From Exposure to Action:
Enhancing the Effectiveness of Front-of-Pack Nutrition Labels

Eva-Maria Schruff-Lim

Propositions

1. Front-of-pack nutrition labels are necessary, yet insufficient.
   (this thesis)

2. The effect of front-of-pack nutrition labels varies throughout the shopping trip.
   (this thesis)

3. The use of ChatGPT would save the Academic Board time when assessing propositions.

4. Facilitating students' mobility between applied and research universities is required for equal access to scientific opportunities.

5. Regular exchange of memes enhances workplace connections.

6. Regular desk rotations work only if they are voluntary.

Propositions belonging to the thesis, entitled

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Eva-Maria Schruff-Lim
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Thesis

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Chapter 1

General introduction

Background

Obesity and nutrition-related noncommunicable diseases continue to grow dramatically and pose a major public health crisis worldwide (Ng et al., 2014; World Health Organization, 2021). While several factors can contribute to obesity and nutrition-related noncommunicable diseases, such as genetic predisposition, health conditions, and medicine use, unhealthy eating habits are a major modifiable cause (Popkin, Adair, & Ng, 2012; World Health Organization, 2021). In the past decades, environmental and societal changes have changed what and how humans eat and drink around the world (Popkin, Adair, & Ng, 2012). Due to a rise in labour market participation of secondary (mostly female) earners in the household, time spent on home preparation of food has declined (Griffith, Jin, & Lechene, 2022; Harnack, Jeffery, & Boutelle, 2000). Eating out-of-home has become more common, but has been shown to be associated with higher energy and fat intake and lower micronutrient intake (Gesteiro et al., 2022; Harnack, Jeffery, & Boutelle, 2000; Lachat et al., 2012). In addition, people started to rely more on processed convenience foods instead of cooking from scratch (Griffith, Jin, & Lechene, 2022). Data from a representative sample of US adults showed that ultra-processed foods contribute to 55% of dietary calories on average (Zhang et al., 2021). While industrial food processing has played an important role in the provision of a safe and secure food supply, many industrially processed foods have relatively poor nutritional quality and relatively high energy density (Forde & Decker, 2022). Consumption of ultra-processed foods has been shown to increase risk of cardiovascular events (Qu et al., 2024; Zhang et al., 2021). Sugar and fat are relatively inexpensive ingredients, making processed energy-dense foods cheaper (Herforth et al., 2020). Innate liking for foods high in sugar and fat can lead to compulsive consumptions of processed energy-dense foods (Gearhardt & Schulte, 2021). This results in a vicious cycle in which demand for cheap, processed energy-dense foods is met with an increased supply in the market (i.e. lock-in effect; van Rijnsoever, van Lente, & van Trijp, 2011).

The modern food distribution system has replaced the direct link between producers and consumers with a complex network of food system actors. As a result it has become harder for consumers to judge the origin, content, and quality of foods (Fernqvist & Ekelund, 2014). Perceived quality judgments are based on intrinsic and extrinsic quality cues and experience and credence quality attributes (Steenkamp, 1990). Quality cues are concrete product characteristics, while quality attributes are more abstract benefit-generating product aspects

(Ophuis & van Trijp, 1995). Intrinsic quality cues are part of the physical product, such as colour and appearance, whereas extrinsic quality cues are only related to the product, such as price or brand. While quality cues can be observed before a choice is made, experience quality attributes can only be determined after consumption (e.g. taste). Credence quality attributes, such as healthfulness and sustainability of a food, are uncertain and unverifiable for consumers. Hence, for unfamiliar products only quality cues can be processed and evaluated at the point of choice (Steenkamp, 1990).

However, consumers may still use quality cues to form beliefs about experience and credence quality attributes through either inferential belief formation or the informational belief formation process (Fishbein & Ajzen, 1975). In the inferential belief formation process consumers utilize quality cues to draw inferences. The inferences are made based on existing associations or prior knowledge about the perceived relationship between a quality cue and a quality attribute. For example, a prevailing association is that darker-coloured bread is deemed nutritionally superior. Consumers hence infer the nutritional quality of bread (credence quality attribute) from the colour of the bread (intrinsic quality cue). Individuals may further integrate multiple quality cues to form a complete inferential belief of a single quality attribute. For example, consumers may not only use the colour of the bread, but also the packaging design (e.g. imagery, colour) to infer the nutritional quality of bread. At the same time, a single quality cue can inform beliefs about multiple quality attributes. The colour of the bread, for instance, may not only shape perceptions about the nutritional quality of bread, but also the tastiness (Fishbein & Ajzen, 1975). While consumers may utilize quality cues to draw inferences about both experience and credence quality attributes, the key difference lies in the verification of the inference. Consumers can verify their inferences about experience quality attributes through consumption and learn from their experiences. In contrast, inferences about credence quality attributes cannot be verified even after purchase and consumption (Fishbein & Ajzen, 1975).

In the informational belief formation process consumers form beliefs through processing and accepting direct information that is provided by authoritative sources. For instance, the explicit communication of a product's nutritional quality via nutrition labels serves as a primary example of this process. This direct form of information allows consumers to make informed decisions without the need for inference from indirect cues, relying instead on the information provided by manufacturers or regulatory bodies. As such, informational belief formation represents a critical pathway through which consumers acquire knowledge about products, guiding their choices and perceptions based on direct information that is provided by others. Since information about credence quality attributes cannot be verified, trust in the source and the message plays a major role in whether the information is accepted (Fishbein & Ajzen, 1975).

It has been suggested that inferential belief formation is less important for credence quality attributes as consumers have less opportunity to learn about the relationship between cues and quality attributes based on their experience. However, as seen from the example above, consumers engage in inferential belief formation when informational cues are not available, not attended to, or not understood (Steenkamp, 1990). Hence, provision of nutrition information is an important tool to provide transparency about the nutritional content of a food and to reduce information asymmetry between product manufacturers and consumers (van Trijp, 2009; Verbeke, 2005).

Short history of nutrition labelling

Food labelling evolved across the 20th and into the early 21st centuries as a response to the rise of the processed food industry and growing public health concerns. Initially, in the early 1900s, efforts in food labelling were rudimentary, primarily focusing on combating adulteration and ensuring the purity of products. These early attempts at regulation featured basic measures such as listing ingredients, stating the net weight, and providing manufacturer information to foster transparency and consumer trust. In the early 1970s, the landscape of food labelling started to focus on nutrition. This change was driven by accumulating scientific evidence that highlighted the link between diet and chronic diseases, coupled with an increasing demand from consumers for nutrition information. Food labelling established the right of consumers to know the content and composition of food products. The Nutrition Labeling and Education Act of 1990 in the United States was the first to mandate the standardized provision of nutrition information in the form of the Nutrition Facts Panels (NFP) on most packaged foods. The NFP is commonly provided on the back of food packages and includes detailed information on serving sizes, the amounts of specific nutrients, and the percentage of these nutrients relative to their recommended daily values (Wartella, Lichtenstein, & Boon, 2010). In the European Union, Regulation (EU) No 1169/2011 (European Union, 2011) requires the mandatory provision of NFPs on most pre-packaged foods since 2016 (Storcksdieck genannt Bonsmann et al., 2020).

Albeit an important step towards ensuring transparency, consumers have difficulties understanding the NFP (Campos, Doxey, & Hammond, 2011; Cowburn & Stockley, 2005). As a result, simpler front-of-pack (FOP) nutrition labels have gained increasing popularity in research, marketing, and public policy (Kanter, Vanderlee, & Vandevijvere, 2018). The World Health Organization, the European Commission, and the US administration have identified the introduction of FOP nutrition labels as a priority policy issue (European Commission, 2020b; Kelly & Jewell, 2018; The White House, 2022). FOP nutrition labels provide nutrition information in the principal field of vision on food and drinks packages rather than on the back of food packages (Storcksdieck genannt Bonsmann et al., 2020). Existing FOP nutrition label designs vary significantly in their approach to conveying nutrition information. The designs range in their level of information aggregation from highlighting specific nutritional content to summary interpretative designs, which combine the nutritional content into an overall healthfulness indicator of the product. Nutrient-specific designs can be subdivided into reductive designs that describe the information of the NFP in a reduced version and evaluative designs which offer interpretation of the nutrition information (e.g. in the form of colour) (Ikonen et al., 2020). Some FOP nutrition labels are only applied to foods fulfilling a certain criterion (e.g. warning labels or positive endorsement labels) while graded label designs show the whole range of levels (Storcksdieck genannt Bonsmann et al., 2020).

The European Union's Farm to Fork strategy initially committed to the adoption of a harmonized FOP labelling system by the end of 2022 (European Commission, 2020a), but the proposal is currently delayed with no clear timeline for its implementation (European Parliament, 2024). One FOP nutrition label that has become increasingly popular across several European countries, is the Nutri-Score (Storcksdieck genannt Bonsmann et al., 2020). The Nutri-Score is a summary interpretative FOP nutrition label that assigns foods into one of five categories from A (denoting most healthy, also indicated by a green colour) to E (denoting least healthy, also indicated by a red colour). The classification is based on an absolute score that is calculated by considering both positive nutrients, such as protein and fibre, and negative nutrients, such as salt and sugar (Julia & Hercberg, 2017). As a result, negative nutrients can be cancelled out with positive nutrients. Following criticism from nutritionists and physicians, the algorithm was updated in 2023 to better align with food-based dietary guidelines (FBDGs) across countries engaged in the system (Merz et al., 2024).

Many FOP nutrition labels do not repeat the information provided in the NFP but rather provide additional voluntary nutrition information (e.g. by providing an overall healthfulness indicator) and hence fulfil the criteria of a claim (Storcksdieck genannt Bonsmann et al., 2020). Under EU regulation, a claim is defined as “any message or representation, which is not mandatory under EU or national legislation, including pictorial, graphic or symbolic representation in any form that states, suggests or implies that a food has particular characteristics” (European Union, 2016, Key Terms section). A distinction is made between nutrition claims and health claims. Nutrition claims refer to the nutritional content of a food that meets a specific amount criterion (i.e. content claim; “high in fibre”) or compare the nutritional content of a range of foods within the same food category (i.e. comparative claim; “30% less fat”). Nutrition claims can refer to the presence or absence of nutritional content (e.g. “high in fibre” versus “no added sugars”). Health claims suggest a cause-and-effect relationship between a food and health effects and have been scientifically evaluated. Health claims consists of function claims, risk reduction claims, and claims related to the development of children (e.g. “This food is a good source of calcium. Adequate intake of calcium may reduce the risk of osteoporosis.”) (European Commission, n.d.-a). Many popular FOP nutrition labels in the EU, such as the Nutri-Score, are legally classified as a nutrition claim. Health claims do not fall under the definition of FOP nutrition labelling (Storcksdieck genannt Bonsmann et al., 2020) and are consequently excluded from the scope of the current thesis.

Towards a multifaceted policy program

The goals of nutrition labelling are usually two-fold: 1) to encourage informed healthy choices by consumers and 2) to motivate healthier product reformulation by manufacturers (Kanter, Vanderlee, & Vandevijvere, 2018). The focus in this thesis is on the first policy goal, contributing to the understanding of consumer reactions to FOP nutrition labels. The exposure to validated nutrition information provides individuals with the opportunity to process the information. Such transparent information is a necessary but not sufficient requirement for consumers to make informed healthy choices. To make informed healthy choices, consumers need to 1) understand the information correctly and 2) act upon the knowledge to make healthier choices at moment of purchase (Grunert, Wills, & Fernández-Celemín, 2010; Hornik, 1989; Storcksdieck genannt Bonsmann et al., 2020).

Previous reviews have warned that FOP nutrition labels achieve their goal to improve awareness and understanding of nutrition information, but are less impactful in stimulating healthier choices (e.g. Cadario & Chandon, 2020b; Ikonen et al., 2020). Food choices are difficult to change because they are complex behaviours, driven by a multitude of individual and environmental factors. Rothschild (1999) proposes a comprehensive framework that allows to categorize the large and diverse number of potential determinants of healthy food choices into three primary categories: motivation, ability, and opportunity. Motivation refers to the consumer's perceived self-interest in initiating a behaviour. Abilities encompass the specific resources needed to convert this motivation into actual behaviour, while opportunity relates to the degree to which the environment either supports or hinders this behaviour (van Trijp, Brug, & Van der Maas, 2005).

Rothschild (1999) suggest to link the intervention strategies to the barriers of the behaviour. Michie et al. (2011, p. 1) define behaviour change interventions as "coordinated sets of activities designed to change specified behaviour patterns". The intervention ladder by Nuffield (2007) categorizes interventions based on their level of intrusiveness. Less intrusive interventions, such as providing nutrition information, place the responsibility on the individual and require sustained adherence to be effective. Since these interventions are easy and cheap to ignore, they require individuals to be motivated to engage in the suggested behaviour. More intrusive interventions, such as restricting or eliminating choices, change the environment and may be required when individuals are unmotivated to engage in the suggested behaviour (Capewell & Capewell, 2018; Reisch, Eberle, & Lorek, 2013). Since more intrusive interventions interfere stronger in people's lives, they require a stronger justification (Nuffield, 2007). Research has shown that public acceptance of an intervention is strongest for the least intrusive interventions, which are often the least effective (Diepeveen et al., 2013).

It has been criticised that a multifaceted policy program is required to achieve informed healthier choices rather than relying on a single intervention (Capewell & Capewell, 2018; Lee et al., 2017; Rutter et al., 2017; van Kleef & Dagevos, 2015). While providing nutrition information is important for providing transparency about the content and composition of food products, it may not be enough for large-scale behaviour change. Nutrition information may need to be combined with complementary interventions to ensure that information is turned into action. Evidence about which interventions can support FOP nutrition labels for behavioural change is scattered. More research is required to understand the barriers of FOP nutrition label use and how supporting interventions could address these barriers.

From laboratory experiments to field experiments

Most studies on the influence of FOP nutrition labels on food choices have been confined to (online) laboratory experiments that rely on hypothetical scenarios (Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020). Laboratory experiments are important, especially in the infancy of a new intervention, to provide a proof of principle. The highly controlled environment makes it possible to control for confounding variables, to randomise subjects to conditions, and to precisely measure the outcome variable which provides high confidence in the cause and effect relationships. However, the highly controlled environment also limits the generalizability of the findings, as the studies may not accurately capture consumer behaviour under real-world shopping conditions. Proof-of-concept and proof-of-implementation studies that increase external validity are needed (van Kleef & van Trijp, 2018).

Food shopping is a low involvement process and can therefore become habitual. Individuals with habitual shopping patterns often do not notice subtle changes in the environment (Verplanken & Wood, 2006; Wood & Rünger, 2016), such as the introduction of a FOP nutrition label. Motivation is required to search for and process nutrition information (Bialkova & van Trijp, 2011; Grunert, Wills, & Fernández-Celemín, 2010; Van Loo et al., 2015). Conscious processing of information demands more cognitive effort compared to the more automatic inferential belief formation (Evans & Stanovich, 2013). Time constraints, fatigue, hunger, and high number of alternatives in real-world supermarkets may reduce consumers' ability and motivation to process and interpret the information (Storcksdieck genannt Bonsmann et al., 2020). Informational belief formation is more likely for relatively unfamiliar products without well-learned memory representations, and for products with which the consumer is more involved (Steenkamp, 1990). Previous research has shown that consumers overreport looking for nutrition information, with only 27% objectively attending to nutrition information (Grunert, Wills, & Fernández-Celemín, 2010).

Another issue is that FOP nutrition labels must compete with a range of other factors influencing choice, such as price and brand loyalty, in real-world settings. Competing food choice motives play a stronger role when food choices have actual consequences compared to hypothetical scenarios. Since food choice motives with more immediate consequences are often valued more, food choice motives with less immediate consequences often face a disadvantage. Even though healthfulness is generally important to individuals based on a high level of abstraction (i.e. relevance), it is often not decisive in the concrete choice (i.e. determinance) (Myers and Alpert, 1977, van Dam and van Trijp, 2013, van Ittersum et al., 2007). Food choice motives that have more immediate consequences (i.e. lower psychological distance), such as flavour and price, receive more importance in actual food choices than food choice motives with more distant consequences (i.e. higher psychological distance), such as healthfulness (Fagerstrøm et al., 2019, Glanz et al., 1998).

In addition, consumers may use nutrition labels to make inferences about other quality attributes such as taste. Research has shown that consumers associate lower nutritional quality with tastiness (i.e. unhealthy=tasty intuition) (Bialkova, Sasse, & Fenko, 2016; Raghunathan, Naylor, & Hoyer, 2006). Thus, testing FOP labels in real-world environments is critical to accurately assess their impact on actual consumer behaviour and public health outcomes. More field experiments are needed to provide a clearer understanding of how these labels function in everyday shopping contexts.

One size does not fit all

Consumers differ by age, education, income, health status, and many other attributes that influence their behaviour. Hence the same intervention cannot be expected to have the same effect across different types of consumers. Social marketing underscores the necessity of understanding the barriers individuals face in behaviour change to tailor interventions for maximum effectiveness (Grier & Bryant, 2005). The European Commission specified that nutrition labelling should "support all consumers, in particular those from lower socio-economic groups" (European Commission, 2020b, p. 16). This is especially important since health inequalities between individuals with lower and higher socio-economic status (SES) have persisted through time (Phelan, Link, & Tehranifar, 2010). Yet much research on nutrition labelling is conducted among higher-educated individuals (Storcksdieck genannt Bonsmann et al., 2020). Individuals with lower SES face different barriers than individuals with higher SES. For example, individuals with lower levels of education may encounter challenges in comprehending FOP nutrition label information (Ducrot et al., 2015; Feng & Fox, 2018), while those with lower income levels might not be able to afford healthier food options (Appelhans et al., 2017; Phelan, Link, & Tehranifar, 2010). Despite these insights, supermarket field studies that compare the effect of FOP nutrition labels on actual purchasing across different levels of SES are so far lacking (Roberto et al., 2021; Shrestha et al., 2023). Real-world studies can provide insights into how different demographic groups respond to FOP nutrition labels, which is essential for tailoring public health interventions to maximize their effectiveness across diverse populations. As a result, research needs to be done on a large and varied sample.

Motivating consumers' willingness to make healthier choices

Based on the current evidence, the effect of FOP nutrition labels on food choice may be small on its own (e.g. Cadario & Chandon, 2020b; Ikonen et al., 2020). Research has shown that health-motivated consumers are searching for and using nutrition information, whereas less motivated consumers require additional interventions (Van Loo et al., 2015; Visschers et al., 2013). Salience of health motivation can be influenced by external factors, enhancing an individual's focus on health-related behaviours. One method is health goal priming, where specific cues in the environment serve as reminders of health goals, thereby influencing information processing and behaviour (Papies, 2016). For instance, seeing a poster that primes a health and dieting goal increases attention to and choice of healthier foods (van der Laan et al., 2016). Another approach is construal level priming, which involves activating a more abstract mindset. Higher construal level influences individuals to shift their focus towards the long-term benefits and higher goals associated with a behaviour (Trope & Liberman, 2003). For example, high construal level reduces consumption of high energy dense snacks (Price, Higgs, & Lee, 2016).

More research is required on how to activate health goals so that consumers are willing to use FOP nutrition labels to identify and buy healthier products (Storcksdieck genannt Bonsmann et al., 2020). One suggestion are public education campaigns that support the introduction of nutrition labels (Nohlen et al., 2022; Roberto et al., 2021). Furthermore, new digital interventions are emerging as a result of increased use of digital technology during food shopping (e.g. online supermarkets, handheld barcode scanners, mobile phones). It is now possible to adapt interventions just-in-time to specific consumer actions, such as unhealthy choices (van der Laan & Orcholska, 2022). One example are food swap recommendations that automatically suggest healthier alternatives whenever an unhealthy choice is made. Individuals are required to make a deliberate choice to keep their originally chosen (unhealthy) option or to replace it with a recommended (healthier) alternative

(Forwood et al., 2015; Jansen, van Kleef, & Van Loo, 2021). This makes it more difficult for consumer to ignore FOP nutrition information. More research is required on how supporting interventions interact with FOP nutrition labels (Storcksdieck genannt Bonsmann et al., 2020).

Thesis overview

To better understand how FOP nutrition labels influence food choices, the present dissertation aims to answer the following research questions:

1. *What barriers prevent consumers from using FOP nutrition labels in making healthier food choices, and which complementary interventions can address these barriers?*
2. *How do FOP nutrition labels influence supermarket sales in real-life?*
3. *Do different consumer groups in society benefit equally from FOP nutrition labels?*
4. *To what extent do complementary interventions enhance the effect of FOP nutrition labels?*

These research questions will be addressed in the **chapters 2-5**. Figure 1.1 presents a proposed theoretical framework, outlining the effect of nutrition labels on healthy food choice and illustrating the relationship among the chapters.

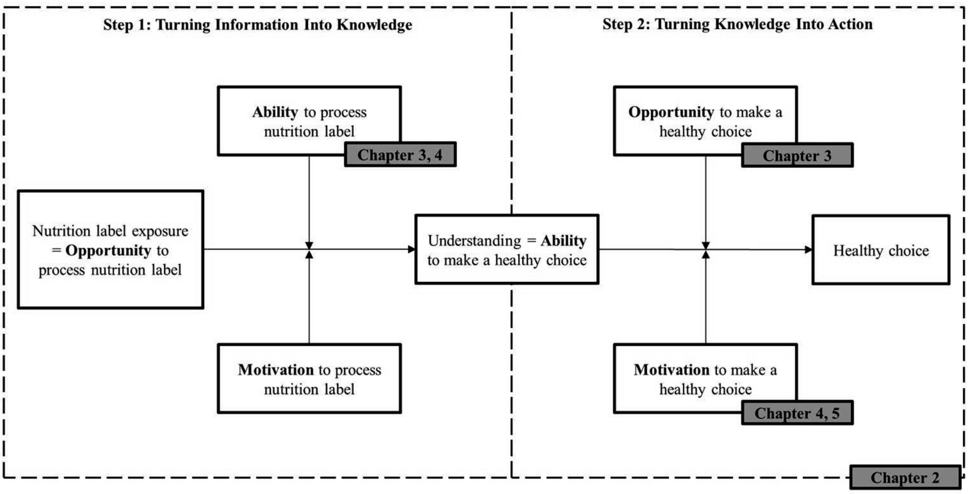

Figure 1.1. Theoretical framework and overview of the thesis.

Chapter 2 provides a theoretical framework on barriers of FOP nutrition label use and how supporting interventions could address these barriers (**RQ 1**, Figure 1.1). A systematic literature search was used to identify existing research on multicomponent nutrition label interventions (*label+ interventions*) and to categorize complementary interventions within the theoretical framework. The evidence of their effectiveness in changing dietary choices was synthesized in a narrative form.

Chapters 3 and 4 examine how FOP nutrition labels affect supermarket sales, thereby providing valuable insights into their effectiveness in a real-world context, bridging the gap between stated and revealed preferences (**RQ 2**). Specifically, **Chapter 3** assesses the effect of introducing a FOP fibre label system in the bread category of a Dutch discounter supermarket. It further explores how the SES of the area in which the store is located influences the effect of FOP fibre labels, shedding light on the role of SES in moderating the effectiveness of FOP nutrition labels (**RQ 3**).

Chapter 4 extends the findings of Chapter 3 by using a different label system (Nutri-Score) and different product category (dairy) (**RQ 2**). The chapter further investigates how educational signage can support FOP nutrition labels in improving the dietary quality of supermarket sales (**RQ 4**). Educational signage with varying messages about the Nutri-Score label were added in stores (n = 100). The neutral signage showcased the Nutri-Score and visually explained that A indicates most healthy and E indicates least healthy. The transparency signage additionally included a message highlighting the ease of identifying the product's healthfulness ("Clear at a glance: more and less healthy products"), while the motivating signage additionally included a call to action ("Couldn't be easier. Choose also healthier with Nutri-Score"). The combined signage included all of the information of the other signage. The control stores did not receive any signage.

Chapter 5 examines how healthier food swap recommendations can support FOP nutrition labels. By providing interventions at different times in the customer journey, Chapter 5 provides insights into who does and does not act upon Nutri-Score labels (**RQ 3**) and assesses the effect of additional food swap recommendations compared to only providing Nutri-Score labels (**RQ 4**). Chapter 5 further examines how the similarity of the alternatives influences the acceptance of food swap recommendations, contributing to a deeper understanding of underlying factors that influence the acceptance of alternatives in food swap recommendations.

Chapter 6 provides a general discussion of the results of chapter 2-5 and highlights future research and policy implications.

2

Chapter 2

Turning FOP nutrition labels into action: A systematic review of label+ interventions

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Abstract

The effectiveness of nutrition labels in modifying dietary choices remains limited. Information provision alone is a necessary yet insufficient condition for behaviour change to occur. Individuals need to 1) turn information into knowledge and 2) turn knowledge into behaviour. This article provides a theoretical framework that suggests that complementary interventions may be needed to target barriers that prevent individuals from processing and acting upon FOP nutrition labels. Evidence about which interventions can support nutrition labels for behavioural change is scattered. This article addresses this research gap through a systematic review of multicomponent nutrition label interventions (*label+ interventions*) and their effects on the actual healthfulness of dietary choices. From the 3519 records identified, 85 label+ interventions were included. The findings provide limited evidence for the effectiveness of supporting nutrition labels with educational material or reference information. The evidence for supporting nutrition labels with interactive digital interventions, such as basket feedback, or financial incentives is promising. Overall, the findings indicate that more intrusive interventions are required to give cause to act on nutrition labels. Implications and future research avenues for the various label+ categories are discussed.

Introduction

Empowering consumers to make informed dietary choices has been an important strategy in reducing non-communicable diseases and obesity. However, the early attempts of providing nutrition information in the form of the nutrition facts panel on the back of products have been met with poor understanding by consumers (Campos, Doxey, & Hammond, 2011; Cowburn & Stockley, 2005). As a consequence, simpler FOP nutrition labels have gained increasing popularity in research, marketing, and public policy (Kanter, Vanderlee, & Vandevijvere, 2018) with the aim to improve the salience, understanding, and use of nutrition information (FDA, 2010). A variety of FOP nutrition labels (see Figure 2.1) have been developed which vary in their level of aggregation (nutrient-specific vs. summary indicators) and interpretation (reductive/descriptive vs. interpretative/evaluative) (Ikonen et al., 2020; Kanter, Vanderlee, & Vandevijvere, 2018). However, when making food choices, consumers' attention to and use of FOP nutrition labels is often low (Grunert, Wills, & Fernández-Celemín, 2010). As such, the effect of FOP nutrition labels on actual behaviour remains limited regardless of the design (e.g. Bauer & Reisch, 2019; Cadario & Chandon, 2020a; Ikonen et al., 2020; Perez-Cueto, 2019).

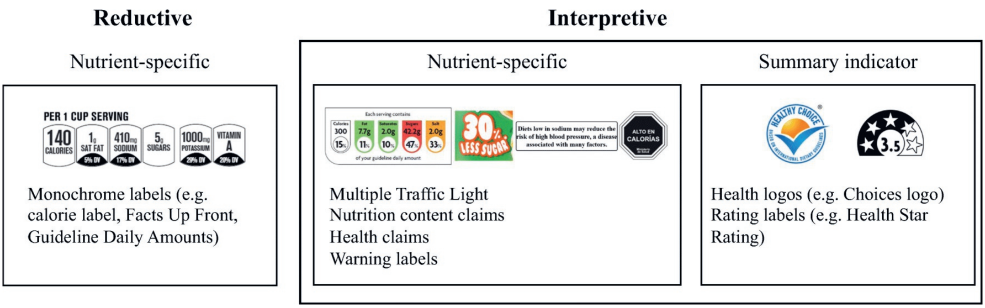

Figure 2.1. Typology and selective examples of FOP nutrition labels (Reproduced from Ikonen et al. (2020), used under the terms of the Creative Commons Attribution 4.0 license).

Complementary interventions may be needed to target barriers that prevent individuals from processing and acting upon FOP nutrition labels (hereafter called *label+ interventions*). The aim of the current study is to provide a theoretical framework on barriers of FOP nutrition label use and how supporting interventions could address these barriers. A systematic search was used to identify existing research on label+ interventions and the evidence of their effectiveness in changing dietary choices is synthesized in a narrative form. To the authors' knowledge, this is the first review to focus on nutrition label+ interventions. The review provides insights about which interventions most effectively support nutrition labels and identifies future research recommendations.

Theoretical background

The challenge of purposive communication consists of two steps, 1) to turn information into knowledge and 2) to turn knowledge into behaviour (Hornik, 1989). Individuals need to process nutrition information, understand it, and decide to act upon it in their decision (Grunert, Wills, & Fernández-Celemín, 2010). Processing and acting upon nutrition information in food choices, like any behaviours, are driven by an individual's motivation, opportunity, and ability (MOA) (MacInnis & Jaworski, 1989; Rothschild, 1999). The MOA framework has been used to describe, understand, and predict when information is being processed (Grunert, 2011; MacInnis & Jaworski, 1989) and when a behaviour is performed (Brug, 2008; Ölander & Thøgersen, 1995; Rothschild, 1999). In the current study these frameworks are integrated into an overall theoretical framework, explaining when and how nutrition information is turned into knowledge and ultimately into action (see Figure 2.2). We suggest that turning information into knowledge (step 1) achieves transparency of nutrition information. Following the definition by Michener and Bersch (2013), transparency is achieved when individuals are able to detect (i.e. visibility) and understand nutrition information (i.e. inferability). Converting knowledge into action (step 2) achieves actionability of the information, defined in this article as giving individuals cause for action.

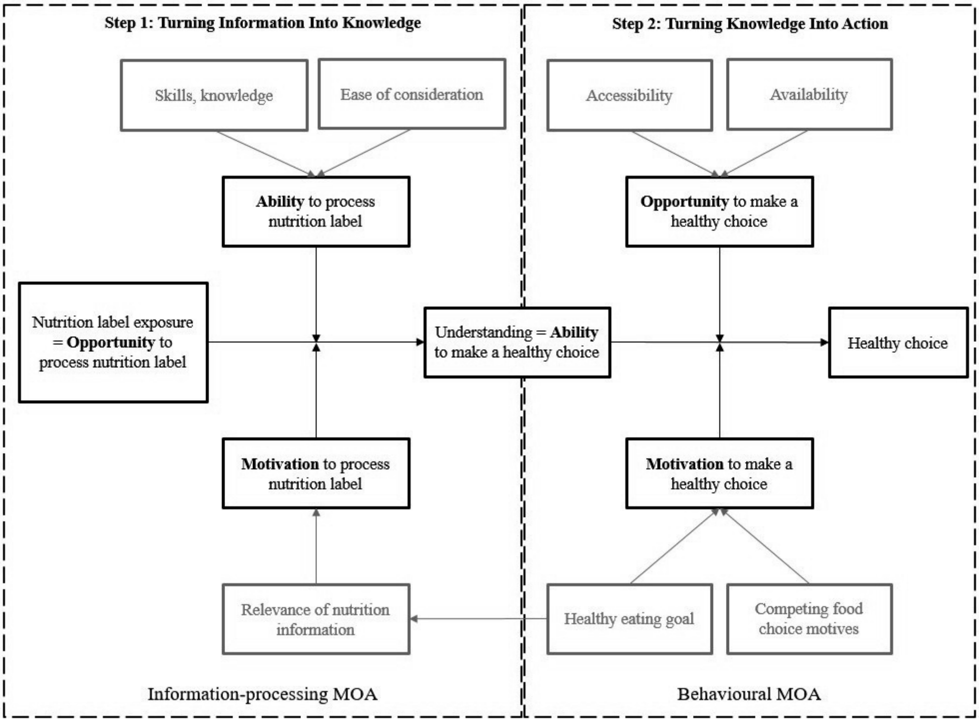

Figure 2.2. Theoretical framework guiding the review.

FOP nutrition labels provide individuals the opportunity to objectively process nutrition information (De Bauw et al., 2022; Grunert, Hieke, & Wills, 2014; Hung et al., 2017). As the nutritional content of a food product cannot be observed (i.e. credence quality attribute), nutrition information needs to be explicitly communicated to reduce information asymmetry between manufacturers and individuals (van Trijp, 2009; Verbeke, 2005). However, providing opportunity to process nutrition information is a necessary but not sufficient condition for FOP nutrition labels to be processed when making food choices. To process the information various processing operations need to be undertaken which require an increasing amount of processing capacity, starting from noticing the cue (feature analysis), recognizing it is a nutrition label (basic categorization), understanding the absolute healthfulness of the individual product (meaning analysis), understanding the relative healthfulness across a set of products (information integration), and ultimately relating the healthfulness information to prior knowledge and to the self (constructive processes and role-taking operations) (MacInnis & Jaworski, 1989). According to the elaboration-likelihood model (Petty & Cacioppo, 1986), the depth of information search and processing depends on the individual's ability and motivation. However, even if individuals understand the nutrition information (i.e. have the ability to make a healthy choice), they might not turn this knowledge into behaviour (knowledge-behaviour gap, Hornik 1989) because they lack motivation or opportunity to act upon the nutrition information (Rothschild, 1999).

Step 1: Turning information into knowledge

Barrier 1: Lack of ability to process nutrition information

Considering nutrition information requires individual's ability to search, process, and comprehend the information. The ability to process nutrition information can be constrained by personal and environmental barriers. The personal barrier and main aspect of ability relates to an individual's skills and knowledge to interpret the information (MacInnis, Moorman, & Jaworski, 1991). Prior research confirms that FOP nutrition labels are generally well understood and increase individuals' ability to rank products according to nutritional quality (e.g. Ikonen et al., 2020; Nohlen et al., 2022). However, individuals with lower educational level, income, self-reported nutritional knowledge, and higher age have more difficulties to understand FOP labels (Ducrot et al., 2015; Nohlen et al., 2022). Possible interventions that increase consumers' ability to use nutrition information by increasing the skills and knowledge to interpret the information could be providing education and trainings (Michie et al., 2011; Rothschild, 1999). Consumer education campaigns should support the introduction of FOP nutrition labels and could inform the public about FOP nutrition labels and how to correctly use them (Nohlen et al., 2022; Roberto et al., 2021).

The environmental barrier of ability to process nutrition information relates to the ease with which nutrition information can be considered in an information overloaded environment (Bauer & Reisch, 2019). Especially in supermarkets consumers are presented with a variety of competing information sources (e.g. regarding brand, flavour, price, nutrition information) across a large choice set which makes the choice process cognitively demanding (Ketron, Spears, & Dai, 2016). Rather than assessing all available information, as rational choice theory (Aleskerov, Bouyssou, & Monjardet, 2007) would suggest, consumers' limited time and cognitive capacities often lead to quick decisions without examining and weighting all information (Cohen & Babey, 2012; Schulte-Mecklenbeck et al., 2013; Simon, 1955). This highlights the need for supportive environments that facilitate using nutrition labels by reducing complexity of processing nutrition information during the shopping trip (De Bauw et al., 2022). Possible interventions that increase consumers ability to use nutrition information by making it easier to consider nutrition labels could be presentation alterations (e.g. benefit-based categorization, sorting, filtering).

Barrier 2: Lack of motivation to process nutrition information

Processing information requires a certain level of motivation and the lack of motivation presents a major barrier to the effectiveness of nutrition labels (Bialkova & van Trijp, 2011; Grunert, Wills, & Fernández-Celemín, 2010; Van Loo et al., 2015). In the current study, motivation to process is defined as the individuals' desire or readiness to process the nutrition information in the food choice (MacInnis, Moorman, & Jaworski, 1991). Motivation to process nutrition information is driven by an interest in healthy eating (Hung et al., 2017). Individuals engage in a behaviour when it serves their self-interest (Rothschild, 1999). As such increasing the personal relevance of the information (e.g. through personalization) could lead to higher motivation to process the information (De Bauw et al., 2022). Personalization has been shown to increase attention to the message and in turn to positively affect the attitude towards the message (Maslowska, Smit, & van den Putte, 2016). One example of personalizing the information is providing basket feedback during the shopping trip. Basket feedback integrates nutrition information of multiple food choices into an overall indicator which makes it easier for individuals to keep track of their basket healthfulness (De Bauw et al., 2022; Gustafson & Zeballos, 2019). Realizing that the food basket is becoming unhealthy might increase the relevance of nutrition information and in turn motivate individuals to search for nutrition labels to make healthier choices. Possible interventions that increase consumers motivation to process nutrition information by increasing the personal relevance of nutrition information in food choices could be highlighting consequences of unhealthy diets or using basket feedback.

Step 2: Turning knowledge into action

Barrier 3: Lack of motivation to make healthy choices

Acting upon nutrition information requires individual's motivation to make a healthy choice. Even though healthfulness is generally important to individuals based on a high level of abstraction (i.e. relevance), it is often not decisive in the concrete choice (i.e. determinance) (Myers & Alpert, 1977; van Dam & van Trijp, 2013; van Ittersum et al., 2007). Benefits that have more proximate consequences (i.e. lower psychological distance), such as flavor and price, receive more importance in actual food choices than benefits with more distant consequences (i.e. higher psychological distance), such as healthfulness (Fagerstrøm et al., 2019; Glanz et al., 1998). However, when a product characteristic does not differ among choice options, it does not play a role in the decision (van Ittersum et al., 2007). As such, one possibility to increase the likelihood that knowledge is turned into action is to align benefits that have more proximate consequences with the healthy choice. Possible interventions that increase consumers motivation to act upon nutrition information by decreasing the influence of competing food choice motives could be discounts on healthy items, surcharges on unhealthy items, or taste cues.

Individuals with stronger health motivation are more likely to act upon nutrition information in their food choice (Hess, Visschers, & Siegrist, 2012; van Herpen & van Trijp, 2011; Visschers, Hess, & Siegrist, 2010). Health motivation can be activated externally by goal reminders in the environment (i.e. goal priming) (Papies, 2016) or by priming a more abstract mindset, causing individuals to focus more on higher construal benefits (i.e. construal level priming) (Price, Higgs, & Lee, 2016). Basket feedback that signals that the food basket is becoming unhealthy might activate healthy eating goals to compensate previous unhealthy choices. Healthier food swap recommendations that automatically suggest alternative healthier products when an individual makes an unhealthy choice may shift individuals out of their routine food choices and remind individuals of their health goals (i.e. "stop and rethink"). Examples of these interactive digital interventions are provided in Figure 2.3. Possible interventions that increase consumers motivation to act upon nutrition information by activating healthy eating goals could be health goal priming, construal level priming, food swap recommendations, or social norms (i.e. "Increasingly people choose healthy foods").

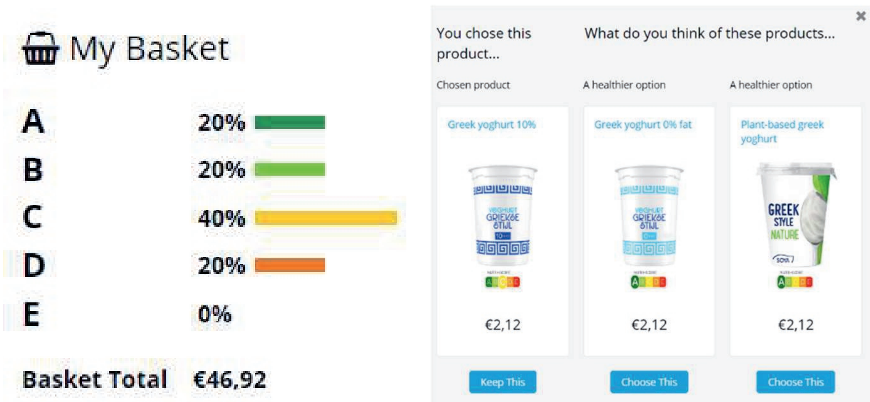

Figure 2.3. Examples of interactive digital interventions: basket feedback (left) and food swap recommendations (right).

Barrier 4: Lack of opportunity to make healthy choices

Acting upon nutrition information requires individual's opportunity to make a healthy choice. The opportunity to make healthy choices can be constrained by personal and environmental barriers. We define accessibility of healthy choices as the extent to which individuals have the required resources to make a healthy choice (e.g. money, time). The price of food is a major determinant in food choice (Fagerstrøm et al., 2019). Since energy-dense foods high in sugar and saturated fat cost less on a per-calorie basis than energy-dilute foods, the price of food presents both a real and perceived barrier to healthy diets, especially among low-income individuals (Drewnowski, 2004; Herforth et al., 2020). Individuals with lower income purchase foods with a lower per-calorie cost and as such purchase food higher in fat and lower in nutrients (Appelhans et al., 2012). In addition, unhealthy foods are heavily promoted (Coates et al., 2019; Qutteina et al., 2019; Story & French, 2004) and are more frequently discounted than healthier products (Ravensbergen et al., 2015). A possible intervention that increases consumers opportunity to act upon nutrition information by increasing accessibility is to reduce the price of healthier foods.

Availability of healthy choices refers to the extent to which the environment offers and facilitates healthy choices. Today's food environment is often referred to as an obesogenic environment (Swinburn, Egger, & Raza, 1999). Developments in the food industry have led to an increase in the supply of ultra-processed energy-dense (ED) foods (Zobel et al., 2016). As a result, the availability of unhealthy ultra-processed foods has dramatically increased and exceeds the availability of healthier less-processed foods in supermarkets (Luiten et al., 2016). Possible interventions that increase consumers opportunity to act upon nutrition information by increasing availability are to introduce new healthy foods, to increase the facings of healthier foods, or to reformulate existing unhealthier foods.

Removing barriers with supportive interventions

Targeting barriers of behaviours by means of interventions is a standard practice in intervention research (Michie et al., 2011; Rothschild, 1999). Since previous reviews (e.g. Bauer & Reisch, 2019; Cadario & Chandon, 2020a; Ikonen et al., 2020; Perez-Cueto, 2019) have pointed out that nutrition labels on their own have limited effectiveness to change dietary choices, complementary interventions may be needed to target barriers that prevent individuals from processing and acting upon nutrition labels. Multicomponent interventions have been suggested as a promising strategy to improve the healthfulness of consumers' choices as information provision alone seems not sufficient (Adam & Jensen, 2016; Kahn-Marshall & Gallant, 2012; Perez-Cueto, 2019). However, since a combination of interventions can have synergistic, additive, or even harmful effects, it is important to understand how intervention components interact (Capewell & Capewell, 2018; Mazza et al., 2018). So far little research has focused specifically on how complementary interventions can support nutrition labels and how these intervention components interact.

Previous reviews on nutrition labels have focused on assessing which label is most effective and as a result have identified which design characteristics are most promising. The use of interpretative summary labels that use colour, symbols, a range of all possible score, and are displayed on both healthy and unhealthy products have been suggested to be most promising (e.g. the Nutri-Score label) (e.g. Ikonen et al., 2020; Nohlen et al., 2022; Roberto et al., 2021). However, these reviews focused on the nutrition label itself and ignored how complementary interventions can increase the effectiveness of nutrition labels. Past reviews on nudging (Adam & Jensen, 2016; Cadario & Chandon, 2020a; Harbers et al., 2020; Liberato, Bailie, & Brimblecombe, 2014) included studies with label+ interventions but grouped these together with other multicomponent interventions that did not include nutrition labels (e.g. nudge + nudge). Thus, conclusions are limited to the effectiveness of multicomponent interventions in general, but not for label+ interventions specifically. As such, a review about label+ interventions that assesses how nutrition labels can be supported is lacking. To fill this research gap, this review will focus on multicomponent interventions that include a nutrition label and a complementary intervention component that supports the nutrition label (i.e. label+ interventions). In the following we refer to the term intervention as the whole (multicomponent) treatment a group receives and to intervention components as the individual parts a multicomponent intervention contains. Following this definition, label+ interventions are a specific type of multicomponent interventions that contain a nutrition label and a plus (i.e. complementary) intervention component.

Methods

In order to identify studies, a review protocol was developed and preregistered on Prospero (ID: ID: CRD42020183141). The guidelines of the preferred reporting items for systematic reviews and meta-analyses (PRISMA) were followed during the review process (Moher et al., 2009) (see Appendix 1).

Search strategy

The Boolean search query was developed using the PICOS framework and is reported in Table 1.1. Since the plus intervention components were not known a priori, the search terms for the intervention only referred to the label component to maximize the yield of the search. The search was conducted without date restrictions on both general databases (Web of Science, Scopus) and specific consumer behaviour and psychology databases (APA PsycInfo, APA PsycArticles, Psychology and Behavioral Sciences Collection, SocINDEX). The search query was restricted to the title, abstract, and article keywords. Alerts were established to identify new publications following the initial database search in April 2020 and were screened with the same criteria until July 2022.

Table 1.1. Search query for Web of Science

PICOS	Search terms
Population	None
Intervention	TOPIC: (label*)
Comparison	AND TOPIC: (intervention* OR condition*)
Outcome	AND TOPIC: (choice* OR choos* OR chos* OR decision* OR basket* OR sales OR sold OR spend* OR spent OR select* OR purchas* OR order* OR behav* OR prefer*)
Setting	AND TOPIC: (nutrition* OR health* OR obes* OR diet*) AND TOPIC: (food* OR snack* OR drink* OR beverage* OR meal*)

Selection of studies and inclusion criteria

The review was restricted to studies that satisfied the following inclusion criteria: a) were written in English, b) used an empirical study design (i.e. no reviews), c) included a nutrition label+ intervention, d) measured food and/or beverage choices or purchases directly (i.e. hypothetical choices or real purchases), and e) compared a nutrition label+ intervention to an eligible comparator (i.e. a control group, a label only, or a plus only group). We excluded studies that used dietary recall measures to reduce heterogeneity of the included studies and as dietary recall measures can be influenced by social desirability bias (Hebert et al., 1995). Eligible nutrition label+ interventions consisted of any nutrition label on the front-of-pack, shelf, or menu in combination with any behaviour change intervention component that is separate from the nutrition label component and supported the label. Thus, we excluded studies that included back-of-pack nutrition labels (i.e. Nutrition Facts Panel), compared different labels (e.g. calorie label vs. calorie label + exercise equivalent), or studies in which the plus component targeted only non-labelled products (e.g. calorie labels for soup but accessibility improvements for bread). Two changes to the preregistered inclusion criteria were made. In the process of the review it became clear that many studies combined nutrition labels with multiple plus components (e.g. label+ nudge + discount). Due to the large number of different combinations and their heterogeneity, it was impossible to provide clear conclusions of the findings for these studies. Thus, we decided to exclude interventions that combined nutrition labels with multiple plus components (n = 15). In addition, studies that used children or individuals with chronical diseases as participants were excluded in order to reduce heterogeneity of the included studies and provide more generalizable conclusions (n = 8).

After deleting the duplicates in Endnote the titles and abstracts of the remaining records were screened. For all potentially relevant records full-text articles were acquired and screened. All studies about nutrition labels were included for the full-text screening in order to avoid excluding any label+ interventions. The first author (ESL) was responsible for the screening procedure and the second author (EVL) screened a randomly selected subsample of the articles eligible for full text screening (n = 25, 13%). Disagreements or uncertainties were resolved through discussion within the review team. The Cohen's kappa was 0.80 which reflects substantial agreement (McHugh, 2012).

Quality assessment

The quality of the studies was assessed using the Quality Assessment Tool for Quantitative Studies developed for the Effective Public Health Practice Project (Thomas et al., 2004). This tool was used as it was established for public health interventions and can be used for a range of study designs. It assesses the risk of bias for six individual criteria: (A) selection bias, (B) study design, (C) confounders, (D) blinding, (E) data collection method, and (F) withdrawals and dropouts. Each of the six criteria is assigned a weak, moderate, or strong rating (see Table 1.2). In line with the recommendation by the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2022), we report the ratings for the individual criteria in Appendix 2 rather than the overall quality score which is difficult to interpret and does not provide guidance for future research. In addition, we further assessed whether studies were incentive-compatible, pre-registered, and provide open access to their data.

Table 1.2. Assessment criteria for the risk of bias in the individual studies

Risk of bias	Explanation	Coding
Selection Bias	How representative is the sample? What percentage of selected individuals agreed to participate (i.e. risk of self-selection)?	Strong: representative sample Moderate: customers of field study, non-representative panel sample Weak: convenience sample, university sample
Study Design	What is the likelihood of bias due to the allocation process in an experimental study?	Strong: RCT, CT Moderate: Pre-post with control Weak: Pre-post without control
Confounders	Were there important differences between groups prior to the intervention? If yes, were these differences controlled for (in the design or analysis)?	Strong: no baseline differences Moderate: matched control sites, baseline difference which are controlled for Weak: Unclear risk of confounders (e.g. maturation and history in pre-post designs without control group) Unclear: not reported
Blinding	To which extent does detection bias (i.e. non-blind assessors) and reporting bias (i.e. non-blind subjects) play a role?	Strong: blinded assessors and subjects (e.g. customers unaware of experiment and data is collected electronically) Moderate: one is not blinded (e.g. unclear whether participant are blinded, but data is collected electronically) Weak: both are not blinded Unclear: not reported
Data collection method	To which extent are the data collection methods valid and reliable?	Strong: electronic sales data, electronically recorded choices Moderate: manual recording of choices Weak: non-reliable and non-valid data collection Unclear: not reported
Withdrawal, Drop-outs	To which extent is the study affected by attrition bias?	Strong: attrition max 20% Moderate: attrition max 40% Weak: attrition more than 40% Unclear: not reported
Incentive-compatible	To which extent is the participant incentivized to make real choices?	Yes: choice has consequences (monetary or food) No: hypothetical choice
Pre-registered	Was the study pre-registered?	Yes: pre-registered protocol, published protocol No: none available
Open access data	Is open access to the data provided?	Yes: open access database, e.g. OSF No: data available upon request

Data extraction and synthesis

Data extraction was performed by the first author (ESL) using a standardized data extraction form. Data was extracted from each included study regarding the study context, study design, intervention characteristics, outcomes, and results. If studies contained multiple conditions, we included all conditions that represented a label+ intervention. The study design was coded as randomized control trial (RCT), controlled trial (CT), and pre-post design. The setting was coded as either (online) lab or field. Lab experiments are defined as those studies that are conducted in an artificial and controlled environment. In contrast, natural field experiments are conducted in the real-world setting where the subjects naturally undertake the task (Levitt

& List, 2007).[1] Field experiments were further differentiated in the specific environment the study took place (e.g. supermarkets, canteens). Following the Quality Assessment Tool for Quantitative Studies developed for the Effective Public Health Practice Project (Thomas et al., 2004), a randomized controlled trial (RCT) is defined as a design in which researchers randomly allocate participants to an intervention or control group. For an appropriate method of randomization, each participant needs to have the same chance of receiving each intervention and the researcher could not predict which intervention was next. A controlled trial is an experimental study design where the method of allocating study subjects to intervention or control groups is not random, but transparent before assignment and open to the researchers (e.g. allocation by alternation). In a pre-post design with control group the exposure to the intervention is not under the control of the investigators (i.e. allocation of stores decided by the retailer). The groups are assembled according to whether exposure to the intervention has occurred and as such might be nonequivalent or not comparable on some feature that affects the outcome. In a pre-post design without control group, the same group is pretested, given an intervention, and tested immediately after the intervention. The nutrition labels were classified as reductive nutrient-specific labels (e.g. numeric calorie labels), interpretative nutrient-specific labels (e.g. multiple traffic light), and interpretative summary labels (e.g. Nutri-Score). The plus intervention components were tabulated and classified according to the barriers in the theoretical framework (see Table 1.3).[2] Through discussion and testing examples and counter-examples we arrived at the final plus coding.

[1] Note that our dichotomous distinction does not depend on the subject pool (student vs. non-student samples) nor the framing (hypothetical vs. incentive-compatible choice). Hence, artefactual and framed field experiments are coded as lab experiments.

[2] Change from registered protocol: Initially it was planned to categorize label+ interventions according to the intervention typology of the behavior change wheel (Michie et al. 2011). However, it was decided to use a taxonomy that emerges from the included studies and to integrate it to the guiding theoretical framework instead of imposing an existing taxonomy ex-ante.

Table 1.3. Overview of plus intervention components in the included studies

Plus component	Barrier	MOA component	n
Reference information	Skills, knowledge	Ability to process nutrition labels	12
Education material	Skills, knowledge		24
Training to use labels	Skills, knowledge		1
Presentation order	Ease of consideration		5
Information about health risks	Relevance	Motivation to process nutrition labels	1
Basket feedback	Relevance	Motivation to process nutrition labels	13
	Health goals	Motivation to make a healthy choice	
Social norm message	Health goals	Motivation to make a healthy choice	1
Healthy eating prompts	Health goals		4
Food swap recommendation	Health goals		4
Financial incentive	Accessibility	Opportunity to make a healthy choice	19
	Competing food choice motives	Motivation to make a healthy choice	
Introduction of healthy foods	Availability	Opportunity to make a healthy choice	1

The data was synthesized using tabulation of main study characteristics and findings. For label+ categories with many observations (n > 5) findings were visualized in harvest plots. Since many studies reported multiple outcomes, we followed an outcome hierarchy to keep the tables and harvest plots comprehensible and to avoid overreporting some studies. If possible, we always used overall measures such as healthfulness scores or total calories of the whole basket. If this was not possible, we used the sales of healthy and unhealthy choices. If this was not reported either, we used specific nutrients (e.g. fat, sodium). If outcomes relating to both the whole basket and specific food groups (e.g. both total calories and snack and beverage calories) were reported, we always used the basket measures. If outcomes from multiple time points were reported, we always used the longest intervention duration. Some studies reported multiple outcomes that were independent (i.e. sales of green and red products). In these cases more than one outcome was included. Since we were interested in how label+ interventions compare to the individual components of the intervention, all reported pairwise comparisons of the label+ intervention to a control, label only, and plus only condition were included.

Harvest plots allow to visualize the distribution of the evidence from a diverse set of studies. Studies are grouped in a matrix according to the significance and direction of the intervention effect (i.e. column). Similar to Chan, McMahon, and Brimblecombe (2021), findings were rated as benefit (i.e. beneficial effects as intended), promising (i.e. potentially beneficial effects with change in power, dose, exposure, or analysis), mixed (beneficial effects for some outcomes, while no effect or negative effect for other outcomes), no effect, or harm (i.e. harmful effects in opposite direction as intended). Different pairwise comparisons are reported in separate rows (i.e. control, label only, or plus only). Not only the evidence, but also the study characteristics can be visualized in harvest plots (Ogilvie et al., 2008). The height of each bar represents the study design (i.e. higher bars represent RCTs and CTs) and the width of the bar visualizes the intervention duration (i.e. wider bars represent longer durations). The letter above the bar indicates the setting of the study (e.g. restaurant) while the number below the bar refers to the study ID in Appendix 2. The colour of the bar illustrates the outcome measure used (i.e. overall nutritional quality, healthy, or unhealthy choices).

Results

The study selection process is displayed in the PRISMA flowchart (see Figure 2.4). The database search produced 3519 records. After 1341 duplicates were removed, the title and abstract of 2178 records were screened. 192 reports were eligible for full-text screening. 35 reports met the inclusion criteria and were included in the review along with 19 additional reports that were identified from the search alerts after the database search in April 2020 until July 2022, resulting in a total of 54 reports included in the review. The reports describe 85 label+ interventions in 62 studies. An overview of the included label+ interventions and their findings is provided in Appendix 2.

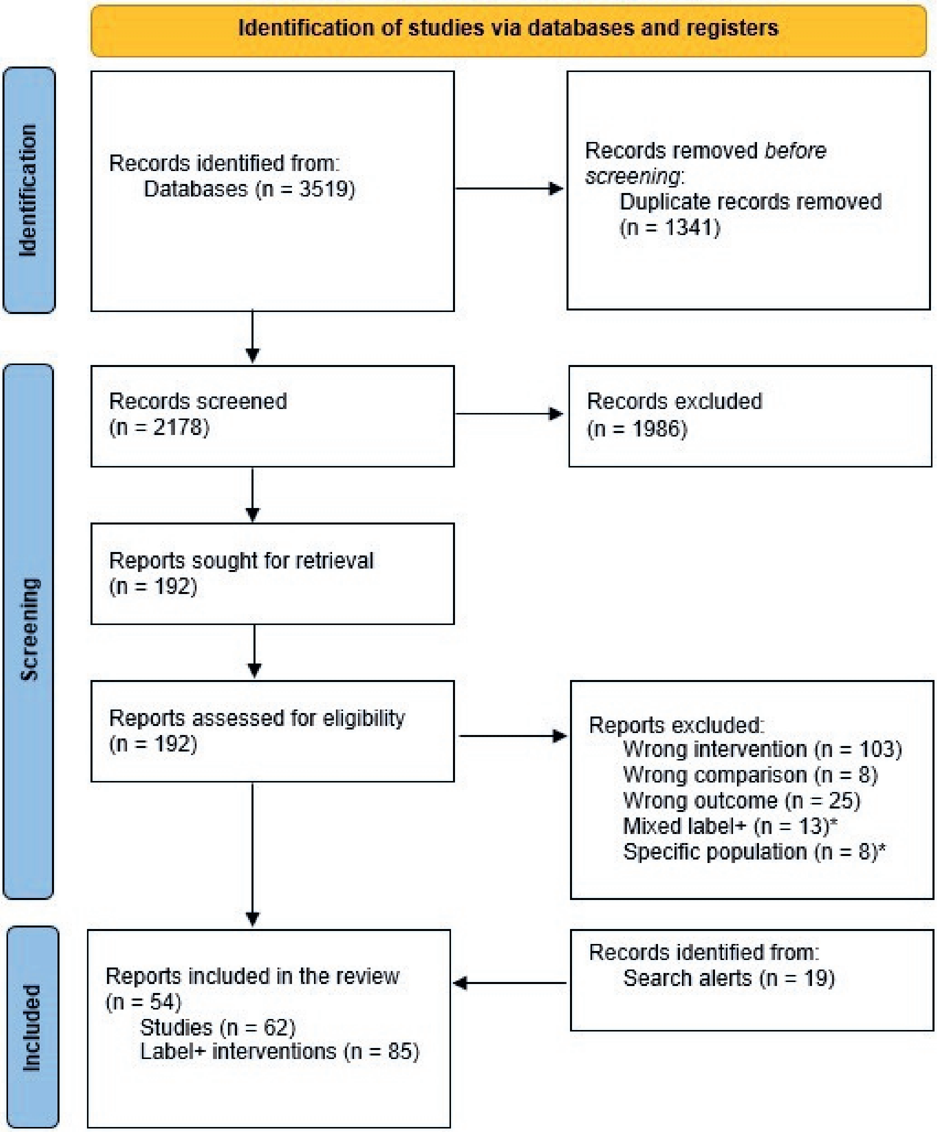

Figure 2.4. PRISMA flow diagram.
Note: * Change from preregistered protocol.

Characteristics of included studies (n = 62)

The review includes both lab (n = 33) and field studies (n = 29). The setting of the field studies ranges from canteens (n = 12), (online) supermarkets and small food stores (n = 10), restaurants (n = 5), to vending machines (n = 2). The included studies are evenly distributed between randomized controlled trials (n = 21), controlled trials (n = 23), before-after designs with control group (n = 8), and before-after designs without control group (n = 10). The majority of included studies (n = 55) was published after 2010 and took place in the United States (n = 33). Only three studies compared the effectiveness of a label+ intervention across different levels of SES (Acton, Kirkpatrick, & Hammond, 2021; Marty, Jones, & Robinson, 2020; Thorndike et al., 2014). The quality assessment indicates that the most common risk of bias relates to selection bias from using convenience sampling methods or a university sample (n = 18), followed by risk of confounding (n = 11) and study design (n = 10). Especially pre-post designs without control group should be treated with caution as these studies cannot account for effects that might arise due to time (e.g. maturation and history). All field studies (n = 29), yet only nine lab studies (n = 9 / 33) were incentive-compatible. As such, the majority of lab studies measured hypothetical choices. Twelve studies were pre-registered (n = 12) and only three studies provide open access to the data (n = 3).

Characteristics of included label+ interventions (n = 85)

Types of nutrition labels

Our dataset suggests that most label+ interventions include a reductive nutrient-specific label (n = 32), specifically numeric calorie labels (n = 25). This can be explained by the high number of US based studies included in the review and the strong research interest in calorie labels following the 2010 Affordable Care Act which mandated menu labels in US food chain establishments (FDA, 2014). The other label+ interventions include an interpretative summary (n = 33) and interpretative nutrient-specific labels (n = 20).

Types of plus intervention components

The majority of label+ interventions combined nutrition labels with further information (n = 24 educational material about the nutrition labels, n = 12 reference information about the recommended daily calorie intake), followed by financial incentives based on the nutrition information (n = 19), and real-time feedback on the basket healthfulness (n = 13).

Effectiveness of label+ interventions

Label+ Reference information

The review included 12 interventions that supported nutrition labels with reference information about the nutrition labels (e.g. daily calorie intake reference statement) (Downs, Wisdom, & Loewenstein, 2015; Finkelstein et al., 2021; Harnack et al., 2008; Liu et al., 2012; Marty, Jones, & Robinson, 2020; Oh, Huh, & Mukhopadhyay, 2020; Oliveira et al., 2020; Pang & Hammond, 2013; Roberto et al., 2010). The harvest plot in Figure 2.5 visualizes the evidence from the label+ reference information interventions for all outcomes and pairwise comparisons (n = 20 bars). All the evidence in this subcategory stems from lab experiments that measure decisions at a single time point (n = 20 / 20). Most studies use reductive nutrient-specific labels (predominantly numeric calorie labels) (n = 18 / 20). Effects were most often measured using overall nutritional outcomes (i.e. the calorie content of the choices, n = 16 / 20) and compared to control (n = 12 / 20).

Compared to a control condition (n = 12), label+ reference information interventions predominantly do not show an effect (n = 9 / 12), while 3 studies report beneficial or promising findings (n = 3 / 12). Compared to a label only condition (n = 7), all the evidence indicates no additional benefit of providing reference information to nutrition labels. Compared to a plus only condition (n = 1), the evidence indicates no additional benefit of providing nutrition labels to reference information.

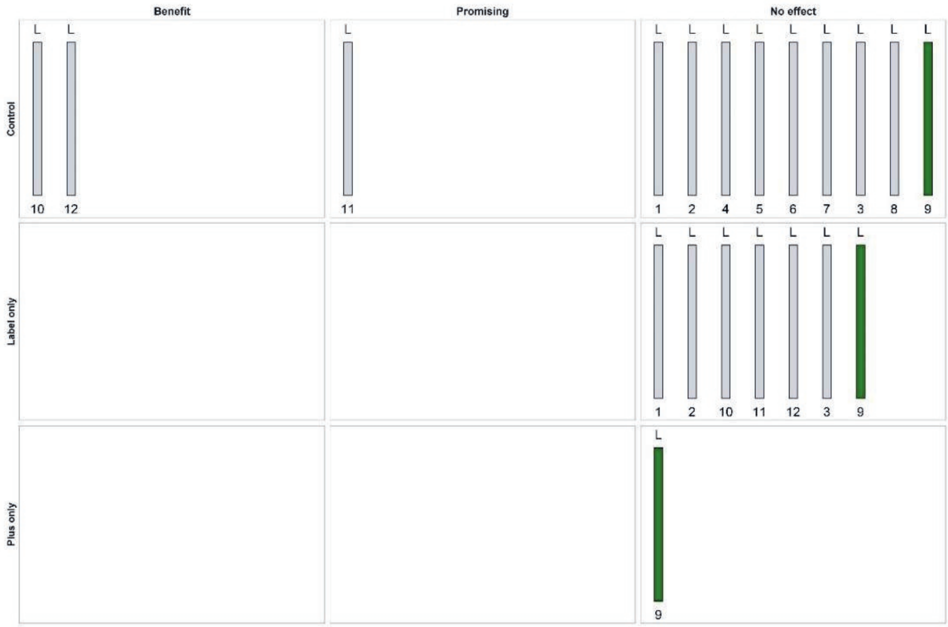

Figure 2.5. Harvest plot for label+ reference information interventions for each pairwise comparison.
Figure key: The colour of the bar represents the outcome type (green = healthy, red = unhealthy, grey = overall nutritional quality); the bar length indicates the study design (RCT+CT = high, pre-post = low); the bar width indicates the intervention duration (the wider, the longer); the letter above the bars describes the setting (L = lab; C = canteen; R= restaurant; S = supermarket and convenience store; V = vending machine); the number below the bar refers to the study ID.

Label+ Education material

The review included 24 interventions that supported nutrition labels with educational material about the nutrition labels (e.g. flyers, signage) (Albright, Flora, & Fortmann, 1990; Dingman et al., 2015; Dubois et al., 2021; Freedman & Connors, 2010; Hobin et al., 2017; Hoenink et al., 2021; Julia et al., 2021; Julia et al., 2016; Marty et al., 2020; Montagni et al., 2020; Mora-Garcia, Tobar, & Young, 2019; Olstad et al., 2015; Osman & Thornton, 2019; Rodgers et al., 1994; Roy & Alassadi, 2021; Sacks et al., 2011; Sproul, Canter, & Schmidt, 2003; Sutherland, Kaley, & Fischer, 2010; Thorndike et al., 2014; Thorndike et al., 2012; Vyth et al., 2011). The harvest plot in Figure 2.6 visualizes the evidence from the label+ educational material interventions for all outcomes and pairwise comparisons (n = 27 bars)[3]. The majority of the evidence in this subcategory stems from field studies (n = 22 / 27) and relates to the introduction of an interpretative summary labels (e.g. Nutri-Score) (n = 21 / 27). Effects were most often measured using overall nutritional outcomes (n = 16 / 27), medium durations (1 < month(s) ≤ 6, n = 11 / 27), and compared to control (n = 25 / 27).

Compared to a control condition (n = 25), the evidence of the effectiveness of label educational material interventions is mixed and remains inconclusive. The evidence is rated as benefit (n = 11 / 25), promising (n = 3 / 25), mixed (n = 3 / 25), and no effect (n = 8 / 25). All the included studies that report beneficial or promising findings used an interpretative summary label. 71% (n = 12 / 17) of the studies with an interpretative summary label report beneficial or promising findings. The effectiveness of studies varies based on the outcome measure used. Improvements are sometimes restricted to specific product categories (Dubois et al., 2021; Julia et al., 2016; Rodgers et al., 1994; Vyth et al., 2011). Some studies suggest that the label+ information intervention had stronger effects in categories with greater variability in nutritional content (Dubois et al., 2021; Hobin et al., 2017) and in categories that are perceived as more healthy (Hobin et al., 2017). Some studies report that the intervention only increased the purchasing likelihood of healthier products without reducing the purchasing likelihood of less healthy products, resulting in no changes in the overall healthfulness of the basket (Dubois et al., 2021; Mora-Garcia, Tobar, & Young, 2019). Whereas other studies report that sales of healthier products increased and sales of less healthy products decreased (Olstad et al., 2015; Sutherland, Kaley, & Fischer, 2010; Thorndike et al., 2012). Some studies observe that the number of products purchased per

[3] Some studies report multiple outcome measures and pairwise comparisons.

transaction and the price per product increases (Hobin et al., 2017; Julia et al., 2016) while others find no change in the number of products and total costs of the basket (Marty et al., 2020; Osman & Thornton, 2019; Sacks et al., 2011). Overall, this highlights that the measured effects of label+ education material are small and not robust.

Two studies examine the additional benefit of providing educational material to nutrition labels. In the study by Julia et al. (2016) label+ educational material only marginally improved the healthfulness of the overall choices, but significantly improved the healthfulness of choices in the sweet biscuits category. In the study by Mora-Garcia, Tobar, and Young (2019) label+ educational material did not affect the calorie content of purchases, but significantly increased the likelihood of healthy choices. Even though the effect on behaviour is modest, both studies demonstrate that combining nutrition labels with educational materials can improve important mediating outcomes, such as awareness (Julia et al., 2016; Mora-Garcia, Tobar, & Young, 2019) and understanding of nutrition labels compared to only providing nutrition labels (Julia et al., 2016). However, these effects may be lower in information overloaded settings such as supermarkets and when not all products are labeled. Hobin et al. (2017) reported that less than 10% of survey respondents were aware of nutrition labels in a supermarket study that showed a Guiding Stars label on 48% of the products. In contrast, awareness of nutrition labels was between 39-85% among participants in canteens, restaurants, and vending machines (Albright, Flora, & Fortmann, 1990; Dingman et al., 2015; Mora-Garcia, Tobar, & Young, 2019; Olstad et al., 2015; Roy & Alassadi, 2021; Sproul, Canter, & Schmidt, 2003).

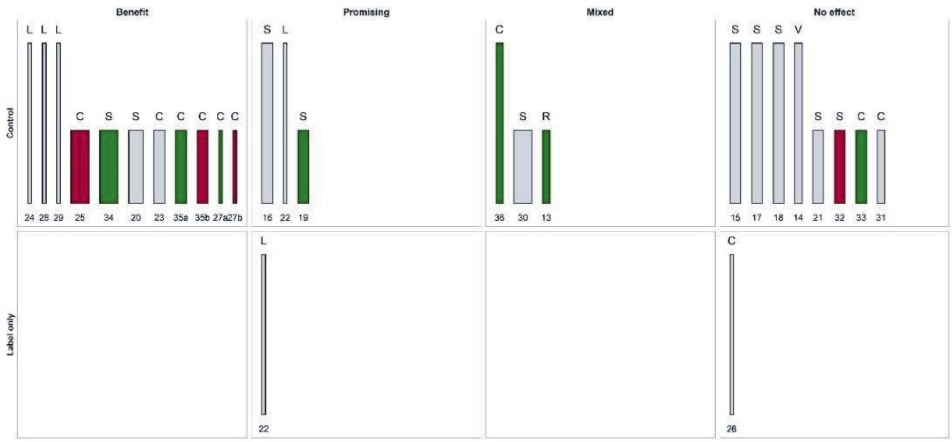

Figure 2.6. Harvest plot for label+ educational material interventions for each pairwise comparison.

Figure key: The colour of the bar represents the outcome type (green = healthy, red = unhealthy, grey = overall nutritional quality); the bar length indicates the study design (RCT+CT = high, pre-post = low); the bar width indicates the intervention duration (the wider, the longer); the letter above the bars describes the setting (L = lab; C = canteen; R= restaurant; S = supermarket and convenience store; V = vending machine); the number below the bar refers to the study ID.

Label+ Training

Only one study included a label+ training intervention. Specifically, Adams et al. (2014) trained participants how to convert abstract numeric sugar content labels into more concrete images of sugar cubes. The label+ training treatment significantly reduced the likelihood of selecting sugar-sweetened beverages (SSBs) compared to the label only treatment.

Label+ Presentation order

Of the five studies changing the product placement in addition to nutrition labels, four studies sorted products according to their healthfulness to facilitate the use of the label (Allan, Johnston, & Campbell, 2015; Downs, Wisdom, & Loewenstein, 2015; Grandi, Burt, & Cardinali, 2021; Shah et al., 2016) and one study grouped healthier products together in a separate promotional shelf (Närhinen, Nissinen, & Puska, 2000). Providing nutrition labels and grouping healthier products in a separate promotional shelf did not increase the sales of promoted products (Närhinen, Nissinen, & Puska, 2000). However, a short intervention duration was used that might have been unable to capture any changes. Sorting products according to their healthfulness resulted in significant improvements in the measured outcomes in three studies (Allan, Johnston, & Campbell, 2015; Downs, Wisdom, & Loewenstein, 2015; Grandi, Burt, & Cardinali, 2021) and no changes in one study (Shah et al., 2016). However, in the study by Allan, Johnston, and Campbell (2015) and Grandi, Burt, and Cardinali (2021) the improvements were limited to specific product categories. Downs, Wisdom, and Loewenstein (2015) report that when nutrition labels are present, both systematic orderings (i.e. from low to high vs. from high to low calories) led to a reduction in calories compared to a random order. However, when nutrition labels were absent, individuals selected earlier listed products (i.e. convenience effect), resulting in lower calorie choices in ascending assortments and higher calorie choices in descending assortments.

Label+ Information about health risks

Only one study (Adams et al., 2014) combined nutrition labels with information of health risks. (Adams et al., 2014) supported numeric sugar content labels with information about health risks from sugar consumption. The label+ health risk treatment did not have a significant effect on the selection of SSBs compared to the label only treatment.

Label+ Basket feedback

The review included 13 interventions that supported nutrition labels with basket feedback (De Bauw et al., 2022; Gustafson & Zeballos, 2019; Shin et al., 2022; VanEpps et al., 2021). Basket feedback summarizes the healthfulness of the items in the basket into an overall score and thus eases interpretation of the overall healthfulness of the basket. The harvest plot in Figure 2.7 visualizes the evidence from the label+ basket feedback interventions for all outcomes and pairwise comparisons (n = 15 bars). All the evidence in this subcategory stems from lab experiments that measure one-time decisions using overall nutritional outcomes (n = 15 / 15). Most studies used reductive nutrient-specific labels (predominantly numeric calorie labels) (n = 13 / 15) and compared the effects to a label only condition (n = 11 / 15).

Compared to a control condition (n = 4), label+ basket feedback interventions predominantly are effective (n = 3 / 4), while one study by De Bauw et al. (2022) does not find a significant improvement in the basket healthfulness. However, in this study participants first made their choices (with or without nutrition labels) and only afterwards received the label+ basket feedback intervention in the overview screen of their baskets at checkout. The subset of participants that received nutrition labels (without additional interventions) during their initial choices had significantly healthier baskets than participants that did not receive nutrition labels, but basket feedback did not lead to additional improvements in the basket healthfulness (De Bauw et al., 2022). Compared to a label only condition (n = 11), the majority of evidence (n = 8 / 11) indicates additional benefit of providing basket feedback to nutrition labels.

The studies provide promising evidence that combining nutrition labels with real-time basket feedback can significantly reduce total calories ordered (Gustafson & Zeballos, 2019; VanEpps et al., 2021) and improve the basket healthfulness (Shin et al., 2022). Participants initially make similar choices but significant differences in total calorie ordered are caused by differences in calories from later choices (Gustafson & Zeballos, 2019). When baskets become relatively unhealthy, participants with basket feedback revised high-calorie orders more frequently and chose fewer and less high-calorie items (VanEpps et al., 2021). Participants without basket feedback significantly underestimated the calories of their order

(Gustafson & Zeballos, 2019). Even though different formats of basket feedback were successful in reducing total calories ordered, the most effective format was an intuitive traffic-light basket feedback (VanEpps et al., 2021). More evidence is required from studies with higher external validity (e.g. field studies or using incentive-compatible designs) and longer intervention durations.

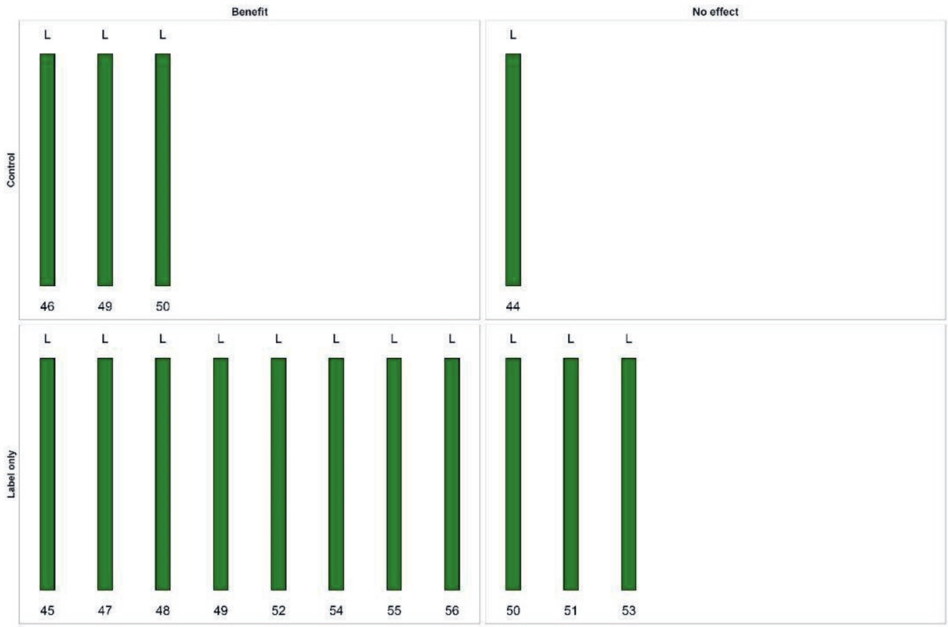

Figure 2.7. Harvest plot for label+ basket feedback interventions for each pairwise comparison.
Figure key: The colour of the bar represents the outcome type (green = healthy, red = unhealthy, grey = overall nutritional quality); the bar length indicates the study design (RCT+CT = high, pre-post = low); the bar width indicates the intervention duration (the wider, the longer); the letter above the bars describes the setting (L = lab; C = canteen; R= restaurant; S = supermarket and convenience store; V = vending machine); the number below the bar refers to the study ID.

Label+ Social norm message

Only one study (Jansen, van Kleef, & Van Loo, 2021) supported nutrition labels with information about health eating social norms ("Dutch consumers more often choose healthy products."). Nutrition labels had a main effect on the nutritional quality of the shopping basket, while the main effect of social norms and their interaction was not significant.

Label+ Healthy eating prompts

Four studies (Bergen & Yeh, 2006; Lee-Kwan et al., 2015; Levin, 1996; Scourboutakos et al., 2017) supported nutrition labels with healthy eating prompts. Bergen and Yeh (2006) randomly assigned eight vending machines in a college to either control, label only, or label+

motivational posters that encouraged the purchase of water and diet sodas. The growth rate of SSBs was significantly lower in the label+ motivational poster vending machines compared to the control vending machines. However, baseline sales were much lower in control vending machines (58 SSBs sold per week, SD = 16.97) compared to label+ vending machines (153.67 SSBs sold per week, SD = 58.74). No effect was found for water or diet sodas. Lee-Kwan et al. (2015) supported the introduction of menu nutrition labels with menu revisions that promoted the healthier menu items, but did not find a significant increase in the choice likelihood of healthier items compared to control restaurants. Levin (1996) supported the introduction of menu nutrition labels with signage that prompted to the label ("Look for the [heart symbol] for your low-fat entree selection"). The proportion of labelled food items sold increased significantly at the treatment canteen during the intervention period compared to the control canteen. Scourboutakos et al. (2017) supported the introduction of beverage nutrition labels with signage that encouraged the purchase of water ("Drink water when you are thirsty"). The calories of beverage choices did not differ between the control and intervention period, but the proportion of student who selected water (SSBs) increased (decreased).

Label+ Food swap recommendation

Three studies supported nutrition labels with healthier food swap recommendations in the lab (De Bauw et al., 2022; Jansen, van Kleef, & Van Loo, 2021) and in the field (van der Laan & Orcholska, 2022). Food swap recommendations automatically suggest alternative healthier products when an individual makes an unhealthy choice. The recommendation can either pop up directly after the individual makes an unhealthy choice (Jansen, van Kleef, & Van Loo, 2021; van der Laan & Orcholska, 2022) or at the basket overview before checkout (De Bauw et al., 2022).

In the study by Jansen, van Kleef, and Van Loo (2021) both nutrition labels and food swap recommendations had an independent main effect on the nutritional quality of the shopping basket which was not qualified by an interaction. In the study by van der Laan and Orcholska (2022) food swap recommendation increased the proportion of labelled products sold compared to the control condition, but adding nutrition labels to food swap recommendations reduced the proportion of labelled products sold compared to label+ food swap recommendations. As such the proportion of labelled products sold was not significantly higher in the label+ food swap recommendation condition compared to the control condition.

De Bauw et al. (2022) finds that nutrition labels significantly improved the nutritional content of the basket, but food swap recommendations at checkout did not further improve the nutritional content of the basket. As such, the evidence on label+ food swap recommendation interventions is mixed

Label+ Financial incentive

The review includes 19 interventions that supported nutrition labels with a financial incentive for healthy choices (Acton & Hammond, 2018; Acton et al., 2019; Acton, Kirkpatrick, & Hammond, 2021; Elbel et al., 2013; Ellison, Lusk, & Davis, 2014; Giesen et al., 2011; Mazza et al., 2018; Shah et al., 2014). The majority combined a nutrition label with a tax on unhealthy products (n = 17 / 19). Two interventions used a subsidy on healthy products and a tax on unhealthy products (n = 2 / 19). The price changes ranged from 10% to 50%. Most interventions (n = 13 / 19) did not explicitly communicate the price change (i.e. non-itemized), while six interventions explicitly indicated the price change (i.e. itemized).

The harvest plot in Figure 2.8 visualizes the evidence from all label+ financial incentive interventions (n = 33 bars[4]). Effects were most often measured using overall outcomes (n = 18 / 33), short durations (≤ 1 week, n = 24 / 33), and compared to control (n = 20 / 33). Compared to a control condition (n = 20), the evidence of the effectiveness of label+ financial incentive interventions is largely promising. Studies most often report beneficial (n = 10 / 20) or promising findings (n = 7 / 20). Few studies report no effect (n = 2 / 20) or mixed effects (n = 1 / 20). Label+ itemized price changes (i.e. explicitly communicated) are consistently resulting in improvements (n = 6 / 6) whereas non-itemized price changes are only showing beneficial or promising effects in 75% of studies (n = 11 / 14). Findings from factorial designs indicate that significant improvements compared to a control condition are often driven by the tax while nutrition labels only have a small or no effect (Acton & Hammond, 2018; Acton et al., 2019; Giesen et al., 2011). Although most studies with a factorial design do not find an interaction effect between nutrition labels and price changes (Acton & Hammond, 2018; Acton et al., 2019; Ellison, Lusk, & Davis, 2014), one study reports that combining nutrition labels and taxes can have negative effects (Giesen et al., 2011). For high-restrained eaters nutrition labels improved dietary choices only when taxes were absent and taxes improved dietary choices only when nutrition labels were absent. For

[4] Some studies report multiple outcome measures and pairwise comparisons.

low-restrained eaters nutrition labels did not have an effect, but taxes improved dietary choices regardless of the presence of nutrition labels.

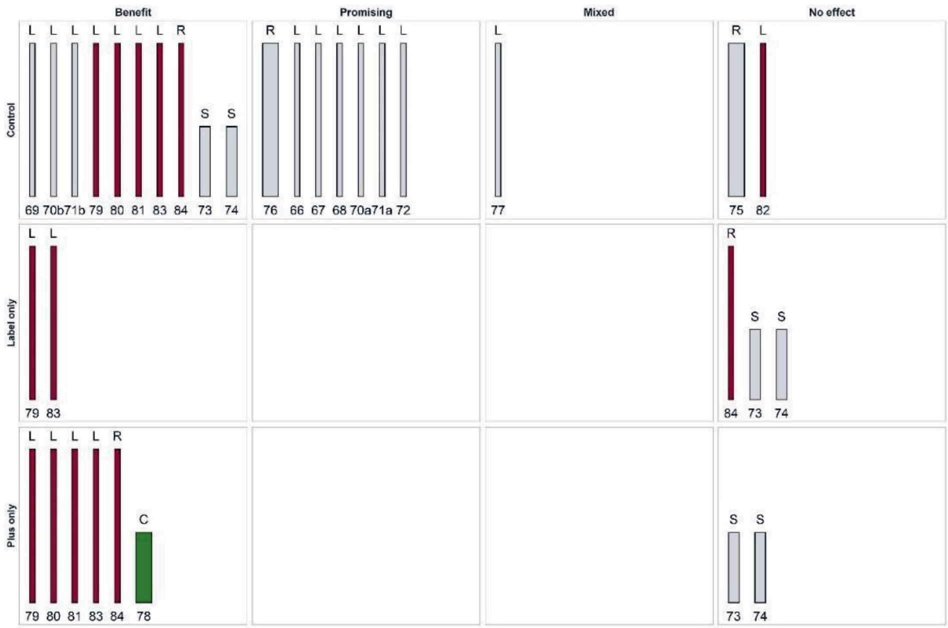

Figure 2.8. Harvest plot for label+ financial incentive interventions for each pairwise comparison.
Figure key: The colour of the bar represents the outcome type (green = healthy, red = unhealthy, grey = overall nutritional quality); the bar length indicates the study design (RCT+CT = high, pre-post = low); the bar width indicates the intervention duration (the wider, the longer); the letter above the bars describes the setting (L = lab; C = canteen; R= restaurant; S = supermarket and convenience store; V = vending machine); the number below the bar refers to the study ID.

Compared to only providing a label (n = 5), the evidence is unclear whether the addition of price changes provides benefit (n = 2 / 5) or no effect (n = 3 / 5). Compared to only changing prices (n = 8), the evidence indicates a tendency that the addition of price changes provides benefit (n = 6 / 8) as opposed to no effect (n = 2 / 8). However, this comparison might be biased to comparing a label+ itemized tax to a non-itemized tax only condition. Across four studies, Shah et al. (2014) report that a label+ itemized tax led to a significantly greater reduction in unhealthy choices compared to control, label only, and non-itemized tax only. Label+ itemized taxes explicitly communicate that an item is unhealthy and that it is taxed. Since no itemized tax only condition (i.e. explicitly communicating that a product is taxed without giving a health reason) was used, it remains unclear whether the increased effectiveness compared to label only and non-itemized tax only is due to drawing attention to the tax (i.e. salience of the tax) or the interaction between the salience of the tax and the highlighted reason for the tax (i.e. tax and health salience).

Label+ Introduction of healthy foods

Only one study (Lowe et al., 2010) supported nutrition labels with increasing the availability of healthy choices by introducing ten new low-energy-dense foods. The calories of lunch meal choices in the canteen did not significantly change in the intervention period compared to the baseline period.

Discussion

Main findings and directions for future research

The aim of the current study was to provide a theoretical framework on barriers of FOP nutrition label use and how supporting interventions could address these barriers. The theoretical framework integrates existing information-processing and behavioural MOA frameworks into one overall theoretical framework. Nutrition label provision alone is a necessary yet insufficient condition for behaviour change to occur. Individuals need to 1) turn the information into knowledge and 2) turn the knowledge into behaviour (Hornik, 1989).

A systematic search was used to identify existing research on label+ interventions and the evidence of their effectiveness in changing dietary choices was synthesized in a narrative form. In total 85 label+ interventions were included. Most interventions (n = 24) supported nutrition labels with educational material about the nutrition labels, followed by financial incentives (n = 19), basket feedback (n = 13), and reference information (n = 12). Other label+ categories had too little observations ($n \leq 5$) to draw solid conclusions and generalize about their effectiveness. Two label+ categories are situated in the first step of the model (turning information into knowledge). Both reference information and educational material increase individuals' skills and knowledge to interpret the nutrition labels and as such target the ability to process nutrition labels. One label+ category is situated both in the first and second step of the model. Basket feedback summarizes the healthfulness of food choices in the basket in real-time and as such can highlight when the basket becomes unhealthy. This can highlight the personal relevance of nutrition information and as such target the motivation to process nutrition labels. In addition, it can activate healthy eating goals and the motivation to make healthy choices to balance previous unhealthy choices. One label+ category is situated in the second step of the model (turning knowledge into action). Financial incentives can reduce the price difference between unhealthy and healthy foods and as such increase the influence of other food choice motives, such as healthfulness. Making healthier foods cheaper can also provide individuals with the required resources to make a healthy choice. The study characteristics and evidence were tabulated and visualized in harvest plots. Table 1.4 summarizes the main findings of this review and provides recommendations for future research.

Table 1.4. Key findings of the review

Step	Category	n	Key finding	Future research
1) Turn information into knowledge	Label+ reference information	12	No robust effect on behaviour change	More research is required to understand whether reference guidelines can be useful for more habitual shopping situations
	Label+ educational material	24	No robust effect on behaviour change, but improvements in awareness and understanding	More research on how label+ information campaigns can build support for more upstream policy measures
1) + 2)	Label+ basket feedback	13	Generally effective, but only studies with short timeframes	More research with longer intervention durations in real-world settings is needed
2) Turn knowledge into action	Label+ financial incentive	19	Generally effective, but driven by the strong effect of the tax	More research on the underlying psychological mechanism of label+ itemized taxes is needed to understand why label+ itemized taxes are more effective

The evidence for label+ *reference information* interventions indicates no effect in improving the healthfulness of dietary choices. Reasons could be the strong reliance on reductive nutrient-specific labels (e.g. numeric calorie labels) and unhealthy product categories (e.g. fast food meals, snacks). Previous reviews indicate that nutrition labels that use numeric information are more difficult to understand, especially for individuals with lower educational level (Campos, Doxey, & Hammond, 2011; Hersey et al., 2013; Roberto et al., 2021). In addition, individuals are less interested in nutrition information on product categories that are perceived as a treat (Grunert & Wills, 2007) and as such might have been more likely to ignore the information. More research is required to understand whether reference guidelines can be useful for more habitual shopping situations (e.g. supermarket food choices).

The evidence about the effectiveness of label+ *educational material* interventions in improving the healthfulness of dietary choices is not very convincing. Most studies report no significant improvements in dietary choices and small effect sizes. Effects were not robust across nutrition label, product category, and outcome measure used. Studies were more often effective when using an interpretative summary nutrition label. Prior research suggests that design characteristics of interpretative summary labels, such as the use of a single summary indicator on both healthier and unhealthier products, showing a range of possible scores, and utilizing symbols and colours that leverage automatic associations, are most promising for attention, understanding, and use of FOP nutrition labels (e.g. Dubois et al., 2021; Ikonen et al., 2020; Nohlen et al., 2022; Roberto et al., 2021). Especially the five-coloured summary FOP nutrition label Nutri-Score has been shown to better increase individuals' ability to rank products according to nutritional quality compared to other interpretative labels (Dubois et al., 2021; Hagmann & Siegrist, 2020), particularly among individuals with low self-reported nutritional knowledge (Ducrot et al., 2015). In line with previous meta-analyses on nutrition labels (Cecchini & Warin, 2016; Ikonen et al., 2020), there is some evidence that label+ educational material interventions are effective in encouraging purchases of healthier products to a small extent but unable to discourage purchases of less healthy products. This might explain the null effect on the overall nutritional content of the shopping basket (Dubois et al., 2021; Mora-Garcia, Tobar, & Young, 2019). However, combining nutrition labels with educational materials can improve important prerequisites for informed nutrition label use, such as awareness (Julia et al., 2016; Mora-Garcia, Tobar, & Young, 2019) and understanding of nutrition labels compared to solely providing nutrition labels (Julia et al., 2016). Due to the limited details on the education material used in some studies, an in-depth analyses on the medium and the message type was not possible. Further research is needed to conclude whether the type of medium (e.g. flyers, aisle signage) and message (e.g. gain vs. loss frame) can influence effectiveness.

The evidence for label+ *basket feedback* interventions is promising but limited due to the short timeframes and strong reliance on lab-based studies. Label+ basket feedback interventions significantly increased revisions of high-calorie choices and in turn improved the nutritional quality of the basket (Gustafson & Zeballos, 2019; Shin et al., 2022; VanEpps et al., 2021). Combining nutrition labels with real-time basket feedback enables consumers to keep a more accurate overview of their basket healthfulness (Gustafson & Zeballos, 2019) and eases consideration of nutrition information as it does not require consumers to integrate nutrition information from multiple product choices (VanEpps et al., 2021). More research is needed how these effects develop over longer intervention durations and in real-world settings.

Another example of an interactive digital intervention is a recommender system that can be used to react to unhealthy choices by automatically recommending healthier alternative products (i.e. food swap recommendation). Only one of the three included label+ *food swap recommendation* interventions provides evidence that nutrition labels and food swap recommendations have an independent main effect on the basket healthfulness (Jansen, van Kleef, & Van Loo, 2021). In combination with nutrition labels, healthier food swap recommendations may be able to inform inattentive consumers that they made an unhealthy choice just-in-time and draw their attention to nutrition labels. However, the findings from van der Laan and Orcholska (2022) suggest that adding nutrition labels to food swap recommendation may be harmful. A possible explanation is that the nutrition label activated a healthy = untasty intuition (Raghunathan, Naylor, & Hoyer, 2006) and as such reduced the effectiveness of food swap recommendations. Another reason could be that the study by van der Laan and Orcholska (2022) only labelled the healthier alternative, while Jansen, van Kleef, and Van Loo (2021) used a graded label design that highlights the relative health gain of the recommendation. The lack of effect in the study by De Bauw et al. (2022) might be explained by the timing of the food swap recommendations. Providing food swap recommendations at checkout is less effective than providing food swap recommendation directly after an unhealthy choice is made (Forwood et al., 2015). More research is required to understand when and why food swap recommendations are accepted.

The findings for label+ *financial incentive* interventions indicate support for combining nutrition labels with price changes to improve dietary choices. Especially combining nutrition labels with itemized price changes that explicitly indicate the presence and reason for the price change showed promising results compared to price changes that are included in the price without highlighting their presence (i.e. non-itemized taxes) (Shah et al., 2014). This difference may be explained by the salience of the tax. When price changes are included in the price without highlighting their presence (i.e. non-itemized taxes), smaller price changes are often not noticed by consumers as they often do not remember the original price (Claudy et al., 2021). Highlighting the presence of a tax increases the awareness of the tax. Salience of a tax has been shown to improve effectiveness of a tax (Chetty, Looney, & Kroft, 2009; Zizzo et al., 2021). The salience of the tax might further avoid misconceptions about quality perceptions of more expensive foods (Shah et al., 2014). Highlighting the reason of a tax may signal in addition that unhealthy choices are penalized, increase awareness of negative health consequences, and remind consumers of their health goals, which in turn might encourage the purchase of healthy products even if they can afford unhealthy products (Claudy et al., 2021). However, the fact that in all included label+ itemized tax studies the presence and reason for the tax were highlighted simultaneously, prevents from solid conclusions on whether highlighting the health reason for the tax provides additional benefit to highlighting the presence of a tax. More research on the underlying psychological mechanism of label+ itemized taxes is needed to understand whether label+ itemized taxes operate only through the price mechanism (i.e. avoiding more expensive products) or also through activating health awareness.

Overall, the evidence for the label+ categories situated in the first step of the model, ensuring that information translates into knowledge, is not promising, whereas label+ categories that are situated in both steps or the second step, ensuring that knowledge translates into action, provide evidence of effectiveness. This suggest that activating interventions are required to ensure that information translates into behaviour.

Implications for public policy

The objectives of FOP nutrition labelling are twofold: to improve the salience, understanding, and use of nutrition information among consumers and to encourage manufacturers to develop healthier products, either by reformulating existing products or by introducing new healthy products (FDA, 2010; Kanter, Vanderlee, & Vandevijvere, 2018; Nohlen et al., 2022). Previous reviews have warned that FOP nutrition labels achieve their goal to improve awareness and understanding of nutrition information, but are less impactful in stimulating healthier choices (e.g. Bauer & Reisch, 2019; Cadario & Chandon, 2020a; Ikonen et al., 2020; Perez-Cueto, 2019). Our theoretical framework and systematic review allow a better understanding of the aspects affecting the effectiveness of FOP nutrition labels. To achieve maximum possible health gains, complementary interventions may be needed to target barriers that prevent individuals from processing and acting upon FOP nutrition labels. A multifaceted policy program rather than relying on a single intervention is required to achieve this goal (Capewell & Capewell, 2018; Claudy et al., 2021; Lee et al., 2017; Rutter et al., 2017; van Kleef & Dagevos, 2015). More intrusive interventions may be required to give cause for action when individuals are unmotivated to engage in the suggested behaviour

(Capewell & Capewell, 2018). In line with this, we found that supporting nutrition labels with more intrusive interventions such as interactive digital interventions and financial incentives were more effective than purely information-based interventions (i.e. label+ reference information and label+ education material).

Policymakers need to determine whether to rely on voluntary compliance by retailers or impose mandatory interventions. The decision to impose mandatory interventions on retailers should be based on a careful assessment of the feasibility of implementation, their potential impact, and the need of governmental interference in the market. For interactive digital interventions, this assessment likely differs between online and physical environments. Current evidence of effectiveness of digital interventions is based mainly on online lab experiments. As online shopping environments can closely mimic lab experiments, implementation of interactive digital interventions, such as basket feedback or food swap recommendations, is feasible and relevant. However, in physical shopping environments the effectiveness of interactive digital interventions is still largely unknown. If interventions require effort, such as downloading an app or manually replacing unhealthy choices, the effectiveness is likely lower as this targets health-motivated individuals who are already sensitive to nutrition information (Van Loo et al., 2015). Consumers might also be less willing to manually put back unhealthy choices in physical stores as touch can increase perceived ownership and valuation of the product (Peck & Shu, 2009). The necessity to impose mandatory intervention can be subject to scrutiny, as several companies are already implementing digital interventions voluntarily as part of their corporate social responsibility efforts (Albert Heijn, n.d.; Jumbo, 2022; Stuber et al., 2022; van der Laan & Orcholska, 2022). However, public policies are needed to address ethical and legal concerns surrounding these emerging digital technologies. Among others it is imperative that interactive digital interventions are based on an official source (e.g. the Nutri-Score) to avoid harmful recommendations. In addition, vulnerable groups (e.g. individuals suffering from eating disorders) should be able to opt out of such health-promoting interactive digital interventions (for a more detailed discussion, see Calvaresi et al., 2022).

Providing financial disincentives for consumers to purchase unhealthy food is likely not implemented voluntarily by retailers. Unhealthy products are generally less expensive (Herforth et al., 2020) and perceived as more tasty (Raghunathan, Naylor, & Hoyer, 2006). This creates demand for low-cost unhealthy products. In order to stay competitive, retailers offer unhealthy products to fulfil consumer demand and even promote unhealthy products more than healthy products (Hendriksen et al., 2021; Ravensbergen et al., 2015). These interdependencies in the food system create a lock-in effect of supply and demand for unhealthy products that requires policy interventions (van Rijnsoever, van Lente, & van Trijp, 2011). To correct relative price differences subsidies on healthier foods and/or taxes on unhealthier foods can be considered. Combined fiscal policies have larger effects on dietary choices as greater relative price differences can be achieved which incentivizes consumers to switch from taxed unhealthy to subsidized healthy foods (Caro et al., 2020; Claudy et al., 2021; Niebylski et al., 2015; Pearson-Stuttard et al., 2017). Taxes lead to a larger tax burden and welfare loss for low-income consumers, whereas combined fiscal policies reduces health disparities and results in welfare gains for low-income consumers (Caro et al., 2020; Claudy et al., 2021). Research has suggested that fiscal policies are most effective when they are at least 10-20% (Claudy et al., 2021; Niebylski et al., 2015), when they are directly passed into the price tag (Zheng, Huang, & Ross Jr, 2019), and when their presence is signposted (Chetty, Looney, & Kroft, 2009; Zizzo et al., 2021). A recent successful example of an unhealthy food tax is the UK Soft Drinks Industry Levy. After overcoming industry opposition, the policy was implemented and has led to product reformulations (Scarborough et al., 2020) and healthier consumer choices (Pell et al., 2021). Previous research has found that taxes receive more public support when the tax revenue is used for other policy measures to reduce obesity, such as information campaigns or subsidies for healthier foods (Brownell & Frieden, 2009). Health communication campaigns have been used across a range of health-risk behaviours (e.g. smoking, binge drinking, unhealthy eating) to increase public awareness of health risks, concern over such health risks, social acceptability of the behaviour, and ultimately support for more restrictive policies (Durkin, Brennan, & Wakefield, 2012; Murukutla et al., 2020). Policymakers might benefit from building public support for bolder policies to accelerate food consumer behaviour change.

Conclusion

Our theoretical framework and systematic review allow a better understanding of the aspects affecting the effectiveness of FOP labels. Complementary interventions may be needed to target barriers that prevent individuals from processing and acting upon FOP nutrition labels. The findings provide limited evidence for the effectiveness of supporting nutrition labels with reference information. Even though label+ *educational material* interventions have beneficiary effects on important requirements of nutrition label use (awareness and understanding), effects on consumer behaviour were small and not robust across studies. Interactive digital interventions, such as basket feedback, and financial incentives provide promising evidence in supporting nutrition labels. If the goal of FOP nutrition labelling is not only transparency but also the use of nutrition information in dietary choices, it is unlikely sufficient to support nutrition labels with further information about nutrition labels. More intrusive interventions may be required when individuals are not motivated to engage in the behaviour.

3

Chapter 3
Impact of front-of-pack fibre labels on supermarket sales at different levels of socio-economic status: A natural experiment

This chapter is submitted as:

Schruff-Lim, E. M., van Kleef, E., Van Loo, E. J., van der Lans, I. A., & van Trijp, H. C. M. (2024). Impact of front-of-pack fibre labels on supermarket sales at different levels of socio-economic status: A natural experiment.

Abstract

There is limited evidence on the benefit of FOP nutrition labels across SES subgroups. With a natural experiment, the effect of FOP fibre labels on the fibre content of supermarket bread sales across stores in lower and higher SES area is examined. FOP fibre labels produced small shifts in market share of low and medium fibre breads towards high fibre breads. This resulted in an increase of 3.45% in the mean fibre content per 100g of bread sold (0.15g, $p < .001$). Importantly, the effect of FOP fibre labels did not differ across stores in lower and higher SES areas, suggesting that both areas benefitted from the FOP label introduction.

Introduction

Poor diet is a major risk factor for obesity and non-communicable diseases (NCD), such as heart disease, diabetes, and cancer (Kelly & Jewell, 2018). As diet is a modifiable risk factor, much interest has been placed on how to improve diets. Public health policies are increasingly encouraging the introduction of simple FOP nutrition labels to: 1) enable consumers to make informed healthier dietary choices, and 2) encourage manufacturers to offer healthier products (see Kanter, Vanderlee, & Vandevijvere, 2018 for a timeline of global FOP nutrition label policies). Most recently, the World Health Organization, the European Commission, and the US administration have identified the introduction of FOP nutrition labels as a priority policy issue (European Commission, 2020b; Kelly & Jewell, 2018; The White House, 2022).

In order for nutrition labels to impact food choices, individuals need to process and act upon the nutrition information in their decisions (e.g. Grunert, Wills, & Fernández-Celemín, 2010). Recent reviews indicate that FOP nutrition labels, especially simple designs, are generally well-understood and improve consumers' ability to identify healthier choices (Ikonen et al., 2020; Storcksdieck genannt Bonsmann et al., 2020). To which extent consumers act upon this knowledge in their food choices is still unclear. Existing research is primarily laboratory based and suggests small effect sizes (Ikonen et al., 2020; Storcksdieck genannt Bonsmann et al., 2020). Since individuals with habitual shopping patterns often do not notice small changes in the environment (Verplanken & Wood, 2006; Wood & Rünger, 2016), it is questionable whether laboratory-based results generalize to the real world. For instance, the effect size found in a field study testing the effect of four different interpretative FOP nutrition labels on the healthfulness of purchases in 60 supermarkets in France was 17 times smaller on average than in a comparable laboratory study (Dubois et al., 2021). Therefore, field studies are needed to realistically estimate the effect size of FOP nutrition labels in their natural environment (Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020).

Furthermore, there is limited evidence on whether all population subgroups benefit from FOP nutrition labels. Since health inequalities between individuals with lower and higher SES have persisted through time, health policies need to be evaluated on their effect across different levels of SES to avoid furthering health inequalities (Phelan, Link, & Tehranifar, 2010). However, existing studies that compare the effect of FOP nutrition labels on food choices are pre-dominantly conducted in simulated lab settings with hypothetical outcomes and show mixed results (Nohlen et al., 2022; Shrestha et al., 2023). Field studies that compare the effect of FOP nutrition labels on actual sales across different levels of SES under real-world conditions are needed (Nohlen et al., 2022; Roberto et al., 2021; Shrestha et al., 2023). To close this knowledge gap, this study examines the effect of FOP fibre labels on the fibre content of supermarket bread sales across stores in lower and higher SES areas using a natural experiment. In the following we will first provide a brief overview on the existing research on the effect of FOP nutrition labels on supermarket purchases and the moderating influence of SES.

Theoretical background

Impact of FOP nutrition labels on dietary choices

Following the typology by Ikonen et al. (2020), FOP nutrition labels can be categorized into three types: reductive nutrient-specific, interpretative nutrient-specific, and interpretative summary FOP nutrition labels. Reductive nutrient-specific labels provide objective information about nutrient content in a more condensed manner than the nutrition facts panel (e.g. Guideline Daily Amount), while interpretative nutrient-specific labels offer additional evaluation of this nutrient-level information (e.g. multiple traffic light). Interpretative summary labels aggregate nutrient-level information into an overall indicator and offer interpretation (e.g. Nutri-Score).

Interpretative FOP nutrition labels have been shown to increase purchase intentions of virtue products, but failed to influence purchase intention of vice products (Ikonen et al., 2020). A recent randomized field experiment by Dubois et al. (2021) tested the effect of four different interpretative FOP nutrition labels (Nutri-Score, SENS, Nutri-Repère, Nutri-Couleurs) on the healthfulness of purchases in four product categories (fresh prepared foods such as pizzas, pastries, breads, and canned prepared meals such as ravioli) in 60 supermarkets in France. Nutri-Score labels performed best, resulting in a significant increase of 14.4% in the purchases of healthier products, but failed to reduce purchases of less healthy products. Limited real-world evidence suggest that well-designed FOP nutrition labels can have small but positive on the healthfulness of purchases (Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020).

Existing research has recommended design characteristics for more effective FOP nutrition labels. First, it has been suggested that FOP nutrition labels should utilize symbols and colours that leverage automatic associations. Numeric information, without any evaluation or guidance, can be more difficult to understand compared to interpretative symbols (Hersey et al., 2013; Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020). Second, interpretative summary FOP nutrition labels improve understanding more compared to interpretative nutrient-specific FOP nutrition labels (Ikonen et al., 2020). FOP nutrition labels with a combination of nutrients have been shown to increase processing time compared to simpler FOP nutrition labels and are hence less appropriate for fast-paced environments such as supermarkets (Feunekes et al., 2008). The effectiveness of FOP nutrition labels with a single nutrient in influencing consumer purchases differs depending on which nutrient is highlighted and hence may depend on the relevance of the respective nutrient in the food category (Kiesel & Villas-Boas, 2013). Other design characteristics, such as labelling both healthier and less healthy products and showing a range of possible scores have been suggested to be promising for attention, understanding, and use of FOP nutrition labels (Dubois et al., 2021; Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020).

However, in many field studies the introduction of FOP nutrition labels is accompanied by education material about the FOP nutrition labels (Dubois et al., 2021; Hobin et al., 2017; Hoenink et al., 2021; Sacks et al., 2011; Sutherland, Kaley, & Fischer, 2010; Vandevijvere & Berger, 2021) or other policy regulations such as limiting food marketing and sales of less healthy products in schools (Taillie et al., 2020). This makes it difficult to isolate the effect of FOP nutrition labels. More field studies are needed to realistically estimate the effect size of FOP nutrition labels in their natural environment (Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020).

Impact of socio-economic status on the effectiveness of FOP nutrition labels

Risk of developing and dying from non-communicable diseases is higher for individuals with lower SES compared to individuals with higher SES (Di Cesare et al., 2013; Sommer et al., 2015). According to the fundamental cause theory, these health inequalities persist across time and place because individuals with higher SES have more flexible resources (e.g. knowledge, money, access) to avoid health risks and adopt preventative measures, such as a healthy diet (Clouston & Link, 2021; Link & Phelan, 1995). Especially knowledge and money are flexible resources that may influence the effectiveness of FOP nutrition labels.

With regard to knowledge, lower SES, especially lower education, contributes to lower health literacy leading to worse health outcomes and behaviours (Stormacq, Van den Broucke, & Wosinski, 2019). Health literacy is defined as an individual's ability to access, understand, appraise and apply health information (Sørensen et al., 2012). Consequently, lower health literacy may hinder understanding of and acting upon nutrition information. Individuals with lower SES have been shown to have more difficulties interpreting nutrition labels (Ducrot et al., 2015; Goodman et al., 2018). Simplified FOP nutrition labels using pictures and symbols rather than numeric information improve understanding of nutrition labels for individuals with all SES levels (Nohlen et al., 2022; Shrestha et al., 2023; Storcksdieck genannt Bonsmann et al., 2020). Individuals with lower SES may especially profit from simplified FOP nutrition labels as their nutritional knowledge of their food choices may be lower (Shrestha et al., 2023).

Financial resources can constrain an individual's opportunity to make healthy choices (Schruff-Lim et al., 2023). A meta-analysis found that healthier diets cost $1.48 / day ($1.01 to $1.95) and $1.54 / 2000 kcal ($1.15 to $1.94) more than less healthy diets (Rao et al., 2013). In a more recent study, Herforth et al. (2020) used food prices in 170 countries in 2017 to estimate the minimum cost of three types of diets: energy sufficient, nutrient adequate, and healthy. The global average costs for a diet meeting daily energy needs with the least-cost starchy staples is $0.79 / day, followed by $2.33 / day for a diet fulfilling all essential nutrients requirements to avoid deficiencies, and $3.27 - 4.57 / day for a healthy diet aligned with dietary guidelines. Individuals with lower SES often do not have the financial resources to pay higher prices for healthier foods (Phelan, Link, & Tehranifar, 2010). Individuals with lower SES tend to buy energy in cheaper forms (i.e. lower $ / kcal), which results in a diet with lower nutritional quality per kcal (higher in total fat, lower in protein, fibre, and vegetables) (Appelhans et al., 2012). Consequently, even if individuals with lower SES understand FOP nutrition labels, they may not be able to act upon the knowledge due to financial constraints.

Existing evidence on the effect of FOP nutrition labels on purchases across socio-economic groups is contradicting (Nohlen et al., 2022). While Taillie et al. (2020) finds a larger effect of the Chilean Law of Food Labelling and Advertising on the purchase of sugar-sweetened beverages for households with higher education levels, Fichera and von Hinke (2020) finds a lower effect of the traffic light label on the purchase of store-brand labelled foods for households with higher socio-economic status. More research is required to gain a better understanding on the effectiveness of FOP nutrition labels on purchases across socio-economic groups (Nohlen et al., 2022; Roberto et al., 2021; Shrestha et al., 2023).

Method and Data Description

Study Design

The research design used in the present study can be classified as a natural experiment. Natural experiments are characterised by a natural environment in which participants undertake familiar tasks; participants' unawareness of being part observed, collection of revealed preference data from secondary sources, and the researchers inability to influence the randomization of the treatment (Caputo & Just, 2022). In March 2021 a Dutch discounter supermarket introduced a FOP fibre label with three levels on all packaged bread products (n = 36) to provide information about the fibre content (see Figure 3.1). The label consists of three grain spikes which visually showcase the fibre level of the bread. The label fulfils many of the recommended design characteristics, such as highlighting a single nutrient on both healthier and less healthy products, showing a range of possible scores, and utilizing symbols that leverage automatic associations. In addition, nutrition claims in line with EU regulation (low in fibre = 0-3g/100g, source of fibre = 3-6g/100g, high in fibre = at least 6g/100g) (European Commission, n.d.-b) and reference information (amount of fibre in grams per slice of bread) are displayed. The supermarket did not advertise the new nutrition label nor provided consumers with any education material about the FOP fibre labels during the study period. Table 3.1 provides an overview of the included products. Comparison of the products across fibre levels did not indicate differences in packaging size nor original prices of products ($p > .05$).

Figure 3.1. Examples of products with low fibre (left, 'Farmers white sesame. Every day fresh. Low in fibre. 1 slice

provides at least 0.9 g fibre.'), medium fibre (middle, 'Farmers brown. Every day fresh. Source of fibre. 1 slice provides at least 1.3 g fibre.') and high fibre (right, 'Extra whole grain. Every day fresh. High in fibre. 1 slice provides at least 3.0 g fibre.').

Table 3.1. Descriptive statistics of the bread SKUs.

	Low fibre SKUs	Medium fibre SKUs	High fibre SKUs	p
Number of SKUs[1]	15 (41.67)	13 (36.11)	8 (22.22)	
Mean weight in g[2]	586 (184)	612 (215)	588 (230)	.94
Mean price per 100g[2]	0.24 (0.10)	0.21 (0.10)	0.22 (0.08)	.74

Note. [1] n (%). [2] Mean (SD). One-way ANOVA. Means within rows with differing superscripts are significantly different at the $p < .05$ level based on Tukey HSD post-hoc paired comparisons.

To examine whether the effect of the FOP fibre label differs across SES, stores from areas with both lower ($n = 30$) and higher SES ($n = 28$) were selected based on matching the postcode of the stores with public data about the SES status score (CBS, 2022). The SES status score is derived from the income, education level, and employment history of households in a postcode area, with higher scores reflecting higher SES. Further data was available about the number of households in the postcode area (CBS, 2022) and the store size (provided by the retailer). As intended, the SES status score differed between the lower and higher SES stores ($M_{Lower} = -0.26$, $M_{Higher} = 0.13$, $t(51.18) = 9.26$, $p < .001$, Cohen's $d = 2.39$), but neither the number of households in the postcode area ($M_{Lower} = 4510$, $M_{Higher} = 3653.57$, $t(55.86) = -1.66$, $p = .101$) nor the store size differed ($M_{Lower} = 1240.37$, $M_{Higher} = 1257.84$, $t(52.26) = 0.39$, $p = .697$).

Dataset

For each store ($n = 58$), weekly sales data of each product in the bread category ($n = 36$) was made available for 27 weeks before and 14 weeks after the FOP fibre label was introduced (Figure 3.2). The transition period in which FOP fibre labels were introduced (calendar week 10-12) was excluded from analysis. Since the FOP fibre labels were introduced in all stores, no control stores were available. In line with Sim et al. (2022), the same time period of the previous year was used as the control group. This allowed a controlled pretest-posttest design. Observations that had no bread sales at all for a given week in a given store ($n = 86$ observations), were excluded from the analysis rather than imputed with 0 as we were interested in the effects of the factors conditional on selling bread and as these observations indicate either supply or data issues rather than effects of the intervention. In addition to the sales data, information about the products (weight of package, fibre content) and weekly prices of each products (after applying price promotions) was shared.

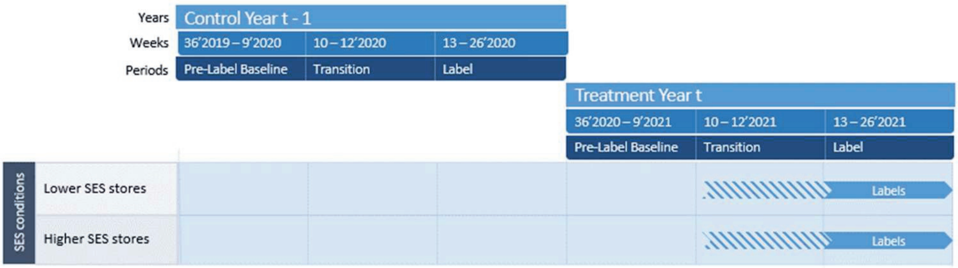

Figure 3.2. Study overview.

Chapter 3

Data Analysis

To quantify the effect of the FOP fibre label, a difference-in-difference analysis was used, which compares the change between pre-label and label period in the treatment year to the change between the same time periods of the previous year (Wing, Simon, & Bello-Gomez, 2018). To investigate whether the effect of the FOP fibre label differs across SES area, a three-way interaction between period (pre-label vs. label), year (control vs. treatment), and SES area (higher vs. lower) was added to the model. The following model was estimated:

$$y_{it} = \beta_0 + \beta_1\, Period_t + \beta_2\, Year_t + \beta_3\,(Period_t \times Year_t) + \beta_4\, SES\ area_i + \beta_5\,(Period_t \times SES\ area_i) + \beta_6\,(Year_t \times SES\ area_i) + \beta_7\,(Period_t \times Year_t \times SES\ area_i) + \beta_8\, MPL_t + \beta_9\, MPM_t + \beta_{10}\, MPH_t + \mu_i + \epsilon_{it},$$

where y_{it} indicates the mean fibre content (in g) per 100g of breads sold at store i at time t (week). $Period_t$ indicates a dummy variable that is equal to 0 in the pre-label period (week 36-9) and 1 in the label period (week 13-26). $Year_t$ indicates a dummy variable that is equal to 0 in the control year (2019-2020) and 1 in the treatment year (2020-2021). $SES\ area_i$ indicates a dummy variable that is equal to 0 for stores in higher SES areas and 1 for stores in lower SES areas. MPL_t, MPM_t, and MPH_t indicate the weekly mean price of low, medium, high fibre breads, respectively. μ_i represents the time-invariant individual error component and ϵ_{it} represents the time-varying idiosyncratic error term.

The primary outcome measure was the mean fibre content in grams per 100g of bread sold in a given store in a given week. In the present study, sales units are measured in 100g (i.e. weight-equalized sales units) rather than in packages (i.e. volume sales units) as the former accounts for differences in packaging size (Maesen et al., 2021). As such, the mean fibre content sold in a given store in a given week is displayed per 100g just like the fibre content of a product in the nutrition facts panel (equivalent to 2-3 slices of bread). To further understand how sales shifted across the three levels of the fibre label, the analyses were repeated with the weight-equalized market share of low, medium, and high fibre products from the total weight-equalized sales.

Due to the cross-sectional and time-series dimension of the data, linear panel data models were estimated in R (Version 4.3.3) with the plm package (Croissant & Millo, 2008). The Hausman test indicated that the individual errors are not correlated with the independent variables and hence a random effects model is preferred over a fixed effects model (Hausman, 1978). Random effects models account for unobserved time-invariant heterogeneity across stores (e.g. due to store size). Since the diagnostic checks (Croissant & Millo, 2008) indicated presence of heteroskedasticity and serial correlation, heteroskedasticity and autocorrelation consistent estimations of the standard errors were used (Zeileis, 2004). All data was analysed with a significance level α of .05. Since this study used secondary sales data, it was exempt from ethical review and approval.

Results

Impact on the weekly mean fibre content per sales unit

Figure 3.3 visualizes the unadjusted trend in mean fibre content during the study periods. Visual inspection indicates that pre-label period (Week 36-9) trend is sufficiently parallel between the control year and the treatment year. As such any differences between years is assumed to be constant over time and does not bias the estimation of the treatment effect. Due to small differences in the first and last week of the pre-label period across years, robustness checks were used to confirm that results remained consistent and are not sensitive to excluding these observations (see Appendix 3).

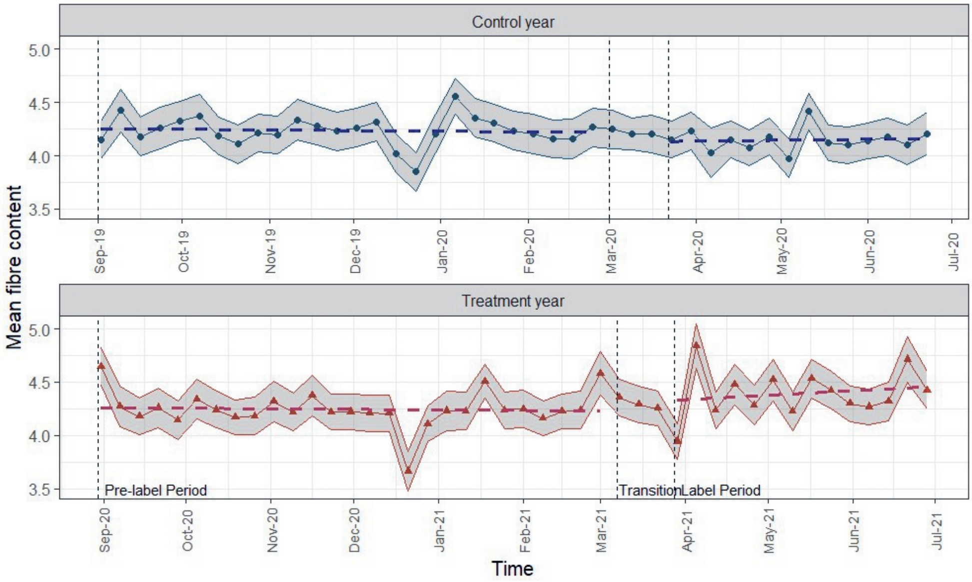

Figure 3.3. Development of mean fibre sold during the study period.
Note: The x-axis is organized by date. As week 10 and 13 differ in date between the years, the vertical lines are not exactly parallel.

Table 3.2 reports the results of the final random effect regression models. Including SES area and its interactions with period and year did not improve model fit. The three-way interaction between period, year, and SES area was not significant, indicating that the effect of the FOP fibre label is not moderated by the SES of the area. Hence, SES area and its interactions with period and year was removed from the model. The final model accounts for 40.5% of variance in the mean fibre content per 100g of bread sold. In the control year the mean fibre content reduced from pre-label to label period by 1.76% ($b = -0.08$g, $p < .001$), whereas in the treatment year the mean fibre content increased from pre-label to label period by 1.55% ($b = 0.07$g, $p < .001$). As a result, an increase of 3.45% in mean fibre content can be attributed to the FOP fibre label ($b = 0.15$g, $p < .001$). Several robustness checks (see Appendix 3) confirmed that results remain consistent when including the transition period (week 10-12, treatment effect = 0.14g, $p < .001$, 3.27%), when using an alternative control year (two years prior to the treatment year, treatment effect = 0.15g, $p < .001$, 3.46%), and when using an alternative price covariate (mean price for 1g of fibre, treatment effect = 0.29g, $p < .001$, 6.78%).

Impact on the market share of low / medium / high fibre sales

To further understand how sales shifted across the three levels of the fibre label, the final model was also estimated with the market share of low, medium, and high fibre from the total weight-equalized sales (see Table 3.2). The effect of the FOP fibre label was significant for all three market shares ($p < .001$). The FOP fibre label reduced the share of low ($b = -0.007$, $p < .001$, -1.94%) and medium fibre sales ($b = -0.022$, $p < .001$, -5.31%) and increased the share of high fibre sales ($b = 0.102$, $p < .001$, 10.74%).

Table 3.2. Impact of fibre label on outcomes, adjusted for the weekly mean price of low, medium, high fibre breads respectively.

	Control year[1]		Treatment year[1]		Diff-in-Diff	
	Pre-label	**Label**	**Pre-label**	**Label**	**Coeff.[2]**	**SE[3]**
Mean fibre content (g) per unit	4.26 (0.02)	4.18 (0.02)	4.25 (0.02)	4.32 (0.02)	0.147*	0.009
Share of low-fibre sales	0.36 (0.00)	0.38 (0.00)	0.36 (0.00)	0.37 (0.00)	-0.007*	0.002
Share of medium-fibre sales	0.41 (0.00)	0.40 (0.00)	0.40 (0.00)	0.37 (0.00)	-0.022*	0.002
Share of high-fibre sales	0.22 (0.02)	0.22 (0.00)	0.24 (0.00)	0.26 (0.00)	0. 102[a]*	0.007[a]

Note: [1] Values represent estimated marginal means (standard errors in parentheses). [2] The difference-in-difference estimator reflects whether the mean change between periods was different between the control and treatment year. [3] Heteroskedasticity and autocorrelation consistent standard errors. [a]: log-transformed. * $p < .001$.

Discussion

FOP nutrition labels are increasingly adopted worldwide. Yet evidence of their effectiveness in improving the healthfulness of food purchases in supermarkets and across SES levels is scarce. This study contributes to the understanding of the effect of FOP nutrition labels on the healthfulness of food sales and how this effect is influenced by SES. The introduction of a FOP fibre label increased the mean fibre content per 100g of bread sold by 3.45% (absolute fibre increase = 0.15g). Additionally, bread sales shifted from low and medium to high fibre breads. These findings highlight the positive effect of the FOP fibre label on consumer choices, increasing the sales of bread products with greater fibre content.

Several design characteristics of the FOP fibre label may have contributed to its small impact compared to other field studies that did not find any effect of FOP nutrition labels (e.g. Sacks, Rayner, & Swinburn, 2009; Sacks et al., 2011). First of all, the FOP fibre label had a simple and easy-to-understand design, showed the range of all possible scores, utilized symbols that leverage automatic associations, and integrated informational messaging (Dubois et al., 2021; Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020). Second, all packaged bread products were labelled. Previous research has suggested that mandatory nutrition labelling policies are required for maximizing the effectiveness as the effect of nutrition labels on awareness, understanding, and product reformulation is typically lower when not all products are labelled (Hagmann & Siegrist, 2020; Roberto et al., 2021). When not all products are labelled under voluntary labelling policies, individuals make inferences about non-labelled products which can lead to misinterpretations. As a result individuals may be more likely to choose labelled products compared to non-labelled products as they perceive products with nutrition labels as healthier (Storcksdieck genannt Bonsmann et al., 2020).

Another important finding of our study is that the effect of the FOP fibre label on the mean fibre content was not moderated by the SES of the area. This study provides novel real-world evidence that the introduction of FOP fibre labels can benefit both lower and higher SES areas. This finding is in contrast with the heterogeneity in FOP label effectiveness across SES found in the studies by Taillie et al. (2020) and Fichera and von Hinke (2020). Two factors might have contributed to the observed uniform effect across lower and higher SES areas in our study. First, a simple interpretative label design was used which has been shown to be well understood by individuals with all SES levels (Shrestha et al., 2023; Storcksdieck genannt Bonsmann et al., 2020). Second, there was no financial barrier to shift to higher fibre products as products across fibre levels did not differ in price. Consequently, understanding of nutrition labels and affordability of healthier options did not pose a barrier to customers in lower SES areas.

Albeit an increase of 3.45% (0.15g) in the mean fibre content is an important step in the right direction towards promoting healthier food choices, a FOP fibre label alone is insufficient to increase fibre intake to recommended daily intake levels of 25-29g (Reynolds et al., 2019). Considering the average daily fibre intake of 20g in the Netherlands (Stephen et al., 2017), an increase between 25% and 45% is needed to meet recommended fibre intake levels. In addition, it is unclear if the effect of the FOP fibre label would apply to product categories beyond bread and to all consumers. The generalizability of the FOP fibre label's impact on the fibre intake in other product categories and consumer segments requires further investigation. In line with earlier discussions (e.g. van Kleef & Dagevos, 2015; Verplanken & Wood, 2006), it is unlikely that any single intervention can yield strong enough (and lasting) behaviour change across all consumer segments. Food choices are complex and influenced by a multitude of factors. While FOP nutrition labels can provide valuable information, a supportive food environment is needed that offers sufficient healthy alternatives and promotes a healthy diet. For instance, in the current study most products were classified as low fibre and least products as high fibre. Additional complementary interventions are needed to ensure that FOP labels lead to meaningful behaviour change (Schruff-Lim et al., 2023).

The study is not without limitations. First, the FOP fibre label was implemented only in one product category that did not differ in brands. As such, it is unclear whether the effect would generalize to other fibre containing product categories (e.g. pasta) and to settings where brand preferences play a role. In addition, we cannot rule out that the observed shifts in the purchases led to undesirable shifts in other categories as the available data is limited to the target product category. Research has shown that relatively healthy food choices in one product category are generally followed by relatively unhealthy in subsequent product categories (van Ittersum et al., 2024). Future research should extend this research across a broader range of product categories. Second, aggregated store data does not allow to draw inferences about individuals. Hence it is unclear whether the effectiveness of FOP fibre label extends to all population subgroups or only health-motivated individuals who are motivated to process nutrition information (Berry et al., 2019; Hung et al., 2017). Third, the postcodes of the stores were used as a proxy for the SES of the customers. While such an area-based SES measure is frequently used when individual-level SES measures are unavailable (Crockett et al., 2014; Dana et al., 2019; Pettigrew et al., 2017), discrepancies between area-based and individual-level measures can exist. Hence caution is necessary when interpreting the results as the findings only apply to the group of individuals within a given area rather than individuals (Demissie et al., 2000; van Lier et al., 2014). Moreover, even though the areas differ in SES, it remains unclear whether customers in lower and higher SES areas differed in SES. It may be possible that the discounter supermarket chain attracts a certain socio-economic group in both lower and higher SES areas. Access to individual level data of the customers would rule out ambiguity about the SES of the customers of the included stores. Future research with data at the individual level is required to validate the initial findings of the present study.

Conclusion

This study provides novel real-world evidence on the effectiveness of FOP on supermarket purchases across areas with different levels of SES. The implementation of a FOP fibre label increased the mean fibre content per 100g of bread sold by 3.45%, demonstrating small but noticeable shifts in market share from low and medium fibre breads towards high fibre breads. Importantly, the effect of the FOP fibre label did not differ across stores in lower and higher SES areas. The use of a single product category is a limitation of the current study, and may limit the generalization for the effect of FOP fibre labels in other product categories. However, considering the large bread consumption in the Netherlands and other Western countries, the findings of this study can guide future research on diet-related health inequalities and inform policymakers in setting health-promoting policies. Future research should explore the impact of FOP labels across a broader range of product categories and within diverse demographic groups to further validate and extend these findings.

4

Chapter 4
Identifying the effect of Nutri-Scores and in-store shelf communication on the healthfulness of dairy supermarket sales

This chapter is submitted as:

Schruff-Lim, E. M., Van Loo, E. J., & van Trijp, H. C. M. (2024). Identifying the effect of Nutri-Scores and in-store shelf communication on the healthfulness of dairy supermarket sales.

Abstract

The Nutri-Score FOP labelling system is endorsed in many countries across Europe. However, evidence demonstrating the effectiveness of Nutri-Scores in real-world settings remains limited. It has further been suggested that public education campaigns should accompany the introduction of nutrition labels. This study capitalized on a natural field experiment in 100 discounter supermarkets in the Netherlands to examine to which extent the Nutri-Score labelling system and in-store communication through shelf signage (none, neutral, transparency, motivating, combined) improve the healthfulness of dairy supermarket sales. The transparency message highlighted the ease of identifying the product's healthfulness with Nutri-Scores, while the motivating message included a call to action. The key outcome measure was the weight sold of a given product in a given store in a given week. Results showed that the effect of introducing Nutri-Scores differs across dairy product categories. While Nutri-Scores had a positive effect on the nutritional quality of milk/cream and butter/margarine sales, Nutri-Scores had no effect on the nutritional quality of yoghurt/quark sales and even a negative effect on the nutritional quality of dairy desserts. The shelf signage unexpectedly led to negative effects on the sales of yoghurts/quarks and desserts with Nutri-Score A/B.

Introduction

Obesity and nutrition-related noncommunicable diseases remain an issue in countries around the world, causing not only severe consequences for individuals but also for economies and public health (Ng et al., 2014; World Health Organization, 2021). FOP nutrition labelling has been repeatedly recommended by the World Health Organization as part of a broader strategy to improve population diets (European Commission, 2020b). FOP nutrition labels provide individuals with at-a-glance nutrition information in a simpler and more user-friendly format compared to the mandatory nutrition information on the back-of-pack (Kanter, Vanderlee, & Vandevijvere, 2018). In Europe, many countries have endorsed the FOP nutrition label Nutri-Score (Storcksdieck genannt Bonsmann et al., 2020). The Nutri-Score system summarizes the nutritional content into an overall score which is then used to categorize foods into five distinct levels of healthfulness (Julia & Hercberg, 2017). So far, evidence on the effect of FOP nutrition labels in real-world supermarket settings is limited, especially for newer label designs such as the Nutri-Score (Nohlen et al., 2022; Roberto et al., 2021). Understanding how these labels influence consumer behaviour in actual shopping environments is crucial for assessing their potential public health impact.

To address this knowledge gap, this study utilized a natural experiment at a Dutch discounter supermarket. The supermarket gradually introduced Nutri-Scores on products in the dairy assortment, providing a unique opportunity to examine the effect of Nutri-Scores on the nutritional quality of supermarket sales. Specifically, we assessed the effect of Nutri-Scores across four subcategories in the dairy assortment. In a second phase, stores were randomized to one of five in-store shelf communication conditions. The shelf communication explained the Nutri-Score system and was, in some conditions, combined with transparency or motivational messages. This experimental design allowed us to explore the relative effectiveness of different communication strategies in enhancing the impact of Nutri-Scores on consumer choices.

Theoretical background

FOP nutrition labels

Since the nutritional content of a food product is not directly observable (i.e. credence quality attribute), nutrition information needs to be explicitly communicated to reduce information asymmetry between manufacturers and individuals (van Trijp, 2009; Verbeke, 2005). However, the mandatory nutrition information in form of the nutrition facts panel has been shown to be poorly understood (Campos, Doxey, & Hammond, 2011; Cowburn & Stockley, 2005). FOP nutrition labels simplify complex nutritional information into easily understandable formats and are designed to improve the salience, understanding, and use of nutrition information (FDA, 2010). Consumers generally appreciate the provision of FOP nutrition labels, especially those featuring a coloured and directive design (Nohlen et al., 2022). FOP nutrition labels have been shown to help consumers identify healthier options (Ikonen et al., 2020). Nutri-Scores are especially useful in improving understanding of nutrition information for individuals with no nutritional knowledge (Ducrot et al., 2015). To which extent consumers act upon this knowledge in their food choices is still unclear as the majority of the evidence is restricted to laboratory settings (Nohlen et al., 2022; Roberto et al., 2021).

Education campaigns

For nutrition labels to be able to influence dietary choices, individuals must not only understand the information, but also be willing and have the opportunity to use it to make healthier choices (Grunert, Wills, & Fernández-Celemín, 2010; Storcksdieck genannt Bonsmann et al., 2020). To achieve this, complementary interventions can target barriers that may prevent individuals from processing and acting upon nutrition labels (hereafter called *label+ interventions*) (Schruff-Lim et al., 2023). Past research has called for public education campaigns that support the introduction of nutrition labels to achieve optimal effectiveness (Nohlen et al., 2022; Roberto et al., 2021). Public education campaigns intend to influence specific outcomes in a relatively large number of individuals through an organized set of communication activities with the aim to improve their personal and societal welfare (Weiss & Tschirhart, 1994). Although typically created by government or non-governmental organizations (e.g. World Health Organization), education campaigns can also be initiated by for-profit corporations as long as the campaigns do not directly promote products or services (i.e. revenue-raising strategies). Such campaigns have been used to influence awareness, knowledge, attitude, intention, and behaviour across multiple domains, such as risk of smoking (Colston et al., 2021), sugary drinks (Boles et al., 2014), and antibiotics (Huttner et al., 2010). Supporting nutrition labels with education signage that explain the nutrition labels has shown to improve visual attention (Graham, Heidrick, & Hodgin, 2015), awareness (Julia et al., 2016; Mora-Garcia, Tobar, & Young, 2019), and understanding of nutrition labels compared to solely providing nutrition labels (Julia et al., 2016). However, no robust evidence has been found for the effectiveness of nutrition label+ educational material in improving dietary choices (Schruff-Lim et al., 2023). Some studies reported positive effects (Hobin et al., 2017; Julia et al., 2021; Montagni et al., 2020; Olstad et al., 2015; Sutherland, Kaley, & Fischer, 2010; Thorndike et al., 2012) while others reported mixed (Dubois et al., 2021; Graham et al., 2017; Julia et al., 2016; Rodgers et al., 1994; Vyth et al., 2011), or no effect on dietary choices (Hoenink et al., 2021; Roy & Alassadi, 2021; Sacks et al., 2011; Sproul, Canter, & Schmidt, 2003). Two limitations in evaluating the effectiveness of nutrition label+ education campaigns in field experiments are not testing campaigns separately from the introduction of nutrition labels and the lack of detail about the campaigns (e.g. message, source, channel). As such, it is difficult to differentiate between different education campaigns and identify specific success factors that contribute to their effectiveness (Schruff-Lim et al., 2023). Consequently, research on the design of education campaigns that support nutrition labels is needed (Roberto et al., 2021; Schruff-Lim et al., 2023).

Methods

Study design

This study used a controlled pretest-posttest design to evaluate the impact of two interventions on the nutritional quality of dairy sales (see Figure 4.1). First, a discounter supermarket chain in the Netherlands gradually introduced the FOP nutrition label Nutri-Score in the dairy assortment (n = 83 products) across all their stores. For this first intervention a control group was unavailable as the new packaging with Nutri-Scores was rolled out at the same time across all stores. In order to control for seasonality, the sales from the same stores of the same time period in the previous year were used as the control group (following the approach from Sim et al., 2022). Second, educational signage with varying messages about the Nutri-Score label were added on the shelves in stores (n = 100). The stores were randomized to one of four signage conditions (neutral, transparency, motivating, combined). However, as some of these stores (n = 15) failed to receive the in-store signage, it was decided to assign these stores as no-signage control stores.

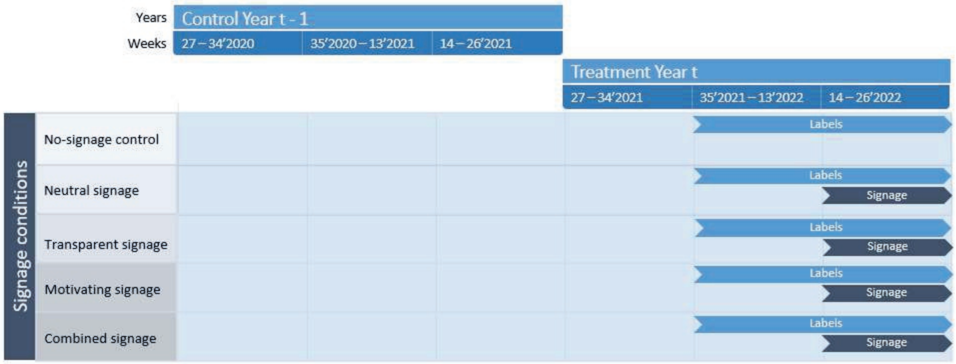

Figure 4.1. Study design.

Figure 4.2. Example of Nutri-Scores and shelf signage.

Description of the FOP nutrition labels

The Nutri-Score is an interpretative nutrition label that summarizes the nutritional content of a product into five levels (ranging from A healthiest to E least healthy) based on a single summary nutritional score. It is adapted from the nutrient profiling system of the UK Food Standards Agency (henceforth FSA score, Julia & Hercberg, 2017; Rayner, Scarborough, & Lobstein, 2009). The FSA score ranges between -15 to 40, with lower scores indicating better overall nutritional quality per 100g. The score is calculated by deducting points for positive nutrients (e.g. fibre, protein, and fruit/vegetable content) from the points for negative nutrients (e.g. energy, salt, sugar, and saturated fat). Most products in the dairy assortment had a Nutri-Score A (28%) or C (29%), followed by Nutri-Score B (22%), D (14%), and E (7%). The weight of products differed across Nutri-Score levels ($p < .001$), with A products being the largest (e.g. milk) and E products being the smallest (e.g. desserts).

From calendar week 35 of 2021 (September), the supermarket chain gradually introduced Nutri-Score labels on the FOP for the products in the dairy category ($n = 83$ products) (see Figure 4.3). However, since the packaging of the old products were replaced after using all existing inventory, the introduction was slower than planned. Most products were labelled in calendar week 1 to 9 of 2022 (January to March). From this point, 61% of the products ($n = 51/83$) were labelled. By the introduction of the in-store signage in calendar week 14 of 2022 (April 4) not all products were labelled yet. Some products were labelled only in the week before the signage period ($n = 8/83$), during the signage period ($n = 12/83$), or not at all during the study ($n = 12/83$), consequently not providing data for the effect of Nutri-Scores.

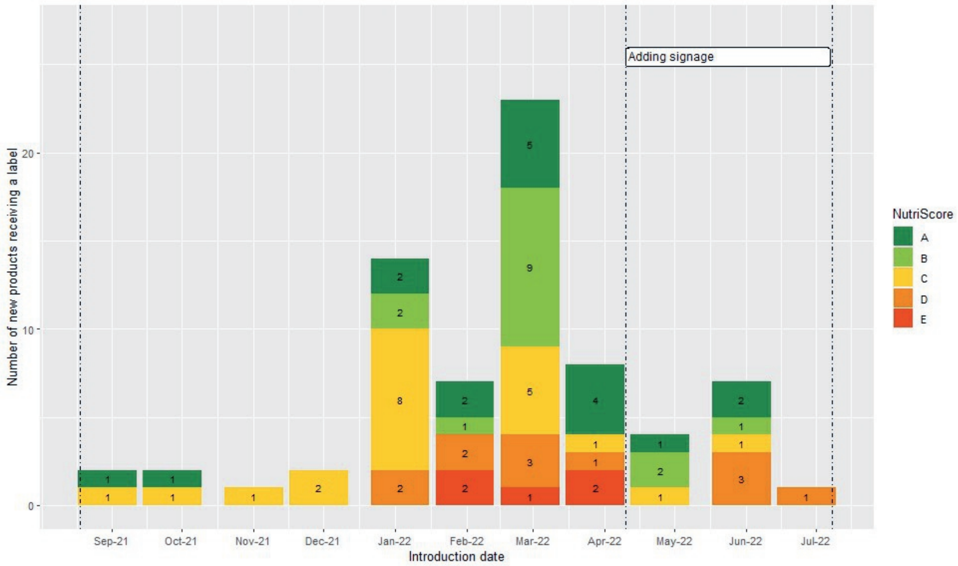

Figure 4.3. Monthly distribution of new products labelled with Nutri-Score.

Description of the in-store shelf signage

From calendar week 14 of 2022 (April 4), educational shelf signage with varying messages were added in the stores according to the stores' condition (see Figure 4.4 and Table 4.1). The neutral signage showcased the Nutri-Score and visually explained that A indicates most healthy and E indicates least healthy. Depending on the condition, a transparency and/or motivating message was added based on the two-step theoretical framework by Schruff-Lim et al. (2023). Transparency of nutrition information can be achieved when information is visible and understandable (step 1). The information becomes actionable when it gives cause for action (step 2). In line with this, the transparency message highlighted the ease of identifying the product's healthfulness ("Clear at a glance: more and less healthy products"), while the motivating message included a call to action ("Couldn't be easier. Choose also healthier with Nutri-Score").

Figure 4.4. In-store signage for the combined message condition in Dutch
Note. Dutch translations: "Most healthy products": "Meest gezonde producten"; "Least healthy products": "Minst gezonde producten"; "Clear at a glance: more and less healthy products": "In één oogopslag helder: meer en minder gezonde producten";" Couldn't be easier. Choose also healthier with Nutri-Score": "Makkelijker kan haast niet. Kies ook gezonder met Nutri-Score!"

Table 4.1. Overview of the in-store signage conditions

Condition	**Messages on the signage**		
	"Most healthy products … Least healthy products"	"Clear at a glance: more and less healthy products"	"Couldn't be easier. Choose also healthier with Nutri-Score"
No-signage Control			
Neutral	X		
Transparency	X	X	
Motivating	X		X
Combined	X	X	X

Selection of the stores

The stores were selected and randomized to one of the four in-store signage conditions by the supermarket chain. The supermarket chain confirmed that the stores were comparable across conditions in their assortment, pricing, weekly total sales, and the number of receipts per week. In addition, we matched the postcode of the selected stores with public data about the SES status of the area (CBS, 2022) and number of households (CBS, 2019). There were no significant differences between conditions in the SES status of the area, the number of households in the area, nor the total dairy sales before randomization to in-store signage conditions (Table 4.2; $p > .05$).

Table 4.2. Overview of the included stores (total n =100)

	Control (n=15)	**Neutral (n=20)**	**Transparency (n=23)**	**Motivating (n=21)**	**Combined (n=21)**	**p**[1]
SES Score 2019	-0.16 (0.25)	-0.07 (0.16)	-0.09 (0.25)	-0.11 (0.27)	-0.12 (0.24)	.879
Number of Households 2017	3807 (1352)	3675 (1499)	3826 (1395)	3952 (1362)	3738 (1131)	.974
Mean dairy weight sold per week in baseline	44919 (15250)	56556 (17638)	49314 (13505)	50657 (17442)	47690 (12828)	.223

Note: Values represent means (standard deviations in parentheses). [1] One-way ANOVA.

Description of the data received from the supermarket chain

Weekly sales data for each stock-keeping unit (SKU) in the dairy category (n = 83) was shared for each selected store (n = 100) for the whole study period (105 weeks, ranging from week 27, 2020 to week 26, 2022). Furthermore, information about each product (e.g. nutrition information, timing of the Nutri-Score addition) and presence of price promotions was provided. Based on the retailer categorization, the dairy category consisted of five subcategories: milk and cream, yoghurt and quark, desserts, and butter and margarine.

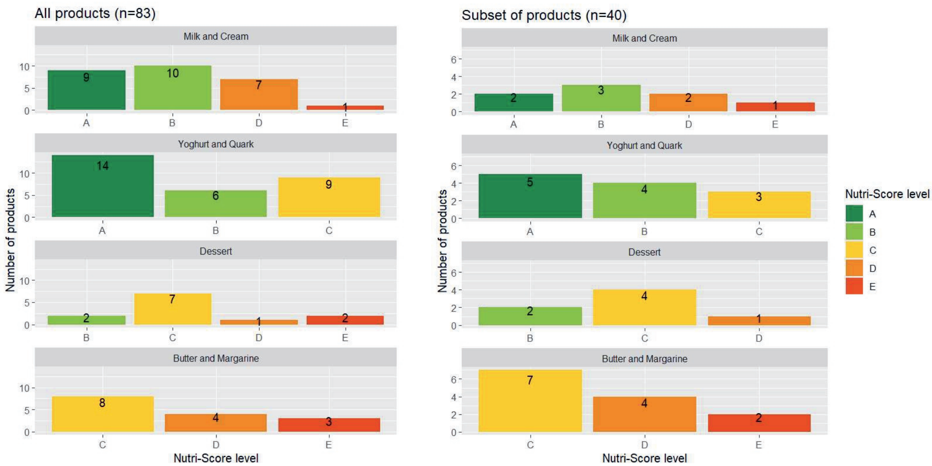

Figure 4.5. Distribution of products by Nutri-Score level across product categories.

Some SKUs (n = 29/83) had multiple taste variants (e.g. taste variants Strawberry and Honey for Yoghurt). Since multiple taste variants were delivered in a single carton tray, the retailer listed them under a single SKU. As a result, this practice made it impossible to distinguish sales between the different taste variants. This created problems in a number of ways. Firstly, taste variants differed in nutritional quality for some SKUs (n = 9 SKUs with different FSA score, n = 3 SKUs with different FSA score and different Nutri-Scores). For these SKUs it was impossible to interpret the health impact of a change in sales. Secondly, some taste variants of an SKU were labelled at different time points or only some taste variants of an SKU were labelled (n = 14 SKUs). Partial labelling influences the intervention strength and hence the power to detect an effect. Thirdly, it was reported that for some SKUs a taste variant was discontinued during the study period (n = 8 SKUs). As changes in the variety of taste variants likely influence the sales of the product, it confounds the true effect of the interventions. As a result, the effect of the interventions is estimated on a subset of SKUs that is not affected by these issues and were labelled before the in-store signage was introduced (n = 40 SKUs). The products excluded did not differ from the products included in analysis in terms of product weight, mean FSA, nor Nutri-Scores (Table 4.3, p > .05). However, excluded products had more taste variants and differed in product category (p < .001). For a robustness check, the effect is also estimated including all 83 products (see Appendix 6-15) and any differences are discussed.

Table 4.3. Descriptive statistics of the dairy assortment

	Included products (n = 40)	**Excluded products (n = 43)**	**All products (n = 83)**	**p**
Mean product weight[1]	614.38 (334.92)	692.93 (417.67)	655.07 (379.81)	.346
Mean FSA[1]	6.15 (7.18)	3.81 (6.58)	4.94 (6.93)	.126
Mean number of taste variants[1]	1.08 (0.35)	2.28 (1.86)	1.70 (1.48)	**< .001**
Nutri-Scores[2]				.352
A	7 (17.50)	16 (37.21)	23 (27.71)	
B	9 (22.50)	9 (20.93)	18 (21.69)	
C	14 (35.00)	10 (23.26)	24 (28.92)	
D	7 (17.50)	5 (11.63)	12 (14.46)	
E	3 (7.50)	9 (6.98)	6 (7.23)	
Categories[2]				**.002**
Milk/cream	8 (20.00)	22 (51.16)	30 (36.14)	
Yoghurt/quark	12 (30.00)	14 (32.56)	26 (31.33)	
Butter/margarine	13 (32.50)	2 (4.65)	15 (18.07)	
Dessert	7 (17.50)	5 (11.63)	12 (14.46)	

Note: [1] M (SD). Two-Sample t-test. [2] n (%). Fisher-Freeman-Halton exact test.

Outcome measures

A detailed description of the relevant variables can be found in Table 4.4. The outcome of interest in this study is how the interventions affect the nutritional quality of supermarket sales. Following earlier studies (Maesen et al., 2021; Nikolova & Inman, 2015), this was measured with the volume sales (quantity in grams) of a product sold in a given store in a given week. The dependent variable was log-transformed to reduce skewness of the data.

Table 4.4. Detailed description of the variables of interest

Variable	Description
Weight sold	Indicates the weight sold in grams of a given product *j* sold in a given store *i* in a given week *t*
Nutri-Score level	Categorical variable with two levels: A/B and C/D/E
Product category	Categorical variable with four levels: milk/cream, yoghurt/quark, dessert, butter/margarine
Intervention 1: introducing Nutri-Scores	
Year	Step dummy that takes the value of 1 for the treatment year (CW 27'2021 – 26'2022) and 0 for the control year (CW 27'2020 – 26'2021)
Nutri-Score presence	Step dummy that takes the value of 1 from the week onwards that the Nutri-Score is added to a given product, and 0 otherwise (Nikolova & Inman, 2015). The weeks in the control year are coded analogous to the treatment year even though no label was present.
Year x Nutri-Score presence	DiD estimate = effect of adding Nutri-Score labels
Intervention 2: adding educational signage	
Signage condition	Categorical variable with five levels: no-signage control, neutral, transparency and/or motivating message
Signage presence	Step dummy that takes the value of 1 for when the signage is present (CW 14'2022 – 26'2022) and 0 otherwise (CW 9'2022 – 13'2022)
Signage condition x Signage presence	DiD estimate = effect of adding in-store signage
Control variables	
Product discounted	Step dummy that indicates whether a given product was discounted during a given week (1 = yes, 0 = no)
Multiple taste variants	Step dummy that indicates whether a given product has multiple taste variants (1 = yes, 0 = no)
Product weight	Weight of a given product in grams

Note: CW = calendar week, DiD = Difference-in-difference

Data analysis

To examine the effect of the interventions on the weight sold, a difference-in-difference analysis was used. A difference-in-difference analysis is commonly used in controlled pretest-posttest study designs in which researchers do not have influence on the randomization (Wing, Simon, & Bello-Gomez, 2018).

To estimate the effect of introducing Nutri-Scores, no control stores were available as Nutri-Scores were rolled out across all stores at the same time. Therefore the sales from the same stores of the same time period in the previous year were used as the control group to control for seasonality (following the approach from Sim et al., 2022). The change in weight sold between the weeks without and with Nutri-Score in the treatment year is compared to the change between the same weeks in the control year for each product. Hence, the effect of Nutri-Scores is expressed as the interaction between year (2: treatment year vs. control year) and Nutri-Score presence (2: yes vs. no). Since products were labelled at different time points, the presence of the Nutri-Score label is captured by a dummy that indicates whether a given product was labelled during a given week (1 = yes, 0 = no). In the treatment year, the dummy equals 1 from the week that the label was added to a specific product in the treatment year and 0 in the weeks before. To enable a difference-in-difference analysis, the weeks in the control year were coded the same as the weeks in the treatment year even though no label was added.

To estimate the effect of adding educational in-store signage, the availability of no-signage control stores within the same treatment year offered a direct counterfactual for the treated signage stores, thus eliminating the need for a control year comparison. The change in weight sold between the weeks without and with signage in the treated signage stores is compared to the change between the same time period in the no-signage control stores. Hence, the effect of adding signage is expressed as the interaction between group (5: 4 signage conditions vs. no signage control condition) and signage presence (2: yes vs. no). The signage condition of a given store is indicated by a categorical variable with five levels (no-signage control, neutral, transparency and/or motivating message), using the no-signage control condition as a reference level. The presence of signage materials in the store is indicated with a dummy that takes the value of 1 for when the signage is present (calendar week 14'2022 – 26'2022) and 0 for the preceding five weeks during which the included products were labelled (calendar week 9'2022 – 13'2022).

To account for the cross-sectional and the time series dimension in the data, linear panel data models were estimated in R (Version 4.3.3) with the plm package (Croissant & Millo, 2008). The Hausman test indicated that the individual errors are not correlated with the independent variables and hence a random effect model is preferred over a fixed effect model (Hausman, 1978). Random effect models account for the unobserved time-constant differences that exist between product-store combinations (e.g. store location, store layout). Since the diagnostic checks (Croissant & Millo, 2008) indicated presence of heteroskedasticity and serial correlation, heteroskedasticity and autocorrelation consistent (HAC) estimations of the standard errors were used (Zeileis, 2004). Separate models were used to estimate the average treatment effect of the interventions for healthier (Nutri-Score A/B) and less healthier products (Nutri-Score C/D/E) in each product category. Control variables for discounts, multiple taste variants, and product weight were included in the models.

This study was exempt from ethical review and approval as it utilized anonymized, store-level data collected by the supermarket chain. Power analyses were not conducted since the supermarket chain chose the number of stores to roll out the interventions.

Results

Effect of intervention 1: Introducing Nutri-Scores

Results from the random effect regression models can be found in Table 4.5 and in Appendix 6-7. The introduction of Nutri-Score improved the nutritional quality of sales in the milk and cream category. For products with Nutri-Score A/B, the average weight sold increased between weeks without and with Nutri-Score in the treatment year ($b = 0.087$, $p < .001$), whereas it did not change between the same weeks in the control year ($b = 0.007$, $p = .461$). As a result, an increase of 8.33% in weight of products with Nutri-Score A/B can be attributed to the introduction of Nutri-Scores ($b = 0.08$, $p < .001$). For products with Nutri-Score C/D/E the average weight sold decreased between weeks without and with Nutri-Score in the treatment year ($b = -0.049$, $p < .001$), whereas it increased between the same weeks in the control year ($b = 0.03$, $p < .001$). As a result, a decrease of 7.6% in weight of products with Nutri-Score C/D/E can be attributed to the introduction of Nutri-Scores ($b = -0.079$, $p < .001$). Based on the categorization from the retailer, products with Nutri-Score A/B in this category are milk drinks, while products with Nutri-Score C/D/E are creams and alternatives. Therefore we further explored whether there is a shift from B to A products (see Appendix 14). Since the products with Nutri-Score C/D/E all had a Nutri-Score D with the exception of one product, we did not conduct further explorative analysis for these products. Results from the random effect regression models indicate that the effect of Nutri-Scores is positive for both, but the effect of Nutri-Scores is larger for milk drinks with Nutri-Score A than for milk drinks with Nutri-Score B ($b_{\text{Nutri-Score A}} = 0.158 > b_{\text{Nutri-Score B}} = 0.034$, $p < .001$).

The introduction of Nutri-Score did not change the nutritional quality of sales in the yoghurt and quark category. The average weight sold increased between weeks without and with Nutri-Score in the same extent in both years for products with Nutri-Score A/B ($b_{\text{Control}} = 0.023$, $b_{\text{Treatment}} = 0.017$, both $p < .001$, $p_{\text{Difference}} > .05$[5]) and products with Nutri-Score C/D/E ($b_{\text{Control}} = 0.081$, $b_{\text{Treatment}} = 0.075$, both $p < .001$, $p_{\text{Difference}} > .05$).

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[5] When including all A/B yoghurt products ($n = 20$), the effect of Nutri-Score is estimated to lead to a 8.2% increase in average weight sold ($b = 0.079$, $p < .001$).

The introduction of Nutri-Score decreased the nutritional quality of sales in the dessert category. For desserts with Nutri-Score A/B the average weight sold did not change between weeks without and with Nutri-Score in the treatment year ($b = 0.014$, $p = .135$), whereas it increased between the same weeks in the control year ($b = 0.071$, $p < .001$). As a result, a decrease of 8.15% in weight of desserts with Nutri-Score A/B can be attributed to the introduction of Nutri-Scores ($b = -0.085$, $p < .001$). For desserts with Nutri-Score C/D/E the average weight sold increased more between weeks without and with Nutri-Score in the treatment year compared the same weeks in the control year ($b_{Control} = 0.071$, $b_{Treatment} = 0.099$, both $p < .001$). As a result, an increase of 2.84% in weight of desserts with Nutri-Score C/D/E can be attributed to the introduction of Nutri-Scores ($b = 0.028$, $p < .001$).

The introduction of Nutri-Score improved the nutritional quality of sales in the butter and margarine category. For products with Nutri-Score C/D/E the average weight sold decreased between weeks without and with Nutri-Score in the treatment year ($b = -0.051$, $p < .001$), whereas it increased between the same weeks in the control year ($b = 0.01$, $p = .022$). As a result, a decrease of 5.92% in weight of products with Nutri-Score C/D/E can be attributed to the introduction of Nutri-Scores ($b = 0.062$, $p < .001$). Since no healthier products with Nutri-Score A/B existed in the butter and margarine category, we further explored whether there was a shift from D/E to C products (see Appendix 15). The negative effect of Nutri-Scores is the same for products with Nutri-Score C and with Nutri-Score D/E ($b_{Nutri\text{-}Score\ C} = -0.062 > b_{Nutri\text{-}Score\ D/E} = -0.074$, $p = .44$).

Table 4.5. Impact of Nutri-Score on product weight sold (log-transformed)

	All categories		**Milk / Cream**		**Yoghurt / Quark**		**Dessert**		**Butter / Margarine**	
	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
A/B products	**0.023**	**0.008**	**0.080**	**0.014**	-0.006	0.009	**-0.085**	**0.019**	No products	
R^2	*0.041*		*0.031*		*0.060*		*0.119*			
N	*125,653*		*39,063*		*70,858*		*15,732*			
C/D/E products	**-0.037**	**0.005**	**-0.079**	**0.012**	-0.006	0.018	**0.028**	**0.010**	**-0.062**	**0.008**
R^2	*0.026*		*0.007*		*0.026*		*0.054*		*0.033*	
N	*185,106*		*23,602*		*23,532*		*39,373*		*98,599*	

Note: Difference-in-difference estimator are shown (i.e. interaction between Year and Nutri-Score presence). Bold estimators are significant with $p < .05$.

Chapter 4

Effect of intervention 2: Adding in-store educational signage

Results from the random effect regression models can be found in Table 4.6 and in Appendix 10-11. For milk and cream products, adding signage did not have an effect on the product sales. For yoghurts and quarks with Nutri-Score A/B, the transparency signage had a negative effect on the average weight sold compared to the change in the control condition during the same time period ($p = .016$), but not on the average weight sold of yoghurts and quarks with Nutri-Score C/D/E ($p > .05$). When including all products in the analysis, all signage except for the neutral signage had a negative effect on the average weight sold of yoghurts and quarks with Nutri-Score A/B (see Appendix 12). All signage conditions had a negative effect on the average weight sold of desserts with Nutri-Score A/B compared to the change in the control condition during the same time period ($p < .01$, $p = .054$ for the neutral signage), but not on the average weight sold of desserts with Nutri-Score C/D/E ($p > .05$). Adding signage did not have an effect on the product sales of the butter and margarine category ($p > .05$).

Table 4.6. Impact of in-store signage on mean FSA (log-transformed), adjusted for SES score of the area and presence of discounts

	All categories		**Milk / Cream**		**Yoghurt / Quark**		**Dessert**		**Butter / Margarine**	
	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
A/B										
Neutral	-0.012	0.017	0.024	0.030	-0.014	0.023	-0.090	0.047*		
Transpar.	**-0.054**	**0.017**	-0.021	0.031	**-0.052**	**0.022**	**-0.140**	**0.043**		
Motiv.	**-0.034**	**0.017**	0.014	0.030	-0.041	0.022	**-0.112**	**0.044**		
Combined	-0.022	0.017	0.008	0.031	-0.016	0.021	**-0.118**	**0.043**		
R^2	*0.037*		*0.097*		*0.045*		*0.033*			
N	*28412*		*8919*		*15905*		*3588*			
C/D/E										
Neutral	0.013	0.021	-0.005	0.049	0.040	0.045	0.023	0.027	0.001	0.044
Transpar.	-0.012	0.020	-0.003	0.044	-0.010	0.042	-0.033	0.026	0.000	0.039
Motiv.	-0.026	0.020	-0.014	0.043	-0.045	0.046	-0.022	0.025	-0.024	0.041
Combined	-0.015	0.020	0.007	0.043	-0.040	0.041	-0.010	0.024	-0.019	0.042
R^2	*0.347*		*0.057*		*0.036*		*0.170*		*0.470*	
N	*30379*		*5253*		*5392*		*8973*		*10761*	

Note: Difference-in-difference estimator are shown (i.e. interaction between Signage condition and Signage presence). Bold estimators are significant with p < .05. * Marginally significant with p = .054.

Discussion

Overview of findings

Real-world evidence on the effect of Nutri-Scores on actual food purchases in supermarkets is still scarce due to the relative newness of the FOP nutrition label. The present study examined the effect of introducing the FOP nutrition label Nutri-Score and educational shelf signage with varying messages on the nutritional quality of dairy sales of 100 supermarkets. Across the whole dairy category, the results indicate that the introduction of Nutri-Scores led to a 2.33% increase in weight sold for products with Nutri-Score A/B and a 3.63% decrease in weight sold for products with Nutri-Score C/D/E across the whole dairy category. Our field study is the first to show that Nutri-Scores do not only have a positive effect on the sales of healthier products, but can also lead to a negative effect on the sales of less healthy products. Vandevijvere and Berger (2021) investigated the effect of Nutri-Score shelf labels on the nutritional quality of store-level sales in 58 product categories in 57 supermarkets. In their study, the effect of Nutri-Scores had a positive impact on the share of total food sales for products with Nutri-Score B and C (0.11%, -0.06% respectively), but also increased the share of total food sales for products with D (0.12%). Similarly, Dubois et al. (2021) investigated the effect of four FOP nutrition labels (SENS, Nutri-Score, Nutri-Repère, Nutri-Couleur) on the nutritional quality of individual-level purchases in four product categories (fresh prepared foods, pastries, breads, and canned prepared foods) in 60 supermarkets. In their study Nutri-Score increased the purchases of the healthier products by 14%, but did not change the purchases of medium, less healthy, and unlabelled products.

In line with other FOP labelling studies, our results indicate that the effect of FOP nutrition labels varies across product categories. While Nutri-Scores had a positive effect on the nutritional quality of sales in the milk/cream and in the butter/margarine category, Nutri-Scores did not have any effect of yoghurts/quarks. Vandevijvere and Berger (2021) observed a shift in yoghurt sales from products with Nutri-Score E to D, however the category also contained soft white cheeses and desserts. One possible explanation for the lack of effect in the yoghurt/quark category in this study may be the low variability of Nutri-Scores in this category (ranging from Nutri-Score A to C). Findings from previous research suggest that the effectiveness of Nutri-Scores improves with increasing variability of nutritional quality within a product category (Dubois et al., 2021). Consumers tend to react more strongly to extreme values of nutrition labels (Crosetto et al., 2020). Based on the health belief model (Janz & Becker, 1984), the likelihood of switching to a healthier alternative is influenced by the perceived severity of making a food choice with Nutri-Score C and the perceived benefit of switching to a healthier alternative. Additionally, dissonance theory suggests that consumers are motivated to change their behaviour when they perceive a discrepancy between their actions (food choice) and goals (health) (Harmon-Jones & Mills, 2019), which is likely stronger for food choices with extreme negative nutrition values. Future research should explore whether extreme values of nutrition labels influence perceived severity and whether a larger health gain positively affects the perceived benefit of switching to a healthier alternative.

In the present study, the introduction of Nutri-Score labels backfired in the dairy dessert category, leading to a decrease of healthier and increase of less healthy product sales. In line with this, Vandevijvere and Berger (2021) observed unfavourable effects for the categories ice-cream/frozen desserts, cakes/pastries, and sweet biscuits. Consumers have expressed reservations for FOP nutrition labels on indulgence products (Grunert & Wills, 2007). One possible explanation for these results is that Nutri-Scores may trigger consumers' unhealthy = tasty intuition (Raghunathan, Naylor, & Hoyer, 2006). Consumers' unhealthy = tasty intuition may be more pronounced in indulgence product categories. Supporting this, previous research has demonstrated that labelling chips as lower in fat can negatively affect their perceived tastiness (Bialkova, Sasse, & Fenko, 2016), while no effect of Nutri-Scores on tastiness was found for ready-to-eat meals (De Temmerman et al., 2021). However, in the latter study Nutri-Scores only ranged from A to C which might also explain non-significant differences in tastiness. In indulgence categories, consumers may experience dissonance from conflicting goals of wanting to indulge and wanting to make healthy choices. As a result consumers may avoid nutrition information or justify unhealthy food choices to reduce dissonance (Harmon-Jones & Mills, 2019). Consumers generally weigh short-term consequences, such as taste, more than long-term consequences, such as health (Fagerstrøm et al., 2019). Future research should explore whether only labelling less healthy products is more effective in this category. Which inferences and choices do consumers make if only less healthy products are labelled and healthier products are not labelled? Do consumers choose the products with unknown nutritional quality to avoid feelings of dissonance or does partial labelling of less healthy products shape consumers' perceptions that unhealthy choices are normal?

Based on the current evidence, it seems that Nutri-Scores can lead to small improvements in some product categories, but further strategies may be necessary to achieve larger and more widespread changes in consumer behaviour. In the present study, the introduction of educational shelf signage unexpectedly led to adverse effects on the sales of yoghurts/quarks and desserts with Nutri-Score A/B, with effect sizes even larger than for introducing Nutri-Scores. One explanation may be that the shelf signage increased attention to FOP nutrition labels as shown in the study by Graham, Heidrick, and Hodgin (2015) and hence exacerbated the negative effects of FOP nutrition labels on desserts. Comparing the findings from this study with other supermarket studies is challenging as those studies provided educational signage in stores alongside the introduction of FOP nutrition labels. One notable difference may be the perceived credibility of the educational material. While the educational signage in the present study was created by the retailer, the educational material in the study by Dubois et al. (2021) mentioned the external sponsors (French Government, National Health Care, French Fund for Food and Health) and highlighted that each labelling system was validated by a scientific committee. The endorsement by recognized and trusted entities likely enhanced the credibility of the information, potentially influencing consumer trust and behaviour more effectively. Previous research has shown that trust in the FOP nutrition label is a key driver in FOP nutrition label acceptance and effectiveness (Mazzù et al., 2022).

Implications for industry and public policy

For manufacturers, the findings of the present study underscore the importance of tailoring marketing strategies to the varying effects of Nutri-Scores across product categories. In the product categories milk/cream and butter/margarine, manufacturers benefit from highlighting the nutritional quality of healthier products, but face declining sales for less healthy products. To meet consumers' demand for healthier products in these categories, manufacturers could consider introducing healthier variants or reformulating existing less healthy products. This is particularly relevant in categories where healthier alternatives are currently unavailable (e.g. butter/margarine and cream), presenting an opportunity for manufacturers to gain a competitive advantage. Since consumers are more willing to switch towards similar healthier alternatives (Breathnach et al., 2020; Schruff-Lim et al., 2024), adoption of healthier variants is likely more effective than guiding consumers to different product categories. However, the high saturated fat content and low levels of positive nutrients inherent to these product categories poses a challenge. Additionally, reformulation of existing products will only be successful in the market if manufacturers are able to retain the sensory appeal of the original products (Forde & Decker, 2022; Mai & Hoffmann, 2015). Such potential may be substantial as one study has shown that a 10% reduction in salt did not influence the perceived taste of the pizza dough (Campo, Rosato, & Giagnacovo, 2020). In the dessert category, manufacturers do not benefit from highlighting the nutritional quality of products, likely due to existing unhealthy=tasty beliefs for indulgent product categories. Besides informing consumers about the nutritional quality of foods, traditional food marketing approaches that emphasize health-unrelated positive attributes, such as the sensory appeal, and trigger affective responses may be needed to persuade consumers to buy healthier foods (Bublitz & Peracchio, 2015; Mai & Hoffmann, 2015). Combining the FOP nutrition label with a taste claim may be successful in overcoming unhealthy=tasty beliefs (Maesen et al., 2021).

For public policy, the findings of the present study highlight that FOP nutrition labels can improve the nutritional quality of sales to a small extent but (commercial) educational campaigns about new nutrition label systems may not show the desired effects. At the time of the present study, the Nutri-Score system was new and only being piloted by few supermarkets with little public information towards consumers. Previous research suggests that educational campaigns initiated by trusted sources can improve awareness and understanding of new nutrition labels (Graham, Heidrick, & Hodgin, 2015; Julia et al., 2016;

Mora-Garcia, Tobar, & Young, 2019). The effect of Nutri-Scores may increase with wider adoptions as familiarity with the Nutri-Score label has been shown to be a predictor of making healthier choices (Schruff-Lim et al., 2024). However, both FOP nutrition labels and educational signage still place the responsibility and effort of making healthier choices on the individual (Capewell & Capewell, 2018; Reisch, Eberle, & Lorek, 2013). While educational signage may be able to increase motivation by discussing consumers' self-interest in making healthier choices (Rothschild, 1999), it is easy to ignore and requires sustained adherence to be effective. In addition, the marketing budget of food manufacturers is generally larger than that of public campaigns and often focuses on unhealthy foods, suggesting the need for public-private partnerships in shaping a healthy=tasty perception (Mai & Hoffmann, 2015) or restrictions of marketing less healthy foods (Boyland et al., 2022).

Limitations and further research

By capitalizing on a natural experiment, this study analyses real-world data from a large number of stores across the Netherlands (n = 100). The difference-in-difference approach accounts for biases caused by changes over time unrelated to the intervention (e.g. growth trends and seasonality) and those that are caused by permanent differences between non-equivalent groups when randomization is not possible (Wing, Simon, & Bello-Gomez, 2018). However, individual-level data was not available which could have provided valuable insights into how the effect differs across consumer groups. Research has shown that health-motivated consumers are searching for and using nutrition information, whereas less motivated consumers require additional interventions (Van Loo et al., 2015; Visschers et al., 2013). Furthermore, the study was restricted to one product category with multiple subcategories, limiting the generalizability of the findings. In addition, the depth of the product assortment of the discounter supermarket was small. Estimating the average treatment effect over a small number of products (e.g. n = 2 desserts with Nutri-Score A/B), increases the risk that the results may not be generalizable or may be influenced by unique characteristics specific to those few products. In some cases, no healthier alternatives were available (e.g. cream), making it impossible for consumers to switch to healthier alternatives. Consequently, it remains unclear whether consumers opted out of purchasing these products altogether or simply replaced them with other alternatives. This ambiguity complicates the assessment of the intervention's health impact. Lastly, discounter stock only few brands reducing the brand influence on product choices, limiting the generalizability of the findings. Future research should address these limitations by examining the effect of Nutri-Scores in other product categories with a wider selection of brands and products. Longitudinal studies are needed to understand the long-term effect of Nutri-Scores on consumer behaviour. Finally, qualitative research in stores could have provided insights into consumers' motivations and barriers when choosing between healthier and less healthy products, contributing to more effective health promotion strategies.

5

Chapter 5
Impact of food swap recommendations on dietary choices in an online supermarket: A randomized controlled trial

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Abstract

One novel strategy to shift food choices in digital shopping environments is to automatically recommend healthier alternatives when an unhealthy choice is made. However, this raises the question which alternative products to recommend. This study assesses 1) whether healthier food swap recommendations are effective, even though the unhealthy choice was made in the presence of visible FOP nutrition labels and 2) how the similarity of the alternatives influences the acceptance of food swap recommendations. Based on a pre-test, similarity of the recommendation was operationalized in terms of animal-based versus plant-based options. A randomized controlled trial (healthy food swap recommendation conditions: none, similar animal-based, dissimilar plant-based, or mixed animal- and plant-based) with 428 Dutch participants was conducted in a simulated online supermarket. Additional healthier food swap recommendations improved the nutritional quality of the final basket compared to only providing Nutri-Score nutrition labels (-1.7 mean FSA score, $p < .001$, medium Cohen's $d = -0.48$). Compared to the dissimilar condition, acceptance of an alternative was more likely in the mixed (odds-ratio = 2.78, $p = .015$) and in the similar condition (odds-ratio = 2.24, $p = .048$), but the nutritional quality of the final basket did not differ between treatment conditions. Individuals in treatment conditions who did not receive any recommendation (i.e. only made healthy choices) had higher Nutri-Score familiarity and general health interest than individuals who received recommendations. This suggests that for individuals with higher knowledge and motivation FOP nutrition labels were sufficient, whereas for individuals with lower knowledge and motivation additional food swap recommendations can improve dietary choices. Food swap recommendations may act as meaningful reminders by disrupting the automatic choice process and triggering individuals to rethink their (unhealthy) choice.

Introduction

Improving the nutritional quality of diets remains a challenge around the world (Swinburn et al., 2019). Assuming that individuals can be persuaded to engage in the desired behaviour if they have the right information (Olejniczak, Śliwowski, & Leeuw, 2020), public health policies long focused on providing individuals with the information needed to make informed dietary choices (Capacci et al., 2012), starting with the Nutrition Facts panel on the back of food products and recently with simpler and more prominent FOP nutrition labels (Kanter, Vanderlee, & Vandevijvere, 2018). Many European countries (e.g. France, Belgium, Spain, Germany, the Netherlands, and Luxembourg) have officially recommended the use of the nutrition label Nutri-Score (Storcksdieck genannt Bonsmann et al., 2020). The Nutri-Score is a summary interpretative FOP nutrition label that combines the nutritional content of a food into five categories from A (most healthy, also indicated by a green colour) to E (least healthy, also indicated by a red colour) (Julia & Hercberg, 2017). However, FOP nutrition labels have a very small effect on the nutritional quality of actual food choices (Dubois et al., 2021). During food choices, individuals might not notice nutrition information (i.e. lack of salience) or choose to ignore it in their choice (i.e. lack of determinance) (Myers & Alpert, 1977; van Ittersum et al., 2007) due to humans' bias for short-term benefits (van Dam & van Trijp, 2013). As such, only individuals that are motivated to eat healthy search for and use nutrition labels, while others need more support to make healthier food choices (Visschers et al., 2013). Complementary interventions are needed to target barriers that prevent individuals from processing and acting upon FOP nutrition labels (Schruff-Lim et al., 2023).

Due to increased use of digital technology during food shopping (e.g. online supermarkets, handheld barcode scanners, mobile phones), it is possible to adapt to specific consumer actions, such as unhealthy choices, and to provide additional interventions just-in-time (van der Laan & Orcholska, 2022). One example is a food swap recommendation that automatically suggests healthier alternatives whenever an unhealthy choice is made. Individuals are required to make a deliberate choice to keep their originally chosen (unhealthy) option or to replace it with a recommended (healthier) alternative (Forwood et al., 2015; Jansen, van Kleef, & Van Loo, 2021). Food swap recommendations that pop up directly after an unhealthy choice may act as meaningful reminders by disrupting the automatic choice process and triggering individuals to rethink their (unhealthy) choice (Granato, Fischer, & van Trijp, 2022).

Existing studies illustrate that offering a healthier food swap recommendation (either focused on specific separate nutrients, or on overall healthfulness) improves the nutritional content of the basket (Eyles et al., 2017; Forwood et al., 2015; Jansen, van Kleef, & Van Loo, 2021; Koutoukidis et al., 2019; Payne Riches et al., 2019; van der Laan & Orcholska, 2022). However, the proportion of accepted food swap recommendations varies widely between studies and between types of food swap recommendations, from 0-14% (Bunten et al., 2021; Koutoukidis et al., 2019) to 33-34% (Payne Riches et al., 2019). This indicates the presence of underlying factors that influence the acceptance of alternatives in food swap recommendations.

One factor influencing the acceptance rate of food swap recommendations might be the similarity of the recommended alternatives to the original choice. Consumers report that they would be more likely to accept alternatives similar to their original choice (Breathnach et al., 2020). To the best of our knowledge no previous study has directly manipulated the similarity of the recommended alternatives. However, alternatives that bring greater health gain are often less similar to the original choice as there is often more variation in nutritional quality in wider product categories (e.g. salty snacks) compared to more narrow product categories (e.g. chips, Payne Riches et al., 2019). As a result, manipulating the health gain of alternatives might in turn also manipulate their similarity to the original choice. Two previous studies (Forwood et al., 2015; Payne Riches et al., 2019) have provided insights into how health gain influences acceptance of recommendations. Forwood et al. (2015) did not manipulate health gain, but found that food swap recommendations with larger reductions in energy density resulted in lower levels of acceptance. Payne Riches et al. (2019) manipulated health gain with the low health gain alternative being from the same subcategory while the large health gain alternative was not restricted to the same subcategory. There was no difference in acceptance between a recommendation with a (similar) low health gain alternative and a recommendation with both a (similar) low health gain alternative and a (potentially dissimilar) large health gain alternative. However, in neither study perceived similarity of the recommendation was measured and hence it remains unclear to which extent similarity of the recommended alternative confounded the findings. In addition, the number of recommended alternatives differed across conditions and might have influenced the findings by Payne Riches et al. (2019). As such, the unique relationship between the similarity of the recommended alternative and its acceptance remains unclear. The aim of the present study is to examine: 1) to which extent healthier food swap recommendations increase the basket healthfulness when nutrition labels are present and 2) how and why the similarity of the alternatives to the original choice influences the basket healthfulness.

Theoretical background

Food swap recommendations, unlike other interventions, aim to influence decisions after a choice has been made, rather than before a choice is made. Research has shown that choice and (perceived) ownership influence preferences (Huang, Wang, & Shi, 2009). According to the concept of utility maximization, consumers weigh product characteristics to calculate the utility of each option in the assortment and choose the product that provides them with the highest utility (Aleskerov, Bouyssou, & Monjardet, 2007). After a choice is made, preference for the chosen option increases while preference for the rejected option decreases (Brehm, 1956). As the characteristics of the original choice are valued the most, any departure from the original choice results in a loss of utility. However, the magnitude of this loss in utility depends on the similarity of the alternative to the original choice. Similarity is defined as the extent that products share characteristics (Tversky, 1977). As dissimilar alternatives share less characteristics with the original choice, they likely lead to a larger loss in utility compared to similar alternatives (Payne Riches et al., 2019). When the dissimilarity is perceived to be too large, individuals tend to overestimate the dissimilarity and as a result are even more likely to reject the persuasion attempt or even react in the opposite direction than intended (contrast effects, Hovland, Harvey, & Sherif, 1957). Based on this, we hypothesize that the acceptance of food swap recommendations is a function of the similarity of the alternatives to the original choice.

H1: Offering healthier food swap recommendations increases basket healthfulness compared to not offering healthier food swap recommendations.

H2a: Alternatives in similar food swap recommendations are more likely to be accepted and as such improve basket healthfulness more compared to alternatives in dissimilar food swap recommendations.

We suggest as a first underlying mechanism that the difference in acceptance can be explained by individuals trading off the product characteristics of the original choice and the product characteristics of the alternative. The extent that individuals are asked to give up some original product characteristics for an increase in healthfulness is perceived to be larger for dissimilar compared to similar alternatives. Thus, dissimilar alternatives are less likely to be accepted because the perceived compromise is perceived to be larger than for similar alternatives.

A second underlying mechanism, may be that dissimilar alternatives signal stronger that one is guided in their choice. Food swap recommendations may be perceived as a threat to individuals' freedom of choice and individuals may become disengaged when being suggested only dissimilar alternatives (Breathnach et al., 2020). Perceived threat to freedom of choice is an antecedent of psychological reactance (Shen, 2015). Unsolicited advice that contradicts initial attitudes has been shown to activate psychological reactance which in turn has resulted in behavioural backlash (Fitzsimons & Lehmann, 2004). Thus, we suggest as a second mechanism that dissimilar alternatives are met with lower acceptance compared to similar alternatives because they are perceived as a larger threat to individuals' freedom of choice. The conceptual framework is depicted in Figure 5.1.

H2b: The differences between the effect of similar and dissimilar food swap recommendations on basket healthfulness is mediated by perceived compromise and perceived threat to freedom of choice.

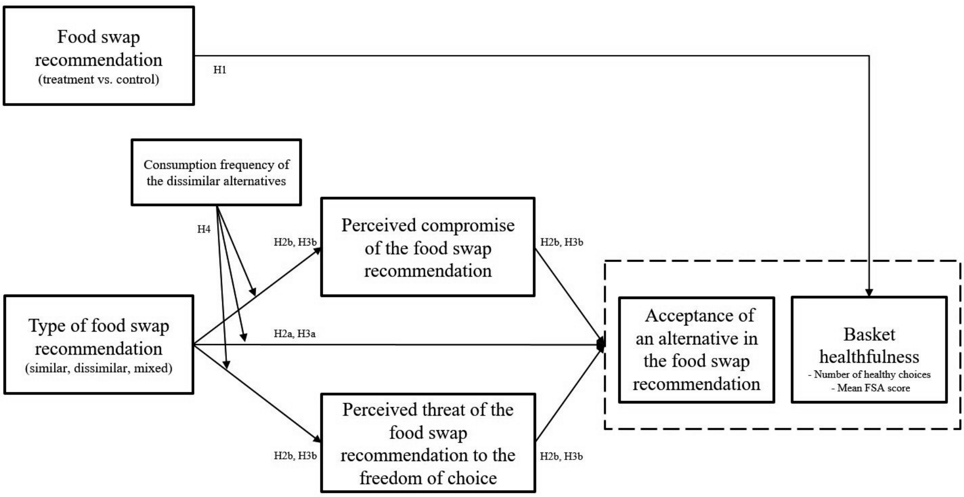

Figure 5.1. Conceptual framework.

Although similar alternatives are thus hypothesized to be more promising, we suggest that there are advantages to include dissimilar alternatives next to similar alternatives in food swap recommendations with multiple product alternatives. As preference judgments are constructed in the moment, they are dependent on the available options in the choice set

(Slovic, 1995; Tversky & Simonson, 1993). In a choice between two alternatives that are each dominant on one product characteristic individuals have to choose which product characteristic is given more value. The attraction effect (Huber, Payne, & Puto, 1982; Simonson, 1989) describes how the addition of a third, asymmetrically dominated option (i.e. the decoy) can lead consumers to change their preference between two alternatives. To be asymmetrically dominated, the decoy needs to be dominated by the target but not by the competitor. Individuals find it easier to justify the choice of the target as it is clearly dominating the decoy and as such expect less criticism (Simonson, 1989).

Inspired by the attraction effect, we suggest that adding a dissimilar alternative next to a similar alternative may render the similar alternative more attractive by comparison. Hence alternatives in mixed food swap recommendations are more likely to be accepted than alternatives in similar food swap recommendations. We further suggest that this is due to a reduced perceived compromise of the food swap recommendation. Since the addition of a decoy can increase the weight placed on the characteristic for which the target is dominant (Huber, Payne, & Puto, 1982), the perceived loss from replacing the original choice with the healthier similar alternative is perceived to be smaller in mixed food swap recommendations compared to similar food swap recommendations. In addition, we also expect increased acceptance due to a lower perceived threat to freedom of choice from mixed food swap recommendations compared to similar food swap recommendations, as the alternatives vary more and thus signal freedom of choice.

H3a: Alternatives in mixed food swap recommendations are more likely to be accepted and as such improve basket healthfulness more compared to alternatives in similar food swap recommendations.

H3b: The differences between the effect of mixed and similar food swap recommendations on basket healthfulness is mediated by perceived compromise and perceived threat to freedom of choice.

This parallel mediation model is assumed to be moderated by consumption frequency of dissimilar alternatives. Individuals who consume dissimilar alternatives more often are more likely to accept dissimilar food swaps than individuals who consume dissimilar alternatives less often due to lower perceptions of compromise and intrusiveness. As a result, the consumption frequency of the dissimilar alternative moderates the differences in effectiveness between the food swap conditions. Dissimilar food swaps are less effective compared to similar and mixed food swaps for individuals who consume dissimilar alternatives less often, whereas there is no difference in effectiveness for individuals who consume dissimilar alternatives more often. As such we hypothesize:

H4: The higher a consumer's consumption frequency of dissimilar alternatives, the smaller the differences in perceived compromise and perceived threat between dissimilar food swap recommendations on the one hand, and similar and mixed food swap recommendations on the other hand become.

Method

Study design

A 4-arm randomized controlled trial (RCT) was conducted in a simulated online supermarket using the Gorilla Shop Builder platform (see Figure 5.2). Based on a pre-test, similarity of the recommendation was operationalized in terms of animal-based versus plant-based options. Plant-based substitutes were selected as being less similar to animal-based products than animal-based alternatives across multiple product categories (see Appendix 16). The online supermarket contained 89 products in six product categories. In the three target product categories (yoghurt, meat slices, and meat), the Nutri-Score of each product was displayed below its image. Within each subcategory the Nutri-Score was the same across the healthy products (Nutri-Score A or B) and across unhealthy products (Nutri-Score C, D, or E). Each subcategory contained four unhealthy animal-based products, two healthy animal-based products, and two healthy plant-based products. Price and brand were constant in each subcategory. Prices were set at the average retail price of the products in each subcategory. The other three categories (bread, pasta, vegetables) were filler categories to conceal the study aim. Products in these categories all had a Nutri-Score A, but the Nutri-Score was not shown to avoid influence on subsequent purchasing decisions in other product categories (e.g. licensing). The study was approved by the Ethics Review Committee of of Wageningen University & Research. The preregistration and the data of this study are publicly available on the Open Science Framework project page (DOI: 10.17605/OSF.IO/T89VP).

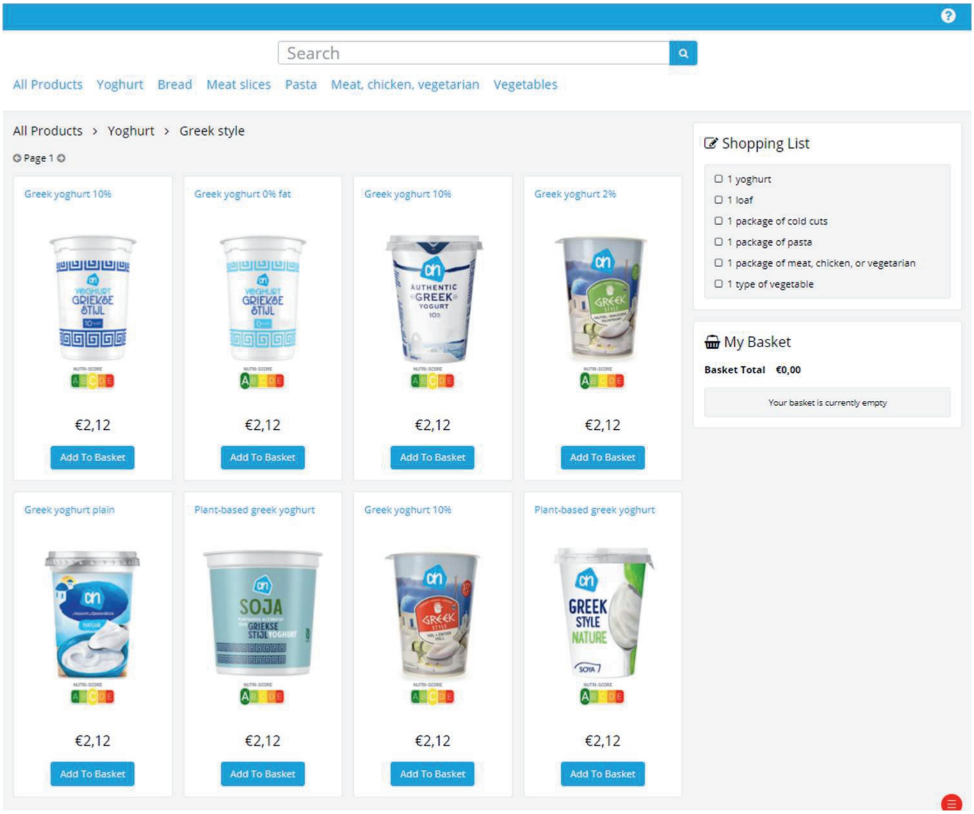

Figure 5.2. Translated screenshot of the simulated online grocery store environment
Note. Brands and prices are photoshopped.

Participant recruitment

Participants were recruited by a market research agency in January 2023 using a representative panel for the Netherlands in terms of age and gender. Dutch residents who speak Dutch, are older than 18 years, do at least some of the household grocery shopping (i.e. spend at least €25 per week on grocery shopping), and at least sometimes buy meat for themselves or their household, were recruited. Participants who did not follow the shopping instructions (i.e. buying the six products in the shopping list), did not finish the whole study, or failed an attention check, were excluded.

Procedure

Participants took part in the online study on a computer at home. Participants were broadly informed that the research is about how consumers make food choices in online supermarkets. After providing consent and answering screening questions, participants were informed about the shopping task and the online supermarket. Participants were asked to buy the six items in the shopping list, but did not have to pay for their choices, nor did they actually receive them. To reduce the hypothetical bias, participants read a paragraph instructing them to imagine doing their groceries and asking them to make realistic choices (adapted from Payne Riches et al., 2019). After the shopping task, participants answered questions measuring the mediators, moderators, and background characteristics. The full procedure can be found in Appendix 17.

Experimental conditions

Participants were randomly assigned to one of four conditions (healthy food swap recommendation: none, similar animal-based, dissimilar plant-based, or mixed animal- and plant-based) in a balanced way by the online platform. Participants in the control condition did not receive any food swap recommendation when they made an unhealthy choice (e.g. Greek yoghurt with Nutri-Score C). Participants in the three treatment conditions received food swap recommendations directly when they made an unhealthy choice (see Figure 5.3). The recommendations appeared in a pop-up window that showed the originally selected product and two healthier alternatives ('You chose this one. What about these products'). Products were displayed with their product name, image, Nutri-Score, and price. Healthier alternatives were from the same subcategory, at least one Nutri-Score level better than the original choice, from the same brand, had the same price, and were described as "a healthier alternative" (i.e. the meaning provider). Participants were asked to choose to either keep their originally chosen option ('I keep this one') or replace it with one of the healthier alternatives ('I choose this one'). Since participants were able to add and remove products from the basket during the shopping procedure, they could receive multiple food swap recommendations in each of three target categories. No food swap recommendations were provided, if participants only made healthy choices.

Similarity of the alternative to the original choice was manipulated by recommending animal- and/or plant-based alternatives. In the similar condition, the recommended alternatives were the two healthier animal-based products from the same product subcategory (e.g. two cow-milk Greek yoghurts with Nutri-Score A). In the dissimilar condition, the recommended alternatives were the two healthier plant-based products from the same product subcategory (e.g. two Soya Greek yoghurts with Nutri-Score A). In the mixed condition, the recommended alternatives included one randomly chosen healthier animal-based product and one randomly chosen healthier plant-based products from the same product subcategory (e.g.

one cow-milk Greek yoghurt with Nutri-Score A and one Soya Greek yoghurt with Nutri-Score A).

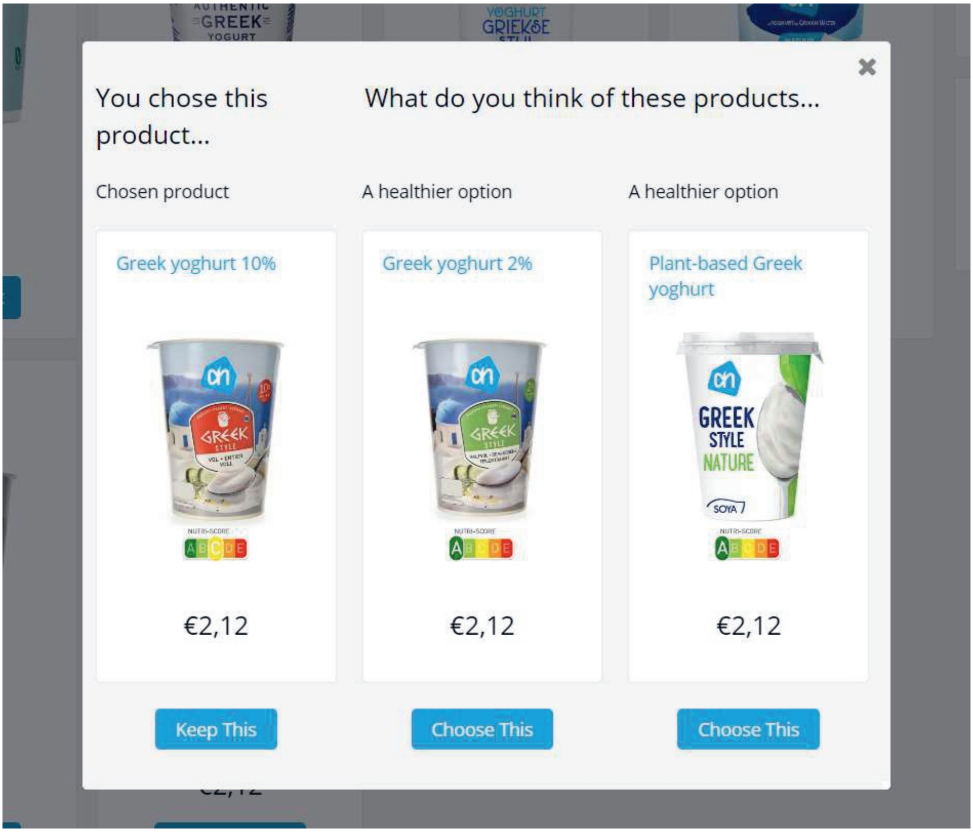

Figure 5.3. Example of a mixed food swap recommendation for the Greek yoghurt product category.
Note. Brands and prices are photoshopped.

Measures

Awareness and manipulation check: Recall of receiving food swap recommendation during the shopping task was measured with one item ('Did you receive such recommendations for alternative products during your food choices?'). Answer options included "yes", "no", and "I don't know". Perceived similarity was measured by asking to what extent individuals perceived the alternatives as similar to their original choices. The self-developed five-item scale from the pre-test was reduced to three items based on inter-item correlation and content validity. Answers to the three items were given on a 7-point rating scale ranging from 1 = "not at all" to "7 = very". Mean scores were calculated for perceived similarity (Cronbach's α =.92).

Dependent variables: The main outcome of interest is the healthfulness of the final selected basket operationalized with two measures: healthy-choice likelihood and the mean nutritional-quality score. The first one measures whether the final choice in each of the three target product category was healthy (0 = "unhealthy" and 1 = "healthy"). The second measure is the mean nutritional-quality score based on the nutrient profiling system developed by the UK Food Standards Agency (FSA), which also forms the basis for the Nutri-Score categories (Julia & Hercberg, 2017). The FSA score ranges between -15 to 40, with lower numbers indicating better overall nutritional quality per 100g. The score is calculated by deducting points for positive nutrients (e.g. fibre, protein, and fruit/vegetable content) from the points for negative nutrients (e.g. energy, salt, sugar, and saturated fat). The nutritional-quality score of the basket was calculated as the mean FSA score of the final choices in the three target categories. Both measures do not only capture the direct reaction to food swap recommendations (acceptance or rejection of the alternatives), but also possible carry-over effects on original choices in subsequent product categories. The difference between the two measures is that the number of healthy choices is insensitive to the size of the actual differences in nutritional quality (though such difference may have had an impact on the choices that the participants made), whereas the mean FSA score is sensitive to that.

Next to these two measures, the acceptance of an alternative in the food swap recommendation is used as a third measure of basket healthfulness for each recommendation received (0 = "rejected" and 1 = "accepted") because it has been used in previous studies (Breathnach et al., 2021; Bunten et al., 2021; Forwood et al., 2015; Koutoukidis et al., 2019; Payne Riches et al., 2019). In contrast to the other two measures, the number of observations differs between participants for this dependent variable as it depends on the number of food swap recommendations received. This measure allows to compare the effectiveness in convincing individuals to replace their original choice between different types of food swap recommendations. The limitation with this measure is that it does not reflect carry-over effects of food swap recommendations on subsequent choices and does not allow for meaningful comparisons with the control condition.

Mediators: Perceived compromise was measured by asking to what extent individuals perceived the food swap recommendations as a trade-off of benefits vis-a-vis their original choices.[6] Answers to four items were given on a 7-point rating scale ranging from 1 = "not at all" to 7 = "very much". Perceived threat to freedom of choice was measured with four items by Dillard and Shen (2005) on a 7-point rating scale ranging from 1 = "strongly disagree" to 7 = "strongly agree". Mean scores were calculated for both perceived compromise (Cronbach's α = .89) and perceived threat to freedom of choice (Cronbach's α = .91).

Moderators: Consumption frequency of plant-based substitutes was measured with one item taken from Hoek et al. (2011) asking individuals how often they eat plant-based substitute products on a 7-point rating scale ranging from 1 = "never" to 7 = "five times per week or more".[7]

Other measures: For the purpose of randomization checks we measured demographics (age, gender, education). Other variables included possible confounders; choice realism, product category familiarity, meat consumption frequency (Hoek et al., 2011), general health interest (Hung et al., 2017; Roininen, Lähteenmäki, & Tuorila, 1999, Cronbach's α =.73)[8], hunger, dieting status, dietary requirements, and Nutri-Score familiarity. In addition, recall of the Nutri-Score label was measured to examine whether food swap recommendations highlight an attribute in the assortment (in this case nutrition information) that was initially visually ignored (i.e. not salient). Participants were shown four labels (Nutri-Score, Multiple-Traffic Light, Choices logo, Dutch 'Beter leven') and were asked whether they saw any of these labels during the online grocery shopping task.

Sample size determination

Based on previous research (Jansen, van Kleef, & Van Loo, 2021) a medium-sized effect of food swap recommendations on basket healthfulness compared to a control group was expected. Power analysis with the R package Superpower (Lakens & Caldwell, 2021) showed

[6] As it was technically not possible to again show participants the individual food swap recommendations they received at this stage of the questionnaire, this was measured across all food swap recommendations.
[7] According to the pre-registration, food neophobia, was measured with a Likert scale with five items by Van Wezemael et al. (2010) (based on Pliner & Hobden, 1992) with a 7-point rating scale ranging from "1=strongly disagree" to "7 = strongly agree". It was collected as an alternative to the moderator consumption frequency of plant-based substitutes. Since the factor structure and reliability were problematic due to two reverse-coded items, it was excluded from the analysis.
[8] Since one reverse-coded item (''The healthiness of food has little impact on my food choices") did not load on the same factor and had low inter-item correlations, mean scores for health interest were calculated from only three items. The same item was excluded for the same reasons in the study by Hung et al. (2017).

that with a total sample size of n = 460 (115 per condition) small-to-medium sized pairwise differences of d = 0.37 are detectable with a power of α = .80.[9] This corresponds to an absolute treatment difference of 5.7 FSA points (change of 4.9%) based on the mean FSA basket score from a previous study (mean = 11.57, SD = 15.44) (Jansen, van Kleef, & Van Loo, 2021). Assuming that not all participants would complete the shopping task and that not all participants would receive a food swap recommendation, the total sample size was increased to 520 (oversampling by 15 participants per condition).

Statistical Analysis

Randomization checks were carried out for the demographic and other control variables (possible confounders) using one-way ANOVAs (for age, choice realism, product category familiarity, meat and plant-based consumption frequency, Nutri-Score familiarity, general health interest, hunger) and Pearson Chi-Square tests (for gender, education, current dieting status, dietary requirements).

To test whether any differences exist in receiving and recalling of the food swap recommendations, Pearson Chi-Square tests were used. To check the manipulation of perceived similarity, a one-way ANOVA with Tukey HSD post-hoc tests was used for participants that received at least one food swap recommendation.

The analyses for the model and the hypotheses were conducted in two steps (Figure 5.4). At a first step, the analysis for healthy-choice likelihood and mean FSA score of the final basket included all participants regardless of receiving any food swap recommendations. Differences between conditions in healthy-choice likelihood were assessed with mixed-effects logistic regressions. To assess differences between conditions in the mean FSA score of the final basket, a one-way ANOVA with Tukey HSD post-hoc tests was used. To explore whether food swap recommendations highlight the salience of the Nutri-Score, differences in the recall of the Nutri-Score between the treatment and control conditions were checked with a Pearson Chi-Square test.

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[9] Since differences between food swap conditions was expected to be small (Payne Riches et al., 2019), the original, preregistered goal was to be able to detect small sized pairwise differences of d = 0.2. In our original power analysis, we however misinterpreted "n" as the required total sample size instead of the required group size.

At a second step, the analysis for the acceptance of an alternative in the food swap recommendation included only participants who received at least one food swap recommendation. To assess differences between conditions in acceptance of alternatives in food swap recommendations, mixed-effects logistic regressions were used.

To explore the mediating effect of perceived compromise and perceived threat to freedom, while also taking into account the moderating effect of consumption frequency of plant-based substitutes (moderated mediation, 10,000 bootstraps; 95% percentile bootstrap confidence intervals), we used the SPSS macro PROCESS (Version 3.5) by Hayes (2017) with the mean FSA scores as the measure of basket healthfulness. The mediation analysis only included participants that received at least one food swap recommendation, since those who did not could logically not be affected by any perceived compromise or perceived threat to freedom due to offered food swap recommendations.

To control for the effects of other sources of variation in the basket healthfulness measures, Pearson correlations between the control variables and outcome variables were checked. Primary analyses were repeated by controlling for any variable that significantly correlated with the outcome variables.

The mixed-effects logistic regressions were analysed using the R packages lme4 (version 1.1-27.1) and built stepwise on the basis of improved model fit using the Bayesian information criterion (Kuha, 2004). All other analysis were conducted using IBM SPSS Statistics Version 25 with a significance level α of .05.

Results

Descriptive statistics and randomization check

The flow diagram of participant allocation and inclusion in analyses is provided in Figure 5.4. 520 participants were randomly allocated to the conditions. Of these, 92 (17.7%) were excluded from analysis in a first step for not following the shopping instructions (i.e. not buying one product from each product category). 428 participants were included in the analyses comparing healthy-choice likelihood, mean FSA score, and Nutri-Score salience between treatment and control conditions (H1). From the 313 participants in the treatment conditions, 56 (17.9%) did not receive any food swap recommendation (i.e. only made healthy choices). The number of participants who only made healthy original choices did not differ compared to the control group ($p > .05$). Therefore, at a second step 257 participants were included in the analyses comparing swap recommendation acceptance across treatment conditions and the moderated-mediation analysis (H2-4). The number of excluded participants at both steps did not differ across conditions (p > .05).

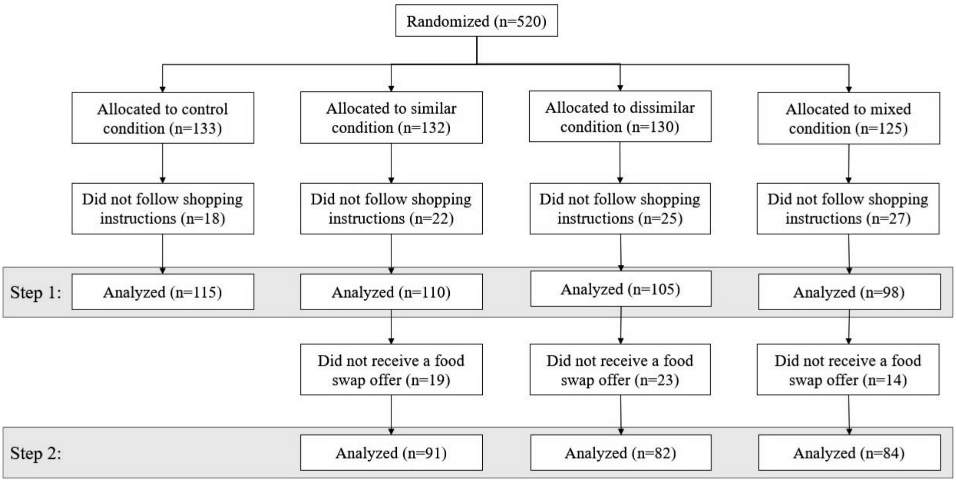

Figure 5.4. Flow diagram of the participant allocation and inclusion.

Descriptive statistics for demographic variables can be found in Table 5.1. Further participant characteristics and the randomization checks can be found in Appendix 18. At both steps, the allocation to conditions was balanced for demographic and possible confounder variables (p > .05). Participants in treatment conditions who did not receive any food swap recommendations had higher Nutri-Score familiarity, general health interest, and self-reported consumption frequency of plant-based products than individuals who received food swap recommendations (p < .05).

Table 5.1. Demographic variables per condition.

Step 1: All participants	**Control (n=115)**	**Similar (n=110)**	**Dissimilar (n=105)**	**Mixed (n=98)**	**p-value**
Gender (n, %)					
Male	46 (40.0)	55 (50.0)	50 (47.6)	47 (48.0)	.461[1]
Female	69 (60.0)	54 (49.1)	55 (54.4)	51 (52.0)	
Other	0 (0.0)	1 (0.9)	0 (0.0)	0 (0.0)	
Education (n, %)					
Low	21 (18.3)	12 (10.9)	20 (19.0)	20 (20.4)	.481[1]
Medium	47 (40.9)	49 (44.5)	36 (34.3)	37 (37.8)	
High	47 (40.9)	49 (44.5)	49 (46.7)	41 (41.8)	
Age in years (M, SD)	47.8 (16.0)	46.0 (15.4)	49.2 (17.7)	47.9 (14.6)	.533[2]
Step 2: Participants who received recommendation(s)		**Similar (n=91)**	**Dissimilar (n=82)**	**Mixed (n=84)**	**p-value**
Gender (n, %)					
Male		47 (51.6)	42 (51.2)	41 (48.8)	.728[1]
Female		43 (47.3)	40 (48.8)	43 (51.2)	
Other		1 (1.1)	0 (0.0)	0 (0.0)	
Education (n, %)					
Low		11 (12.1)	16 (19.5)	18 (24.4)	.300[1]
Medium		43 (47.3)	28 (34.1)	33 (39.3)	
High		37 (40.7)	38 (46.3)	33 (39.3)	
Age in years (M, SD)		46.9 (15.8)	49.2 (17.7)	48.7 (14.3)	.595[2]

Note. [1] Pearson Chi-square test. [2] One-way ANOVA.

Awareness of food swap recommendations and manipulation check

Per-condition means and standard deviations for awareness and manipulation check measures can be found in Table 5.2. At Step 1, over 248 (79.23%) participants in the treatment conditions correctly recalled whether or not they received a food swap recommendation. 53 (16.93%) participants in the treatment conditions did not recall receiving a food swap recommendation even though they received at least one. 12 (3.83%) participants recalled receiving a food swap recommendation even though they did not receive any. There were no significant differences in the correct recall across the three treatment conditions; X^2 (2) = 1.579, p = .454.

At Step 2, participants that received at least one recommendation, received on average 1.84 (SD = 0.88, max = 6) food swap recommendations (each recommendation suggesting two alternative products). A one-way ANOVA revealed that the number of food swap recommendations received did not significantly differ between treatment conditions (p = .951). With regards to the manipulation check for perceived similarity of the alternatives to the original choice, significant differences were found between treatment conditions; F (2,254) = 7.976, p < .001. Pairwise comparisons indicated that participants in the dissimilar condition perceived the recommendations as significantly less similar to their original choices than participants in the similar ($p < .001$, medium Cohen's d = 0.58) and mixed conditions ($p = .005$, medium Cohen's d = 0.48). There was no difference in perceived similarity between the similar and mixed condition ($p = .867$, small Cohen's d = 0.08). Participants in the mixed condition, more often accepted the similar alternative (65%) rather than the dissimilar alternative (35%).

Table 5.2.. Per-condition means and standard deviations for awareness of food swap recommendations and manipulation check measures.

Step 1: All participants	**Similar (n=110)**	**Dissimilar (n=105)**	**Mixed (n=98)**	**p-value**
Participants who did not receive any swaps (n, %)	19 (17.3)	23 (21.9)	14 (14.3)	.359[1]
Participants who correctly recalled whether or not they received a swap (n, %)	90 (81.8)	79 (75.2)	79 (80.6)	.454[1]
Step 2: Participants who received recommendation(s)	**Similar (n=91)**	**Dissimilar (n=82)**	**Mixed (n=84)**	**p-value**
Number of swaps received (M, SD)	1.84 (0.9)[a]	1.83 (0.8)[a]	1.87 (0.9)[a]	.951[2]
Perceived similarity (M, SD)	4.11 (1.5)[b]	3.22 (1.6)[a]	3.99 (1.6)[b]	**< .001[2]**

Note. [1] Pearson Chi-square test. [2] One-way ANOVA. Means within rows with differing superscripts are significantly different at the $p < .05$ level based on Tukey HSD post hoc paired comparisons.

Differences between conditions in basket healthfulness (H1, H2a, H3a)

At Step 1, the number of healthy choices in the final basket across conditions is in line with hypotheses H1, H2a, and H3a ($M_{Control} = 1.38 < M_{Dissimilar} = 1.85 < M_{Similar} = 1.89 < M_{Mixed} = 1.91$). The results of the logistic regression model using healthy choice as criterion with random intercepts for participants is presented in Table 5.3. The final model has a discriminating power (Tjur, 2009) of .273 in healthy-choice likelihood of which .06 stems from the main effects of conditions and product categories and the remaining .213 from the random intercepts. The odds for a healthy choice were at least 2.18 more likely in the treatment conditions than in the control condition ($OR \geq 2.18$, $p < .001$), supporting Hypothesis 1. Differences between treatment conditions were small and not significant ($OR \geq 1.03$-1.11, $p > .05$), providing no support for Hypothesis 2a and 3a. The odds for healthy choices were smaller in the meat slices category compared to the meat (OR = 0.42) and compared to yoghurt category (OR = 0.56, $p < .001$). These effects remained significant after a sensitivity analysis adjusting for the effect of low education, familiarity with the Nutri-Score, and plant-based and meat consumption frequency.

Table 5.3. Mixed-effects logistic regression results using healthy choice as criterion.

Effects	Exp (B)	95% CI for Exp (B)		p	Fit
		LL	UL		
Fixed effects					
Intercept	1.209	0.855	1.708	0.283	
Condition					
Similar vs. control	2.348	1.524	3.617	**< .001**	
Dissimilar vs. control	2.180	1.409	3.372	**< .001**	
Mixed vs. control	2.426	1.552	3.792	**< .001**	
Similar vs. dissimilar	1.077	0.693	1.674	.742	
Mixed vs. dissimilar	1.113	0.706	1.754	. 645	
Mixed vs. similar	1.033	0.6599	1.621	.886	
Product Category					
Meat slices vs. meat	0.420	0.308	0.574	**< .001**	
Yoghurt vs. meat	0.751	0.552	1.023	0.069	
Meat slices vs. yoghurt	0.559	0.412	0.758	**< .001**	
Random effects					
Participant					
σ^2					3.29
ICC					.23
Marginal / Conditional Tjur's R^2					*.060 / .273*
BIC					*1704*

Table 5.4 shows means and standard deviations for the mean FSA score of product choices in the three target categories across conditions. A one-way ANOVA revealed significant differences between conditions in the mean FSA score of products in the basket ($p < .001$). In line with Hypothesis 1, the mean FSA score was significantly improved in the treatment conditions compared to the control condition ($p < .001$, medium Cohen's $d = -0.48$). These effects remained significant after a sensitivity analysis adjusting for the effect of gender, education, familiarity with the Nutri-Score, and plant-based substitutes and meat consumption frequency. No differences were found between treatment conditions neither for the full sample ($p > .05$, small Cohen's d's ≤ -0.10) nor for those participants that received food swap recommendations ($p > .05$, small Cohen's d's ≤ -0.27), providing no support for Hypothesis 2a and 3a.

Table 5.4. Per-condition means and standard deviations for mean FSA score of product choices in the three target categories, and one-way ANOVA results.

	Control	Similar	Dissim.	Mixed	F	p	η_p^2
Step 1: All participants	5.44 (3.68)^b	3.66 (3.45)^a	3.96 (3.51)^a	3.60 (3.47)^a	6.718[1]	**< .001**	.045
Step 2: Participants who received recommendation(s)		4.50 (3.19)^a	5.09 (3.12)^a	4.21 (3.38)^a	1.608[2]	.202	.013

Note. Means within rows with differing superscripts are significantly different at the $p < .05$ level based on Tukey HSD post hoc paired comparisons. [1] $df_N = 3$, $df_D = 424$. [2] $df_N = 2$, $df_D = 254$. Findings were also confirmed with Kruskal-Wallis tests as normality assumptions were violated (based on Shapiro-Wilk test of normality).

At Step 2, the proportion of accepted food swap recommendations across treatment conditions is in line with Hypothesis 2a and 3a ($M_{Dissimilar}$ = 13.92% < $M_{Similar}$ = 22.16% < M_{Mixed} = 29.05%). The results of the logistic regression model using acceptance of a recommended alternative as criterion with random intercepts for participants is presented in Table 5.5. The final model has a discriminating power of .353 in acceptance of food swap recommendations of which .059 stems from the fixed effects and the remaining .294 from the random intercepts. The odds of accepting an alternative in a food swap recommendation was not significantly increased in the similar condition compared to the dissimilar condition (OR = 2.08, p = .073) The odds in the mixed condition was increased compared to the dissimilar condition (OR = 2.78, p = .015), but not compared to the similar condition (OR = 1.34, p = .434). The odds of acceptance was higher in the yoghurt category compared to the meat slices category (OR = 2.17, p = .020). After a sensitivity analysis adjusting for the effect of familiarity with the Nutri-Score and plant-based consumption frequency, the difference between similar and dissimilar food swap recommendations became significant (OR = 2.24, p = .048). The results provide weak support for the lower effectiveness of dissimilar food swap recommendations (Hypothesis 2a) and no support for a difference in the effectiveness of similar and mixed food swap recommendations (Hypothesis 3a).

Table 5.5. Mixed-effects logistic regression results using acceptance of an alternative in the food swap recommendation as criterion.

Effects	Exp (B)	95% CI for Exp (B)		p	Fit
		LL	UL		
Fixed effects					
Intercept	0.200	0.095	0.424	**< .001**	
Condition					
Mixed vs. similar	1.336	0.647	2.758	.434	
Similar vs. dissimilar	2.081	0.933	4.637	.073	
Mixed vs. dissimilar	2.779	1.218	6.341	**.015**	
Product Category					
Meat slices vs. meat	0.580	0.290	1.159	.123	
Yoghurt vs. meat	1.258	0.634	2.495	.512	
Yoghurt vs. meat slices	2.168	1.132	4.155	**.020**	
Random effects					
Participant					
σ^2					3.29
ICC					.31
Marginal / Conditional Tjur's R^2					*.060 / .273*
BIC					*1704*

Moderated mediation analysis (H2b, H3b)

The results of the moderated mediation analysis are reported in Table 5.6 and 5.7. The analysis did not provide support for the moderation effects of consumption frequency of plant-based substitutes ($p > .05$). That is, adding interaction effects between treatment condition and consumption frequency of plant-based substitutes did not improve model fit for neither mean FSA score (R^2 change = .004, $p = .525$), nor perceived compromise (R^2 change = .003, $p = .665$), nor perceived threat to freedom of choice (R^2 change = .005, $p = .547$). As expected from the non-significant total effect, no support was provided for any direct effect or mediation of the effect of food swap recommendation similarity on mean FSA scores by perceived compromise or perceived threat to freedom of choice ($p > .05$). In fact, there were no significant differences between treatment conditions in perceived compromise or perceived threat to freedom of choice. There was also no support for an effect of perceived threat to freedom of choice on mean FSA score. Surprisingly, perceived compromise had a significant effect on the mean FSA score of product choices in the opposite direction than was hypothesized. As such, the more participants perceived the food swap recommendations as a trade-off to their original choice, the more likely they accepted the food swap recommendations and the healthier their basket became. The analysis provides no support for Hypothesis 2b and 3b.

Table 5.6. Regression results using the mediators as the criteria.

	Perceived compromise		Perceived threat to freedom of choice	
Effects	Coefficient	95%CI	Coefficient	95%CI
Intercept[1]	**3.203**	**[2.873, 3.532]**	**3.322**	**[2.977, 3.667]**
Main/Simple effects				
Condition[2]				
Dissimilar vs. similar	-0.071	[-0.550, 0.407]	-0.106	[-0.606, 0.395]
Mixed vs. similar	0.026	[-0.450, 0.502]	0.145	[-0.352, 0.643]
Mixed vs. dissimilar	0.098	[-0.391, 0.586]	0.251	[-0.259, 0.761]
Plant-based consumption frequency[3]	0.091	[-0.070, 0.252]	**-0.213**	**[-0.382, -0.045]**
Interaction effects				
Condition×Plant-based consumption frequency				
Dissimilar vs. similar	0.074	[-0.192, 0.339]	0.150	[-0.127, 0.427]
Mixed vs. similar	0.111	[-0.138, 0.359]	0.088	[-0.172, 0.348]
Mixed vs. dissimilar	0.037	[-0.247, 0.321]	-0.062	[-0.358, 0.235]
Fit		*$R^2 = .031$* *$F(5, 251) = 1.624$* *$p = .154$*		*$R^2 = .035$* *$F(5, 251) = 1.831$* *$p = .107$*

Note. Coefficients represent unstandardized regression weights. Significant regression weights are indicated by a bold typeface. [1] Intercept from the analysis in which Similar was the reference category. [2] Plant-based consumption frequency was mean-centered, and therefore the effects of condition are the simple effects at its mean value (M=3.08). [3] Simple effect of plant-based consumption frequency in the Similar condition.

Table 5.7. Direct, indirect, and total effects from the moderated mediation analysis using mean FSA score as criterion.

Path	Direct Effect	Indirect Effect		Total Effect
		Via Perceived compromise	Via Perceived threat to freedom of choice	
	Coefficient [95%CI]	Coefficient [95%CI]	Coefficient [95%CI]	Coefficient [95%CI]
Main/Simple effects				
Condition[1]				
Similar vs. Dissimilar	0.508 [-0.358, 1.374]	0.049 [-0.306, 0.367]	0.010 [-0.050, 0.110]	0.566 [-0.360, 1.493]
Similar vs. Mixed	-0.328 [-1.189, 0.533]	-0.018 [-0.371, 0.322]	-0.013 [-0.106, 0.066]	-0.359 [-1.280, 0.562]
Dissimilar vs. Mixed	-0.836 [-1.720, 0.049]	-0.067 [-0.398, 0.291]	-0.023 [-0.145, 0.052]	-0.926 [-1.871, 0.019]
Plant-based consumption frequency[2]	**-0.321 [-0.616, -0.025]**	Not provided	Not provided	**-0.699 [-1.107, -0.291]**
Perceived compromise	**-0.690 [-0.917, -0.463]**			
Perceived threat to freedom	-0.090 [-0.307, 0.127]			
Interaction effects				
Condition×Plant-based consumption frequency				
Similar vs. Dissimilar	-0.271 [-0.752, 0.210]	-0.051 [-0.230, 0.135]	-0.014 [-0.077, 0.030]	-0.335 [-0. 848, 0.179]
Similar vs. Mixed	-0.153 [-0.604, 0.297]	-0.076 [-0.271, 0.121]	-0.008 [-0.058, 0.035]	-0.238 [-0.719, 0.243]
Dissimilar vs. Mixed	0.117 [-0.396, 0.630]	-0.026 [-0.229, 0.176]	0.006 [-0.038, 0.065]	0.097 [-0.452, 0.646]
Fit	$R^2 = .228$ $F(7, 249) = 10.529$ $p < .001$			$R^2 = .109$ $F(5, 251) = 6.127$ $p < .001$

Note. Coefficients represent unstandardized regression weights. Significant regression weights are indicated by a bold typeface. [1] Plant-based consumption frequency was mean-centered, and therefore the effects of condition are the simple effects at the mean value (M=3.08) of it. [2] Simple effect of PB consumption frequency in the Similar condition.

Differences between conditions in salience of the Nutri-Score

Overall, 57.7% of participants correctly recalled seeing the Nutri-Score label while 26.4% did not recall seeing any label. Few incorrectly recalled seeing the Dutch 'Beter leven' (7.0%), Choice logo (6.8%), and Multiple Traffic Light labels (2.1%). A Pearson chi-square test did not provide support for a difference in the recall of the Nutri-Score label between the treatment conditions and the control condition; $X^2(1) = 0.552$, p = .457.

Discussion

The present study examines whether providing healthier food swap recommendations in addition to FOP nutrition labels improves the healthfulness of shopping baskets compared to only providing FOP nutrition labels. In addition, it provides initial insights on how the similarity of the alternatives to the original choice influences the effectiveness of food swap recommendations. Based on a pre-test, (healthier) plant-based substitutes were selected as being less similar to unhealthy animal-based products than (healthier) animal-based alternatives across multiple product categories.

The findings provide strong evidence that food swap recommendations increase the basket healthfulness (both in terms of number of healthy products as well as mean nutritional-quality score) compared to only providing FOP nutrition labels. The findings are in line with prior research suggesting that FOP nutrition labels work for health-motivated individuals, but should be supported by other interventions to reach less health-motivated individuals (Schruff-Lim et al., 2023; Visschers et al., 2013). Individuals in treatment conditions who did not receive any food swap recommendation (i.e. only made healthier choices) had higher Nutri-Score familiarity and general health interest than individuals who received food swap recommendations. This suggests that for individuals with higher knowledge and motivation FOP nutrition labels were sufficient, whereas for individuals with lower knowledge and motivation supportive interventions are needed. Individuals might not notice FOP nutrition labels (i.e. lack of salience) or choose to ignore them in their choice (i.e. lack of determinance) (Myers & Alpert, 1977). Previous research has illustrated that highlighting a product characteristic (e.g. healthfulness) in a recommender system renders this product characteristic more important in the choice and even subsequent choices (i.e. increase in determinance) (Häubl & Murray, 2003). Since there were no significant differences in the recall of the Nutri-Score, differences between the control and treatment conditions cannot be explained by differences in noticing the nutrition label. Food swap recommendations may act as meaningful reminders by disrupting the automatic choice process and triggering individuals to rethink their (unhealthy) choice (Granato, Fischer, & van Trijp, 2022). This might activate health goals and as such the weight given to nutrition information (i.e. determinance). Alternatively, the repeated exposure to nutrition information might bias the individual to give it more importance in the choices (i.e. mere-exposure effect). An additional explanation is the framing of the recommendations as healthier alternatives, which might have provided meaning to the nutrition label. Previous research has found both positive (Breathnach et al., 2021) and negative effects (van der Laan & Orcholska, 2022) of including nutrition information in the explanation for the recommendation. Future studies should therefore also measure the understanding and determinance of Nutri-Scores. In the present study it was not possible to extract the original choices. Analysing whether the healthfulness of original choices changed after individuals received the first food swap recommendation could provide insight into whether individuals give more importance to nutrition information in subsequent choices.

Findings of the current study provide only little evidence that the similarity of alternatives influences the effectiveness of food swap recommendations. One of the reasons may be that the current sample size provides insufficient power to detect effects that are smaller than Cohen's d = 0.37. No differences were found between treatment conditions in basket healthfulness (neither in terms of number of healthy products nor in mean nutritional-quality score). However, food swap recommendations in the dissimilar condition had a significantly lower odd of being accepted compared to food swap recommendations in the mixed condition and compared to the similar condition when controlling for the effect of Nutri-Score familiarity and plant-based substitutes consumption frequency. No difference was found between the mixed and similar condition. Participants in the mixed condition more often accepted the similar alternative (65%) rather than the dissimilar alternative (35%). Future research should further examine the influence of similarity of the alternatives in the food swap recommendations by operationalizing similarity differently (e.g. in terms of product category) and using larger sample sizes. In the pre-test similarity perceptions were measured for sets of products which were grouped according to animal source. This might have increased salience of animal source and as a result inflated the effect this characteristic has on similarity perceptions. In addition, possible variations in similarity perceptions across individual products could not be detected. As such there remains a possibility that in the similar condition one similar alternative is perceived as being dominated by the other similar alternative on product characteristics that we are not aware of. For example, even though the stated health gain was the same across alternatives, it is possible that the perceived health gain differed across alternatives. However, it can be expected that the perceived dominance between alternatives is larger in the mixed condition compared to the similar condition as dominance can be identified more easily. While the participant in the mixed condition more often accepted the similar compared to the dissimilar alternative, participants in the similar condition accepted the similar alternatives in an equal ratio for most subcategories. Future studies should measure similarity perceptions between pairs of individual products. In addition, research on other factors influencing food swap acceptance, such as differences in stated health gain of the recommended alternative and number of recommended alternatives (Bollen et al., 2010), is needed.

Further research is required to understand the underlying mechanism that explains which food swap recommendations lead to higher acceptance rates and healthier baskets. The suggested mediators in this study, perceived compromise and perceived threat to freedom of choice, did not differ between treatment conditions. Perceived threat to freedom of choice further did not have an effect of basket healthfulness, while the relationship between perceived compromise of the food swap recommendation and basket healthfulness was in the opposite direction than was hypothesized. The more participants perceived the food swap recommendations as a trade-off to their original choice, the more likely they accepted the food swap recommendations and the healthier their basket became. One possible explanation for this is that our items measured the extent that participants realized that the food swap recommendation offered a gain in healthfulness rather than the extent they had to give up benefits of their original choice (e.g. "giving up some benefits to gain other benefits"). As such, participants who were more aware of the gain in healthfulness, were more likely to replace their original choice. Another explanation might be that participants focused on the finally selected option as the object of the question rather than on how the recommended alternative compared to the originally selected choice. If participants did not replace their originally selected choice, they did not experience a compromise. The more participants accepted the alternatives, the more they perceived a compromise. As it was not possible to measure mediators individually for each received food swap recommendation, it is not possible to explore this. Measuring the mediators across all food swap recommendations might not have been accurate because differences between individual recommendations likely existed.

The main limitations of this study relate to the experimental design and the trade-off between internal and external validity. Since participants did neither pay for their choices nor receive the products, the choices remained hypothetical. As a result, participants might have been indifferent to their choices. This might overestimate the willingness to accept alternatives as following the recommendation did not incur any personal cost. Since the control condition did not receive any recommendations, indifference of food choices might have been more pronounced in the treatment conditions. Hence it remains uncertain whether the difference between control and treatment conditions is due to indifference in following the recommendations or due to real considerations of the health effects. The self-reported realism of food choices did not show differences between conditions, but future studies could reduce the concern of indifference by using an alternative control treatment that receives food swap recommendations unrelated to nutrition or by using an incentive-compatible design. Even though an experimental mock-up online grocery store was used for a more realistic online shopping experience than simple choice screens, prices and brands did not differ across alternatives to control for their influence on similarity perceptions and food choices. Differences in pricing or brand perceptions may have still influenced food choices. Some products might have been perceived as bargains due to the equal prices which in turn might have increased choice likelihood. Participants might still have recognized the original brand from the product image which could have influenced food choices through brand loyalty or perceived quality. The extent to which these effects were present in the current study remains unclear as similarity perceptions were not measured at the individual product level. Future studies with greater external validity (e.g. incentive-compatible experiments or field experiments) are required to substantiate these initial findings.

Conclusion

The current study contributes to a growing literature on food swap recommendations as a novel digital intervention at the moment of purchase. In the presence of FOP nutrition labels, offering healthier food swap recommendations improved the number of healthy choices and nutritional quality of the basket compared to only providing FOP nutrition labels. There were no differences between treatment conditions in the number of healthy choices and mean nutritional quality of the basket. However, dissimilar recommendations were less successful in stimulating acceptance of alternatives than similar recommendations and mixed recommendations with both similar and dissimilar alternatives. Individuals in treatment conditions who did not receive any recommendation (i.e. only made healthier choices) had higher Nutri-Score familiarity and general health interest than individuals who received recommendations. This suggests that for individuals with higher knowledge and motivation FOP nutrition labels were sufficient, whereas for individuals with lower knowledge and motivation additional food swap recommendations can improve dietary choices. Food swap recommendations may act as meaningful reminders by disrupting the automatic choice process and triggering individuals to rethink their (unhealthy) choice.

6

Chapter 6
General discussion

Overall, the aim of the present thesis was to contribute to the understanding of consumers' use of FOP nutrition labelling in supermarket settings. To accomplish this overall aim, four studies were carried out. First, a systematic literature review established the theoretical framework of this thesis, providing a comprehensive overview of barriers in FOP nutrition label usage and potential interventions that could address these barriers (RQ 1, Chapter 2). The empirical studies focused on the effect of FOP nutrition labels in real-life supermarket environments (RQ 2, Chapter 3 and 4), whether different consumer groups in society benefit equally from FOP nutrition labels (RQ 3, Chapter 3 and 5), and explored how complementary interventions could support FOP nutrition labels (RQ 4, Chapter 4 and 5). This chapter presents an overview of the results in relation to the research questions and discusses the implications for science and practice. Furthermore, limitations and suggestions for further research are outlined.

Overview of the main findings

RQ 1: What barriers prevent consumers from using FOP nutrition labels in making healthier food choices, and which complementary interventions can address these barriers?

This research question was explored through a systematic review of the literature (Chapter 2) to better understand which barriers hinder consumers to use FOP nutrition labels in their food choice and how complementary interventions could address these barriers. Building on existing theoretical frameworks on information processing (Grunert, 2011; Hornik, 1989; MacInnis & Jaworski, 1989) and healthy and sustainable choice behaviour (Brug, 2008; Ölander & Thøgersen, 1995; Rothschild, 1999), our theoretical framework delineates two essential steps in how nutrition information translates into healthy choice. Consumers need to 1) understand the provided information correctly and 2) act upon the knowledge to make informed healthier choices. For each step two barriers were suggested. In the first step, consumer's ability and motivation to process the provided information influences the extent to which consumers understand the information (Petty & Cacioppo, 1986). In the second step, consumer's motivation and opportunity to make a healthy choice influences the extent to which consumers act upon the knowledge to make healthier choices (Rothschild, 1999).

We identified and classified complementary interventions that could address these four barriers. We reviewed the strength of evidence of label+ interventions for which we had sufficient evidence. The majority of label+ interventions combined nutrition labels with further information (n = 24 educational material about the nutrition labels, n = 12 reference information about the recommended daily calorie intake), followed by financial incentives based on the nutrition information (n = 19), and real-time feedback on the basket healthfulness (n = 13). Situated in the first part of the theoretical framework, the findings provide limited evidence for the effectiveness of supporting nutrition labels with further information such as reference information about the recommended daily calorie intake or educational material about the nutrition labels. However, education material has shown to improve awareness and understanding of nutrition labels compared to only providing nutrition labels. Situated in both parts of the theoretical framework, the evidence for supporting nutrition labels with basket feedback is promising. Basket feedback makes it easier for consumers to keep an overview of the nutritional quality of their basket (Gustafson & Zeballos, 2019). Realizing that the food basket is becoming unhealthy increases the relevance of nutrition information and motivates consumers to use nutrition labels to make healthier choices (VanEpps et al., 2021). Situated in the second part of the theoretical framework, the evidence for supporting nutrition labels with financial incentives is promising. Financial incentives can provide consumers with the opportunity to make healthier choices by making healthier foods more accessible through discounts. Furthermore, reducing the price difference between healthier and less healthy products can reduce the influence of competing food choices motives, such as price, and hence increase consumers' motivation to make healthier choices. Overall, the findings indicate that interventions that address barriers in the second part of the theoretical framework (i.e. ensuring that consumers apply the knowledge from FOP nutrition labels to make healthier choices) are more promising.

RQ 2: How do FOP nutrition labels influence supermarket sales in real-life?

Two empirical studies explored how FOP nutrition labels influence supermarket sales in real-life (Chapter 3 and 4). Each study utilized a natural experiment at different discounter supermarket chains in the Netherlands which introduced a FOP nutrition label in the bread (Chapter 3) and dairy (Chapter 4) assortment. Both studies confirm that the introduction of FOP nutrition labels can have a small effect on the nutritional quality of supermarket sales. The introduction of FOP fibre labels on bread (Chapter 3) shifted the market share from low and medium fibre breads towards high fibre breads. This resulted in a small increase of 3.45% in the mean fibre content per 100g of bread sold (equivalent to 0.15g). Adding FOP Nutri-

Score labels on dairy products (Chapter 4) led to a 2.33% increase in weight sold for dairy products with Nutri-Score A/B and a 3.63% decrease in weight sold for dairy products with Nutri-Score C/D/E. In addition, the results indicate that the effect of Nutri-Scores varies across product categories. While Nutri-Scores had a positive effect on the nutritional quality of milk, cream, and butter sales (i.e. increase in sales of products with Nutri-Score A/B and/or decrease in sales of products with Nutri-Score C/D/E), Nutri-Scores had no effect on yoghurt sales and even a negative effect on the nutritional quality of dessert sales (decrease in sales of products with Nutri-Score A/B and increase in sales of products with Nutri-Score C/D/E).

RQ 3: Do different consumer groups in society benefit equally from FOP nutrition labels?

Previous literature suggests that lower SES status may hinder the ability to process nutrition information (step 1) and the opportunity to act upon the nutrition knowledge (step 2) (Phelan, Link, & Tehranifar, 2010; Shrestha et al., 2023). To investigate this, we examined whether the SES of the store's area moderates the effect of FOP nutrition labels on sales (Chapter 3). Sales data was shared from stores in areas with both lower (n = 30) and higher SES (n = 28). The effect of the FOP fibre label did not differ across stores in lower and higher SES. Two factors likely contributed to the consistent effect across lower and higher SES areas. First, a simple interpretative label design was used which has been shown to be well understood by individuals with all SES levels (Shrestha et al., 2023; Storcksdieck genannt Bonsmann et al., 2020). Second, the absence of price differences between breads with varying fibre content removed financial barriers, likely facilitating the shift toward higher fibre products. Overall, these results suggest that both lower and higher SES areas can benefit from the introduction of FOP fibre labels, provided that the labels are easy to understand and that healthier options are made financially accessible to consumers in lower SES areas.

While the provision of nutrition information provides individuals with the opportunity to process the information, individuals may not act upon the information in their choices. Chapter 5 showcases that some individuals make unhealthy choices despite the presence of FOP nutrition labels. Individuals with lower Nutri-Score familiarity and general health interest were more likely to make unhealthy choices and hence more likely to receive food swap recommendations. Overall, these findings suggest that for individuals with higher knowledge (step 1) and health motivation (step 2) FOP nutrition labels were sufficient to make healthy choices, whereas for individuals with lower knowledge and motivation complementary interventions are needed to improve dietary choices.

RQ 4: To what extent do complementary interventions enhance the effect of FOP nutrition labels?

Targeting barriers of behaviours by means of interventions is a standard practice in intervention research (Michie et al., 2011; Rothschild, 1999). To explore how complementary interventions can support the effect of FOP nutrition labels, educational shelf signages were tested in the supermarkets. While some signages explained the FOP nutrition label system (step 1), others included activating messages (step 2). The shelf signage unexpectedly led to negative effects on the sales of yoghurts/quarks and desserts with Nutri-Score A/B and had no effect on any other product category. The negative effect of the shelf signage highlights the need for careful design and testing of promotional materials to ensure they effectively support the intended public health message without causing unintended consequences.

While FOP nutrition labels target individuals before a choice is made, some novel digital interventions allow to deliver interventions after a choice is made. One example are healthier food swap recommendations that automatically suggest alternative healthier products when an individual makes an unhealthy choice. Healthier food swap recommendations may disrupt routinized food choices and remind individuals of their health goals (step 2). The results of an online experiment with 428 Dutch participants (Chapter 5) showcased that additional food swap recommendations can improve the nutritional quality of food baskets compared to only providing Nutri-Score labels. The similarity of the recommended alternatives with the initial choice influenced the acceptance of an alternative in the food swap recommendations. Acceptance of an alternative in the food swap recommendations was less likely when food swap recommendations only included dissimilar alternatives. However, this did not translate into differences in the nutritional quality of food baskets, potentially due to the few numbers of product categories in which food swap recommendations were offered. Perceived intrusiveness and perceived compromise did not explain the differences between types of food swap recommendations.

Theoretical contributions

The present thesis contributes valuable insights into the dynamics of nutrition communication and consumer behaviour in retail settings. Several relevant theories are discussed throughout the chapters to place the findings of the studies in context of existing behavioural, psychological, economic, and communication theories. The unique contribution of the present thesis comes from developing a more comprehensive framework that builds on two existing MOA framework traditions; one in information processing (Grunert, 2011; Hornik, 1989; MacInnis & Jaworski, 1989) and one in healthy and sustainable choice behaviour (Brug, 2008; Ölander & Thøgersen, 1995; Rothschild, 1999). It clearly separates the two crucial steps of 1) information processing (transparency) and 2) consumer inducement towards use of that information in choice (activation), and identifies individual and environmental barriers that prevent consumers from processing and acting upon FOP nutrition labels effectively in their choice.

While targeting barriers of behaviours by means of interventions is a standard practice in intervention research (Michie et al., 2011; Rothschild, 1999), this thesis suggests a novel approach to address barriers in the usage of one intervention (namely FOP nutrition labels) with complementary interventions. Little research has focused specifically on how complementary interventions can support nutrition labels and how these intervention components (labels and support) interact and synergise. We reviewed the strength of evidence of the various label+ categories and tested various complementary interventions empirically. The theoretical framework provided the structure of the remaining chapters. The interventions tested in the present thesis varied in their position of the theoretical framework, with labels and informative educational signage (Chapter 4) focusing on the first step of the model (turning information into knowledge), and motivational educational signage (Chapter 4) and food swap recommendations (Chapter 5) focusing on the second step of the model (acting upon the knowledge).

This thesis extends existing research on FOP nutrition labels by showing that the provision of FOP nutrition labels improves the nutritional quality of sales to a small, but significant extent (Chapter 3 and 4). It further illustrates that the effect of FOP nutrition labels differs across product categories (Chapter 4), highlighting the complexity of the process. The findings suggest that other factors influence how FOP nutrition labels are processed and incorporated into decision-making. While the field studies do not provide evidence on the underlying mechanism, the present thesis discusses avenues for future research to better understand why the effect of FOP nutrition labels varies across product categories. The lack of effect in the yoghurts/quarks category could stem from the low variability of Nutri-Scores

(A to C) within this category. In line with the health belief model (Janz & Becker, 1984) and dissonance theory (Harmon-Jones & Mills, 2019), consumers might perceive a yoghurt with Nutri-Score C on a scale ranging from A to E as relatively healthy which in turn reduces consumers' motivation to switch to healthier alternatives. The harmful effect in the dessert category may be due to evoked tastiness inferences (Bialkova, Sasse, & Fenko, 2016) and resulting indulgence-health goal conflicts (Harmon-Jones & Mills, 2019).

Social marketing emphasizes the need to understand people's barriers to behaviour change in order to tailor interventions and maximize their effectiveness (Grier & Bryant, 2005). Previous field studies (e.g. Dubois et al., 2021; Vandevijvere & Berger, 2021) focused on the overall effect of FOP nutrition labels on purchasing or sales. This thesis extends earlier research by focusing on the differential effectiveness of FOP nutrition labels across socio-economic status of the area. Existing evidence on the effect of FOP nutrition labels on food choice across SES levels was lab-based and showed mixed effects (Nohlen et al., 2022). This thesis illustrated that the effect of FOP nutrition labels on store sales does not differ across areas with higher and lower SES (Chapter 3). An easy-to-understand label design (step 1) and affordability of healthier options (step 2) are suggested as potential factors that might contribute to the uniform effect across areas in the present thesis. Furthermore, this thesis showcased that familiarity with FOP labels (step 1) and health motivation (step 2) were barriers to FOP label usage but that additional food swap recommendations were effective in stimulating healthier food choices (Chapter 5). The similarity of the recommended alternatives is illustrated as one factor influencing the acceptance of food swap recommendations. The suggested mediators, perceived intrusiveness and perceived compromise, did not explain differences between types of food swap recommendations. Future research should investigate the role of other variables such as variables from the technology acceptance model (e.g. perceived usefulness).

Methodological contributions

Diverse research methods were used to answer the research questions, spanning from a systematic review (Chapter 2), randomised experimental designs in the lab and the field (Chapter 4 and 5), to natural experiments in the field (Chapter 3 and 4). Previous research on the effect of FOP labels was dominantly based in lab environments using hypothetical outcomes (Roberto et al., 2021; Storcksdieck genannt Bonsmann et al., 2020). The present thesis extends beyond such experimental restrictions and provides important proof-of-implementation insights on the effect of FOP nutrition labels in supermarket settings (Chapter 3 and 4). The high external validity of field-based studies promotes understanding of consumer behaviour in complex real-world contexts and enhances the generalizability of the effect (van Kleef & van Trijp, 2018). The included studies used actual sales data, involved a large number of stores (n = 58-100 stores) and data from long time spans (n = 82 – 105 weeks). Even though the real-life implementation of FOP nutrition labels did not allow for control stores due to nation-wide replacement of the original packaging, the studies applied a novel difference-in-difference approach by using data from the same time period of the previous year as a counterfactual to avoid common limitations of pre-post studies. Furthermore, the outcomes increased from single product categories (Chapter 3 and 4) to the nutritional quality of baskets (Chapter 5), acknowledging that consumers do not make food choices in isolation, but rather make sequential food choices from various product categories when shopping for groceries in supermarkets.

Practical implications for industry and policy

This thesis provides important implications for industry and policy. Overall, the introduction of FOP nutrition labels led to a shift to healthier food choices, indicating a consumer willingness and demand for a healthy diet. Manufacturers and retailers can meet this demand by providing salient and easy-to-understand FOP or shelf labels voluntarily.

However, the effects of FOP nutrition labels were small. The thesis showed that FOP nutrition labelling is useful for knowledgeable and motivated consumers, but is less impactful for the remaining consumer segment. These consumers need to be activated towards use of that information in their choices. While in-store signage did not show the desired effects, healthier food swap recommendations were effective in further stimulating healthier choices. Retailers have also been seen to link price promotions to Nutri-Score levels A and B (Ahold Delhaize, 2022). Especially in online retail environments, many novel interventions are emerging.

The thesis showed that, for desserts, FOP nutrition labels led to undesirable effects, likely due to existing unhealthy=tasty beliefs for indulgent product categories and resulting goal conflicts between indulgence and health. When lacking information about a particular quality attribute, consumers often rely on other, sometimes unrelated, information as cues to make inferences about the missing quality attribute (Fishbein & Ajzen, 1975; Steenkamp, 1990).

FOP nutrition labels have been shown to activate unhealthy=tasty beliefs (Bialkova, Sasse, & Fenko, 2016; Ikonen et al., 2020). Food manufacturers may need to emphasize health-unrelated positive attributes (Bublitz & Peracchio, 2015; Mai & Hoffmann, 2015) and/or use taste claims to lessen the activation of unhealthy=tasty beliefs (Maesen et al., 2021). Imagery can be a powerful tool in shaping consumers' inferences. A recent study alarmingly showed that health-related images increased participants' tendency to falsely remember reading health claims, even when direct nutrition information was available (Delivett et al., 2022). While this underscores the need for marketing regulations concerning imagery on unhealthy foods, it also suggest that taste imagery on healthier foods could help reduce the activation of unhealthy=tasty beliefs.

Consumers strong unhealthy=tasty beliefs is not surprising considering how the environment promotes unhealthy food choices. Marketing for unhealthy foods is prevalent. Research has shown that child-focused marketing is predominantly linked to unhealthy foods, shaping preferences for unhealthy foods from an early age (Cairns et al., 2013; Smith et al., 2019). Similarly, adolescents are mostly exposed to unhealthy food promotions on social media (Van der Bend et al., 2022). The majority of price-promoted products in supermarkets flyers do not contribute to a healthy diet (Hendriksen et al., 2021; Ravensbergen et al., 2015). Since the marketing budget of the food and beverage industry is larger than that of governments, the food and beverage industry needs to be incentivised to adopt a marketing for healthier food (Bublitz & Peracchio, 2015; Mai & Hoffmann, 2015) or restricted in their marketing efforts for less healthy foods (Boyland et al., 2022).

While FOP nutrition labelling policies are important in creating transparency about the nutritional content of packaged foods, they are insufficient on their own in combating obesity and nutrition-related noncommunicable diseases. Multifaceted policy programs also need to address the role of the environment in promoting unhealthy food choices. To create a more supportive environment for healthy eating, complementary policies are essential. These may include regulating the marketing of unhealthy foods, especially to vulnerable groups such as children and adolescents, implementing fiscal policies like taxes on sugary drinks and subsidies for fruits and vegetables, and enhancing the availability of healthy food options in retail settings. By addressing both individual and environmental factors, a comprehensive policy approach can more effectively combat obesity and nutrition-related noncommunicable diseases, leading to better public health outcomes.

Limitations and future research

While study-specific limitations are discussed within the respective chapters, this section provides a discussion of the overall limitations of the thesis. While the field-based studies provided high external validity and important insights into the real-life effects of FOP nutrition labels, the insights are limited to the effects on the outcome variable rather than the underlying process. Future research should investigate the inferences consumers make to better understand the differences of FOP nutrition label effectiveness across product categories. Furthermore, the provided sales data was aggregated at the store-level and hence did not allow to draw conclusions at the individual-level. Especially in the analysis of socio-economic differences in the effect of FOP nutrition labels, it is unclear whether the results using an area-based SES measure extend to individuals differing in SES. Further studies with individual-level data are needed to validate the initial findings of Chapter 3. Individual-level data can further provide insights into shopping dynamics within a single shopping trip and over multiple shopping trips. Within a single shopping trip, consumers have shown to balance a relatively healthy choice with a subsequent relatively unhealthy choice during their shopping trip (van Ittersum et al., 2024). Across time, familiarity with the FOP labelling system has been reported to improve evaluation and usage of FOP nutrition labels (Nohlen et al., 2022). Future research should investigate whether individuals stick with their healthier choices or whether they revert back to their less healthy choices.

Another limitation is that the long-term health impacts of the interventions are unclear. While purchases in supermarkets constitute to a majority of food choices, it does not reflect what consumers actually consumed. Longitudinal data on nutritional intake is required to judge long-term health outcomes (Nohlen et al., 2022). Especially for a summary nutrition label like the Nutri-Score health impacts are unclear because an improvement in Nutri-Score can result from an increase of positive nutrients and/or decrease in negative nutrients. However, based on the Nutri-Score effect estimate on the nutritional quality of food choices in the experiment by Crosetto et al. (2020), a modelling study estimated that Nutri-Scores are estimated to prevent 3.4% of all deaths from diet-related non-communicable diseases (Egnell et al., 2019).

The scope of the present thesis did not include industry responses to the introduction of FOP labels. Previous reviews have indicated that manufacturers improve the product formulation as a strategic response to the introduction of FOP nutrition labels, especially if the introduction of FOP labels is mandatory (Bauner & Rahman, 2024; Nohlen et al., 2022; Roberto et al., 2021). However, concerns have been raised that manufacturers strategically may only reformulate products that are close to the nutrient threshold, only reformulate just enough to reach the threshold (Bauner & Rahman, 2024; Roberto et al., 2021), and only reformulate nutrients that are captured by the FOP nutrition labels (Nohlen et al., 2022). Furthermore, the mandatory introduction of warning labels in Chile led to a price increase of labelled unhealthy products and a decrease of unlabelled healthier products (Pachali et al., 2023). These findings indicate that industry responses may be able to reinforce the effect of FOP nutrition labelling policies on health outcomes and should be included in any policy evaluation.

Final conclusion

This thesis shows that the introduction of FOP nutrition labels has small, but overall positive effects on the nutritional quality of food sales for supermarkets in both lower and higher SES areas. However, for indulgent categories, such as desserts, FOP nutrition labels led to lower nutritional quality of food sales. Due to their salient and easy-to-understand design, FOP nutrition labels are especially useful for knowledgeable and motivated consumers. Less knowledgeable and less motivated consumers need activation towards use of FOP nutrition labels. While educational campaigns about the FOP nutrition labels did not improve healthy choices, disrupting unhealthy choices by providing healthier food swap recommendations has been shown to motivate consumers to make healthier choices.

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Appendices

Appendix 1. Prisma checklist (Chapter 2).

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2-5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	10
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	11-12
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	10-11
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	11: Table 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	12
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	13
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	13
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	12
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	13-14
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	13-14

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA[1]
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA[2]
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	16
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Table S1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table S1
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table S1[3]
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA[4]
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA[1]
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA[2]
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	29-34
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	29-34
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	34-35
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	File 1

[1] Given our inability to perform a meta-analysis, the risk of bias could not be assessed across studies, but only within individual studies.
[2] In the present review, we did not perform any additional analyses.
[3] In line with the qualitative synthesis, we described the main findings qualitatively and did not provide effect estimates and confidence intervals.
[4] Given our inability to perform a meta-analysis, we have synthesized the findings narratively (pp. 17-28) and visualized the findings in harvest plots (Fig. 3-6)

Appendix 2A. Summary of included studies (Chapter 2).

ID	Author(s)	Year	Setting	Design	Study size	Outcome	Comp. to Control	Comp. to Label	Comp. to Plus
Reference information									
1	Downs, Wisdom, & Loewenstein	2015	Lab	CT	921 participants	Calories of snacks choices	No effect	No effect	
2	Downs, Wisdom, & Loewenstein	2015	Lab	CT	921 participants	Calories of snacks choices	No effect	No effect	
3	Finkelstein et al.	2021	Lab (online)	RCT	106 participants	Calories per serving	No effect	No effect	
4	Harnack et al.	2008	Lab	CT	594 participants	Calories of fast food meal choices	No effect		
5	Liu et al.	2012	Lab	RCT	418 participants	Calories of meal choices	No effect		
6	Marty et al.	2020	Lab (online)	RCT	868 participants	Calories of meal choices	No effect		
7	Marty et al.	2020	Lab (online)	RCT	875 participants	Calories of meal choices	No effect		
8	Oh, Huh, & Mukhopadhyay	2020	Lab (online)	RCT	275 participants	Choice of low calorie option	No effect		
9	Oliveira et al.	2020	Lab	CT	480 participants	Number of healthy choices	No effect	No effect	No effect
10	Pang & Hammond	2013	Lab	CT	213 participants	Calories of snacks choices	Benefit	No effect	
11	Pang & Hammond	2013	Lab	CT	213 participants	Calories of snacks choices	Promising	No effect	
12	Roberto et al.	2010	Lab	RCT	295 participants	Calories of meal choices	Benefit	No effect	
Information about labels									
13	Albright, Flora, & Fortmann	1990	Restaurant	PP	4 restaurants	Sales of healthy labelled entrees	Mixed: Benefit in 2 of 4 restaurants		
14	Dingman et al.	2015	Vending machine	CT	18 VMs	Calories of snack purchases	No effect		
15	Dubois et al.	2020	Supermarket	CT	60 supermarkets	Basket healthiness score	No effect		
16	Dubois et al.	2020	Supermarket	CT	60 supermarkets	Basket healthiness score	Promising		
17	Dubois et al.	2020	Supermarket	CT	60 supermarkets	Basket healthiness score	No effect		
18	Dubois et al.	2020	Supermarket	CT	60 supermarkets	Basket healthiness score	No effect		
19	Freedman & Connors	2010	Small food store	PP	1 convenience store	Sales of promoted items	Promising		
20	Hobin et al.	2017	Supermarket	PPwC	126 supermarkets	Mean star rating per product	Benefit		
21	Hoenink et al.	2021	Supermarket	PPwC	41 supermarkets	Beverage sales in each category	No effect		
22	Julia et al.	2016	Lab	CT	901 participants	Basket healthiness score	Promising	Promising	
23	Julia et al.	2021	Canteen	PPwC	2 canteens	Basket healthiness score	Benefit		
24	Marty et al.	2020	Lab (online)	RCT	899 participants	Energy density of the basket	Benefit		

25	Montagni et al.	2020	Canteen	PPwC	2 canteens	Proportion of lunch meals sold with no healthy item included	Benefit	
26	Mora-Garcia, Tobar, & Young	2019	Canteen	CT	485 participants	Calories of purchases		No effect
27	Olstad et al.	2015	Canteen	PP	1 canteen	a) Sales of green items b) Sales of red items	a) Benefit b) Benefit	
28	Osman & Thornton	2019	Lab (online)	RCT	101 participants	Basket healthiness score	Benefit	
29	Osman & Thornton	2019	Lab (online)	RCT	273 participants	Basket healthiness score	Benefit	
30	Rodgers et al.	1994	Supermarket	PPwC	40 supermarkets	a-d) Sales proportion of promoted dry cereals, total sales of canned / frozen beans, dried beans, and dried fruits e) Sales proportion of promoted baked goods f-h) Sales proportion of promoted fresh produce, frozen vegetables, canned vegetables	Mixed: a-d) No effect e) Harm f-h) Benefit	
31	Roy & Alassadi	2021	Canteen	PPwC	2 takeout food outlets	Percentage of promoted items sold	No effect	
32	Sacks et al.	2011	Supermarket	PPwC	2 online supermarkets	Sales of red-labelled items	No effect	
33	Sproul, Canter, & Schmidt	2003	Canteen	PP	1 canteen	Sales of promoted entrees	No effect	
34	Sutherland, Kaley, & Fischer	2010	Supermarket	PP	168 supermarkets	Sales of promoted items	Benefit	
35	Thorndike et al.	2012, 2014	Canteen	PP	1 canteen	a) Sales of green items b) Sales of red items	a) Benefit b) Benefit	
36	Vyth et al.	2011	Canteen	RCT	25 canteens	a) Sales of promoted sandwiches b) Sales of promoted soups c) Sales of promoted fruit units	Mixed: a-b) No effect c) Benefit	
Training								
37	Adams et al.	2014	Lab	CT	109 participants	Selection of SSB		Benefit
Presentation order								
38	Allan, Johnston, & Campbell	2015	Restaurant	RCT	1 coffee shop	a) Sales of high calorie snacks b) Sales of high calorie beverages	Mixed: a) Benefit b) No effect	

39	Downs, Wisdom, & Loewenstein	2015	Lab	CT	610 participants	Calories of snacks choices	Benefit	
40	Grandi, Burt & Cardinali	2021	Lab (online)	RCT	234 participants	a) Percentage of healthy breakfast cereals b) Percentage of healthy cereal bars		Mixed: a) No effect b) Benefit
41	Närhinen, Nissinen, & Puska	2000	Supermarket	PP	1 supermarket	Sales of promoted items	No effect	
42	Shah et al.	2016	Lab	RCT	372 participants	Calories of fast food meal choices	No effect	
Information about health risks								
43	Adams et al.	2014	Lab	CT	109 participants	Selection of SSB		No effect
Basket feedback								
44	De Bauw et al.	2022	Lab (online)	RCT	994 participants	Basket healthiness score	No effect	
45	Gustafson & Zeballos	2019	Lab (online)	RCT	344 participants	Calories of sandwich choices		Benefit
46	Shin et al.	2022	Lab (online)	RCT	748 participants	Basket healthiness score	Benefit	
47	vanEpps et al.	2021	Lab (online)	CT	509 participants	Calories of meal choices		Benefit
48	vanEpps et al.	2021	Lab (online)	CT	1803 participants	Calories of meal choices		Benefit
49	vanEpps et al.	2021	Lab (online)	CT	2437 participants	Calories of meal choices	Benefit	Benefit
50	vanEpps et al.	2021	Lab (online)	CT	2437 participants	Calories of meal choices	Benefit	No effect
51	vanEpps et al.	2021	Lab (online)	CT	3002 participants	Calories of meal choices		No effect
52	vanEpps et al.	2021	Lab (online)	CT	3002 participants	Calories of meal choices		Benefit
53	vanEpps et al.	2021	Lab (online)	CT	3010 participants	Calories of meal choices		No effect
54	vanEpps et al.	2021	Lab (online)	CT	3010 participants	Calories of meal choices		Benefit
55	vanEpps et al.	2021	Lab (online)	CT	3010 participants	Calories of meal choices		Benefit
56	vanEpps et al.	2021	Lab (online)	CT	3010 participants	Calories of meal choices		Benefit
Social norm message								
57	Jansen et al.	2021	Lab (online)	RCT	550 participants	Basket healthiness score	Promising: Label: Benefit, Plus: No effect, Interaction: No	
Healthy eating prompts								
58	Bergen & Yeh	2006	Vending machines	CT	8 VMs	a) The growth rate of SSB sales b) The growth rate of water and diet soda sales	a) Benefit b) No effect	
59	Lee-Kwan et al.	2015	Restaurant	CT	7 restaurants	Sales of healthy items	No effect	
60	Levin	1996	Canteen	PPwC	2 canteens	Sales of promoted entrees	Benefit	

61	Scourboutakos et al.	2017	Canteen	PP	6412 observations	a) Sales of water b) Sales of SSBs	Benefit		
Food swap recommendations									
62	De Bauw et al.	2022	Lab (online)	RCT	994 participants	Basket healthiness score	No effect	No effect	
63	Jansen et al.	2021	Lab (online)	RCT	550 participants	Basket healthiness score	Benefit: Label: Benefit, Plus: Benefit, Interaction: No		
64	van der Laan et al.	2022	Supermarket	RCT	1783 observations		No effect		Harm
65	van der Laan et al.	2022	Supermarket	RCT	1783 observations		No effect		Harm
Financial incentives									
66	Acton & Hammond	2018	Lab	CT	675 participants	Calories of beverage purchases	Promising: Label: No effect, Plus: Benefit, Interaction: No		
67	Acton & Hammond	2018	Lab	CT	675 participants	Calories of beverage purchases	Promising: Label: No effect, Plus: Benefit, Interaction: No		
68	Acton & Hammond	2018	Lab	CT	675 participants	Calories of beverage purchases	Promising: Label: No effect, Plus: Benefit, Interaction: No		
69	Acton et al.	2019, 2021	Lab	CT	3584 participants	a) Calories of beverage purchases b) Calories of snack purchases	Benefit: a+b) Label: Benefit, Plus: Benefit, Interaction: No		
70	Acton et al.	2019, 2021	Lab	CT	3584 participants	a) Calories of beverage purchases b) Calories of snack purchases	a) Promising: Label: No effect, Plus: Benefit, Interaction: No b) Benefit: Label: Benefit, Plus: Benefit, Interaction: No		
71	Acton et al.	2019, 2021	Lab	CT	3584 participants	a) Calories of beverage purchases b) Calories of snack purchases	a) Promising: Label: No effect, Plus: Benefit, Interaction: No b) Benefit: Label: Benefit, Plus: Benefit,		

							Interaction: No		
72	Acton et al.	2019, 2021	Lab	CT	3584 participants	a) Calories of beverage purchases b) Calories of snack purchases	a+b) Promising: Label: No effect, Plus: Benefit, Interaction: No		
73	Elbel et al.	2013	Small food store	PP	1 convenience store	Calories of purchases	Benefit	No effect	No effect
74	Elbel et al.	2013	Small food store	PP	1 convenience store	Calories of purchases	Benefit	No effect	No effect
75	Ellison, Lusk, & Davis	2014	Restaurant	CT	1 restaurant	Calories of menu purchases	No effect: Label: No effect, Plus: No effect, Interaction: No		
76	Ellison, Lusk, & Davis	2014	Restaurant	CT	1 restaurant	Calories of menu purchases	Promising: Label: Benefit, Plus: No effect, Interaction: No		
77	Giesen et al.	2011	Lab	CT	178 participants	Calories of lunch meal purchases	Mixed: Label: Benefit, Plus: Benefit, Interaction: Harmful		
78	Mazza et al.	2018	Canteen	PP	1 canteen	a) Sales of healthy beverages b) Sales of healthy chips			a) Benefit b) Benefit
79	Shah et al.	2014	Lab (online)	RCT	1200 participants	Selection of red entree	Benefit	Benefit	Benefit
80	Shah et al.	2014	Lab (online)	RCT	894 participants	Selection of red entree	Benefit		Benefit
81	Shah et al.	2014	Lab (online)	RCT	894 participants	Selection of red entree	Benefit		Benefit
82	Shah et al.	2014	Lab (online)	RCT	894 participants	Selection of red entree	No effect		
83	Shah et al.	2014	Lab (online)	RCT	1987 participants	Selection of red entree	Benefit	Benefit	Benefit
84	Shah et al.	2014	Restaurant	CT	464 orders	Selection of red entree	Benefit	No effect	Benefit
Introduction of healthy foods									
85	Lowe et al.	2010	Canteen	CT	96 participants	Calories of lunch meal purchases	No effect		

Appendix 2B. Individual quality criteria (Chapter 2).

ID	Author(s)	A) Selection bias	B) Study design	C) Confounders	D) Blinding	E) Data collection	F) Withdrawals and drop-outs
Reference information							
1	Downs, Wisdom, & Loewenstein	Weak	Strong	Moderate	Strong	Moderate	Unclear
2	Downs, Wisdom, & Loewenstein	Weak	Strong	Moderate	Strong	Moderate	Unclear
3	Finkelstein et al.	Weak	Strong	Moderate	Moderate	Strong	Strong
4	Harnack et al.	Weak	Strong	Strong	Moderate	Moderate	Strong
5	Liu et al.	Moderate	Strong	Strong	Strong	Strong	Strong
6	Marty et al.	Strong	Strong	Strong	Strong	Strong	Moderate
7	Marty et al.	Strong	Strong	Strong	Strong	Strong	Moderate
8	Oh, Huh, & Mukhopadhyay	Moderate	Strong	Unclear	Moderate	Strong	Unclear
9	Oliveira et al.	Moderate	Strong	Strong	Unclear	Strong	Unclear
10	Pang & Hammond	Weak	Strong	Strong	Unclear	Moderate	Strong
11	Pang & Hammond	Weak	Strong	Strong	Unclear	Moderate	Strong
12	Roberto et al.	Weak	Strong	Strong	Moderate	Moderate	Strong
Information about labels							
13	Albright, Flora, & Fortmann	Moderate	Weak	Weak	Strong	Strong	Strong
14	Dingman et al.	Weak	Strong	Moderate	Strong	Moderate	Strong
15	Dubois et al.	Moderate	Strong	Moderate	Strong	Strong	Strong
16	Dubois et al.	Moderate	Strong	Moderate	Strong	Strong	Strong
17	Dubois et al.	Moderate	Strong	Moderate	Strong	Strong	Strong
18	Dubois et al.	Moderate	Strong	Moderate	Strong	Strong	Strong
19	Freedman & Connors	Weak	Weak	Weak	Strong	Strong	Strong
20	Hobin et al.	Moderate	Moderate	Moderate	Strong	Strong	Strong
21	Hoenink et al.	Moderate	Moderate	Moderate	Strong	Strong	Strong
22	Julia et al.	Weak	Strong	Strong	Moderate	Moderate	Strong
23	Julia et al.	Moderate	Moderate	Moderate	Strong	Strong	Strong
24	Marty et al.	Strong	Strong	Strong	Strong	Strong	Strong
25	Montagni et al.	Moderate	Moderate	Moderate	Strong	Strong	Strong
26	Mora-Garcia, Tobar, & Young	Weak	Strong	Strong	Strong	Moderate	Unclear
27	Olstad et al.	Moderate	Weak	Weak	Strong	Moderate	Strong
28	Osman & Thornton	Weak	Strong	Unclear	Strong	Strong	Unclear
29	Osman & Thornton	Moderate	Strong	Unclear	Strong	Strong	Unclear
30	Rodgers et al.	Moderate	Moderate	Moderate	Strong	Strong	Strong
31	Roy & Alassadi	Moderate	Moderate	Moderate	Moderate	Strong	Strong
32	Sacks et al.	Moderate	Moderate	Moderate	Strong	Strong	Strong
33	Sproul, Canter, & Schmidt	Moderate	Weak	Weak	Moderate	Strong	Strong
34	Sutherland, Kaley, & Fischer	Moderate	Weak	Weak	Strong	Strong	Strong
35	Thorndike et al.	Moderate	Weak	Weak	Strong	Strong	Strong
36	Vyth et al.	Moderate	Strong	Moderate	Strong	Strong	Strong
Training							
37	Adams et al.	Weak	Strong	Moderate	Strong	Strong	Strong
Presentation order							

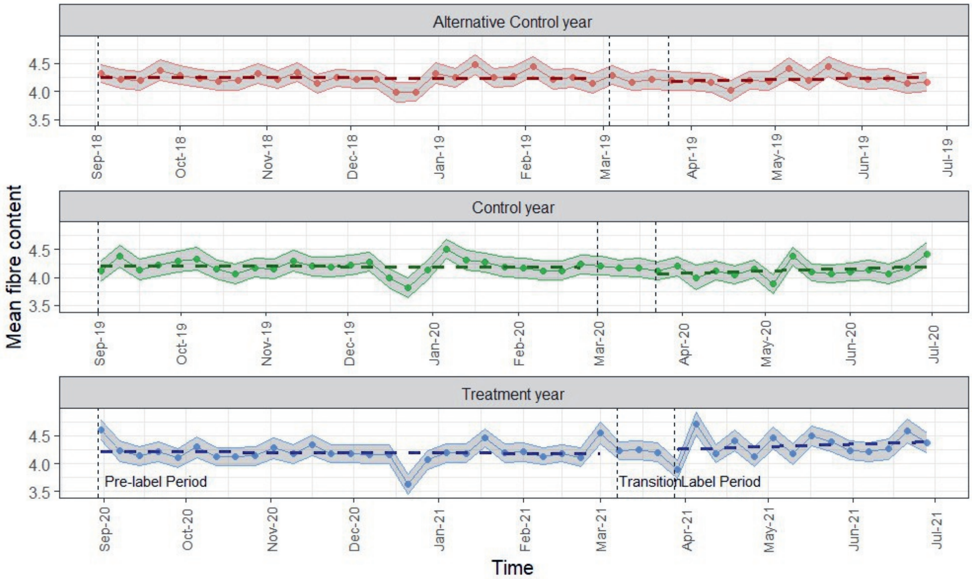
38	Allan, Johnston, & Campbell	Moderate	Strong	Unclear	Strong	Strong	Strong
39	Downs, Wisdom, & Loewenstein	Weak	Strong	Moderate	Strong	Strong	Unclear
40	Grandi, Burt & Cardinali	Moderate	Strong	Strong	Moderate	Strong	Strong
41	Närhinen, Nissinen, & Puska	Moderate	Weak	Weak	Strong	Strong	Strong
42	Shah et al.	Weak	Strong	Strong	Moderate	Moderate	Strong
Information about health risks							
43	Adams et al.	Weak	Strong	Moderate	Strong	Strong	Strong
Basket feedback							
44	De Bauw et al.	Strong	Strong	Strong	Strong	Strong	Strong
45	Gustafson & Zeballos	Moderate	Strong	Strong	Moderate	Strong	Strong
46	Shin et al.	Moderate	Strong	Strong	Strong	Strong	Moderate
47	vanEpps et al.	Weak	Strong	Moderate	Moderate	Strong	Unclear
48	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Strong
49	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Strong
50	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Strong
51	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Moderate
52	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Moderate
53	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Strong
54	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Strong
55	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Strong
56	vanEpps et al.	Moderate	Strong	Moderate	Moderate	Strong	Strong
Social norm message							
57	Jansen et al.	Strong	Strong	Strong	Strong	Strong	Strong
Healthy eating prompts							
58	Bergen & Yeh	Moderate	Strong	Moderate	Strong	Strong	Strong
59	Lee-Kwan et al.	Moderate	Strong	Moderate	Strong	Moderate	Strong
60	Levin	Moderate	Moderate	Moderate	Strong	Strong	Strong
61	Scourboutakos et al.	Weak	Weak	Weak	Weak	Moderate	Strong
Food swap recommendations							
62	De Bauw et al.	Strong	Strong	Strong	Strong	Strong	Strong
63	Jansen et al.	Strong	Strong	Strong	Strong	Strong	Strong
64	van der Laan et al.	Moderate	Strong	Weak	Strong	Strong	Strong
65	van der Laan et al.	Moderate	Strong	Weak	Strong	Strong	Strong
Financial incentives							
66	Acton & Hammond	Weak	Strong	Strong	Unclear	Strong	Strong
67	Acton & Hammond	Weak	Strong	Strong	Unclear	Strong	Strong
68	Acton & Hammond	Weak	Strong	Strong	Unclear	Strong	Strong
69	Acton et al.	Weak	Strong	Strong	Strong	Strong	Strong
70	Acton et al.	Weak	Strong	Strong	Strong	Strong	Strong
71	Acton et al.	Weak	Strong	Strong	Strong	Strong	Strong
72	Acton et al.	Weak	Strong	Strong	Strong	Strong	Strong
73	Elbel et al.	Moderate	Weak	Weak	Moderate	Moderate	Strong
74	Elbel et al.	Moderate	Weak	Weak	Moderate	Moderate	Strong
75	Ellison, Lusk, & Davis	Moderate	Strong	Unclear	Strong	Moderate	Strong
76	Ellison, Lusk, & Davis	Moderate	Strong	Unclear	Strong	Moderate	Strong

77	Giesen et al.	Weak	Strong	Moderate	Moderate	Strong	Unclear
78	Mazza et al.	Moderate	Weak	Weak	Strong	Strong	Strong
79	Shah et al.	Moderate	Strong	Unclear	Moderate	Strong	Strong
80	Shah et al.	Moderate	Strong	Unclear	Moderate	Strong	Strong
81	Shah et al.	Moderate	Strong	Unclear	Moderate	Strong	Strong
82	Shah et al.	Moderate	Strong	Unclear	Moderate	Strong	Strong
83	Shah et al.	Moderate	Strong	Unclear	Moderate	Strong	Strong
84	Shah et al.	Moderate	Strong	Moderate	Strong	Moderate	Strong
Introduction of healthy foods							
85	Lowe et al.	Moderate	Strong	Strong	Moderate	Strong	Strong

Appendix 3. Mean fibre content per 100g (Chapter 3).

	Final model			**Incl. transition period**			**Excl. week 36 and 9**			**Alternative price covariate**			**Alternative control year**		
Predictors	*Estimates*	*SE*	*p*	*Estimates*	*SE*	*p*	*Estimates*	*SE*	*p*	*Estimates*	*SE*	*p*	*Estimates*	*SE*	*p*
(Intercept)	4.256	0.023	**<0.001**	4.255	0.023	**<0.001**	4.250	0.023	**<0.001**	4.232	0.023	**<0.001**	4.243	0.022	**<0.001**
Period [Label]	-0.075	0.006	**<0.001**	-0.070	0.005	**<0.001**	-0.072	0.006	**<0.001**	-0.086	0.006	**<0.001**	-0.026	0.006	**<0.001**
Group [Treatment year]	-0.006	0.007	0.432	-0.005	0.007	0.436	-0.023	0.007	**0.002**	-0.002	0.007	0.742	-0.041	0.009	**<0.001**
Mean price for low fibre	0.050	0.001	**<0.001**	0.047	0.001	**<0.001**	0.051	0.001	**<0.001**						
Mean price for med. fibre	-0.001	0.001	0.091	0.000	0.001	0.858	-0.007	0.001	**<0.001**						
Mean price for high fibre	-0.079	0.002	**<0.001**	-0.076	0.002	**<0.001**	-0.071	0.002	**<0.001**						
Period [Label] × Group [Treatment year]	0.147	0.009	**<0.001**	0.139	0.008	**<0.001**	0.174	0.010	**<0.001**	0.287	0.011	**<0.001**	0.147	0.010	**<0.001**
Mean price for 1g of fibre										0.049	0.001	**<0.001**			
Observations	4616			4961			4387			4616			4396		
R^2	0.405			0.389			0.417			0.228			0.070		

Appendix 4. Development of mean fibre content during the study periods across three years (n_{Stores} = 55, $n_{Articles}$ = 34) (Chapter 3).



Appendix 5. Market Share of Low / Medium / High Fibre Sales (Chapter 3).

	Share of Low Fibre Sales			Share of Medium Fibre Sales			Share of High Fibre Sales[1]		
Predictors	*Estimates*	*SE*	*p*	*Estimates*	*SE*	*p*	*Estimates*	*SE*	*p*
(Intercept)	0.360	0.004	**<0.001**	0.414	0.005	**<0.001**	-1.511	0.021	**<0.001**
Period [Label]	0.015	0.001	**<0.001**	-0.011	0.001	**<0.001**	-0.013	0.005	**0.015**
Group [Treatment year]	0.003	0.001	**0.025**	-0.016	0.001	**<0.001**	0.063	0.006	**<0.001**
Mean price for low fibre	-0.013	0.000	**<0.001**	0.008	0.000	**<0.001**	0.017	0.001	**<0.001**
Mean price for med. fibre	0.009	0.000	**<0.001**	-0.018	0.000	**<0.001**	0.032	0.001	**<0.001**
Mean price for high fibre	0.010	0.000	**<0.001**	0.007	0.000	**<0.001**	-0.065	0.002	**<0.001**
Period [Label] × Group [Treatment year]	-0.007	0.002	**<0.001**	-0.022	0.002	**<0.001**	0.102	0.007	**<0.001**
Observations	4616								
R^2 / R^2 adjusted	0.325								
AIC	-19591.138								

Appendix 6. Effect of Nutri-Scores on A/B product weight sold, robust subset (Chapter 4).

	All (n=16)			**Milk/Cream (n=5)**			**Yoghurt/Quark (n=9)**			**Dessert (n=2)**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	10.191	0.023	**<0.001**	13.712	0.123	**<0.001**	10.032	0.028	**<0.001**	9.992	0.039	**<0.001**
Year [Treatment Year]	-0.109	0.005	**<0.001**	-0.082	0.009	**<0.001**	-0.117	0.007	**<0.001**	-0.135	0.012	**<0.001**
Nutri-Score Presence [1]	0.016	0.005	**0.001**	0.007	0.010	0.461	0.023	0.006	**<0.001**	0.071	0.010	**<0.001**
Product Discounted [1]	0.586	0.014	**<0.001**	0.416	0.030	**<0.001**	0.546	0.016	**<0.001**	0.947	0.028	**<0.001**
Product Weight	0.304	0.026	**<0.001**	-2.810	0.096	**<0.001**	0.762	0.041	**<0.001**	-0.143	0.035	**<0.001**
Year x Nutri-Score Presence	0.023	0.008	**0.004**	0.080	0.014	**<0.001**	-0.006	0.009	0.521	-0.085	0.019	**<0.001**
Observations	125653			39063			70858			15732		
R^2 / R^2 adjusted	0.041 / 0.041			0.031 / 0.031			0.060 / 0.060			0.119 / 0.118		
AIC	65618.421			32526.459			24512.994			4367.723		

Appendix 7. Effect of Nutri-Scores on C/D/E product weight sold, robust subset (Chapter 4).

	All (n=24)			**Milk/Cream (n=3)**			**Yoghurt/Quark (n=3)**			**Dessert (n=5)**			**Butter/Margarine (n=13)**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	10.197	0.020	**<0.001**	11.254	0.179	**<0.001**	10.374	0.119	**<0.001**	9.771	0.029	**<0.001**	10.425	0.030	**<0.001**
Year [Treatment Year]	-0.060	0.004	**<0.001**	-0.015	0.011	0.173	-0.082	0.017	**<0.001**	-0.038	0.007	**<0.001**	-0.076	0.004	**<0.001**
Nutri-Score Presence [1]	0.033	0.003	**<0.001**	0.030	0.009	**0.001**	0.081	0.013	**<0.001**	0.071	0.008	**<0.001**	0.009	0.004	**0.022**
Product Discounted [1]	0.598	0.031	**<0.001**							0.508	0.030	**<0.001**			
Multiple Taste Variants [1]	-0.427	0.042	**<0.001**				1.076	0.185	**<0.001**						
Product Weight	0.792	0.026	**<0.001**	1.660	0.186	**<0.001**	2.271	0.252	**<0.001**	1.125	0.033	**<0.001**	0.962	0.047	**<0.001**
Year x Nutri-Score Presence	-0.037	0.005	**<0.001**	-0.079	0.012	**<0.001**	-0.006	0.018	0.720	0.028	0.010	**0.003**	-0.062	0.008	**<0.001**
Observations	185106			23602			23532			39373			98599		
R^2 / R^2 adjusted	0.026 / 0.026			0.007 / 0.007			0.026 / 0.026			0.054 / 0.054			0.033 / 0.033		
AIC	106567.875			15206.456			18882.931			6156.474			61737.664		

Appendix 8. Effect of Nutri-Scores on A/B product weight sold, all products (Chapter 4).

	All (n=41)			**Milk/Cream (n=19)**			**Yoghurt/Quark (n=20)**			**Dessert (n=2)**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	9.806	0.023	**<0.001**	9.059	0.046	**<0.001**	10.010	0.024	**<0.001**	9.992	0.039	**<0.001**
Year [Treatment Year]	-0.109	0.004	**<0.001**	-0.081	0.005	**<0.001**	-0.134	0.006	**<0.001**	-0.135	0.012	**<0.001**
Nutri-Score Presence [1]	0.007	0.004	0.092	0.036	0.005	**<0.001**	-0.031	0.008	**<0.001**	0.071	0.010	**<0.001**
Product Discounted [1]	0.670	0.013	**<0.001**	0.550	0.022	**<0.001**	0.701	0.018	**<0.001**	0.947	0.028	**<0.001**
Multiple Taste Variants [1]	0.435	0.040	**<0.001**	1.398	0.059	**<0.001**	-0.145	0.047	**0.002**			
Product Weight	0.694	0.019	**<0.001**	1.170	0.027	**<0.001**	0.420	0.029	**<0.001**	-0.143	0.035	**<0.001**
Year x Nutri-Score Presence	0.044	0.007	**<0.001**	0.025	0.009	**0.006**	0.079	0.012	**<0.001**	-0.085	0.019	**<0.001**
Observations	314322			148810			149780			15732		
R^2 / R^2 adjusted	0.039 / 0.039			0.027 / 0.027			0.059 / 0.059			0.119 / 0.118		
AIC	245471.221			133013.725			104064.083			4367.723		

Appendix 9. Effect of Nutri-Scores on C/D/E product weight sold, all products (Chapter 4).

	All (n=42)			**Milk/Cream (n=8)**			**Yoghurt/Quark (n=9)**			**Dessert (n=10)**			**Butter/Margarine (n=15)**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	10.188	0.016	**<0.001**	11.569	0.067	**<0.001**	9.822	0.057	**<0.001**	9.730	0.026	**<0.001**	10.459	0.029	**<0.001**
Year [Treatment Year]	-0.071	0.003	**<0.001**	-0.061	0.005	**<0.001**	-0.105	0.008	**<0.001**	-0.058	0.006	**<0.001**	-0.071	0.005	**<0.001**
Nutri-Score Presence [1]	0.025	0.003	**<0.001**	0.013	0.010	0.184	0.017	0.007	**0.009**	0.062	0.007	**<0.001**	0.013	0.004	**0.001**
Product Discounted [1]	0.643	0.015	**<0.001**				0.631	0.020	**<0.001**	0.646	0.024	**<0.001**			
Multiple Taste Variants [1]	0.504	0.024	**<0.001**	0.710	0.043	**<0.001**	0.771	0.061	**<0.001**	1.222	0.049	**<0.001**			
Product Weight	0.789	0.016	**<0.001**	1.798	0.064	**<0.001**	0.888	0.032	**<0.001**	1.064	0.029	**<0.001**	1.168	0.041	**<0.001**
Year x Nutri-Score Presence	-0.032	0.005	**<0.001**	-0.033	0.014	**0.015**	-0.001	0.010	0.926	0.042	0.010	**<0.001**	-0.067	0.008	**<0.001**
Observations	325777			62981			70486			78009			114301		
R^2 / R^2 adjusted	0.032 / 0.032			0.031 / 0.031			0.066 / 0.066			0.044 / 0.043			0.029 / 0.029		
AIC	161296.221			21414.168			30520.630			31679.219			74291.304		

Appendix 10. Effect of signage on A/B product weight sold, robust subset (Chapter 4).

	All (n=16)			**Milk/Cream (n=5)**			**Yoghurt/Quark (n=9)**			**Dessert (n=2)**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	9.924	0.056	**<0.001**	13.106	0.142	**<0.001**	9.746	0.070	**<0.001**	9.620	0.094	**<0.001**
Signage condition [Neutral]	0.205	0.075	**0.006**	0.109	0.097	0.259	0.230	0.091	**0.011**	0.331	0.125	**0.008**
Signage condition [Transp.]	0.198	0.070	**0.005**	0.126	0.089	0.156	0.221	0.086	**0.010**	0.272	0.119	**0.022**
Signage condition [Motiv.]	0.149	0.073	**0.041**	0.065	0.098	0.504	0.185	0.090	**0.040**	0.194	0.127	0.125
Signage condition [Comb.]	0.114	0.071	0.108	0.013	0.088	0.886	0.120	0.088	0.175	0.334	0.123	**0.007**
Signage Presence [1]	-0.062	0.013	**<0.001**	-0.103	0.023	**<0.001**	-0.055	0.016	**0.001**	-0.002	0.037	0.964
Product Discounted [1]	0.395	0.021	**<0.001**	0.445	0.026	**<0.001**	0.352	0.036	**<0.001**			
Product Weight	0.440	0.027	**<0.001**	-2.321	0.101	**<0.001**	0.937	0.044	**<0.001**	-0.044	0.034	0.188
Signage condition [Neutral] x Signage Presence	-0.012	0.017	0.485	0.024	0.030	0.430	-0.014	0.023	0.545	-0.090	0.047	0.054
Signage condition [Transp.] x Signage Presence	-0.054	0.017	**0.001**	-0.021	0.031	0.486	-0.052	0.022	**0.016**	-0.140	0.043	**0.001**
Signage condition [Motiv.] x Signage Presence	-0.034	0.017	**0.044**	0.014	0.030	0.643	-0.041	0.022	0.064	-0.112	0.044	**0.012**
Signage condition [Comb.] x Signage Presence	-0.022	0.017	0.184	0.008	0.031	0.801	-0.016	0.021	0.455	-0.118	0.043	**0.006**
Observations	28412			8919			15905			3588		
R^2 / R^2 adjusted	0.037 / 0.037			0.097 / 0.096			0.045 / 0.044			0.033 / 0.030		
AIC	14942.262			4983.778			9247.823			570.327		

Appendix 11. Effect of signage on C/D/E product weight sold, robust subset (Chapter 4).

	All (n=24)			Milk/Cream (n=3)			Yoghurt/Quark (n=3)			Dessert (n=5)			Butter/Margarine (n=13)		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	9.971	0.048	**<0.001**	11.002	0.226	**<0.001**	10.372	0.149	**<0.001**	9.670	0.077	**<0.001**	10.150	0.074	**<0.001**
Signage condition [Neutral]	0.112	0.061	0.067	0.002	0.139	0.988	0.003	0.110	0.979	0.189	0.109	0.084	0.145	0.097	0.134
Signage condition [Transp.]	0.107	0.058	0.063	-0.017	0.131	0.897	0.061	0.103	0.551	0.159	0.102	0.121	0.135	0.091	0.137
Signage condition [Motiv.]	0.109	0.060	0.068	0.035	0.134	0.793	0.101	0.110	0.359	0.116	0.103	0.259	0.134	0.095	0.157
Signage condition [Comb.]	0.129	0.058	**0.026**	0.003	0.138	0.985	0.261	0.097	**0.007**	0.133	0.101	0.187	0.126	0.092	0.170
Signage Presence [1]	-0.072	0.015	**<0.001**	-0.030	0.036	0.409	-0.013	0.035	0.702	-0.139	0.021	**<0.001**	-0.029	0.030	0.329
Product Discounted [1]	0.800	0.015	**<0.001**							0.714	0.020	**<0.001**			
Multiple Taste Variants [1]	-0.241	0.044	**<0.001**				0.927	0.190	**<0.001**						
Product Weight	0.861	0.027	**<0.001**	1.490	0.186	**<0.001**	2.243	0.256	**<0.001**	1.120	0.035	**<0.001**	1.085	0.045	**<0.001**
Signage condition [Neutral] x Signage Presence	0.013	0.021	0.540	-0.005	0.049	0.915	0.040	0.045	0.371	0.023	0.027	0.377	0.001	0.044	0.976
Signage condition [Transp.] x Signage Presence	-0.012	0.020	0.525	-0.003	0.044	0.949	-0.010	0.042	0.812	-0.033	0.026	0.206	0.000	0.039	0.998
Signage condition [Motiv.] x Signage Presence	-0.026	0.020	0.204	-0.014	0.043	0.744	-0.045	0.046	0.325	-0.022	0.025	0.383	-0.024	0.041	0.558
Signage condition [Comb.] x Signage Presence	-0.015	0.020	0.446	0.007	0.044	0.866	-0.040	0.041	0.330	-0.010	0.024	0.669	-0.019	0.042	0.648
Observations	30379			5253			5392			8973			10761		
R^2 / R^2 adjusted	0.347 / 0.346			0.057 / 0.055			0.036 / 0.034			0.262 / 0.261			0.470 / 0.469		
AIC	28723.757			5245.531			3688.934			2408.253			15603.011		

Appendix 12. Effect of signage on A/B product weight sold, all products (Chapter 4).

	All (n=41)			**Milk/Cream (n=19)**			**Yoghurt/Quark (n=20)**			**Dessert (n=2)**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	9.649	0.046	**<0.001**	9.067	0.072	**<0.001**	9.787	0.058	**<0.001**	9.620	0.094	**<0.001**
Signage condition [Neutral]	0.160	0.058	**0.006**	0.099	0.083	0.236	0.201	0.074	**0.007**	0.331	0.125	**0.008**
Signage condition [Transp.]	0.161	0.055	**0.003**	0.106	0.079	0.182	0.203	0.070	**0.004**	0.272	0.119	**0.022**
Signage condition [Motiv.]	0.143	0.057	**0.012**	0.091	0.081	0.263	0.187	0.072	**0.009**	0.194	0.127	0.125
Signage condition [Comb.]	0.097	0.057	0.089	0.052	0.082	0.527	0.115	0.071	0.105	0.334	0.123	**0.007**
Signage Presence [1]	-0.062	0.009	**<0.001**	-0.097	0.014	**<0.001**	-0.034	0.013	**0.008**	-0.002	0.037	0.964
Product Discounted [1]	0.581	0.013	**<0.001**	0.552	0.024	**<0.001**	0.594	0.015	**<0.001**			
Multiple Taste Variants [1]	0.431	0.040	**<0.001**	1.328	0.058	**<0.001**	-0.156	0.047	**0.001**			
Product Weight	0.708	0.018	**<0.001**	1.117	0.026	**<0.001**	0.475	0.029	**<0.001**	-0.044	0.034	0.188
Signage condition [Neutral] x Signage Presence	-0.003	0.013	0.806	0.022	0.018	0.238	-0.017	0.019	0.351	-0.090	0.047	0.054
Signage condition [Transp.] x Signage Presence	-0.036	0.012	**0.002**	-0.010	0.018	0.557	-0.049	0.017	**0.003**	-0.140	0.043	**0.001**
Signage condition [Motiv.] x Signage Presence	-0.019	0.012	0.125	0.023	0.018	0.205	-0.048	0.018	**0.006**	-0.112	0.044	**0.012**
Signage condition [Comb.] x Signage Presence	-0.016	0.012	0.192	0.016	0.019	0.383	-0.036	0.017	**0.037**	-0.118	0.043	**0.006**
Observations	72522			33822			35112			3588		
R^2 / R^2 adjusted	0.068 / 0.068			0.072 / 0.072			0.082 / 0.082			0.033 / 0.030		
AIC	60410.347			30855.080			28132.495			570.327		

Appendix 13. Effect of signage on C/D/E product weight sold, all products (Chapter 4).

	All (n=42)			Milk/Cream (n=8)			Yoghurt/Quark (n=9)			Dessert (n=10)			Butter/Margarine (n=15)		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	9.943	0.036	**<0.001**	11.423	0.090	**<0.001**	9.793	0.085	**<0.001**	9.583	0.052	**<0.001**	10.140	0.067	**<0.001**
Signage condition [Neutral]	0.139	0.044	**0.002**	0.040	0.073	0.580	0.130	0.082	0.110	0.200	0.067	**0.003**	0.161	0.085	0.057
Signage condition [Transp.]	0.112	0.042	**0.008**	-0.007	0.069	0.919	0.140	0.077	0.071	0.150	0.065	**0.021**	0.140	0.081	0.083
Signage condition [Motiv.]	0.101	0.044	**0.022**	0.010	0.072	0.894	0.132	0.081	0.105	0.122	0.067	0.067	0.124	0.084	0.142
Signage condition [Comb.]	0.116	0.043	**0.007**	-0.013	0.071	0.857	0.186	0.076	**0.015**	0.162	0.065	**0.012**	0.111	0.083	0.179
Signage Presence [1]	-0.068	0.009	**<0.001**	-0.052	0.016	**0.001**	-0.051	0.019	**0.006**	-0.106	0.015	**<0.001**	-0.059	0.024	**0.014**
Product Discounted [1]	0.777	0.014	**<0.001**				0.762	0.026	**<0.001**	0.756	0.018	**<0.001**	0.834	0.024	**<0.001**
Multiple Taste Variants [1]	0.620	0.025	**<0.001**	0.692	0.044	**<0.001**	0.595	0.063	**<0.001**	1.263	0.052	**<0.001**			
Product Weight	0.796	0.016	**<0.001**	1.723	0.065	**<0.001**	0.882	0.032	**<0.001**	1.041	0.031	**<0.001**	1.218	0.040	**<0.001**
Signage condition [Neutral] x Signage Presence	0.010	0.013	0.426	0.008	0.023	0.734	0.022	0.025	0.376	0.002	0.020	0.925	0.011	0.035	0.753
Signage condition [Transp.] x Signage Presence	-0.014	0.012	0.243	-0.008	0.021	0.713	-0.011	0.023	0.629	-0.041	0.019	**0.030**	0.009	0.031	0.764
Signage condition [Motiv.] x Signage Presence	-0.009	0.012	0.493	-0.013	0.020	0.525	0.005	0.024	0.827	-0.033	0.019	0.077	0.010	0.033	0.756
Signage condition [Comb.] x Signage Presence	-0.007	0.012	0.595	0.015	0.020	0.471	-0.006	0.024	0.799	-0.033	0.018	0.074	0.002	0.033	0.944
Observations	61436			14222			16108			16767			14339		
R^2 / R^2 adjusted	0.261 / 0.261			0.089 / 0.088			0.169 / 0.169			0.372 / 0.372			0.452 / 0.451		
AIC	42952.907			8896.594			8170.671			3346.005			18019.709		

Appendix 14. Effect of Nutri-Scores on milk weight sold, robust subset (Chapter 4).

	A			B		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	15.283	0.177	**<0.001**	13.026	0.125	**<0.001**
Year [Treatment Year]	-0.152	0.011	**<0.001**	-0.050	0.012	**<0.001**
Nutri-Score Presence [1]	-0.006	0.013	0.634	0.004	0.012	0.709
Product Weight	-3.828	0.139	**<0.001**	-2.408	0.104	**<0.001**
Product Discounted [1]				0.398	0.030	**<0.001**
Year x Nutri-Score Presence	0.158	0.019	**<0.001**	0.034	0.015	**<0.001**
Observations	15458			23605		
R^2 / R^2 adjusted	0.074 / 0.074			0.026 / 0.022		
AIC	10951.192			21238.826		

Appendix 15. Effect of Nutri-Scores on butter/margarine weight sold, robust subset (Chapter 4).

	C			D/E		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Intercept	10.416	0.030	**<0.001**	10.888	0.113	**<0.001**
Year [Treatment Year]	-0.040	0.007	**<0.001**	-0.112	0.006	**<0.001**
Nutri-Score Presence [1]	0.027	0.005	**<0.001**	-0.006	0.007	0.447
Product Weight	1.192	0.079	**<0.001**	1.325	0.109	**<0.001**
Year x Nutri-Score Presence	-0.062	0.011	**<0.001**	-0.074	0.011	**<0.001**
Observations	51873			46726		
R^2 / R^2 adjusted	0.021 / 0.020			0.042 / 0.042		
AIC	24172.877			36218.155		

Appendix 16. Pre-test to assess the manipulation of perceived similarity (Chapter 5).
First, we selected animal- versus plant-based as an attribute allowing us to identify clearly similar and clearly dissimilar alternatives across a range of food categories. The reason for that was that animal- versus plant-based products are often not perceived as members of the

same taxonomic product category (i.e. based on shared characteristics) (Hoek et al., 2011) and members of the same taxonomic product category are generally perceived as more similar than members of the same goal-derived product category (Felcher, Malaviya, & McGill, 2001).

Second, we specified product categories that contain animal-based and plant-based products, that are familiar to Dutch consumers, and that have some variation in healthfulness. The product categories yoghurt, meat slices for breads (e.g. ham), meat for dinner (e.g. minced meat), and wine gums were selected. Third, we searched in online supermarkets for unhealthy animal-based products, healthy animal-based products, and healthy plant-based products within these categories. Products with a Nutri-Score C, D, or E were considered unhealthy and products with a Nutri-Score A or B were considered healthy. Based on availability of products that fulfilled the criteria, we selected multiple subcategories to ensure a more realistic online store experience with a wider product assortment. In total nine subcategories were selected (Greek yoghurt, strawberry yoghurt, chicken slices, ham slices, minced meat, burgers, schnitzel, sausages, wine gums). For each subcategory eight products were selected (four unhealthy animal-based products, two healthy animal-based products, and two healthy plant-based products).

A pre-test was conducted to test whether the healthy animal-based versus plant-based alternatives differ in perceived similarity to the unhealthy animal-based products. In the pre-test, participants from a convenience sample ($n = 56$, 69.6% female, $M_{Age} = 28.21$, $SD_{Age} = 11.91$) were asked to rate the similarity of healthy products compared to the unhealthy products (see Figure S1) on five items (Cronbach's $\alpha \geq .795$), using a 7-point rating scale ranging from 1 = "not at all" to 7 = "very much" . The products were shown without any nutrition information and with the same brand (photoshopped in some cases) to avoid brand influence. Each participant rated the similarity of healthy animal-based and plant-based alternatives separately for all nine subcategories in a random order, resulting in 18 perceived similarity ratings per participant (see Figure S2). The results of a repeated-measures ANOVA showed a main effect of source (animal versus plant) ($F(1, 44) = 184.421$, $p < .001$, $\eta_p^2 = .81$) and a main effect of subcategory ($F(4.89, 215.13)$[10] $= 20.01$, $p < .001$, $\eta_p^2 = .31$) on perceived similarity. These main effects were qualified by a significant interaction ($F(8, 352) = 32.12$, $p < .001$, $\eta_p^2 = .42$). Planned contrasts revealed that plant-based substitutes were perceived as less similar to the four unhealthy animal-based products than the healthy animal-based products for all subcategories ($p < .05$). However, since the difference in perceived healthfulness between plant-based and animal-based products was small for wine gums (Cohen's $d_{wine\ gums} = .25$ vs. mean Cohen's $d_{other\ categories} = 2.16$), it was decided to not include this subcategory in the main study.

Figure S1. Stimuli used in the pre-test.
Note: Group A are the four unhealthy products in the assortment. Group B are the two healthier alternatives (left = meat-based, right = plant-based), which are compared separately to the products in Group A.

[10] For the main effect of subcategory the Greenhouse-Geisser estimate of the departure from sphericity was $\varepsilon = .61$.

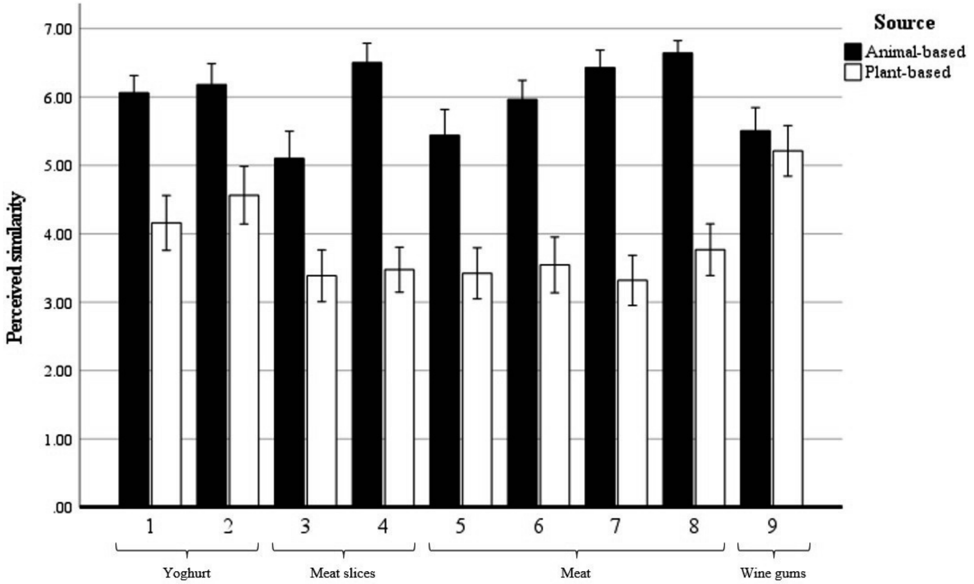


Figure S2. Perceived similarity of healthy animal-based and plant-based alternatives compared to unhealthy animal-based alternatives.
Note: Error bars represent 95% CI.

Appendix 17. Study procedure of the main study, translated from Dutch to English (Chapter 5).

Introduction
Welcome to this research!

You are being invited to participate in a research study by [Author blinded for review] from [University blinded for review]. This study investigates how consumers make food choices in an online supermarket.

Procedure
The study will take about 15 minutes and should be completed without interruptions. You will first see some general questions, then you will be asked to do some online grocery shopping on a supermarket website, and at last we will ask you some questions about your choices and yourself.

Voluntary participation
Participation is **entirely voluntarily**. Therefore, you are allowed to quit at any point in time. Your answers will be handled completely **confidentially** and **anonymously**. Research data that are published in scientific journals will be anonymous and cannot be traced back

to you as an individual. The completely anonymized data can be shared with other researchers.

Should you have any questions about this study at any given moment, please contact the responsible researcher: [Author and e-mail blinded for review]

If you have any privacy concerns, please contact [E-mail blinded for review].

When you click '**I AGREE**', you confirm that:
- You are 18 years or older
- You have read the study information
- You are informed about the nature and procedure of this study
- You voluntarily agree to participate in this study

Block 1: Screening questions

Construct	**Measure**	**Scale**	**Screening**
Dutch resident	Do you live in the Netherlands?	Yes No	No -> exclude
Page Break			
Dutch language	Do you speak Dutch?	Yes No	No -> exclude
Page Break			
Main shopper (adapted from Riches, 2019)	Are you responsible for the grocery shopping in your household?	• Yes, I am responsible for all the grocery shopping • Yes, I am responsible for some of the grocery shopping (i.e. spending at least 25€ on grocery shopping per week) • No, I am not responsible for grocery shopping (i.e. spending less than 25€ on grocery shopping per week)	No -> exclude
Page Break			
Meat Purchaser	This study is about food choices. Do you sometimes buy meat for yourself or your household?	Yes No	No --> exclude
Page Break			
Age	How old are you?	Open text, only numbers allowed	*exclude -18* *12% 18-25 years* *14% 26-34 years* *19% 35-44 years* *20% 45-55 years* *16% 56-65 years* *19% 66+*
Page Break			
Gender	How do you identify?	Male Female Non-binary Prefer to self-identify: [open text]	*48% male* *48% female* *4% other*

Page Break			
Education	What is your highest education level?	• Basisonderwijs • VMBO • MBO-1 • MBO-2 • MBO-3 • MBO-4 • HBO • WO	*30% Low (Basisonderwijs-MBO-1)* *37% Medium (MBO-2-4)* *33% High (HBO/WO)*
Page Break			
Dietary Requirement	Do you follow a diet or do you have an allergy or intolerance that prevents you from eating certain food products? **Also check the following option for verification: "Please also select this option for verification".** It is possible to give multiple answers.	• No • Food allergy (e.g. nuts) • Intolerance (e.g. lactose) • Vegan • Vegetarian • Pescatarian • Flexitarian • Sugar-free (due to health reasons such as diabetes) • Please also select this option for verification • Other: [open text]	-> excluded those who do not select "Please also select this option for verification"

Shopping task

Block 2: Instructions (adapted from Riches et al., 2019):

In the following part you will be asked to do some online grocery shopping on a supermarket website. This is not a real supermarket and you will not be asked to spend your own money.

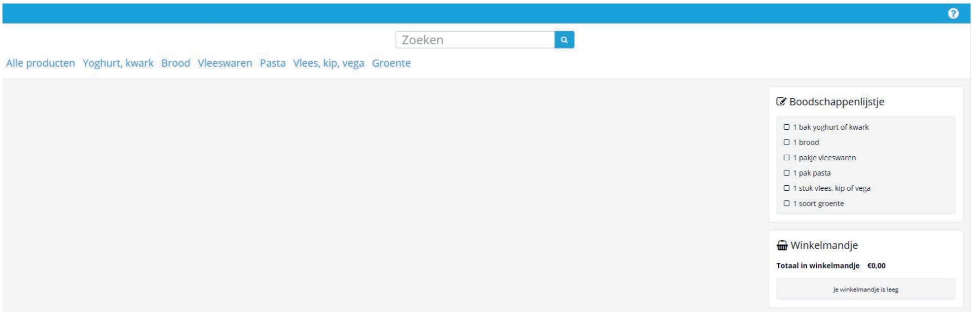
You will see a shopping list on the right of the supermarket website. Please use this shopping list and buy all the items on the list in the stated quantity. Buy **only** products that are on the list. There is no need to purchase additional products in addition to the products on the list or to purchase products that you normally buy.

When you go shopping, try to imagine that you are shopping for yourself and your household. Choose products you would eat based on the options available and the products in the list. Only choose products that you would actually eat. When you are done shopping, you can click on 'Order'. After clicking 'Order' you will be forwarded to the rest of the questionnaire.

You can click the question mark button in the online supermarket to read these instructions again.

Click 'next' to continue to the online supermarket.

[Choices in the online store]



Post-choice questionnaire

In the following we will ask you some more questions about how you made your choices and about yourself. There are no right or wrong answers. It is your opinion that counts and is important for this research.

Block 3: Food-swap related questions

Some participants have received recommendations for alternative products to replace their original product choices. An example of such a product recommendation could have looked as follows:

[picture of the food swap depends on the condition, all have the same originally-chosen product]

[Show participants who were in food swap conditions these questions:]

Construct	Measure	Scale
Food swap received?	Did you receive such recommendations for alternative products during your food choices?	Yes -> Go to instruction mediators

		No -> Go to Instruction imagine I don't know --> Go to instruction imagine
Page Break		
Instruction imagine	Imagine you saw a product recommendation for a healthier product each time you made an unhealthy choice. The product recommendation would have looked something like this: [show picture of food swap again] In the following we will ask you some questions about such a product recommendation. Please indicate to what extent you agree with the following statements	Then go to perceived compromise
Instruction mediators	In the next part some questions are asked about these product recommendations. Please indicate to what extent you agree with the following statements.	Then go to perceived compromise
Page break		
Perceived compromise	To which extent did the choice between your original choices and the product recommendations involve... 1. making trade-offs? 2. letting go of benefits? 3. making compromises to what you initially wanted to choose? 4. giving up some benefits to gain other benefits?	1 (not at all) to 7 (very much)
Page Break		
Perceived intrusiveness from Dillard and Shen (2005)	The product recommendations... 1. threatened my freedom to choose. 2. tried to make purchasing decisions for me. 3. tried to manipulate me. 4. tried to pressure me.	1 (strongly disagree) to 7 (strongly agree)
Page Break		
Manipulation check: perceived similarity of the recommended product	To which extent would you describe your original choices and the recommended products... 1. as similar? 2. as sharing the same product features? 3. as being from the same product category?	1 (not at all) to 7 (very)

[Show participants in the control group:]

Construct	**Measure**	**Scale**
Instruction control group	In the following we will ask you some questions about such a product recommendation. Please indicate to what extent you agree with the following statements	Then go to Acceptance of the intervention

[Show all participants:]

Acceptance of the intervention	Would you like to receive such product recommendations during your online shopping trips in real life?	1 (not at all) to 7 (very)
Page Break		

Intention	How likely is it that you would accept these product recommendations during your online shopping trips in real life?	1 (not at all) to 7 (very)
Page Break		
Perc. Effectiveness	How effective do you think are the product recommendations in making people choose healthier products when grocery shopping?	1 (not at all) to 7 (very)

Block 4: Demographic and control variables

Construct	**Measure**	**Scale**
Realism of the choices	1. The choices that I made are reflective of the choices that I usually would make when grocery shopping. 2. I would make the same choices in a real shopping situation	1 (strongly disagree) to 7 (strongly agree)
Page Break		
Familiarity with the product category	Please indicate how often you buy these products for yourself or your household: ... • Yoghurt or kwark • Bread • Slices of meat • Pasta • Meat, chicken or vegetarian • Vegetables	(1) never, (2) sometimes, (3) often
Page Break		
Plant-based substitute products are foods that are designed to mimic and replace animal-based products. Examples are soy yoghurt or burgers made from wheat. Fish, eggs, cheese, nuts, or legumes are **not** considered as plant-based substitute products in this survey. (adapted from Elzerman 2015)		
Frequency of plant-based substitute consumption (Hoek 2011)	How often do you eat plant-based substitute products?	1 (never) to 7 (five times per week or more) never; tried it once; less than once per month; less than once per week; once or twice per week; three or four times per week, five times per week or more
Page Break		
Perceptions about plant-based substitutes	In my opinion plant-based substitute products are...	Bipolar adjectival items (7-point, -3 to 3, starting at 0): Unhealthy – healthy Not affordable – affordable Bad for the planet – good for the planet Unpopular – popular Not tasty – tasty
Page Break		
Frequency of meat consumption (Hoek 2011)	How often do you eat **animal-based** products?	1 (never) to 5 (five times per week or more) never; less than once per week; once or twice per week; three or four times per week; five times or more per week
Page Break		
In the picture below you see some labels.		

Recall of the Nutri-Score	During the online grocery shopping task did you see any of these labels when making your choices?	1 Nutri-Score 2 Multiple-Traffic Light 3 Choices logo/Vinkje 4 Beter leven 5 None of these
Page Break		
Familiarity with the Nutri-Score	How familiar are you with the Nutri-Score nutrition label?	1 (not at all familiar) to 7 (very familiar)
Page Break		
General health interest from Hung et al. (2017) based on Roininen (1999)	1. I am very particular about the healthiness of food I eat 2. I eat what I like and I do not worry much about the healthiness of food (R) 3. I always follow a healthy and balanced diet 4. The healthiness of food has little impact on my food choices (R)	1 (strongly disagree) to 7 (strongly agree)
Page Break		
Food neophobia from Van Wezemael et al., 2010 based on Pliner & Hobden, 1992	1. I am constantly sampling new and different foods (R) 2. I do not trust new foods 3. If I don't know what it is, I won't try it 4. I am afraid to eat things I have never had before 5. I will eat almost anything (R)	1 (strongly disagree) to 7 (strongly agree)
Page Break		
Hunger	How hungry are you right now?	1 (not at all) to 7 (extremely)
Page break		
Current dieting status	Are you currently on a specific diet?	No Yes, trying to lose weight Yes, other:
Page Break		
Comments	Do you have any comments about this study?	Open answer

Debrief

Thank you for your participation in this study. Some participants saw product recommendations for healthier alternatives after they made a product choice. I am researching how to best design these product recommendations to stimulate healthier food choices.

Should you have any questions about this study, please contact the responsible researcher: [Author and e-mail blinded for review]

Appendix 18. Descriptive statistics per condition (Chapter 5).

Step 1: All participants	Control (n=115)	Similar (n=110)	Dissimilar (n=105)	Mixed (n=98)	p-value
Gender (n, %)					
Male	46 (40.0)	55 (50.0)	50 (47.6)	47 (48.0)	.461[1]
Female	69 (60.0)	54 (49.1)	55 (54.4)	51 (52.0)	
Other	0 (0.0)	1 (0.9)	0 (0.0)	0 (0.0)	
Education (n, %)					
Low	21 (18.3)	12 (10.9)	20 (19.0)	20 (20.4)	.481[1]
Medium	47 (40.9)	49 (44.5)	36 (34.3)	37 (37.8)	
High	47 (40.9)	49 (44.5)	49 (46.7)	41 (41.8)	
Dietary requirements (n, %)	26 (22.6)	39 (35.5)	25 (23.8)	20 (20.4)	**.053[1]**
Food allergies / Intolerance	8 (7.0)	12 (10.9)	9 (8.6)	7 (7.1)	.702[1]
Vegan	2 (1.7)	1 (0.9)	0 (0.0)	1 (1.0)	.614[1]
Vegetarian	3 (2.6)	4 (3.6)	0 (0.0)	4 (4.1)	.244[1]
Pescetarian	1 (0.9)	0 (0.0)	0 (0.0)	1 (1.0)	.561[1]
Flexitarian	16 (13.9)	22 (20.0)	14 (13.3)	10 (10.2)	.231[1]
Sugar-free	2 (1.7)	7 (6.4)	2 (1.9)	3 (3.1)	.186[1]
Other	0 (0.0)	2 (1.8)	3 (2.9)	3 (3.1)	.319[1]
Currently dieting (n, %)	27 (23.5)	30 (27.3)	23 (21.9)	23 (23.5)	.978[1]
Age in years (M, SD)	47.8 (16.0)	46.0 (15.4)	49.2 (17.7)	47.9 (14.6)	.533[2]
Nutri-Score familiarity (M, SD)[a]	3.5 (1.9)	3.5 (1.9)	3.7 (1.9)	3.6 (2.0)	.783[2]
General health interest (M, SD)[a]	3.9 (1.4)	4.2 (1.3)	4.2 (1.1)	4.1 (1.4)	.423[2]
Meat consumption frequency (M, SD)[b]	4.1 (0.9)	4.0 (1.0)	4.1 (1.01)	3.8 (1.2)	.382[2]
Plant-based consumption frequency (M, SD)[a]	3.0 (1.7)	3.2 (2.0)	3.1 (1.8)	3.1 (1.1)	.786[2]
Familiarity with... (M, SD)[c]					
Yoghurt	2.60 (0.57)	2.45 (0.60)	2.58 (0.58)	2.55 (0.58)	.256[2]
Bread	2.78 (0.47)	2.73 (0.52)	2.90 (0.29)	2.78 (0.51)	**.036[2]**
Slices of meat	2.62 (0.54)	2.63 (0.56)	2.72 (0.49)	2.66 (0.52)	.441[2]
Pasta	2.44 (0.55)	2.37 (0.59)	2.48 (0.59)	2.51 (0.52)	.332[2]
Meat, chicken or vegetarian	2.79 (0.43)	2.73 (0.47)	2.79 (0.41)	2.85 (0.36)	.239[2]
Vegetables	2.87 (0.34)	2.85 (0.38)	2.92 (0.27)	2.87 (0.37)	.463[2]
Choice realism (M, SD)[a]	5.6 (1.4)	5.6 (1.4)	5.6 (1.4)	5.7 (1.3)	.925[2]
Hunger (M, SD)[a]	3.6 (1.7)	3.1 (1.5)	3.6 (1.8)	3.3 (1.8)	.207[2]
Step 2: Participants who received recommendation(s)		**Similar (n=91)**	**Dissimilar (n=82)**	**Mixed (n=84)**	**p-value**
Gender (n, %)					
Male		47 (51.6)	42 (51.2)	41 (48.8)	.728[1]
Female		43 (47.3)	40 (48.8)	43 (51.2)	
Other		1 (1.1)	0 (0.0)	0 (0.0)	
Education (n, %)					
Low		11 (12.1)	16 (19.5)	18 (24.4)	.300[1]
Medium		43 (47.3)	28 (34.1)	33 (39.3)	
High		37 (40.7)	38 (46.3)	33 (39.3)	
Dietary requirements (n, %)		64 (70.3)	65 (79.3)	69 (82.1)	.151[1]
Currently dieting (n, %)		25 (27.5)	18 (22.0)	17 (20.2)	.777[1]
Age in years (M, SD)		46.9 (15.8)	49.2 (17.7)	48.7 (14.3)	.595[2]

Nutri-Score familiarity (M, SD)[a]	3.2 (1.9)	3.5 (1.7)	3.4 (2)	.537[2]
General health interest (M, SD)[a]	4.1 (1.3)	4.1 (1.1)	4.1 (1.4)	.998[2]
Meat consumption frequency (M, SD)[b]	4 (1)	4 (1.1)	3.9 (1.2)	.706[2]
Plant-based consumption frequency (M, SD)[a]	3 (2.1)	3 (1.7)	2.9 (1.8)	.885[2]
Familiarity with... (M, SD)[c]				
Yoghurt	2.44 (0.6)	2.6 (0.56)	2.55 (0.59)	.191[2]
Bread	2.76 (0.48)	2.91 (0.28)	2.77 (0.52)	**.043**[2]
Slices of meat	2.67 (0.56)	2.79 (0.41)	2.68 (0.47)	.191[2]
Pasta	2.4 (0.59)	2.52 (0.57)	2.5 (0.53)	.278[2]
Meat, chicken or vegetarian	2.73 (0.47)	2.83 (0.38)	2.83 (0.37)	.146[2]
Vegetables	2.82 (0.41)	2.95 (0.22)	2.87 (0.37)	**.054**[2]
Choice realism (M, SD)[a]	5.7 (1.3)	5.5 (1.4)	5.7 (1.4)	.492[2]
Hunger (M, SD)[a]	3.1 (1.6)	3.2 (1.8)	3.3 (1.8)	.762[2]

Note. [1] Pearson Chi-square test. [2] One-way ANOVA.

[a] Measured on a 7-point scale (range 1–7). [b] Measured on a 5-point scale (range 1–5). [c] Measured on a 3-point scale (range 1–3).

Appendix 19. Correlations of dependent variables with demographic and control variables (Chapter 5).

	Number of healthy choices	**Mean FSA score**	**Swap acceptance rate**	**Proportion of plant-based choices**
Gender (female vs. other)[1]	0.074	**-.096**[*]	0.026	0.007
Education (low vs. other)[1]	**-.120**[*]	**.114**[*]	-0.098	-0.069
Age	-0.058	0.078	0.017	**-.105**[*]
Realism	-0.090	0.078	0.013	-0.052
Hunger	0.016	-0.024	0.081	0.072
Yoghurt category familiarity	0.048	-0.037	0.087	0.006
Meat slices category familiarity	-0.071	0.082	0.067	**-.152**[**]
Meat category familiarity	0.044	-0.045	0.096	-0.034
Nutri-Score familiarity	**.324**[**]	**-.319**[**]	**.226**[**]	**.201**[**]
Plant-based consumption frequency	**.275**[**]	**-.286**[**]	**.148**[*]	**.451**[**]
Meat consumption frequency	**-.104**[*]	**.129**[**]	-0.101	**-.338**[**]

Note. [1] Point-biserial correlation coefficients. * Correlation is significant at the .05 level (2-tailed). ** Correlation is significant at the .01 level (2-tailed).

Appendix 20. Mixed-effects logistic regression results using plant-based choice as criterion (Chapter 5).

Effects	Exp (B)	95% CI for Exp (B)		p	Fit
		LL	UL		
Main-effects model					
Marginal R^2					*.118*
AIC / BIC					*1082 / 1118*
Mixed model					
Fixed effects					
Intercept	0.030	0.016	0.056	**< .001**	
Condition					
Similar vs. control	1.241	0.743	2.073	0.409	
Dissimilar vs. control	1.619	0.974	2.693	0.063	
Mixed vs. control	1.475	0.875	2.485	0.145	
Product Category					
Meat slices vs. meat	0.438	0.287	0.668	**< .001**	
Yoghurt vs. meat	1.230	0.854	1.771	0.266	
Meat slices vs. yoghurt	0.356	0.234	0.541	**< .001**	
Plant-based consumption frequency	1.621	1.457	1.803	**< .001**	
Random effects					
Participant					
σ^2					3.29
ICC					.23
Marginal R^2 / Conditional R^2					*.060 / .273*
AIC / BIC					*1077 / 1118*

Appendix 21. Differences between conditions in attitudes about plant-based products and food swap recommendation (Chapter 5).

	Control (n=115)	Similar (n=110)	Dissimilar (n=105)	Mixed (n=98)	p-value
Attitudes about plant-based products... [1]					
Health	0.83 (1.46)	0.73 (1.54)	1.10 (1.13)	0.86 (1.25)	.219[a]
Affordability	-0.46 (1.60)	0.04 (1.60)	-0.04 (1.38)	-0.19 (1.63)	.082
Good for the planet	0.97 (1.44)	0.85 (1.45)	1.30 (1.32)	0.96 (1.43)	.113
Popularity	0.17 (1.56)	0.40 (1.56)	0.30 (1.41)	0.35 (1.61)	.696
Tasty	-0.50 (1.83)	0.12 (1.87)	-0.05 (1.70)	-0.30 (1.79)	.054
Willingness to receive food swap recommendation [2]	3.53 (1.77)	3.37 (1.96)	3.37 (1.96)	3.37 (1.87)	.896
Likelihood to accept food swap recommendations[2]	3.41 (1.68)	3.38 (1.78)	3.25 (1.73)	3.50 (1.90)	.785
Perceived effectiveness of food swap recommendation[2]	4.10 (1.72)	4.01 (1.67)	3.95 (1.51)	4.02 (1.71)	.936

[1] Measured on a 7-point scale (range -3 – 3). [2] Measured on a 7-point scale (range 1–7). [a] Findings were also confirmed with Welch ANOVA as homogeneity of variance was violated (based on Levene's test).

Summary

Obesity and nutrition-related noncommunicable diseases remain an issue in countries around the world, causing not only severe consequences for individuals but also for economies and public health. FOP nutrition labelling has been repeatedly recommended by the World Health Organization as part of a broader strategy to improve population diets. The goals of nutrition labelling are usually two-fold: 1) to encourage informed healthy choices by consumers and 2) to motivate healthier product reformulation by manufacturers.

This thesis deepens the understanding of consumers' use of FOP nutrition labelling in supermarket settings. Past research provided valuable insights into which FOP nutrition label designs are most effective in promoting understanding and influencing choices in lab environments. This thesis specifically addresses the questions of 1) what barriers prevent consumers from using FOP nutrition labels in making healthier food choices, and which complementary interventions could overcome these barriers, 2) how FOP nutrition labels influence supermarket sales in real-life, 3) whether different consumer groups in society benefit equally from FOP nutrition labels, and 4) to which extent complementary interventions enhance the effect of FOP nutrition labels.

To establish the theoretical framework of this thesis two existing MOA frameworks were combined, separating the information-processing in the first step from the choice process in the second step. Information provision alone is a necessary yet insufficient condition for behaviour change to occur. Individuals need to 1) turn this information into knowledge and 2) apply this knowledge in their choice. In each step barriers can prevent individuals from processing and acting upon FOP nutrition labels. In the first step, a lack of ability to process nutrition labels (e.g. due to low nutritional knowledge) and/or a lack of motivation to process nutrition labels may prevent individuals from processing FOP nutrition labels. In the second step, a lack of opportunity to make a healthy choice (e.g. due to lack of available healthy options) and/or a lack of motivation to make a healthy choice may hinder individuals from acting upon FOP nutrition labels.

This thesis suggests that complementary interventions may be needed to target these barriers for optimal FOP nutrition label effectiveness. The findings of the systematic review provide limited evidence for the effectiveness of supporting nutrition labels with further information, such as educational material or reference information. The evidence for supporting nutrition labels with interactive digital interventions, such as basket feedback, or financial incentives is promising. Overall, the findings indicate that more intrusive interventions are required to encourage action based on nutrition labels.

The thesis utilized two natural experiments at different discounter supermarket chains in the Netherlands to examine the effect of FOP nutrition labels on actual sales. One supermarket chain introduced a FOP fibre label on their whole bread assortment (Chapter 3). The FOP fibre label had three levels and used an easy-to-understand design. The breads across the different levels did not differ in price, minimizing the cost of healthier food as a barrier to healthier choices. FOP fibre labels produced shifts in market share of low and medium fibre breads towards high fibre breads, resulting in a small increase in the mean fibre content per 100g of bread sold. The effect of FOP fibre labels did not differ between stores in lower and higher SES areas.

Chapter 4 extended the findings of Chapter 3 by using a different label and analysed the effect on a different product category. The supermarket chain gradually introduced Nutri-Score labels in their dairy assortment. The introduction of the Nutri-Score label improved the nutritional quality of supermarket dairy sales. However, differences in the label effectiveness were found across subcategories. While Nutri-Scores had a positive effect on the nutritional quality of milk/cream and butter/margarine sales, Nutri-Scores had no effect on the nutritional quality of yoghurt/quark sales and even a negative effect on the nutritional quality of dairy desserts. Additional shelf signage with information about Nutri-Score had unexpected negative effects on sales of yoghurts/quarks and desserts with Nutri-Score A/B. These findings highlight that the effect of FOP nutrition labels may be category-specific.

Additional healthier food swap recommendations improved the nutritional quality of shopping basket compared to only providing Nutri-Score nutrition. Individuals with higher knowledge and motivation used Nutri-Scores to make healthier choices and hence were less likely to receive food swap recommendations. In contrast, individuals with lower knowledge and motivation made unhealthy choices despite Nutri-Scores and hence received food swap recommendations more often. Acceptance of an alternative in the food swap recommendations was less likely when food swap recommendations only included dissimilar alternatives, indicating that at least one of the suggested alternatives should be similar to the original choice.

All in all, the findings indicate that FOP nutrition labels have small effects on supermarket sales on their own. This is likely since knowledgeable and motivated individuals make use of FOP nutrition labels in their food choice, while FOP nutrition labels are not sufficient to stimulate behaviour change for the remaining consumer segment. While FOP nutrition labelling policies can inform consumers about the nutritional content of packaged foods, they are insufficient to create large-scale behaviour change. FOP nutrition labels place the responsibility on the individual and require motivation and sustained adherence to be effective. Policies could focus on educational campaigns to promote health motivation in the public, but this ignores the strong role of the environment in shaping consumer food choices. Multifaceted policy programs also need to address the role of the environment in promoting unhealthy food choices. This may include regulating the marketing of unhealthy foods, especially to vulnerable groups such as children and adolescents, implementing fiscal policies like taxes on sugary drinks and subsidies for fruits and vegetables, and enhancing the availability of healthy food options in retail settings. In addition, digital decision support in the choice environment such as healthier food swap recommendations may disrupt routinized unhealthy food choices. By addressing both individual and environmental factors, a comprehensive policy approach can more effectively combat obesity and nutrition-related noncommunicable diseases, leading to better public health outcomes.

Zusammenfassung
(German summary)

Adipositas und ernährungsbedingte nichtübertragbare Krankheiten bleiben weltweit ein Problem und verursachen nicht nur schwerwiegende Folgen für die betroffenen Individuen, sondern auch für das öffentliche Gesundheitswesen und die Volkswirtschaft. Die Weltgesundheitsorganisation hat wiederholt die „Front-of-Pack"-Nährwertkennzeichnung als Teil einer umfassenderen Strategie zur Verbesserung der Ernährung der Bevölkerung empfohlen. Die Ziele der Nährwertkennzeichnung sind meist zweifach: 1) Verbraucher zu ermuntern, informierte und gesunde Entscheidungen zu treffen, und 2) Hersteller zu motivieren, gesündere Produkte zu reformulieren.

Diese Dissertation vertieft das Verständnis über die Nutzung von „Front-of-Pack"-Nährwertkennzeichnungen durch Verbraucher in Supermärkten. Frühere Forschungen haben wertvolle Einblicke darüber gegeben, welche Nährwertkennzeichnungsdesigns am effektivsten das Verständnis fördern und Entscheidungen in Laborumgebungen beeinflussen. Diese Arbeit beschäftigt sich speziell mit den Fragen: 1) Welche Barrieren hindern Verbraucher daran, Nährwertkennzeichnungen zu nutzen, um gesündere Lebensmittelentscheidungen zu treffen, und welche ergänzenden Interventionen könnten diese Barrieren überwinden? 2) Wie beeinflussen Nährwertkennzeichnungen Kaufentscheidungen in der realen Welt? 3) Profitieren unterschiedliche Verbrauchergruppen in der Gesellschaft gleichermaßen von Nährwertkennzeichnungen? und 4) Inwieweit verbessern ergänzende Interventionen die Wirkung von Nährwertkennzeichnungen?

Um das theoretische Modell dieser Arbeit zu etablieren, wurden zwei bestehende MOA-Modelle kombiniert, wobei die Informationsverarbeitung im ersten Schritt vom Entscheidungsprozess im zweiten Schritt getrennt wurde. Die Bereitstellung von Informationen allein ist eine notwendige, aber nicht ausreichende Bedingung für eine Verhaltensänderung. Individuen müssen 1) diese Informationen in Wissen umwandeln und 2) dieses Wissen in ihrer Entscheidung anwenden. In jedem Schritt können Barrieren Individuen daran hindern, Nährwertkennzeichnungen zu verarbeiten und darauf zu reagieren. Im ersten Schritt kann ein Mangel an Fähigkeiten (z.B. aufgrund geringer Ernährungskenntnisse) und/oder ein Mangel an Motivation die Verarbeitung von Nährwertkennzeichnungen verhindern. Im zweiten Schritt kann ein Mangel an Gelegenheit, (z.B. aufgrund mangelnder Verfügbarkeit gesunder Optionen) und/oder ein Mangel an Motivation Individuen daran hindern, auf Nährwertkennzeichnungen zu reagieren und eine gesunde Wahl zu treffen.

Diese Arbeit schlägt vor, dass ergänzende Interventionen erforderlich sein können, um diese Barrieren für eine optimale Wirksamkeit von Nährwertkennzeichnungen zu beseitigen. Die Ergebnisse der systematischen Review (Kapitel 2) liefern begrenzte Belege für die Wirksamkeit der Unterstützung von Nährwertkennzeichnungen durch weitere Informationen über die Nährwertkennzeichnungen, wie z.B. Bildungsmaterial oder Referenzinformationen. Die Evidenz für die Unterstützung von Nährwertkennzeichnungen durch interaktive digitale Interventionen, wie zusammenfassende Informationen über die Nährwertqualität des Warenkorbs, oder finanzielle Anreize ist vielversprechend. Insgesamt deuten die Ergebnisse darauf hin, dass invasivere Interventionen erforderlich sind, um Entscheidungen basierend auf Nährwertkennzeichnungen zu fördern.

Die Dissertation nutzte zwei natürliche Experimente in verschiedenen Discounter-Supermarktketten in den Niederlanden, um die Wirkung von Nährwertkennzeichnungen auf den tatsächlichen Verkauf zu untersuchen. Eine Supermarktkette führte eine Ballaststoffkennzeichnung für ihr gesamtes Brotsortiment ein (Kapitel 3). Die Ballaststoffkennzeichnung hatte drei Stufen und verwendete ein leicht verständliches Design. Die Brote in den verschiedenen Stufen unterschieden sich nicht im Preis, sodass ein Wechsel zu gesündere Broten nicht durch die Kosten gehindert wurde. Ballaststoffkennzeichnungen führten zu Verschiebungen im Marktanteil von Broten mit niedrigem und mittlerem Ballaststoffgehalt hin zu Broten mit hohem Ballaststoffgehalt. Dies führte zu einem kleinen Anstieg des durchschnittlichen Ballaststoffgehalts pro 100 g verkauftem Brot. Die Wirkung der Ballaststoffkennzeichnungen unterschied sich nicht zwischen Geschäften in Gebieten mit niedrigem und hohem sozioökonomischen Status.

Kapitel 4 erweiterte die Ergebnisse von Kapitel 3 durch die Verwendung einer anderen Nährwertkennzeichnung und einer andere Produktkategorie. Die Supermarktkette führte schrittweise Nutri-Score-Kennzeichnungen in ihrer Milchprodukteabteilung ein. Die Einführung der Nutri-Score-Kennzeichnung verbesserte die Nährwertqualität des Verkaufs von Milchprodukten. Es wurden jedoch Unterschiede in der Wirksamkeit der Kennzeichnung in verschiedenen Unterkategorien festgestellt. Während Nutri-Scores einen positiven Effekt auf die Nährwertqualität von Milch-/Sahne- und Butter-/Margarineverkäufen hatten, hatten Nutri-Scores keinen Effekt auf die Nährwertqualität von Joghurt-/Quarkverkäufen und sogar einen negativen Effekt auf die Nährwertqualität von Milchdesserts. Zusätzliche Regalbeschilderungen mit Informationen über die Nutri-Score-Kennzeichnung hatten unerwartet negative Auswirkungen auf den Verkauf von Joghurts/Quarks und Desserts mit Nutri-Score A/B. Diese Ergebnisse zeigen, dass die Wirkung von Nährwertkennzeichnungen kategoriespezifisch sein kann.

In einer weiteren Studie wurden Probanden gesündere Produktalternativen empfohlen, wenn sie ungesunde Entscheidungen getroffen hatten. Zusätzliche Empfehlungen für gesündere Produktalternativen verbesserten die Nährwertqualität des Einkaufswagens im Vergleich zur alleinigen Bereitstellung von Nutri-Score-Nährwertinformationen. Personen mit höheren Kenntnissen und höherer Motivation nutzten Nutri-Scores, um gesündere Entscheidungen zu treffen, und erhielten daher seltener Empfehlungen. Im Gegensatz dazu trafen Personen mit geringeren Kenntnissen und geringerer Motivation trotz Nutri-Scores ungesunde Entscheidungen und erhielten daher häufiger Empfehlungen zu Produktalternativen. Die Akzeptanz einer Alternative in den Empfehlungen war weniger wahrscheinlich, wenn die Empfehlungen nur unähnliche Alternativen enthielten, was darauf hinweist, dass mindestens eine der vorgeschlagenen Alternativen der ursprünglichen Wahl ähnlich sein sollte.

Übergreifend deuten die Ergebnisse dieser Dissertation darauf hin, dass Nährwertkennzeichnungen allein geringe Auswirkungen auf den Supermarktverkauf haben. Dies liegt wahrscheinlich daran, dass informierte und motivierte Individuen Nährwertkennzeichnungen bei ihrer Lebensmittelwahl nutzen, während Nährwertkennzeichnungen für das verbleibende Verbrauchersegment nicht ausreichen, um eine Verhaltensänderung zu stimulieren. Während Nährwertkennzeichnungen Verbraucher über den Nährwert von verpackten Lebensmitteln informieren können, sind sie nicht ausreichend, um starke Verhaltensänderungen herbeizuführen. Nährwertkennzeichnungen übertragen die Verantwortung auf den Einzelnen und erfordern Motivation und kontinuierliche Einhaltung, um wirksam zu sein. Politikmaßnahmen könnten sich auf Bildungskampagnen konzentrieren, um die Gesundheitsmotivation in der Bevölkerung zu fördern. Jedoch ignoriert dies die starke Rolle der Umwelt bei der Gestaltung von Verbraucherentscheidungen. Vielschichtige Politikmaßnahmen müssen auch die Rolle der Umwelt bei der Förderung ungesunder Lebensmittelentscheidungen angehen. Dies kann die Regulierung des Marketings von ungesunden Lebensmitteln, insbesondere für gefährdete Gruppen wie Kinder und Jugendliche, die Implementierung von Steuermaßnahmen wie Steuern auf zuckerhaltige Getränke und Subventionen für Obst und Gemüse, sowie die Verbesserung der Verfügbarkeit gesunder Lebensmitteloptionen im Einzelhandel umfassen.

Darüber hinaus können digitale Entscheidungshilfen, wie Empfehlungen von gesünderen Produktalternativen, routinierte Lebensmittelentscheidungen durchbrechen. Durch die Berücksichtigung sowohl individueller als auch umweltbedingter Faktoren kann ein umfassender politischer Ansatz Adipositas und ernährungsbedingte nichtübertragbare Krankheiten effektiver bekämpfen.

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About the author

Eva-Maria Schruff-Lim was born in Düren, Germany on February 15th, 1992. After completing a Bachelor degree in International Business Management at the Berlin School of Economics and Law, she obtained her MA degree in Communication, Multimedia, and Market Management from University of Applied Sciences Düsseldorf. After receiving her MSc degree in Human Decision Science from Maastricht University in 2019, Eva started her PhD in the Marketing and Consumer Behaviour group at Wageningen University & Research.

During her PhD her research focused on how FOP nutrition labelling influences consumers food choices and how complementary interventions can support FOP nutrition labels. Within the project, Eva collaborated with supermarkets in the Netherlands to analyse the effect of nutrition labelling on real-life purchasing data. She has presented her research at various international conferences and her research has been peer-reviewed and published in high-ranking journals.

Eva got married to Ian in March 2020 and calls Utrecht home. In her future career, Eva hopes to apply her research skills to further research human behaviour and contribute to socially relevant topics.

Natasha Beddingfield – Unwritten

Staring at the blank page before you

Open up the dirty window

Let the sun illuminate the words that you could not find

Reaching for something in the distance

So close you can almost taste it

Release your inhibitions

Feel the rain on your skin

No one else can feel it for you

Only you can let it in

No one else, no one else

Can speak the words on your lips

Drench yourself in words unspoken

Live your life with arms wide open

Today is where your book begins

The rest is still unwritten

Completed training and supervision plan

Eva-Maria Schruff-Lim

Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
A1 Managing a research project			
'Nutrition labelling and beyond'	Dutch Consumer Behaviour Day, Amsterdam, Netherlands	2024	1
Co-organizing special session *'Front-of-package nutrition labels and beyond: How, when, and with the use of which tools does nutritional information motivate healthy purchases?'*	European Association of Consumer Research, Amsterdam, Netherlands	2023	1
'Optimizing food swap recommendations to increase food basket healthfulness: The role of similarity of recommendations'	EuroSense, Turku, Finland and AAEA Annual Meeting, Anaheim, USA	2022	1
'Offering food swap recommendations to increase basket healthfulness: The role of the similarity of alternatives to the original choice'	EAAE PhD Workshop, Parma, Italy	2022	1
'Nutrition label+ interventions: A systematic review and future research agenda'	EuroSense, Rotterdam, Netherlands	2020	1
MCB PhD colloquia series	WUR	2022-2024	1.5
Writing research proposal	WUR	2020	6
WASS Introduction Course	WASS	2019, 2020	1

A2 Integrating research in the corresponding discipline			
Quantitative Data Analysis: Multivariate Techniques, YRM-50806	WUR	2021	6
Mediation, Moderation, and Conditional Process Modelling	ESADE Business School	2020	2
Systematic Approaches to Reviewing Literature	WASS	2020	4
B) General research related competences			
B1 Placing research in a broader scientific context			
Introduction to programming in R for social sciences	WASS	2021	3
Academic Publication and Presentation in the Social Sciences	WASS	2020	4
B2 Placing research in a societal context			
Interview for article *'You can also choose this healthier alternative'*	Resource Magazine	2024	0.1
Symposium *'Transparant Gezond en Duurzaam'*	CBL	2024	1
C) Career related competences/personal development			
C1 Employing transferable skills in different domains/careers			
Teaching assistant in the courses Advanced Experimental Methods, Consumer Behaviour: Concepts and Research Methods, Digital Food Marketing	MCB, WUR	2020-2024	3

Bachelor and Master thesis supervision	MCB, WUR	2020-2022	1
Organization of the MCB PhD career series	MCB, WUR	2023	0.1
Critical thinking and argumentation	WGS	2022	0.3
Supervising BSc & MSc thesis students	WGS	2020	0.6
Total			**38.6**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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