertise on types of information used to evaluate product quality and purchase intention. Experts, defined as completion of an upper division nutrition course, were more likely to use ingredient list information rather than an “all natural” label claim. Novices, on the other hand, did the opposite. In another study, greater knowledge gained through nutrition education surrounding trans fatty acids (verified through a self-reported measure of knowledge) was associated with increased food label comprehension based on the ingredient list (Pletzke, Henry, Ozier, & Umoren, 2010). This new knowledge was successfully applied to subsequent food choice; participants in the newly acquired knowledge group purchased foods lower in trans fatty acid (assessed using grocery receipts) two weeks later. Finally, researchers found an association between self-reported knowledge and accurate use of food label information that included ingredient lists, as well as nutrient information and nutrient claims (Jacobs et al., 2011).

Although the number of studies that included ingredient lists is very small, the findings are consistent with the notion that knowledge helps individuals use ingredient lists. Because ingredient lists can be long and contain complex terms, nutrition knowledge could help consumers engage in deliberative processing, avoid superficial information, and cross-check nutrition information in the nutrition label. One study relied on expertise differences which relied on an assessment of knowledge administered prior to the study (required to pass a nutrition course), another manipulated knowledge within an intervention context, and the third relied on subjective measures of nutrition knowledge. Each approach yielded a positive association between nutrition knowledge and ingredient list use. Although, ingredient list use was assessed together with the use of other areas of the food label, the assessments are consistent with how ingredient lists are designed to be used, with other nutrition information on the food label rather than as a standalone tool.

Health and nutrient claims

Although prior knowledge has been shown to influence attitudes toward claims (Lähteenmäki, 2013; Leathwood, Richardson, Sträter, Todd, & van Trijp, 2007), there are only a handful of studies investigating the influence of knowledge on the comprehension of claims on food labels. In general, these studies show that nutrition knowledge supports understanding of claims on food labels. For example, Howlett, Burton, and Kozup (2008) investigated the effects of trans fat knowledge on use of claims and nutrition labels in two studies by inducing trans fat knowledge through the exposure to educational materials prior to the rating task. Participants rated the healthfulness of a food package that fell into one of four conditions: presence of a “low trans fat” claim crossed with high (4 g) or low (1 g) trans fat levels in the nutrition label. Study 1 showed that high-knowledge individuals were sensitive to trans fat levels on nutrition labels, whereas low-knowledge individuals made similar ratings regardless of trans fat levels. However, this pattern was not observed for the trans fat claim manipulation. Study 2 showed large effects of manipulated knowledge for those who use labels frequently, but less so for those who do not. Although no means or figures were presented, the authors indicated that a similar pattern was found for trans fat claims. In general, this study provides support for the notion that nutrition knowledge supports nutrition label as well as claim understanding. An unsettling finding, however, was that among those who did not receive trans fat information (i.e., low-knowledge consumers) but were frequent label users, ratings of healthfulness were high for both the low and high trans fat levels. This suggests that frequent use of nutrition labels does not promote understanding of trans fat levels.

Barreiro-Hurlé, Gracia, and De-Magistris (2008) examined food choice based on food label characteristics including nutrition labels and claims. They found that nutrition knowledge was higher among those who primarily used nutrition labels, relative to those who used claims. In a later study, researchers showed a positive association between nutrition knowledge and self-reported frequency of nutrition label use, but not claim use (Barreiro-Hurlé, Gracia, & de-Magistris, 2010). Other work indicates that the effects of nutrition knowledge on claims depend on the claim type, with positive associations for health claims and but not nutrition claims (Petrovici, Fearne, Nayga, & Drolias, 2012).

A few studies assessed comprehension of claims with nutrition labels and/or ingredient lists (Jacobs et al., 2011; Orquin, 2014; Walters & Long, 2012), without an independent assessment of claim use. All of these studies reported that nutrition knowledge was related to comprehension of food label information. For example, Orquin (2014) asked participants to view a variety of food products (containing nutrition labels and claims) and rate the healthfulness of each. Results showed that participants with higher nutrition knowledge scores had higher healthfulness accuracy scores. Overall, there is some suggestion that knowledge may play a greater role in nutrition label use than claim use. However, the number of studies investigating knowledge effects on claim use is small and the findings do not present a clear picture.

Discussion

These data are consistent with the notion that long-term working memory afforded by nutrition knowledge supports both label use frequency and food label comprehension. The more consumers know about nutrition, the more likely they are to consult – and understand – nutrition information on food labels. The majority of studies reviewed here focused on knowledge effects on nutrition label use, with fewer studies on claims, and even fewer on ingredients lists. The finding that ingredient lists are neglected in this literature is surprising given they contain information surrounding diet and health.

Interestingly, food label use as defined by frequency (*how often*) is the most common assessment of food label use, with 26 of the studies including this type of measure. It is possible that nutrition knowledge provides more or less support for food label use depending on whether food label use is defined in terms of *how often* the label is used versus *how well* the information in the label is understood and used to make decisions. However, this distinction was largely confounded with self-reported versus objective assessment types across these studies. Thus, it is unclear whether knowledge effects are qualified by quantity/quality or self-reported/objective factors.

Consistent with the knowledge-is-power position, we found a positive association between knowledge and food label use for 6 of 6 studies using self-reported measures of knowledge and 21 of 33 studies using objective measures of knowledge. All but one (Jacobs et al., 2011) of the studies with self-reported measures also included objective measures. In these 5 studies, one study showed a difference in the pattern of findings (Petrovici et al., 2012) such that only the self-reported measure showed an association with food label use. In general, however, both approaches showed associations with food label use, despite possible differences in social desirability biases or underlying constructs (Palmer, Graham, Taylor, & Tatterson, 2002).

Only a few studies (Howlett et al., 2008; Pletzke et al., 2010; Walters & Long, 2012), examined the effects of newly acquired knowledge on food label use, with half of the participants to be assigned to a knowledge group and half to a control group. This approach is important because, through random assignment, groups should be comparable in all ways but knowledge levels. This approach could also be used as part of an intervention to determine the amount of additional nutrition knowledge required to affect incremental change in food-choice behaviors. However, initial levels of nutrition knowledge are also critical. Past work has found that baseline levels of knowledge were more predictive of weight loss among obese, low-income mothers than were changes in knowledge due to the intervention (Klohe-Lehman et al., 2006).

The model in Fig. 1 suggests that nutrition knowledge supports healthful food choices through information processing associated with food labels. However, we recognize that knowledge could play a broader role in food choice by supporting dietary intake regardless of food label use. Many studies have shown associations between nutrition knowledge and dietary behaviors (Ahmadi, Torkamani, Sohrabi, & Ghahremani, 2013; Bonaccio et al., 2013; Dickson-Spillmann & Siegrist, 2011; Drichoutis, Lazaridis, & Nayga, 2005; Fitzgerald et al., 2008; McKinnon et al., 2014; Wardle, Parmenter, & Waller, 2000; Worsley, 2002).

We also recognize that some consumers are uninterested in eating healthful foods or using food labels, regardless of their nutrition knowledge. Although the present review does not address this issue, motivation may be an important factor in encouraging consumers to think about the importance of nutrition in food choice (Coulson, 2000; Lin, Lee, & Yen, 2004; Petrovici & Ritson, 2006; Suter & Burton, 1996;). Although it is unclear where motivation originates, it is possible that motivation and knowledge co-evolve such that motivation predicts knowledge (Miller & Cassady, 2012) and knowledge predicts motivation (Miller, Gibson, & Applegate, 2010).

Directions for future research

The majority of studies presented here relied on convenience samples. Future research should focus on including a wider, more representative sample. College students, while important for understanding this group, may not inform the literature on other populations in terms of income, education, acculturation, and race/ethnicity. Moreover, few studies included age ranges that would enable an examination of age differences in the effects of knowledge. This is surprising for two reasons. First, food label use may be even more important for older adults because of their higher risk of diet-related chronic diseases (Post, Mainous, Diaz, Matheson, & Everett, 2010). Second, past work has shown the advantages of knowledge in later life on a variety of cognitive tasks (Salthouse, 2003) including comprehension and memory for nutrition texts (Miller, Gibson, Applegate, & de Dios, 2011; Miller, Zirnstein, & Chan, 2013; Olson & Sim, 1980).

Another area of research that warrants greater attention is the conceptualization and measurement of the nutrition knowledge construct. Axelson and Brinberg (1992) have noted that a single-dimension approach to assessing nutrition knowledge likely limits the ability of researchers to detect associations between knowledge and behaviors. Although there is some agreement among researchers that nutrition knowledge needs to be broadly defined in order to capture the complex nature of dietary behaviors (Parmenter & Wardle, 1999), the precise nature of the various dimensions requires greater specification. More research is also needed to understand the relationships among the dimensions, as well as the relationships between dimensions and various behaviors such as learning about nutrition, food label use, and dietary intake.

There is another potentially fruitful approach to conceptualizing and measuring nutrition knowledge. Cognitive researchers have also argued that the distinction between declarative and procedural knowledge is important, particularly in the area of skill development (Anderson, 1982). However, with some exceptions (Dickson-Spillmann & Siegrist, 2011), this distinction is rarely applied to nutrition knowledge and, as far as we know, no studies have included procedural and declarative nutrition knowledge as separate constructs. Based on the cognitive literature, procedural and declarative knowledge can facilitate each other. So, for example, learning how to select healthful foods (procedural) should be easier when consumers have a foundation of declarative knowledge (e.g., what sodium does to blood pressure, which foods are high in saturated fat, recommended daily intake of fiber), and both of these could support food label use. More work is needed to develop procedural and declarative nutrition knowledge, and examine their associations with food label use.

Finally, more research is needed to understand the causal links among nutrition knowledge, food label use, and dietary intake among different populations of consumers in order to design more effective educational programs. Although we found no evidence to support this in the present review, there could be some individuals for whom nutrition knowledge could lend a false sense of security that would lead to ignoring food labels, a form of maladaptive behavior (Szykman, Bloom, & Levy, 1997). More research is also needed to understand how to encourage those who make poor dietary choices to think about nutrition when deciding which foods to eat. It may be the case that providing bursts of nutrition knowledge to some groups of consumers would initiate a positive cycle of motivation and knowledge growth. Research is needed to understand how to sustain the growth of nutrition knowledge so that it leads to meaningful improvements in dietary behaviors.

Conclusions

Consistent with the notion that knowledge-is-power, the findings of this review suggest that nutrition knowledge supports food label use. Although the literature surrounding the use of ingredient lists is limited, evidence from studies investigating nutrition labels and claims suggests that these areas of food label use benefit from prior knowledge. Drawing from the cognitive literature, nutrition knowledge likely helps by directing attention to salient information, promoting comprehension, allowing more accurate information to be stored in memory and used in decision making situations. Although the review highlights gaps in the literature, especially surrounding the role of knowledge among older consumers, findings could suggest that increasing consumers' nutrition knowledge levels may improve nutrition communication through food labels.

References

Ahmadi, A., Torkamani, P., Sohrabi, Z., & Ghahremani, F. (2013). Nutrition knowledge. Application and perception of food labels among women. *Pakistan Journal of Biological Sciences*, *16*(24), 2026–2030. doi:10.3923/pjbs.2013.2026.2030.

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review*, *89*(4), 369–406. doi:10.1037/0033-295X.89.4.369.

Andrews, J. C., Netemeyer, R. G., & Burton, S. (2009). The nutrition elite: Do only the highest levels of caloric knowledge, obesity knowledge, and motivation matter in processing nutrition ad claims and disclosures? *Journal of Public Policy & Marketing*, *28*, 41–55.

Axelson, M. L., & Brinberg, D. (1992). The measurement and conceptualization of nutrition knowledge. *Journal of Nutrition Education*, *24*(5), 239–246. http://dx.doi.org/10.1016/S0022-3182(12)81238-6.

Barreiro-Hurlé, J., Gracia, A., & de-Magistris, T. (2010). Does nutrition information on food products lead to healthier food choices? *Food Policy*, *35*(3), 221–229. http://dx.doi.org/10.1016/j.foodpol.2009.12.006.

Barreiro-Hurlé, J., Gracia, A., & De-Magistris, T. (2008). Using latent classes to determine consumer heterogeneity in nutritional label valuation. *Food Economics - Acta Agriculturae Scandinavica, Section C*, *5*(3), 178–193. doi:10.1080/16507540902944817.

Bialkova, S., Grunert, K. G., Juhl, H. J., Wasowicz-Kirylo, G., Stysko-Kunkowska, M., & van Trijp, H. C. M. (2014). Attention mediates the effect of nutrition label information on consumers' choice. Evidence from a choice experiment involving eye-tracking. *Appetite*, *76*, 66–75. http://dx.doi.org/10.1016/j.appet.2013.11.021.

Bialkova, S., & van Trijp, H. (2010). What determines consumer attention to nutrition labels? *Food Quality and Preference*, *21*(8), 1042–1051. doi:10.1016/j.foodqual.2010.07.001.

Blaylock, J., Smallwood, D., Kassel, K., Variyam, J., & Aldrich, L. (1999). Economics, food choices, and nutrition. *Food Policy*, *24*(2–3), 269–286. <http://dx.doi.org/10.1016/S0306-9192(99)00029-9>.

Block, L. G., & Peracchio, L. A. (2006). The calcium quandary. How consumers use nutrition labels. *Journal of Public Policy & Marketing*, *25*(2), 188–196.

Bonaccio, M., Di Castelnuovo, A., Costanzo, S., De Lucia, F., Olivieri, M., Donati, M. B., et al. (2013). Nutrition knowledge is associated with higher adherence to Mediterranean diet and lower prevalence of obesity. Results from the Moli-sani study. *Appetite*, *68*, 139–146. doi:10.1016/j.appet.2013.04.026.

Bonsmann, S. S., Celemin, L. F., & Grunert, K. G. (2010). Food labelling to advance better education for life. *European Journal of Clinical Nutrition*, *64*(S3), S14–S19.

Bonsmann, S., & Wills, J. (2012). Nutrition labeling to prevent obesity. Reviewing the evidence from Europe. *Current Obesity Reports*, *1*(3), 134–140. doi:10.1007/s13679-012-0020-0.

Burton, S., Garretson, J. A., & Velliquette, A. M. (1999). Implications of accurate usage of nutrition facts panel information for food product evaluations and purchase intentions. *Journal of the Academy of Marketing Science*, *27*(4), 470–480. doi:10.1177/0092070399274006.

Campos, S., Doxey, J., & Hammond, D. (2011). Nutrition labels on pre-packaged foods. A systematic review. *Public Health Nutrition*, *14*(08), 1496–1506. doi:10.1017/S1368980010003290.

Cannoosamy, K., Pugo-Gunsam, P., & Jeewon, R. (2014). Consumer knowledge and attitudes toward nutritional labels. *Journal of Nutrition Education and Behavior*, *46*(5), 334–340. http://dx.doi.org/10.1016/j.jneb.2014.03.010.

Carrillo, E., Varela, P., & Fiszman, S. (2012). Influence of nutritional knowledge on the use and interpretation of Spanish nutritional food labels. *Journal of Food Science*, *77*(1), H1–H8. doi:10.1111/j.1750-3841.2011.02479.x.

Charness, N., Reingold, E., Pomplun, M., & Stampe, D. (2001). The perceptual aspect of skilled performance in chess. Evidence from eye movements. *Memory & Cognition*, *29*(8), 1146–1152. doi:10.3758/BF03206384.

Chiesi, H., Spilich, G., & Voss, J. (1979). Acquisition of domain-related information in relation to high and low domain knowledge. *Journal of Verbal Learning and Verbal Behavior*, *18*(3), 257–273.

Cooke, R., & Papadaki, A. (2014). Nutrition label use mediates the positive relationship between nutrition knowledge and attitudes towards healthy eating with dietary quality among university students in the UK. *Appetite*, *83*, 297–303.

Coulson, N. S. (2000). An application of the stages of change model to consumer use of food labels. *British Food Journal*, *102*(9), 661–668. doi:10.1108/00070700010362031.

Dean, M., Lähteenmäki, L., & Shepherd, R. (2011). Nutrition communication. Consumer perceptions and predicting intentions. *Proceedings of the Nutrition Society*, *70*(01), 19–25. doi:10.1017/S0029665110003964.

Dickson-Spillmann, M., & Siegrist, M. (2011). Consumers' knowledge of healthy diets and its correlation with dietary behaviour. *Journal of Human Nutrition and Dietetics*, *24*(1), 54–60. doi:10.1111/j.1365-277X.2010.01124.x.

Drichoutis, A. C., Lazaridis, P., & Nayga, R. M. (2005). Nutrition knowledge and consumer use of nutritional food labels. *European Review of Agricultural Economics*, *32*(1), 93–118. doi:10.1093/erae/jbi003.

Drichoutis, A. C., Lazaridis, P., Nayga, R., Kapsokefalou, M., & Chryssochoidis, G. (2008). A theoretical and empirical investigation of nutritional label use. *The European Journal of Health Economics*, *9*(3), 293–304. doi:10.1007/s10198-007-0077-y.

Drichoutis, A. C., Nayga, J. R. M., & Lazaridis, P. (2009). Can nutritional label use influence body weight outcomes? *Kyklos*, *62*(4), 500–525. doi:10.1111/j.1467-6435.2009.00448.x.

Elbon, S. M., Johnson, M. A., & Fischer, J. G. (1996). Developing an instrument to measure the influence of knowledge, behaviors, and attitudes on milk consumption patterns in older participants of a community wellness group. *Journal of Nutrition for the Elderly*, *15*(4), 21–37. doi:10.1300/J052v15n04_03.

Elbon, S. M., Johnson, M. A., Fischer, J. G., & Searcy, C. A. (2000). Demographic factors, nutrition knowledge, and health-seeking behaviors influence nutrition label reading behaviors among older American adults. *Journal of Nutrition for the Elderly*, *19*, 31–48.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, *102*(2), 211–245.

Feigenbaum, E. A. (1989). What hath simon wrought? In D. Klahr & K. Kotovsky (Eds.), *Complex information processing: The impact of herbert a. Simon* (pp. 165–182). Hillsdale, NJ: Erlbaum.

Fitzgerald, N., Damio, G., Segura-Pérez, S., & Pérez-Escamilla, R. (2008). Nutrition knowledge, food label use, and food intake patterns among Latinas with and without type 2 diabetes. *Journal of the American Dietetic Association*, *108*(6), 960–967. doi:10.1016/j.jada.2008.03.016.

Food and Drug Administration. (2014). Food Labeling, Food. Designation of ingredients. 21 C.F.R. § 101.4.

Garretson, J. A., & Burton, S. (2000). Effects of nutrition facts panel values, nutrition claims, and health claims on consumer attitudes, perceptions of disease-related risks, and trust. *Journal of Public Policy & Marketing*, *19*(2), 213–227.

Glanz, K., Basil, M., Maibach, E., Goldberg, J., & Snyder, D. A. N. (1998). Why Americans eat what they do. Taste, nutrition, cost, convenience, and weight control concerns as influences on food consumption. *Journal of the American Dietetic Association*, *98*(10), 1118–1126.

Graham, D. J., & Jeffery, R. W. (2011). Location, location, location. Eye-tracking evidence that consumers preferentially view prominently positioned nutrition information. *Journal of the American Dietetic Association*, *111*(11), 1704–1711. doi:10.1016/j.jada.2011.08.005.

Grimes, C. A., Riddell, L. J., & Nowson, C. A. (2009). Consumer knowledge and attitudes to salt intake and labelled salt information. [Article]. *Appetite*, *53*(2), 189–194. doi:10.1016/j.appet.2009.06.007.

Grunert, K., & Wills, J. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health*, *15*(5), 385–399. doi:10.1007/s10389-007-0101-9.

Grunert, K. G., Wills, J. M., & Fernández-Celemín, L. (2010). Nutrition knowledge, and use and understanding of nutrition information on food labels among consumers in the uk. *Appetite*, *55*(2), 177–189. doi:10.1016/j.appet.2010.05.045.

Hasler, C. M. (2008). Health claims in the United States. An aid to the public or a source of confusion? *The Journal of Nutrition*, *138*(6), 1216S–20S.

Hawley, K. L., Roberto, C. A., Bragg, M. A., Liu, P. J., Schwartz, M. B., & Brownell, K. D. (2013). The science on front-of-package food labels. *Public Health Nutrition*, *16*(03), 430–439. doi:10.1017/S1368980012000754.

Hersey, J. C., Wohlgenant, K. C., Arsenault, J. E., Kosa, K. M., & Muth, M. K. (2013). Effects of front-of-package and shelf nutrition labeling systems on consumers. *Nutrition Reviews*, *71*(1), 1–14. doi:10.1111/nure.12000.

Hess, R., Visschers, V. H. M., & Siegrist, M. (2012). The role of health-related, motivational and sociodemographic aspects in predicting food label use. A comprehensive study. *Public Health Nutrition*, *15*(3), 407–414.

Hieke, S., & Taylor, C. R. (2012). A critical review of the literature on nutritional labeling. *Journal of Consumer Affairs*, *46*(1), 120–156. doi:10.1111/j.1745-6606.2011.01219.x.

Howlett, E., Burton, S., & Kozup, J. (2008). How modification of the nutrition facts panel influences consumers at risk for heart disease. The case of trans fat. [Article]. *Journal of Public Policy & Marketing*, *27*, 83–97.

Ippolito, P. M., & Mathios, A. D. (1991). Health claims in food marketing. Evidence on knowledge and behavior in the cereal market. *Journal of Public Policy & Marketing*, *10*(1), 15–32.

Jacobs, S. A., deBeer, H., & Larney, M. (2011). Adult consumers' understanding and use of information on food labels. A study among consumers living in the Potchefstroom and Klerksdorp regions, South Africa. *Public Health Nutrition*, *14*(3), 510–522.

Jacoby, J., Speller, D. E., & Berning, C. K. (1974). Brand choice behavior as a function of information load. Replication and extension. *Journal of Consumer Research*, *1*(1), 33–42. doi:10.2307/2488952.

Jasti, S., & Kovacs, S. (2010). Use of trans fat information on food labels and its determinants in a multiethnic college student population. *Journal of Nutrition Education and Behavior*, *42*(5), 307–314. http://dx.doi.org/10.1016/j.jneb.2009.06.004.

Jones, G., & Richardson, M. (2007). An objective examination of consumer perception of nutrition information based on healthiness ratings and eye movements. *Public Health Nutrition*, *10*(03), 238–244. doi:10.1017/S1368980007258513.

Klohe-Lehman, D. M., Freeland-Graves, J., Anderson, E. R., McDowell, T., Clarke, K. K., Hanss-Nuss, H., et al. (2006). Nutrition knowledge is associated with greater weight loss in obese and overweight low-income mothers. *Journal of the American Dietetic Association*, *106*(1), 65–75.

Labiner-Wolfe, J., Jordan Lin, C.-T., & Verrill, L. (2010). Effect of low-carbohydrate claims on consumer perceptions about food products' healthfulness and helpfulness for weight management. *Journal of Nutrition Education and Behavior*, *42*(5), 315–320. http://dx.doi.org/10.1016/j.jneb.2009.08.002.

Lähteenmäki, L. (2013). Claiming health in food products. *Food Quality and Preference*, *27*(2), 196–201. http://dx.doi.org/10.1016/j.foodqual.2012.03.006.

Leathwood, P. D., Richardson, D. P., Sträter, P., Todd, P. M., & van Trijp, H. C. M. (2007). Consumer understanding of nutrition and health claims. Sources of evidence. *British Journal of Nutrition*, *98*(03), 474–484. doi:10.1017/S000711450778697X.

Legault, L., Brandt, M. B., McCabe, N., Adler, C., Brown, A.-M., & Brecher, S. (2004). 2000–2001 food label and package survey. An update on prevalence of nutrition labeling and claims on processed, packaged foods. *Journal of the American Dietetic Association*, *104*(6), 952–958.

Levy, A. S., & Fein, S. B. (1998). Consumers' ability to perform tasks using nutrition labels. *Journal of Nutrition Education and Behavior*, *30*(4), 210–217.

Li, F., Miniard, P. W., & Barone, M. J. (2000). The facilitating influence of consumer knowledge on the effectiveness of daily value reference information. *Journal of the Academy of Marketing Science*, *28*(3), 425–435. doi:10.1177/0092070300283009.

Lin, C.-T. J., Lee, J.-Y., & Yen, S. T. (2004). Do dietary intakes affect search for nutrient information on food labels? *Social Science & Medicine*, *59*(9), 1955–1967. http://dx.doi.org/10.1016/j.socscimed.2004.02.030.

Lin, C.-T. J., & Yen, S. T. (2010). Knowledge of dietary fats among US consumers. *Journal of the American Dietetic Association*, *110*(4), 613–618. doi:10.1016/j.jada.2009.12.020.

Liu, R., Hoefkens, C., & Verbeke, W. (2015). Chinese consumers' understanding and use of a food nutrition label and their determinants. *Food Quality and Preference*, *41*, 103–111. http://dx.doi.org/10.1016/j.foodqual.2014.11.007.

Mackey, M. A., & Metz, M. (2009). Ease of reading of mandatory information on Canadian food product labels. *International Journal of Consumer Studies*, *33*(4), 369–381. doi:10.1111/j.1470-6431.2009.00787.x.

Macon, J. F., Oakland, M. J., Jensen, H. H., & Kissack, P. A. (2004). Food label use by older Americans. Data from the continuing survey of food intakes by individuals and the diet and health knowledge survey 1994-96. *Journal of Nutrition for the Elderly*, *24*(1), 35–52.

Marietta, A. B., Welshimer, K. J., & Anderson, S. L. (1999). Knowledge, attitudes, and behaviors of college students regarding the 1990 nutrition labeling education act food labels. *Journal of the American Dietetic Association*, *99*(4), 445–449. doi:10.1016/s0002-8223(99)00108-x.

Mathios, A. D., & Ippolito, P. (1999). Health claims in food advertising and labeling disseminating nutrition information to consumers. In E. Frazao (Ed.), *America's eating habits. Changes and consequences* (Vol. AIB750, pp. 189–212). Agriculture Information Bulletin No. (AIB750).

McKinnon, L., Giskes, K., & Turrell, G. (2014). The contribution of three components of nutrition knowledge to socio-economic differences in food purchasing choices. *Public Health Nutrition*, *17*(08), 1814–1824. doi:10.1017/S1368980013002036.

Mhurchu, C. N., & Gorton, D. (2007). Nutrition labels and claims in New Zealand and Australia. A review of use and understanding. *Australian and New Zealand Journal of Public Health*, *31*(2), 105–112. doi:10.1111/j.1753-6405.2007.00026.x.

Miller, C. K., Probart, C. K., & Achterberg, C. L. (1997). Knowledge and misconceptions about the food label among women with non-insulin-dependent diabetes mellitus. *The Diabetes Educator*, *23*(4), 425–432. doi:10.1177/014572179702300407.

Miller, L. M. S. (2014). Quantitative information processing of nutrition facts panels. *British Food Journal*, *116*(7), 1205–1219. http://dx.doi.org/10.1108/BFJ-02-2013-0042.

Miller, L. M. S., & Cassady, D. L. (2012). Making healthy food choices using nutrition facts panels. The roles of knowledge, motivation, dietary modifications goals, and age. *Appetite*, *59*(1), 129–139.

Miller, L. M. S., Cassady, D. L., Applegate, E. A., Beckett, L. A., Wilson, M. D., Gibson, T. N., et al. (2015). Relationships among food label use, motivation, and dietary quality. *Nutrients*, *7*, 1068–1080. doi:10.3390/nu7021068.

Miller, L. M. S., Gibson, T. N., & Applegate, E. A. (2010). Predictors of nutrition information comprehension in adulthood. *Patient Education and Counseling*, *80*(1), 107–112.

Miller, L. M. S., Gibson, T. N., Applegate, E. A., & de Dios, J. (2011). Mechanisms underlying comprehension of health information in adulthood. The roles of prior knowledge and working memory capacity. *Journal of Health Psychology*, *16*(5), 794–806. doi:10.1177/1359105310392090.

Miller, L. M. S., Zirnstein, M., & Chan, P. K. (2013). Knowledge differentially supports memory for nutrition information in later life. *Journal of Health Psychology*, *18*(9), 1141–1152. doi:10.1177/1359105312459896.

Misra, R. (2007). Knowledge, attitudes, and label use among college students. *Journal of the American Dietetic Association*, *107*(12), 2130–2134. http://dx.doi.org/10.1016/j.jada.2007.09.001.

Moorman, C. (1996). A quasi experiment to assess the consumer and informational determinants of nutrition information processing activities. The case of the nutrition labeling and education act. *Journal of Public Policy & Marketing*, *15*(1), 28–44.

Nayga, R. M. (2000). Nutrition knowledge, gender, and food label use. *Journal of Consumer Affairs*, *34*(1), 97–112.

Nelson, D., Graham, D., & Harnack, L. (2014). An objective measure of nutrition facts panel usage and nutrient quality of food choice. *Journal of Nutrition Education and Behavior*, *46*(6), 589–594. http://dx.doi.org/10.1016/j.jneb.2014.04.296.

Norazlanshah, H., Muhammad, I., Hasmira, M., Mashita, M., Norfazilah, M., & Fazlyla Nadya, M. (2013). The use of nutrition label on food purchasing decision among university students in Kuantan, Malaysia. *Health and the Environment Journal*, *4*(4), 1–10.

Norazmir, M. N., Norazlanshah, H., Naqieyah, N., & Anuar, M. I. K. (2012). Understanding and use of food package nutrition label among educated young adults. *Pakistan Journal of Nutrition*, *11*(10), 934–940. doi:10.3923/pjn.2012.934.940.

Ollberding, N. J., Wolf, R. L., & Contento, I. (2010). Food label use and its relation to dietary intake among US adults. *Journal of the American Dietetic Association*, *110*(8), 1233–1237. doi:10.1016/j.jada.2010.05.007.

Olson, J., & Sim, L. (1980). Assessing nutrition knowledge from an information processing perspective. *Journal of Nutrition Education*, *12*(3), 157–161.

Orquin, J. L. (2014). A Brunswik lens model of consumer health judgments of packaged foods. *Journal of Consumer Behaviour*, *13*(4), 270–281.

Palmer, R. F., Graham, J. W., Taylor, B., & Tatterson, J. (2002). Construct validity in health behavior research. Interpreting latent variable models involving self-report and objective measures. *Journal of Behavioral Medicine*, *25*(6), 525–550. http://dx.doi.org/10.1023/A:1020689316518.

Parmenter, K., & Wardle, J. (1999). Development of a nutrition knowledge questionnaire. *European Journal of Clinical Nutrition*, *53*, 298–308.

Pérez-Escamilla, R., & Haldeman, L. (2002). Food label use modifies association of income with dietary quality. *The Journal of Nutrition*, *132*(4), 768–772.

Petrovici, D., Fearne, A., Nayga, R. M., & Drolias, D. (2012). Nutritional knowledge, nutritional labels, and health claims on food a study of supermarket shoppers in the south east of England. *British Food Journal*, *114*(6–7), 768–783. doi:10.1108/00070701211234318.

Petrovici, D., & Ritson, C. (2006). Factors influencing consumer dietary health preventative behaviours. *BMC Public Health*, *6*(1), 222.

Pletzke, V., Henry, B. W., Ozier, A. D., & Umoren, J. (2010). The effect of nutrition education on knowledge, attitude, and behavior relating to trans fatty acids in foods. *Family and Consumer Sciences Research Journal*, *39*(2), 173–183. doi:10.1111/j.1552-3934.2010.02055.x.

Post, R. E., Mainous, A. G., Diaz, V. A., Matheson, E. M., & Everett, C. J. (2010). Use of the nutrition facts label in chronic disease management. Results from the national health and nutrition examination survey. *Journal of the American Dietetic Association*, *110*(4), 628–632.

Rasberry, C. N., Chaney, B. H., Housman, J. M., Misra, R., & Miller, P. J. (2007). Determinants of nutrition label use among college students. *American Journal of Health Education*, *38*(2), 76.

Salthouse, T. (2003). Interrelations of aging, knowledge, and cognitive performance. In U. M. Staudinger & U. Lindenberger (Eds.), *Understanding human development. Dialogues with lifespan psychology* (pp. 265–287). Dordrecht, Netherlands: Kluwer.

Satia, J. A., Galanko, J. A., & Neuhouser, M. L. (2005). Food nutrition label use is associated with demographic, behavioral, and psychosocial factors and dietary intake among African Americans in North Carolina. *Journal of the American Dietetic Association*, *105*(3), 392–402.

Sheard, C. (1984). How effective is our advice to diabetics? A preliminary evaluation. *Human Nutr Appl Nutr*, *38*, 138–141.

Spronk, I., Kullen, C., Burdon, C., & O'Connor, H. (2014). Relationship between nutrition knowledge and dietary intake. *British Journal of Nutrition*, *111*(10), 1713–1726. doi:10.1017/S0007114514000087.

Suter, T. A., & Burton, S. (1996). An examination of correlates and effects associated with a concise measure of consumers' nutrition knowledge. *Family and Consumer Sciences Research Journal*, *25*(2), 117–136. doi:10.1177/1077727x960252002.

Szykman, L. R., Bloom, P. N., & Levy, A. S. (1997). A proposed model of the use of package claims and nutrition labels. *Journal of Public Policy & Marketing*, *16*(2), 228–241.

Verbeke, W., Scholderer, J., & Lähteenmäki, L. (2009). Consumer appeal of nutrition and health claims in three existing product concepts. *Appetite*, *52*(3), 684–692. doi:10.1016/j.appet.2009.03.007.

Vyth, E. L., Steenhuis, I. H., Brandt, H. E., Roodenburg, A. J., Brug, J., & Seidell, J. C. (2012). Methodological quality of front-of-pack labeling studies. A review plus identification of research challenges. *Nutrition Reviews*, *70*(12), 709–720. doi:10.1111/j.1753-4887.2012.00535.x.

Walters, A., & Long, M. (2012). The effect of food label cues on perceptions of quality and purchase intentions among high-involvement consumers with varying levels of nutrition knowledge. *Journal of Nutrition Education and Behavior*, *44*(4), 350–354. http://dx.doi.org/10.1016/j.jneb.2011.08.008.

Wardle, J., Parmenter, K., & Waller, J. (2000). Nutrition knowledge and food intake. *Appetite*, *34*(3), 269–275.

Williams, P. (2005). Consumer understanding and use of health claims for foods. *Nutrition Reviews*, *63*(7), 256–264. doi:10.1111/j.1753-4887.2005.tb00382.x.

Wills, J. M., Storcksdieck genannt Bonsmann, S., Kolka, M., & Grunert, K. G. (2012). European consumers and health claims. Attitudes, understanding and purchasing behaviour. *Proceedings of the Nutrition Society*, *71*(2), 229–236.

Wills, J., Schmidt, D., Pillo-Blocka, F., & Cairns, G. (2009). Exploring global consumer attitudes toward nutrition information on food labels. *Nutrition Reviews*, *67*(s1), S102–S106.

Worsley, A. (2002). Nutrition knowledge and food consumption. Can nutrition knowledge change food behaviour? *Asia Pacific Journal of Clinical Nutrition*, *11*(s3), S579–S585.