The Role of Nudges in Food Choices: An Umbrella Review

Hui Lin[1] Hui.Lin@UGent.be

Marcia Dutra de Barcellos[1,2] [0000-0002-4311-2921] Marcia.DutradeBarcellos@UGent.be

Hans De Steur[1] [0000-0003-1340-0882] Hans.DeSteur@UGent.be

[1] Ghent University, Faculty of Bioscience Engineering, Department of Agricultural Economics, Division Agri-Food Marketing and Chain Management, Coupure Links 653, 9000 Ghent, Belgium

[2] NOVA Information Management School (NOVA IMS), Universidade Nova de Lisboa, Campus de Campolide, Lisboa 1070-312, Portugal

This is the accepted author manuscript of the following article published by Elsevier:

Lin, H., Barcellos, M. D. D., & de Steur, H. (2025). The role of nudges in food choices: An umbrella review. Food Quality and Preference, 134, Article 105679. https://doi.org/10.1016/j.foodqual.2025.105679

The Role of Nudges in Food Choices: An Umbrella Review

Hui Lin [a], Marcia Dutra de Barcellos [a, b], Hans De Steur [a]

[a] Ghent University, Faculty of Bioscience Engineering, Department of Agricultural Economics, Division Agri-Food Marketing and Chain Management, Coupure Links 653, 9000 Ghent, Belgium

[b] NOVA Information Management School (NOVA IMS), Universidade Nova de Lisboa, Campus de Campolide, 1070-312 Lisboa, Portugal

Marcia.DutradeBarcellos@UGent.be; Hans.DeSteur@UGent.be

Corresponding author: Hui.Lin@UGent.be

Abstract

Nudging, a behavioural intervention based on choice architecture, is increasingly used to promote healthier and more sustainable food choices. This umbrella review summarises evidence from systematic reviews to assess its effectiveness and identify research gaps. A systematic search of Web of Science and Scopus identified 36 systematic reviews published between 2013 and 2025. Most systematic reviews focused on health-related food nudges, with only three discussing nudges in the scope of promoting environmentally friendly food choices, highlighting a notable imbalance in the current literature. Reviews were evaluated using the updated version of A Measurement Tool to Assess Systematic Reviews (AMSTAR 2), which revealed that only one review was rated as high quality, 16 as moderate, 9 as low and 10 as critically low, indicating insufficient quality. Results were categorised using an extended Typology of interventions in proximal physical micro-environments (TIPPME) framework. Nudges showed small to moderate effects on food choice, with default and positional

nudges being the most effective. Interventions where nudges were combined with other interventions, such as financial or educational strategies, were more promising than nudges alone, but more evidence is needed. Inconsistencies in the classification of nudges in different studies underline the need for standardisation. Future research should focus on the standardisation of nudge classifications, the evaluation of long-term effects and the exploration of integrated policy approaches.

Keywords: Nudging, Choice architecture, Consumer food choices, Umbrella review

Declarations of interest: none

1. Introduction

Improving dietary behaviour is crucial to improving human health and tackling urgent environmental challenges, as the food we consume can either support or threaten human health and environmental sustainability, calling for a transformation towards healthy diets from sustainable food systems (Willett et al., 2019). Poor dietary habits have contributed significantly to the global rise in non-communicable diseases (NCDs), including cardiovascular disease and diabetes. In 2021, NCDs caused at least 43 million deaths, accounting for 75 % of all non-pandemic deaths worldwide (WHO, 2024b). The rise in obesity is particularly alarming: Since 1990, global obesity rates have more than doubled in adults and quadrupled in adolescents, with 43 % of adults aged 18 and older overweight and 16 % living with obesity in 2022 (WHO, 2024a). At the same time, current food systems and agricultural practices are the main causes of environmental degradation. Agriculture, combined with land-use changes for food production, such as deforestation and peatland degradation, accounts for 18 to 29% of total greenhouse gas emissions (Rosenzweig et al., 2020; Vermeulen et al., 2012). A change in dietary patterns, such as reducing the consumption of animal-based foods, can considerably improve the sustainability of global food systems (Kozicka et al., 2023). Despite the growing awareness of the benefits of a balanced diet and the urgency to reduce the impact of food consumption on the environment, many people find it difficult to make and sustain long-term changes. These challenges stem from ingrained behavioural habits, a food environment that supports unhealthy choices, and a combination of social, cultural and

psychological factors that make promoting healthy and sustainable eating behaviours so complex (Grundy et al., 2022; Hollands et al., 2013; Onwezen & Dagevos, 2024).

To respond to these challenges, public health organisations, governments and other stakeholders have used a variety of policy tools. These include traditional approaches such as public awareness campaigns, financial incentives and regulatory measures (e.g. subsidies and taxes), but their effectiveness varies and they often encounter practical problems in implementation (Barry et al., 2023; Capacci et al., 2012). Information and education campaigns generally only lead to a limited change in behaviour (Albarracin et al., 2024). In comparison, financial interventions tend to be more effective but are generally less accepted by both the public and policymakers (Diepeveen et al., 2013; Marteau et al., 2025).

Recently, there has been an increasing interest in behavioural interventions, particularly nudges, as a subtle but potentially effective approach to influencing consumer behaviour (Sapio & Vecchio, 2024; Wright & Bragge, 2018). Nudges are based on the principles of behavioural economics and involve making small adjustments to the decision-making environment or "choice architecture" in order to encourage individuals to make better choices without restricting their freedom of choice or imposing strict economic incentives (Thaler & Sunstein, 2008). Compared to traditional approaches such as educational campaigns or fiscal measures, which often require sustained cognitive engagement or may encounter public resistance, nudges are particularly well suited to the area of appetite, where food choices are often automatic, habitual and emotionally driven (Meier et al., 2022; Wansink & Sobal, 2007). A large number of studies in the field of food choices have investigated various nudging

interventions, such as adjusting the placement, proximity or accessibility of products and changing the labelling of healthy foods (Bucher et al., 2016; Croker et al., 2020; Schruff-Lim et al., 2023; Shaw et al., 2020). For example, default vegetarian options in canteens, the placement of healthy snacks at eye level or visual labelling with traffic light systems are all widely applied nudges aimed at simplifying healthier food choices. Following its popularity, there is a heterogeneity of nudge frameworks, characterised by different typologies of nudges. These inconsistencies are not only due to differences in theoretical orientation, but also to different definitions of subcategories, different use of key terms or overlaps. And the inclusion of interventions such as pricing or financial incentives in some frameworks is often discussed in the literature as incompatible with the core principles of nudging. Such conceptual ambiguities make it difficult to compare studies and synthesise findings (Hummel & Maedche, 2019) and highlight the need for a more standardised classification framework: one of the main aims of this umbrella review.

In parallel with the rapid increase in empirical studies, reviews of the effects of nudges on food choices have also increased in recent years (Harbers et al., 2020; Schruff-Lim et al., 2023; Valencic et al., 2023). Yet, it is difficult for researchers to keep track of the literature as research is rapidly increasing, making an up-to-date umbrella review, i.e. a systematic review of systematic reviews, necessary and important. An umbrella review allows for the comparison of data obtained from different interventions or conditions and provides policymakers with a more comprehensive summary of available evidence. This approach not only integrates the results of multiple systematic reviews but also identifies inconsistencies, commonalities and

93 methodological differences between studies, thus helping policymakers and scientists
94 understand which interventions are most effective in different contexts (Hunt et al., 2018).
95 This study aims to conduct an umbrella review that provides an up-to-date overview and
96 reflection of comprehensive reviews on the role of nudges on food choices and identify
97 directions for future research. Thereby, it addresses the following research questions:
98 (1) What are the methodological characteristics of the systematic reviews?
99 (2) What types of nudges to promote healthy and environmentally friendly food choices are
100 being investigated in the research? Which kinds of nudge frameworks are followed by the
101 review studies?
102 (3) To what extent are nudges, either alone or in combination with other interventions, effective
103 tools to increase healthy and environmentally friendly food choices?
104 (4) What gaps in knowledge should future research address?
105 This umbrella review builds on and extends previous umbrella reviews, in particular those
106 by Bauer & Reisch (2019) and Wright & Bragge (2018). Bauer & Reisch (2019) provided a
107 broad overview of behavioural insights for food choice and summarised reviews published
108 between 2010 and 2017. However, their classification of nudges was relatively crude: for
109 example, they summarised changes in location, presentation and composition under “Changes
110 to the physical environment” and included incentives as nudges. Our review addresses these
111 limitations by using an extended TIPPME framework to distinguish between availability,
112 position, presentation, size, information, default nudges, combined nudges and combined
113 interventions, while excluding interventions based primarily on financial incentives. In

addition, we update the evidence base to 2025 and apply AMSTAR 2 to assess the methodological quality of the reviews. In contrast, Wright & Bragge (2018) focused exclusively on dining-out settings and three intervention types (social norms, portion size, and health information), whereas our study covers multiple eating environments (e.g., retail, cafeterias, online platforms) and includes both the health and environmental dimensions of food choice. Our review not only includes the latest evidence on this topic, but also compares different nudge frameworks and their underlying nudge types, explores whether and how nudges interact with other intervention strategies, and analyses the results beyond mere evaluation of nudge effectiveness.

2. Methods

The umbrella review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Rethlefsen et al., 2021). The protocol of this review was preregistered on the Open Science Framework (OSF) (DOI: https://doi.org/10.17605/OSF.IO/6U8MV at https://osf.io/6u8mv).

2.1. Eligibility criteria

The eligibility criteria are based on the relevant components of Population, Intervention, Comparator, Outcome and Settings (PICOS). Systematic and scoping reviews that apply systematic methodologies across all age groups were included. The review focus needed to be on the evaluation of nudging effects on food choices, consumption or purchase, either as single or as combined interventions (nudges combined with non-nudge interventions such as

education or price incentives). We excluded the reviews where food choice was not the central focus, such as studies integrating diet as a component of exercise programs. Financial interventions (e.g., incentives or price changes) were not classified as standalone nudges and were only included when used in combination with nudging strategies, as discussed in the section on combined interventions. The detailed inclusion and exclusion criteria can be found in Appendix A.

2.2. Search strategy and screening

The search syntax was developed based on systematic (umbrella) reviews in the field of nudges and food choices (Bauer & Reisch, 2019; Cadario & Chandon, 2020; Laiou et al., 2021; Wright & Bragge, 2018). Terms used to indicate nudges included: nudg*, "behavio$ral economic*," "choice architecture*" and "libertarian paternalism". Terms targeting food choices included: diet*, eat*, nutriti*, food*, meal*, fruit*, vegetables, beverage*, calori*, energ* and menu*. It is important to note that we have made two important decisions regarding the list of search terms to ensure that we focus on the most relevant studies. First, we excluded specific terms concerning "health" or "environmentally friendly" to avoid the ambiguity that could arise from subjective or fluid definitions of health and environmental impact, in line with other systematic reviews (Bauer & Reisch, 2019; Laiou et al., 2021; Wright & Bragge, 2018). Second, we also chose not to focus on specific categories of nudges. The classification of nudges in the literature is not fixed, and the categories can be complex and overlapping. Rather than limiting our review to predefined nudge types, we focused on reviews conducted under the broader

framework of nudging, which allows for a more comprehensive examination of the application of different nudge frameworks. This approach aligns with the eligibility criteria for inclusion of reviews that were conducted within a nudge framework or at least mention the concept or framework of nudging and aims to bring innovative contributions to the field.

The terms were searched within the "Topic" field in Web of Science and within the "Title, Abstract, and Keywords" fields in Scopus. Firstly, we refined the document type as "reviews" to include all kinds of review papers. Then we released this restriction and also added "meta-anal* OR meta-regress*"(Grundy et al., 2022) to the search syntax to include more potential meta-analysis articles. The full syntax applied to both databases is in Appendix B.

In April 2024, the literature search was conducted in the electronic databases of Scopus and Web of Science. All studies citing the work of Thaler and Sunstein (2003), known for their pivotal work on nudging, were also scanned to identify potentially relevant references. Alerts were set up to include new publications and a follow-up search was conducted on 5 July 2025 to identify papers published after the initial search. Newly added articles were screened with the same inclusion criteria. As such, this umbrella review covers systematic review articles published between 2013 and 2025.

The search results were imported into the reference manager software EndNote 21, where duplicates were removed. All review studies were screened on title, abstract, and full text. Following full-text screening, the reference and citation lists for the included reviews were searched to avoid missing relevant research. This step was repeated until no more relevant reviews were searched. One author carried out the screening procedure. In cases where it was

unclear whether an article met the exclusion criteria, the two other authors checked the full texts. Disagreements were resolved through discussion until a consensus was reached. A list of excluded articles after the full-text screening including the reasons for exclusion can be found in Appendix C. In total, 36 review articles met the eligibility criteria and were included (see Fig 1).

[insert Fig 1]

2.3. Data extraction

A standardised form in Microsoft Excel was used to extract the data from the included studies, including basic information about the articles, countries (e.g., USA, UK), products (e.g., fruits, meat), populations (e.g., school children, adults), time framework (e.g., publication years: 2000 to 2020), databases (e.g., PubMed, Scopus), settings (e.g., vendors, cafeterias), primary designs (e.g., RCTs, quasi-experiments), nudge frameworks (e.g., TIPPME, MINDSPACE), nudge types (e.g., default, information), combined interventions (e.g., nudge plus education), findings, and future research. The process of finalising the extraction items was determined through consensus among the three authors. Initially, extraction items were developed based on existing umbrella reviews and in line with our research questions. A pilot extraction was then conducted using five systematic reviews, followed by adjustments to establish the final version of the extraction items.

2.4. Quality appraisal and data synthesis

AMSTAR 2, a 16-item instrument characterised by robust validity and reliability to appraise systematic reviews (Shea et al., 2017), was used to assess the methodological quality of the included reviews. Based on the recommendations of AMSTAR 2, five items (i.e., 2: Protocol registered before commencement of the evaluation, 4: Adequacy of the literature search, 8: Adequate detailed description for the included studies, 9: Risk of bias from individual studies being included in the review, and 13: Consideration of risk of bias when interpreting the results of the review) were identified as critical domains and used as the basis for assessing the overall confidence in the results of each selected review (see Appendix D). Thereby, the included reviews were classified as high, moderate, low, or critical low quality based on the number of critical and non-critical flaws (Løvhaug et al., 2022). It is important to note that the quality rating reflects the ability of the review to answer specific research questions rather than indicating its overall quality (Barry et al., 2023). As a consequence, we reported the outcomes of the quality appraisal for all included articles, rather than using them as exclusion criteria.

The extracted data were analysed and presented through a narrative synthesis, by which the results of the original studies from each review were categorised according to the targeted nudge type(s). The wide variety of reported interventions and outcome measures made it impractical to conduct a meta-analysis. Nevertheless, there are 11 reviews that included or conducted a meta-analysis, of which the results were also discussed in the results section.

3. Results

3.1. Characteristics of included reviews

Table 1 provides a summary of the 36 included reviews. All studies were systematic reviews, of which eleven included a meta-analysis, and one was a scoping review that applied a systematic review methodology. The reviews utilised between 2 and 13 databases for literature searches, with MEDLINE, PubMed, Web of Science, PsycINFO and Scopus being the most frequently cited. Detailed information on the databases searched is provided in Appendix E. While most reviews discussed nudging in the scope of promoting healthy food choices, three reviews explored environmentally friendly food choices: two targeting meat reduction (Bianchi et al., 2018; Meier et al., 2022), and one review examined broader sustainability interventions such as ecolabels and climate labels (Pandey et al., 2023). Bianchi et al. (2018) was the only review to cover both health and environmental outcomes. This distribution shows a surprising scarcity of reviews dealing with environmental goals, which could influence the synthesis and limit the generalisability of the results to contexts of sustainability. Accordingly, we comment explicitly on these three reviews when relevant.

The geographical contexts of these reviews varied, as 16 reviews concentrated on developed countries, 16 reviews covered developed and developing countries, and 4 did not specify the regions studied. Settings for primary studies spanned workplaces, cafeterias, online platforms, grocery stores, and laboratories, with 14 reviews comparing laboratory and real-world environments. Primary study designs predominantly featured randomised controlled trials (RCTs), quasi-experimental designs, and pre-post evaluations, though 6 reviews did not specify this. The targeted population groups spanned a wide range, from the general population

to specific groups such as secondary school students (Schulte et al., 2023) and adults (Harbers et al., 2020; Lindstrom et al., 2023). The primary studies within these reviews were conducted over a broad time frame, from 1975 to 2024, with the number of included studies ranging from 11 to 156. In terms of product focus, most reviews examined a variety of healthy foods like fruits and vegetables, with 2 reviews specifically investigating meat consumption (Bianchi et al., 2018; Meier et al., 2022), reflecting a limited but relevant focus on environmentally impactful food choices. Additionally, ten reviews (IDs 4, 8, 10, 11, 12, 13, 16, 17, 25[e], 29) analysed combined interventions, which are further discussed in Section 3.5.5 Combined interventions.

[insert Table 1]

3.2. Methodological quality of included reviews and primary studies

3.2.1. Methodological quality of included reviews

Using the AMSTAR 2 tool, one review was categorised as high quality (Crocketta et al., 2018), sixteen reviews were of moderate quality (IDs 1, 3[b]-5, 7, 9, 12, 14, 16-18, 21, 24-25[e], 31, 33), nine reviews were of low quality (IDs 6, 8, 13, 20, 23, 26, 27, 29, 36) and ten reviews were of critically low quality (IDs 2, 10, 11, 15, 19, 28[e], 30, 32, 34, 35). Appendix D shows the full quality assessment, including how the reviews were rated for each of the critical items.

Among the five critical domains, the most frequently unmet criterion was the lack of a preregistered protocol (item 2), with 16 reviews not reporting this. In addition, 11 reviews did

not adequately assess the risk of bias in primary studies (item 9), and the same number did not take this bias into account when interpreting the results (item 13). In relation to other non-critical areas, the majority of reviews were deficient in several areas: Item 3, where review authors did not adequately explain their choice of study designs to include; Item 7, where most reviews did not include a list of excluded studies along with justifications for their exclusions; and Item 10, where the funding sources of studies included in the reviews were not adequately reported. These findings indicate significant gaps in compliance with AMSTAR-2 criteria in several areas and point to areas where the quality of systematic reviews can be improved.

3.2.2. Methodological quality of primary studies

A total of thirty reviews assessed the quality of primary studies using various tools and frameworks. Commonly used tools included the Cochrane Risk of Bias (RoB) tool (IDs 4, 5, 9, 13, 14, 16, 22, 25[e]) for randomised trials and the Quality Assessment Tool for Quantitative Studies (IDs 3[b], 7, 12, 18, 23, 24, 26, 27). High or unclear risk of bias and low quality were frequently reported (IDs 1, 4, 7, 9, 13, 14, 17, 22, 24, 31, 35, 36). Broers et al. (2017) and Metcalfe et al. (2020) explicitly excluded low-quality studies from their analyses. While there was considerable variation in the tools and criteria used, the overall trend indicated significant methodological limitations, with the majority of studies rated at high risk of bias or poor quality.

The synthesis of the methodological issues identified in the different reviews reveals several common weaknesses of the primary studies (See Table 2). Many reviews lacked a quality assessment of the included studies, which raised concerns about the credibility and reproducibility of the results. In some cases, only the overall quality distribution was presented

without analysing the reason for the different quality results. In the RCTs, there were common methodological flaws such as inadequate randomisation procedures, inadequate allocation concealment and inadequate blinding, each of which increased the risk of systematic bias. In addition, problems such as high dropout rates or incomplete outcome data were identified, which could lead to dropout bias. Overall, these methodological flaws undermine both the internal and external validity of the studies and emphasise the need for more rigorous design and transparent reporting in future research.

[insert Table 2]

3.3. Nudge frameworks in the reviews

Table 3 presents the different types of nudge frameworks applied in the included reviews. A detailed explanation of the sub-categories in each framework is in Appendix F.

[insert Table 3]

Seven reviews (IDs 3[b], 6, 15, 26, 27, 29, 35) did not refer to a nudge framework, while seven reviews (IDs 2, 5, 8, 12, 14, 25[e], 34) focused on only one type of nudge, making it unnecessary to refer to a broader framework. The TIPPME framework (Hollands et al., 2017) and its earlier version (Hollands et al., 2013) are the most frequently applied among the reviews. This framework effectively captures various nudging interventions and has been extensively

tested for reliability and practical applicability. Nevertheless, other frameworks have also been used to categorise nudging interventions. For example, MINDSPACE (Dolan et al., 2012) focused on psychological mechanisms such as incentives, social norms, and priming, while Muenscher et al. (2016) distinguished between different decision-making processes. Kraak et al. (2017) introduced nudge categories specifically related to food environments, such as placement and pricing, while Cadario and Chandon (2020) proposed a typology based on cognitive, affective, and behavioural interventions. These different frameworks reflect diversity in how nudges are conceptualised and point to different inconsistencies in how interventions are categorised across studies.

First, there exists an inconsistent categorisation of subcategories of nudge interventions across different frameworks, which complicates study comparisons. For example, sensory changes such as lighting or visual cues are sometimes categorised under placement rather than presentation (Kraak et al., 2017), mainly depending on how they impact consumer perception rather than physical placement.

Second, there is a variation in definitions of the same terms across frameworks. For example, salience is sometimes linked to prioritising health in decision-making (Bauer & Reisch, 2019), while it can also refer to visual or verbal cues for priming (as seen in Chambers et al. (2021); Valencic et al. (2023)) or even to attention-grabbing strategies such as positioning healthy foods at the eye level (Dolan et al., 2012).

Third, there are issues with overlapping categories or the way subcategories are combined or not. This is evident in the category profile, i.e. the targeted changes to a product's nutritional

profile and sensory attributes. It is considered as a single category in the framework of Kraak et al. (2017), whereas in the TIPPME framework, it is divided into functionality and presentation. While this division is relevant to distinguishing health benefits from sensory changes, it can create confusion when comparing intervention categories across frameworks, making it challenging to synthesise findings across studies.

Fourth, another complexity relates to the inclusion of marketing measures, such as pricing, in several frameworks (Blumenthal-Barby & Burroughs, 2012; Kraak et al., 2017). These measures often deviate from the core principles of nudging, which emphasise minimal interference and preserving freedom of choice (Kraak et al., 2017). Such a blending can undermine the theoretical consistency of nudge frameworks and make it difficult to distinguish between pure nudging strategies and those that are linked to price-oriented strategic marketing.

3.4. Type of nudges

The aforementioned inconsistencies make it challenging to compare nudges across different studies and emphasise the need for clearer boundaries between subcategories. To address this issue and provide a standardised framework for comparison, we have assigned various (sub)categories from nudge frameworks into relevant subcategories of an extended TIPPME framework. TIPPME is one of the most comprehensive and empirically validated frameworks for classifying nudges at the micro-environmental level and has been widely used in public health and dietary behaviour research. Compared to psychological typologies such as MINDSPACE or cognitive-affective classifications (Cadario & Chandon, 2020), TIPPME

345 focuses on observable, physical changes in the choice environment, making it particularly
346 suitable for umbrella-level synthesis. The clear structure of TIPPME provides a useful lens for
347 synthesising different types of interventions such as positioning, sensory cues and labelling.
348 By extending the original framework to include “default nudges”, “combined nudges” and
349 “combined interventions”, we have addressed common limitations of existing taxonomies,
350 such as their inability to fully capture hybrid or multilevel strategies. While each applied
351 framework has its merits (Cadario & Chandon, 2020), we highlight the ability of this extended
352 TIPPME framework to provide a clearer structure for categorising different nudging
353 interventions across primary and review studies.

354 Table 4 presents the extended TIPPME framework, showing how the scope of different
355 systematic reviews can be categorised according to various nudge interventions. This extended
356 TIPPME framework categorises nudges into several components: Availability (changing the
357 range or quantity of products), Position (modifying the position, proximity or accessibility of
358 products), Functionality (changing the design of products to change how they work or guiding
359 how people interact with products), Presentation (altering visual, tactile, or sensory cues), Size
360 (changing size or shape of products), and Information (modifying words, symbols, numbers or
361 pictures that convey information about the product). Additionally, Default (default menus),
362 Combined nudges (multiple types of nudges) and Combined interventions (nudges plus non-
363 nudge interventions) are included as extended components. The nudge terms listed in the
364 Review ID column are included in the systematic reviews and have been incorporated into an
365 appropriate TIPPME subcategory based on their association with that category. Further

366 explanations of these nudge types and the rationale for their classification can be found in
367 Appendix G.
368
369 [insert Table 4]
370
371 **3.5. Effect of nudges: evidence from systematic reviews**
372 Table 5 presents the size of the evidence base (number of reviews), the overall quality of
373 systematic reviews, and the overall direction of results according to each type of nudge. The
374 effectiveness of each type of nudge in promoting dietary choices in different contexts will be
375 discussed in the following subsections.
376
377 [insert Table 5]
378
379 **3.5.1. Placement**
380 **Availability**. A typical example is increasing the number of healthy food items offered in a
381 cafeteria, such as adding more fruit or salad options. Fourteen reviews (IDs 1, 6, 9, 11, 17, 18,
382 19, 20, 24, 27, 28[e], 29, 31, 36) analysed availability nudges. Four of these reviews (Lycett et
383 al., 2017; Nornberg et al., 2016; Pandey et al., 2023; Roy et al., 2015) reported positive effects,
384 albeit to varying degrees. Notably, all included primary studies that showed positive outcomes
385 were conducted in developed countries. Lycett et al. (2017) and Roy et al. (2015) indicated that
386 interventions aimed at increasing the availability of healthier options in school cafeterias led to

an improvement in fruit and vegetable intake among children and students. Nornberg et al. (2016) concluded that interventions that introduced an increased variety of vegetables effectively increased vegetable intake. Pandey et al. (2023) (ID 28[e]) reported small effects, focusing on sustainable food consumption. Inconclusive results were reported in Gynell et al. (2022) (healthy foods; all populations), Laiou et al. (2021) (both healthy and high-calorie foods; cafeteria users, customers), Almeida et al. (2024) (fruit and vegetables; all populations) and Shaw et al. (2020) (food and beverages; adults). Five reviews (Allan et al., 2017; Arno & Thomas, 2016; Broers et al., 2017; Sapio & Vecchio, 2024; Wilson et al., 2016) included studies on availability nudges but only provided an overall effect for all nudge types. In the review of Al-Khudairy et al. (2019), none of the included studies examined availability alone.

Position. Healthy food positioning can involve placing nutritious items at eye level on shelves or at the checkout area to increase visibility and selection. This subcategory was analysed in 20 systematic reviews. Of these, eleven reviews (IDs 6, 7, 9, 15, 16, 17, 18, 21, 23, 28[e], 30) reported positive effects despite different products and populations. In reviews of Gynell et al. (2022), Almeida et al. (2024) and Fergus et al. (2021), the position was cited as the most effective measure. Harbers et al. (2020) and Pandey et al. (2023) (ID 28[e]) reported a moderate impact. However, Shaw et al. (2020) highlighted that while most results indicated improved dietary behaviour with more prominent positioning of healthy foods or less prominent positioning of unhealthy foods, many results did not show statistical significance. This was probably due to the small sample sizes and low power of the studies, by which the evidence for positioning effects was considered inconclusive. Seven reviews (Allan et al., 2017;

Broers et al., 2017; Cadario & Chandon, 2020; Metcalfe et al., 2020; Sapio & Vecchio, 2024; Vecchio & Cavallo, 2019; Wilson et al., 2016) included studies on position nudges but only provided an overall effect for all nudge types. Slapo et al. (2021) mentioned the positional intervention but did not provide clear conclusions on its effect.

3.5.2. Properties

Functionality. This subcategory was only analysed in three reviews. Harbers et al. (2020) reported the effects of a functional cue: arrows on supermarket floors directing shoppers to fresh produce were associated with increased fruit and vegetable purchases. Laiou et al. (2021) and Almeida et al. (2024) reported inconclusive effects, emphasising the limited scope of interventions to assess the actual effect of functionality.

Presentation. An example is displaying vegetables with appealing lighting and layout to increase selection. This type of nudge was found in eighteen reviews. From this group, nine reviews (IDs 3[b], 4, 8, 9, 10, 15, 24, 28[e], 30) dealt with various types of foods (like a clear focus on meat consumption in Bianchi et al. (2018) (ID 3[b])) and target groups (such as cafeteria users (Laiou et al., 2021) and school-aged children from preschool to secondary school (Lycett et al., 2017; Schulte et al., 2023) reported positive effects. Pandey et al. (2023) (ID 28[e]) identified presentation as the most promising nudge intervention for achieving sustainable food consumption in university canteens or similar settings. Gynell et al. (2022) and Fergus et al. (2021) emphasised the potential of presentation interventions, with Fergus et al. (2021) particularly highlighting their effectiveness in low-income retail food stores, despite the limited

research. Five reviews (Allan et al., 2017; Arno & Thomas, 2016; Broers et al., 2017; Sapio & Vecchio, 2024; Vecchio & Cavallo, 2019) included studies on presentation interventions but only reported an overall effect for all nudge types. Harbers et al. (2020) mentioned the presentation intervention, but no clear conclusions were drawn about its effect.

Size. Portion size adjustments, such as offering smaller plate sizes in buffet settings. It was researched in fifteen reviews. Of these, three reviews (Al-Khudairy et al., 2019; Bianchi et al., 2018; Lycett et al., 2017) reported positive effects, spanning diverse populations (NHS staff with broad dietary analysis, general population with meat consumption focus, and school-age children targeting fruit/vegetable intake). Three reviews (Almeida et al., 2024; Laiou et al., 2021; Skov et al., 2013) provided inconclusive results. Almeida et al. (2024) included a general population and focused on fruit and vegetables. While the range of interventions examining the impact of size was limited, the results of this study were promising. The results relating to container and cutlery size were inconsistent, emphasising the need for further testing in real-life settings (Skov et al., 2013). Six reviews (Allan et al., 2017; Arno & Thomas, 2016; Broers et al., 2017; Metcalfe et al., 2020; Pandey et al., 2023; Vecchio & Cavallo, 2019) included studies on size nudges but only provided an overall effect for all nudge types. Harbers et al. (2020) and Slapo et al. (2021) mentioned the size intervention but did not provide clear conclusions on its effect.

Information. One common strategy is to provide simplified nutrition information, such as traffic light labels. Information-based nudges were widely discussed in 29 reviews. Twelve of these reviews (IDs 5, 7, 10, 13, 14, 15, 16, 18, 23, 24, 28[e], 30) reported positive results. Almeida

et al. (2024) and Fergus et al. (2021) concluded that the provision of information was one of the most effective nudges, while Harbers et al. (2020), which focused on adults and generic foods, reported modest positive effects. The products discussed varied widely, with a focus on broad categories such as food and beverages (Pandey et al., 2023; Song et al., 2021) or healthy foods in general (Almeida et al., 2024; Slapo et al., 2021). Some reviews were more specific and focused on fruit and vegetables (Lindstrom et al., 2023; Lycett et al., 2017) or pre-packaged foods (Croker et al., 2020). Four reviews (Al-Khudairy et al., 2019; Bianchi et al., 2018; Chambers et al., 2021; Gynell et al., 2022) reported no effects. Specifically, Bianchi et al. (2018) (ID 3[b]) reported that interventions that manipulated only verbal descriptions or labelling at the point of purchase showed no effect on reducing meat selection or purchases in virtual environments. Similarly, Gynell et al. (2022) found that signage interventions were largely unsuccessful, possibly due to limited research into such strategies in different menu environments aimed at promoting healthy eating. Inconclusive results were drawn from six reviews (An et al., 2021; Crocketta et al., 2018; Ikonen et al., 2020; Laiou et al., 2021; Roy et al., 2015), dealing with food labelling. These reviews highlighted that nutrition labelling has limited or inconsistent effects on food choice, with some studies being of low quality and inconclusive. In addition, health information at the point of purchase generated some effects, but these were inconsistent across food types (Skov et al., 2013). Six reviews (Allan et al., 2017; Arno & Thomas, 2016; Broers et al., 2017; Cadario & Chandon, 2020; Sapio & Vecchio, 2024; Wilson et al., 2016) included studies on informational nudges but only provided an overall

effect for all nudge types. Schruff-Lim et al. (2023) focused exclusively on the role of information in combination with other measures.

3.5.3. Additional type: Default

Default settings are based on inertia or status quo bias, i.e. the human tendency to stick with preset or existing options rather than actively making a change. It is important to note that the reviews typically identified two types of measures when discussing default nudges: (1) default menus, such as making healthier options the default choice or pre-filling an online grocery cart, and (2) size defaults. This section focuses solely on the analysis of default menus, while size defaults are incorporated into the category of size nudges. The results showed that nine reviews (IDs 4, 6, 10, 11, 13, 15, 16, 25[e], 32) contained this type of nudge. Seven reviews (Chambers et al., 2021; Gynell et al., 2022; Lindstrom et al., 2023; Meier et al., 2022; Slapo et al., 2021; Valencic et al., 2023; Wyse et al., 2021) that assessed the effects of these individual interventions all reported positive outcomes. Chambers et al. (2021) and Gynell et al. (2022) considered the default to be one of the most promising interventions. Chambers et al. (2021) focused on children under the age of 18, while the other reviews focused on the general population. The products assessed ranged from general categories such as fruit and vegetables (Lindstrom et al., 2023) and healthy foods (Gynell et al., 2022; Slapo et al., 2021) to more specific products such as meat (Meier et al., 2022). Two reviews (Sapio & Vecchio, 2024; Vecchio & Cavallo, 2019) included studies on default nudges but only reported an overall effect for all nudge types.

3.5.4. Combined nudges

Combined nudges were found to be generally effective in four reviews (Al-Khudairy et al., 2019; Broers et al., 2017; Lindstrom et al., 2023; Wilson et al., 2016). Priming in combination with salience and affect nudges (Lindstrom et al., 2023; Wilson et al., 2016), and default together with messenger and norms nudges (Lindstrom et al., 2023) were found to be effective strategies. Al-Khudairy et al. (2019) found that labelling alone did not generally influence behaviour but often proved effective when combined with other interventions. Broers et al. (2017) found that the combination of placement and properties was one of the most effective. Overall, the integration of multiple nudge strategies was found to be more effective in influencing food choices.

3.5.5. Combined interventions

While nudges are subtle changes in the environment or choice architecture that encourage people to adopt certain behaviours without restricting choice, combined interventions add other strategies such as financial incentives, regulations or educational efforts to enhance the impact of the nudge.

Kay et al. (2025), Lindstrom et al. (2023), Slapo et al. (2021) and Meier et al. (2022) (ID 25[e]) highlighted the need for further research on combined interventions. They emphasised that nudges should be integrated into a comprehensive, multi-pronged strategy to improve dietary behaviour, rather than used as stand-alone interventions. Chambers et al. (2021) found that 81 % of the 26 interventions that combined incentives with behaviour insights were effective. Sapio

512 and Vecchio (2024) reported inconclusive results from five studies that combined nudges with
513 strategies such as price interventions and nutrition sessions. Schruff-Lim et al. (2023)
514 highlighted the promise of digital tools such as basket feedback and financial incentives to
515 support nutrition labelling and suggested that more intrusive complementary strategies may be
516 needed. Fergus et al. (2021) included a study that demonstrated the success of combining a 20 %
517 discount on certain foods with education and elements from the MINDSPACE (Messenger,
518 Incentives, Norms, Defaults, Salience, Priming, Affect, Commitments, Ego) framework in
519 Australian community stores, which significantly increased fruit and vegetable sales (15 % of
520 a serving per day) with sustained effects after the intervention. Roy et al. (2015) included a
521 study describing a social marketing campaign combined with increased fruit availability on
522 campus, significantly increasing fruit intake. Al-Khudairy et al. (2019) found that strategies
523 targeting the availability of fruit and vegetables, such as healthy snack carts and increased
524 availability of fruit and vegetables in workplace canteens, were effective when combined with
525 educational elements such as seminars, pedometers and access to dietitians. Other successful
526 interventions combined labelling, pricing and availability, including recipe changes and
527 discounts on healthier options that reduced calorie and fat intake in canteens. Also, the training
528 in mindful eating and default healthy options in hospital pre-ordering systems significantly
529 improved the nutritional quality of meals (Al-Khudairy et al., 2019).

530 In summary, combined interventions that integrate nudges with complementary strategies
531 such as financial incentives, education, labelling and availability show promising potential for
532 improving dietary behaviour. However, the effectiveness of these interventions varies by

context, and further research is needed to evaluate the specific contributions of each component and identify the most effective combinations for a sustained impact.

3.6. Effect of nudges: evidence from meta-analyses

There are eleven reviews that included a meta-analysis and primarily reported an overall effect size (See Table 6). Overall, the findings indicated that nudging was generally effective, though its effect size ranged from small to moderate. Four meta-analyses focused on labelling in information nudges found generally small effects (Crocketta et al., 2018; Croker et al., 2020; Ikonen et al., 2020; Song et al., 2021), with minimal impact on behaviour change (Ikonen et al., 2020). The subgroup analysis of Slapo et al. (2021) revealed that the largest effect size was observed in nudge interventions targeting fruits and vegetables (SMD = 0.28). The subgroup analysis of Broers et al. (2017) showed that only altering placement (SMD = 0.39) and combining altering properties and placement (SMD = 0.28) had a significant effect on food choice, again with a medium effect size. Cadario and Chandon (2020) reported effect sizes of three subgroups according to the orientation of nudges: cognition (SMD = 0.12, −64 kcal), affect (SMD = 0.24, −129 kcal) and behaviour (SMD = 0.39, −209 kcal) and indicated that interventions are more effective at reducing unhealthy eating than increasing healthy eating or reducing total eating. Kay et al. (2025) examined seven categories of visual cues and primes, finding relatively small effects on consumption-related behaviours. Specifically, healthy food- and body-related nudges, as well as unhealthy food-specific nudges, showed small to moderate effects compared to neutral controls, while body-related unhealthy nudges had no significant

554 effects. Nudges promoting healthier choices were more effective than less healthy ones. Pandey
555 et al. (2023) (ID 28[e]) provided the only meta-analysis that focused specifically on
556 environmental nudges and found that nudging by altering the properties had a small effect size
557 (SMD = 0.16), while nudging by changing placement showed a medium effect size (SMD =
558 0.21).
559
560 [insert Table 6]
561
562 **3.7. Future research recommendations reported in the included systematic reviews**
563 Table 7 summarises the recommendations for future research made in the included systematic
564 reviews. These suggestions cover four central topics: Improvements in empirical study design,
565 contextual and demographic adaptations, economic and ethical considerations, and stakeholder
566 engagement. Several reviews called for more robust experimental designs (e.g. RCTs in real-
567 life conditions), the investigation of long-term and compensatory behaviours, and the
568 integration of nudges with other interventions such as pricing or education. Others emphasised
569 the importance of tailoring interventions to specific population groups, particularly those from
570 low socio-economic or minority backgrounds. In addition, economic feasibility, ethical
571 acceptability and collaboration with stakeholders such as policymakers and schools were cited
572 as critical to effective and scalable implementation. These findings emphasise the growing
573 importance placed on practical relevance, inclusion and policy alignment.
574

[insert Table 7]

4. Discussion

This umbrella review offers several strengths that enhance its contribution to research and practice in the field of food nudges. By systematically synthesising 35 reviews through the lens of an extended TIPPME framework, we contribute to clarifying inconsistencies in nudge categorisation (Hollands et al., 2013; Hummel & Maedche, 2019), enabling cross-study comparability and clarifying ambiguities in subcategories such as salience and priming. Rigorous adherence to PRISMA guidelines and AMSTAR 2 quality assessment strengthens the reliability of our conclusions. In addition, this umbrella review highlights critical research gaps and provides actionable recommendations for policy and practice, serving as a valuable resource for advancing nudge-based strategies to promote food choices.

4.1. Summary of key findings

The most commonly studied nudge types included positional interventions and informational nudges, both of which generally showed positive effects, albeit with modest or small effect sizes. Default nudges emerged as particularly effective, supported by robust evidence in contexts such as cafeterias and online platforms. However, interventions targeting food availability or presentation showed mixed results, with effectiveness often dependent on contextual factors like the setting and population. Our findings are consistent with previous studies reporting a small to moderate effect of nudges on dietary behaviour and highlighting

596 the potential of positional and default nudges to influence food choice (Bauer & Reisch, 2019;
597 Cadario & Chandon, 2020; Hollands et al., 2017). Although the importance of combined
598 interventions for changing food choices has been repeatedly emphasised (Lindstrom et al.,
599 2023; Meier et al., 2022), most systematic reviews did not report much on these approaches.
600 As a result, the potential benefits and complexity of combined interventions tend to be
601 overlooked. Understanding how these combined approaches work, under what conditions they
602 are most beneficial, and what challenges they may present is critical to advancing both theory
603 and practice in this area. Therefore, further research focusing on combined interventions is not
604 only warranted but essential to gain a more comprehensive understanding of their value and
605 applicability in practice.

606 A notable finding of this umbrella review is the disproportionate amount of attention given
607 to health-oriented food nudges compared to those aimed at environmental sustainability. Only
608 three of the 36 reviews explicitly addressed environmentally motivated dietary behaviour.
609 These reviews primarily focused on interventions such as default vegetarian options, the
610 presentation of meat dishes and sustainability labelling. The limited evidence base emphasises
611 the urgent need for more systematic reviews and meta-analyses to evaluate nudge interventions
612 for environmental outcomes. The only review that addressed both (Bianchi et al., 2018) did not
613 include a comparative analysis of health and environmental nudges, suggesting another area
614 for future research.

615 The effectiveness of nudges varied depending on whether they were aimed at making
616 healthier food choices or reducing the consumption of unhealthy options. There is evidence

that interventions aimed at promoting healthier food choices are generally more effective than those aimed at reducing unhealthy eating (Chambers et al., 2021; Kay et al., 2025; Slapo et al., 2021), though other reviews (Cadario & Chandon, 2020; Schulte et al., 2023) came to the opposite conclusion. These contrasting results may reflect different underlying psychological mechanisms. Nudges that promote healthy food choices may reduce the need for effortful self-control, making it easier for individuals to act in line with long-term goals. Conversely, interventions aimed at reducing unhealthy eating may be particularly effective because they help people avoid short-term temptations that they are likely to regret later by addressing inconsistent preferences and failures of self-control (Cadario & Chandon, 2020; Schwartz et al., 2014; Wertenbroch, 1998). Nevertheless, discrepancies in the effectiveness of nudges targeting healthy or unhealthy food choices could be due to various factors, such as cultural contexts, individual preferences and the specific choice environment of the nudges. For instance, the stage at which researchers intervened in the decision-making process of consumers appears to matter. Nudges aimed at food purchases may be more successful than those designed to influence actual consumption (Almeida et al., 2024). This could be due to the fact that purchase decisions are usually made in controlled retail environments where interventions can be more easily implemented, while actual consumption is subject to various external influences, such as the availability of food at home and personal habits.

The influence of socioeconomic position (SEP) on the effectiveness of nudge was widely discussed. Some reviews suggested that people from lower socioeconomic backgrounds were more likely to respond positively to nudging interventions (Harbers et al., 2020; Laiou et al.,

638 2021; Song et al., 2021). This may be due to their limited access to nutritional information,
639 making simplified decision aids such as front-of-package labels (FOPLs) more effective (Song
640 et al., 2021). However, while observational studies suggested that placement nudges could
641 improve diet and sales in low SEP consumers, controlled studies showed inconsistent results,
642 likely due to external factors such as affordability and cultural influences (Shaw et al., 2020).
643 Despite their potential, not all nudging interventions were successful. Several factors
644 contributed to the failure of certain nudges, including strong pre-existing consumer preferences,
645 counter-nudging efforts by the food industry, compensating behaviour or reactance (Lindstrom
646 et al., 2023; Sunstein, 2017). In addition, nudge acceptance appeared to be an important but
647 not yet sufficiently researched factor influencing the effectiveness of nudges (Sapio & Vecchio,
648 2024).
649
650 **4.2. Limitations**
651 Although our results provide insights, certain limitations must be noted. First, this umbrella
652 review only included systematic reviews that follow a systematic, reproducible method. As a
653 result, it may overlook evidence from other types of reviews, such as narrative or scoping
654 reviews, as well as original studies that were not included in the selected systematic reviews.
655 This could limit the comprehensiveness of the conclusions drawn. Second, our search strategy
656 was based on broad terms related to nudging and food choices and was conducted within the
657 "Topic" field (Web of Science) and "Title, Abstract, and Keywords" fields (Scopus), aiming to
658 capture as many relevant studies as possible. However, we did not explicitly include terms for

specific food categories (e.g., fast food, sugary beverages, soda, or ultra-processed foods). While this approach ensured broad coverage, some reviews focusing exclusively on these specific categories may still have been missed. Third, in our screening, we excluded reviews that did not mention nudges or nudging frameworks. While this decision allowed us to collect and summarise the different nudge frameworks currently in use, it may have led to the omission of some relevant reviews. Fourth, there are overlaps between the primary studies in the included reviews that we did not systematically map. This may bias the results in favour of frequently cited studies, particularly those with clearer terminology or standardised titles, which could amplify publication bias. However, in line with other umbrella reviews in the social and behavioural sciences (e.g., Bauer and Reisch (2019); Begum et al. (2025); Marteau et al. (2025); Wright and Bragge (2018)), we focused on summarising the overall effect of different types of nudges and identifying research gaps rather than conducting a weighted assessment of the evidence. In contrast to medical umbrella reviews, where interventions and outcomes are more homogeneous, quantifying overlap is less meaningful for this review due to the large heterogeneity of nudge interventions, populations and outcomes in this area. We therefore acknowledge that some bias may remain but consider it unlikely to fundamentally alter the overall patterns and conclusions reported. Fifth, although we assessed the methodological quality of the included reviews using AMSTAR 2 and the results are shown in Appendix D and Table 5, it is worth noting that only one review was rated as high quality and about half were rated as low or critically low. Although our inclusion criteria did not exclude any reviews on the basis of quality, which is consistent with the intended use of AMSTAR 2

and the umbrella review methodology (Begum et al., 2025; Hawkins et al., 2024), these differences in quality limit the certainty of the conclusions drawn. We therefore urge caution in the interpretation of results, particularly those based predominantly on low-quality evidence. Future systematic reviews should address the critical flaws we identified, including the lack of preregistered protocols, limited assessment of risk of bias, and insufficient transparency of reporting. Sixth, the effectiveness of different nudges across different populations or products could not be fully assessed due to heterogeneity in outcomes and contexts across reviews. Finally, by only considering English-language publications, relevant reviews published in other languages could be left out, potentially losing valuable insights.

Beyond the methodological limitations of this umbrella review, the included reviews highlighted that caution is needed when interpreting nudge effects on food choices. Firstly, the current evidence base remained insufficient to provide clear recommendations for the implementation of environmental interventions in the workplace, as effect sizes were generally small to medium and are often not calculable (Allan et al., 2017; Shaw et al., 2020). Secondly, most studies focused on short-term outcomes and often used non-randomised designs (Bianchi et al., 2018; Harbers et al., 2020; Laiou et al., 2021), highlighting the need for longer-term studies to assess the sustained effectiveness of nudges. Interestingly, evidence showed that the effect of nudges is independent of the duration of the intervention (Cadario & Chandon, 2020). Finally, there is also a lack of a systematic framework or taxonomy for the design, implementation and evaluation of nudges (Laiou et al., 2021), which limits comparability and the transfer of best practices across studies.

4.3. Future research recommendations for review conduct

Based on our synthesis and critical appraisal, we also propose several recommendations to improve the conduct of future systematic reviews of nudging interventions (Table 8). First, methodological rigour should be improved through the consistent use of assessment tools such as AMSTAR 2. The reviews should clearly indicate both the time frame of the included studies and the period in which the search was conducted, and systematically specify the countries or regions represented. Such transparency is essential to enable cross-national comparisons and to understand contextual moderators, including cultural or political influences. Second, greater standardisation is needed in the classification of nudges. The use of consistent nudge frameworks can reduce inconsistencies and allow for more meaningful comparisons between studies. Reviews should also clearly define whether they are targeting health, environmental or combined objectives to clarify the scope of the intervention and its underlying rationale. Finally, instead of reporting only pooled or overall effects, future reviews should provide effect sizes by nudge subcategory and study context. This would improve the practical value of the results for shaping interventions and policy decisions by identifying which interventions work best for which populations and in which settings.

[insert Table 8]

5. Conclusion

This umbrella review provides a comprehensive synthesis of existing systematic reviews on the role of nudges in shaping food choices. The findings suggest that while nudging strategies can effectively encourage healthier and more sustainable food consumption, their impact is generally small to moderate and varies by context, population, and intervention type. Default nudges and positioning strategies showed the most consistent positive effects. The effectiveness of nudging interventions also appears to be influenced by socioeconomic factors, decision-making contexts, and whether they target the promotion of healthy foods or the reduction of unhealthy options.

It is important to note that the methodological quality of the included reviews was uneven: only one review was rated as high quality, while 16 were moderate, 9 were low, and 10 were critically low according to the AMSTAR 2 assessment. Although all reviews were considered to ensure completeness, the results of low and critically low quality reviews should be interpreted with caution when interpreting the overall effectiveness of nudging interventions.

A key contribution of this umbrella review is the identification of inconsistencies in nudge classification and the introduction of an extended TIPPME framework to improve comparability across studies. The findings further highlight the potential of combined interventions where nudges are integrated with financial, regulatory, or educational strategies as more effective approaches than nudges alone. For policymakers and practitioners, this umbrella review underscores the need for carefully designed and ethically sound nudging strategies that align with public health goals while maintaining individual autonomy. However, further nudging research is needed to better understand its long-term impact, its role

in different cultural and socioeconomic contexts and its interaction with other policy tools. Future research should also address the evident imbalance in the literature by expanding the evidence base for nudging interventions targeting environmentally sustainable food choices.

CRediT authorship contribution statement

Hui Lin: Conceptualisation, Writing - original draft, Writing - review & editing. Marcia Dutra de Barcellos: Writing - original draft, Writing - review & editing, Supervision. Hans De Steur: Conceptualisation, Writing - original draft, Writing - review & editing, Supervision.

Acknowledgement

This research is a part of PhD work co-funded by the China Scholarship Council (CSC) (file no. 202206350057) and by Ghent University (BOF, file no. 01SC2322). The authors gratefully acknowledge Yizhen Yang for his careful proofreading of the manuscript.

References

Al-Khudairy, L., Uthman, O. A., Walmsley, R., Johnson, S., & Oyebode, O. (2019). Choice architecture interventions to improve diet and/or dietary behaviour by healthcare staff in high-income countries: a systematic review [Review]. *Bmj Open*, *9*(1), Article e023687. https://doi.org/10.1136/bmjopen-2018-023687

Albarracin, D., Fayaz-Farkhad, B., & Samayoa, J. A. G. (2024). Determinants of behaviour and their efficacy as targets of behavioural change interventions. *Nature Reviews Psychology*, *3*(6), 377-392. https://doi.org/10.1038/s44159-024-00305-0

Allan, J., Querstret, D., Banas, K., & de Bruin, M. (2017). Environmental interventions for altering eating behaviours of employees in the workplace: a systematic review [Review]. *Obesity Reviews*, *18*(2), 214-226. https://doi.org/10.1111/obr.12470

Almeida, C., Azevedo, J., Fogel, A., Lopes, E., Vale, C., & Padrão, P. (2024). Effectiveness of nudge interventions to promote fruit and vegetables' selection, purchase, or consumption: A systematic review [Review]. *Food Quality and Preference*, *116*, Article 105122. https://doi.org/10.1016/j.foodqual.2024.105122

An, R., Shi, Y., Shen, J., Bullard, T., Liu, G., Yang, Q., Chen, N., & Cao, L. (2021). Effect of front-of-package nutrition labeling on food purchases: a systematic review [Review]. *Public Health*, *191*, 59-67. https://doi.org/10.1016/j.puhe.2020.06.035

Arno, A., & Thomas, S. (2016). The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and meta-analysis [Review]. *Bmc Public Health*, *16*, Article 676. https://doi.org/10.1186/s12889-016-3272-x

Barry, L. E., Kee, F., Woodside, J., Cawley, J., Doherty, E., Clarke, M., Crealey, G. E., Duggan, J., & O'Neill, C. (2023). An umbrella review of the acceptability of fiscal and pricing policies to reduce diet-related noncommunicable disease. *Nutrition Reviews*, *81*(10), 1351-1372. https://doi.org/10.1093/nutrit/nuad011

Bauer, J. M., & Reisch, L. A. (2019). Behavioural Insights and (Un)healthy Dietary Choices: a Review of Current Evidence. *Journal of Consumer Policy*, *42*(1), 3-45. https://doi.org/10.1007/s10603-018-9387-y

Begum, M., Alam, M. J., Parikh, P., & De Steur, H. (2025). Understanding food safety knowledge, attitude, and practices of consumers and vendors: An umbrella review. *Food Control*, *171*, Article 111094. https://doi.org/10.1016/j.foodcont.2024.111094

Bianchi, F., Garnett, E., Dorsel, C., Aveyard, P., & Jebb, S. A. (2018). Restructuring physical micro-environments to reduce the demand for meat: a systematic review and qualitative comparative analysis [Review]. *Lancet Planetary Health*, *2*(9), E384-E397. https://doi.org/10.1016/s2542-5196(18)30188-8

Blumenthal-Barby, J. S., & Burroughs, H. (2012). Seeking Better Health Care Outcomes: The Ethics of Using the "Nudge". *AMERICAN JOURNAL OF BIOETHICS*, *12*(2), 1-10. https://doi.org/10.1080/15265161.2011.634481

Broers, V. J. V., De Breucker, C., Van den Broucke, S., & Luminet, O. (2017). A systematic review and meta-analysis of the effectiveness of nudging to increase fruit and vegetable choice [Review]. *European Journal of Public Health*, *27*(5), 912-920. https://doi.org/10.1093/eurpub/ckx085

Bucher, T., Collins, C., Rollo, M. E., McCaffrey, T. A., De Vlieger, N., Van der Bend, D., Truby, H., & Perez-Cueto, F. J. A. (2016). Nudging consumers towards healthier choices: a systematic review of positional influences on food choice [Review]. *British Journal of Nutrition*, *115*(12), 2252-2263. https://doi.org/10.1017/s0007114516001653

Cadario, R., & Chandon, P. (2020). Which Healthy Eating Nudges Work Best? A Meta-Analysis of Field Experiments. *Marketing Science*, *39*(3), 465-486. https://doi.org/10.1287/mksc.2018.1128

Capacci, S., Mazzocchi, M., Shankar, B., Macias, J. B., Verbeke, W., Pérez-Cueto, F. J. A., Koziol-Kozakowska, A., Piórecka, B., Niedzwiedzka, B., D'Addesa, D., Saba, A., Turrini, A., Aschemann-Witzel, J., Bech-Larsen, T., Strand, M., Smillie, L., Wills, J., & Traill, W. B. (2012). Policies to promote healthy eating in Europe: a structured review of policies and their effectiveness [Review]. *Nutrition Reviews*, *70*(3), 188-200. https://doi.org/10.1111/j.1753-4887.2011.00442.x

Chambers, T., Segal, A., & Sassi, F. (2021). Interventions using behavioural insights to influence children's diet-related outcomes: A systematic review [Review]. *Obesity Reviews*, *22*(2), Article e13152. https://doi.org/10.1111/obr.13152

Crocketta, R. A., King, S. E., Marteau, T. M., Prevost, A. T., Bignardi, G., Roberts, N. W., Stubbs, B., Hollands, G. J., & Jebb, S. A. (2018). Nutritional labelling for healthier food or non-alcoholic drink purchasing and consumption [Review]. *Cochrane Database of Systematic Reviews*(2), 127, Article Cd009315. https://doi.org/10.1002/14651858.CD009315.pub2

Croker, H., Packer, J., Russell, S. J., Stansfield, C., & Viner, R. M. (2020). Front of pack nutritional labelling schemes: a systematic review and meta-analysis of recent evidence relating to objectively measured consumption and purchasing [Review]. *Journal of Human Nutrition and Dietetics*, *33*(4), 518-537. https://doi.org/10.1111/jhn.12758

Diepeveen, S., Ling, T., Suhrcke, M., Roland, M., & Marteau, T. M. (2013). Public acceptability of government intervention to change health-related behaviours: a systematic review and narrative synthesis. *Bmc Public Health*, *13*, Article 756. https://doi.org/10.1186/1471-2458-13-756

Dolan, P., Hallsworth, M., Halpern, D., King, D., Metcalfe, R., & Vlaev, I. (2012). Influencing behaviour: The mindspace way. *Journal of Economic Psychology*, *33*(1), 264-277. https://doi.org/10.1016/j.joep.2011.10.009

Ensaff, H. (2021). A nudge in the right direction: the role of food choice architecture in changing populations' diets. *Proceedings of the Nutrition Society*, *80*(2), 195-206. https://doi.org/10.1017/S0029665120007983

Fergus, L., Seals, K., & Holston, D. (2021). Nutrition Interventions in Low-Income Rural and Urban Retail Environments: A Systematic Review [Review]. *Journal of the Academy of Nutrition and Dietetics*, *121*(6), 1087-1114. https://doi.org/10.1016/j.jand.2020.12.018

Grundy, E. A. C., Slattery, P., Saeri, A. K., Watkins, K., Houlden, T., Farr, N., Askin, H., Lee, J., Mintoft-Jones, A., Cyna, S., Dziegielewski, A., Gelber, R., Rowe, A., Mathur, M. B., Timmons, S., Zhao, K., Wilks, M., Peacock, J. R., Harris, J., . . . Zorker, M. (2022). Interventions that influence animal-product consumption: A meta-review. *FUTURE FOODS*, *5*, 100111. https://doi.org/10.1016/j.fufo.2021.100111

Gynell, I., Kemps, E., & Prichard, I. (2022). The effectiveness of implicit interventions in food menus to promote healthier eating behaviours: A systematic review [Review]. *Appetite*, *173*, Article 105997. https://doi.org/10.1016/j.appet.2022.105997

Harbers, M. C., Beulens, J. W. J., Rutters, F., de Boer, F., Gillebaart, M., Sluijs, I., & van der Schouw, Y. T. (2020). The effects of nudges on purchases, food choice, and energy intake or content of purchases in real-life food purchasing environments: a systematic review and evidence synthesis [Review]. *Nutrition Journal*, *19*(1), Article 103. https://doi.org/10.1186/s12937-020-00623-y

Hawkins, L. K., Burns, L., Swancutt, D., Moghadam, S., Pinkney, J., & Tarrant, M. (2024). Which components of behavioral weight management programs are essential for weight loss in people living with obesity? A rapid review of systematic reviews. *Obesity Reviews*, *25*(10). https://doi.org/10.1111/obr.13798

Her, E., & Seo, S. (2017). Health halo effects in sequential food consumption: The moderating roles of health-consciousness and attribute framing. *International Journal of Hospitality Management*, *62*, 1-10. https://doi.org/10.1016/j.ijhm.2016.11.009

Hollands, G. J., Bignardi, G., Johnston, M., Kelly, M. P., Ogilvie, D., Petticrew, M., Prestwich, A., Shemilt, I., Sutton, S., & Marteau, T. M. (2017). The TIPPME intervention typology for changing environments to change behaviour. *NATURE HUMAN BEHAVIOUR*, *1*(8). https://doi.org/10.1038/s41562-017-0140

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Kelly, M. P., Nakamura, R., Suhrcke, M., & Ogilvie, D. (2013). Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. *Bmc Public Health*, *13*, 1218. https://doi.org/10.1186/1471-2458-13-1218

Hummel, D., & Maedche, A. (2019). How effective is nudging? A quantitative review on the effect sizes and limits of empirical nudging studies. *Journal of Behavioral and Experimental Economics*, *80*, 47-58. https://doi.org/10.1016/j.socec.2019.03.005

Hunt, H., Pollock, A., Campbell, P., Estcourt, L., & Brunton, G. (2018). An introduction to overviews of reviews: planning a relevant research question and objective for an overview. *Systematic Reviews*, *7*, Article 39. https://doi.org/10.1186/s13643-018-0695-8

Ikonen, I., Sotgiu, F., Aydinli, A., & Verlegh, P. W. J. (2020). Consumer effects of front-of-package nutrition labeling: an interdisciplinary meta-analysis [Review]. *Journal of the Academy of Marketing Science*, *48*(3), 360-383. https://doi.org/10.1007/s11747-019-00663-9

Kay, E., Kemps, E., & Prichard, I. (2025). A systematic review and meta-analysis of visual cues and primes for nudging consumption-related behaviours. *Appetite*, *206*, Article 107813. https://doi.org/10.1016/j.appet.2024.107813

Kozicka, M., Havlík, P., Valin, H., Wollenberg, E., Deppermann, A., Leclère, D., Lauri, P., Moses, R., Boere, E., Frank, S., Davis, C., Park, E., & Gurwick, N. (2023). Feeding climate and biodiversity goals with novel plant-based meat and milk alternatives. *Nature Communications*, *14*(1), 5316. https://doi.org/10.1038/s41467-023-40899-2

Kraak, V. I., Englund, T., Misyak, S., & Serrano, E. L. (2017). A novel marketing mix and choice architecture framework to nudge restaurant customers toward healthy food environments to reduce obesity in the United States. *Obesity Reviews*, *18*(8), 852-868. https://doi.org/10.1111/obr.12553

Laiou, E., Rapti, I., Schwarzer, R., Fleig, L., Cianferotti, L., Ngo, J., Rizos, E. C., Wetle, T. F., Kahlmeier, S., Vigilanza, A., Tsilidis, K. K., Trichopoulou, A., Serra-Majem, L., Brandi, M. L., & Ntzani, E. E. (2021). Review: Nudge interventions to promote healthy diets and physical activity [Review]. *Food Policy*, *102*, Article 102103. https://doi.org/10.1016/j.foodpol.2021.102103

Lindstrom, K. N., Tucker, J. A., & McVay, M. (2023). Nudges and Choice Architecture to Promote Healthy Food Purchases in Adults: A Systematized Review [Review]. *Psychology of Addictive Behaviors*, *37*(1), 87-103. https://doi.org/10.1037/adb0000892

Løvhaug, A. L., Granheim, S. I., Djojosoeparto, S. K., Harrington, J. M., Kamphuis, C. B. M., Poelman, M. P., Roos, G., Sawyer, A., Stronks, K., Torheim, L. E., Twohig, C., Vandevijvere, S., van Lenthe, F. J., & Terragni, L. (2022). The potential of food environment policies to reduce socioeconomic inequalities in diets and to improve healthy diets among lower socioeconomic groups: an umbrella review. *Bmc Public Health*, *22*(1), 433. https://doi.org/10.1186/s12889-022-12827-4

Lycett, K., Miller, A., Knox, A., Dunn, S., Kerr, J. A., Sung, V., & Wake, M. (2017). 'Nudge' interventions for improving children's dietary behaviors in the home: A systematic review [Review]. *Obesity Medicine*, *7*, 21-33. https://doi.org/10.1016/j.obmed.2017.06.001

Marteau, T. M., Mantzari, E., & Hollands, G. J. (2025). Do nudges need a regulatory push? Comparing the effectiveness and implementation of exemplar nudge (size-based) and non-nudge (price-based) dietary interventions. *Social Science & Medicine*, *373*, Article 118004. https://doi.org/10.1016/j.socscimed.2025.118004

Meier, J., Andor, M. A., Doebbe, F. C., Haddaway, N. R., & Reisch, L. A. (2022). Review: Do green defaults reduce meat consumption? [Review]. *Food Policy*, *110*, Article 102298. https://doi.org/10.1016/j.foodpol.2022.102298

Metcalfe, J. J., Ellison, B., Hamdi, N., Richardson, R., & Prescott, M. P. (2020). A systematic review of school meal nudge interventions to improve youth food behaviors [Review]. *International Journal of Behavioral Nutrition and Physical Activity*, *17*(1), Article 77. https://doi.org/10.1186/s12966-020-00983-y

Muenscher, R., Vetter, M., & Scheuerle, T. (2016). A Review and Taxonomy of Choice Architecture Techniques. *Journal of Behavioral Decision Making*, *29*(5), 511-524. https://doi.org/10.1002/bdm.1897

Nornberg, T. R., Houlby, L., Skov, L. R., & Perez-Cueto, F. J. A. (2016). Choice architecture interventions for increased vegetable intake and behaviour change in a school setting: a systematic review [Review]. *Perspectives in Public Health*, *136*(3), 132-142. https://doi.org/10.1177/1757913915596017

Onwezen, M. C., & Dagevos, H. (2024). A meta-review of consumer behaviour studies on meat reduction and alternative protein acceptance. *Food Quality and Preference*, *114*, 105067. https://doi.org/10.1016/j.foodqual.2023.105067

Pandey, S., Olsen, A., Perez-Cueto, F. J. A., & Thomsen, M. (2023). Nudging Toward Sustainable Food Consumption at University Canteens: A Systematic Review and Meta-Analysis [Review]. *Journal of Nutrition Education and Behavior*, *55*(12), 894-904. https://doi.org/10.1016/j.jneb.2023.09.006

Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., Koffel, J. B., & Grp, P. S. (2021). PRISMA-S: an extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews. *Systematic Reviews*, *10*(1), 19, Article 39. https://doi.org/10.1186/s13643-020-01542-z

Rosenzweig, C., Mbow, C., Barioni, L. G., Benton, T. G., Herrero, M., Krishnapillai, M., Liwenga, E. T., Pradhan, P., Rivera-Ferre, M. G., Sapkota, T., Tubiello, F. N., Xu, Y. L., Contreras, E. M., & Portugal-Pereira, J. (2020). Climate change responses benefit from a global food system approach [Editorial Material]. *Nature Food*, *1*(2), 94-97. https://doi.org/10.1038/s43016-020-0031-z

Roy, R., Kelly, B., Rangan, A., & Allman-Farinelli, M. (2015). Food Environment Interventions to Improve the Dietary Behavior of Young Adults in Tertiary Education Settings: A Systematic Literature Review [Review]. *Journal of the Academy of Nutrition and Dietetics*, *115*(10), 1647-1681. https://doi.org/10.1016/j.jand.2015.06.380

Sapio, S., & Vecchio, R. (2024). The effect of nudges on healthy food choices of individuals with a low socio-economic position: A systematic literature review [Review]. *Trends in Food Science & Technology*, *147*, 20, Article 104475. https://doi.org/10.1016/j.tifs.2024.104475

Schruff-Lim, E. M., Van Loo, E. J., van Kleef, E., & van Trijp, H. C. M. (2023). Turning FOP nutrition labels into action: A systematic review of label plus interventions [Review]. *Food Policy*, *120*, Article 102479. https://doi.org/10.1016/j.foodpol.2023.102479

Schulte, E. A., Winkler, G., Brombach, C., & Buyken, A. E. (2023). Choice architecture interventions promoting sustained healthier food choice and consumption by students in a secondary school setting: a systematic review of intervention studies [Review]. *Public Health Nutrition*, *26*(9), 1896-1906, Article Pii s1368980023001118. https://doi.org/10.1017/s1368980023001118

Schwartz, J., Mochon, D., Wyper, L., Maroba, J., Patel, D., & Ariely, D. (2014). Healthier by Precommitment. *Psychological Science*, *25*(2), 538-546. https://doi.org/10.1177/0956797613510950

Shaw, S. C., Ntani, G., Baird, J., & Vogel, C. A. (2020). A systematic review of the influences of food store product placement on dietary-related outcomes [Review]. *Nutrition Reviews*, *78*(12), 1030-1045. https://doi.org/10.1093/nutrit/nuaa024

Shea, B. J., Reeves, B. C., Wells, G., Thuku, M., Hamel, C., Moran, J., Moher, D., Tugwell, P., Welch, V., Kristjansson, E., & Henry, D. A. (2017). AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *Bmj-British Medical Journal*, *358*, j4008. https://doi.org/10.1136/bmj.j4008

Skov, L. R., Lourenco, S., Hansen, G. L., Mikkelsen, B. E., & Schofield, C. (2013). Choice architecture as a means to change eating behaviour in self-service settings: a systematic review [Review]. *Obesity Reviews*, *14*(3), 187-196. https://doi.org/10.1111/j.1467-789X.2012.01054.x

Slapo, H., Schjoll, A., Stromgren, B., Sandaker, I., & Lekhal, S. (2021). Efficiency of In-Store Interventions to Impact Customers to Purchase Healthier Food and Beverage Products in Real-Life Grocery Stores: A Systematic Review and Meta-Analysis [Review]. *Foods*, *10*(5), Article 922. https://doi.org/10.3390/foods10050922

Song, J., Brown, M. K., Tan, M., MacGregor, G. A. K., Webster, J. J., Campbell, N. R. C., Trieu, K., Ni Mhurchu, C., Cobb, L. K., & He, F. J. (2021). Impact of color-coded and warning nutrition labelling schemes: A systematic review and network meta-analysis [Article]. *PLoS Medicine*, *18*(10), Article e1003765. https://doi.org/10.1371/journal.pmed.1003765

Sunstein, C. R. (2017). Nudges that fail. *Behavioural Public Policy*, *1*(1), 4-25. https://doi.org/10.1017/bpp.2016.3

Thaler, R. H., & Sunstein, C. R. (2003). Libertarian paternalism. *American Economic Review*, *93*(2), 175-179. https://doi.org/10.1257/000282803321947001

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. Yale University Press.

Valencic, E., Beckett, E., Collins, C. E., Korousic, B., & Bucher, T. (2023). Digital nudging in online grocery stores: A scoping review on current practices and gaps [Review]. *Trends in Food Science & Technology*, *131*, 151-163. https://doi.org/10.1016/j.tifs.2022.10.018

Vecchio, R., & Cavallo, C. (2019). Increasing healthy food choices through nudges: A systematic review [Review]. *Food Quality and Preference*, *78*, Article 103714. https://doi.org/10.1016/j.foodqual.2019.05.014

Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. (2012). Climate Change and Food Systems. In A. Gadgil & D. M. Liverman (Eds.), *Annual Review of Environment and Resources, Vol 37* (Vol. 37, pp. 195-+). Annual Reviews. https://doi.org/10.1146/annurev-environ-020411-130608

Wansink, B., & Sobal, J. (2007). Mindless eating - The 200 daily food decisions we overlook. *Environment and Behavior*, *39*(1), 106-123. https://doi.org/10.1177/0013916506295573

Wertenbroch, K. (1998). Consumption self-control by rationing purchase quantities of virtue and vice. *Marketing Science*, *17*(4), 317-337. https://doi.org/10.1287/mksc.17.4.317

WHO. (2024a). https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

WHO. (2024b). https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L. J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J. A., De Vries, W., Majele Sibanda, L., . . . Murray, C. J. L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, *393*(10170), 447-492. https://doi.org/https://doi.org/10.1016/S0140-6736(18)31788-4

Wilson, A. L., Buckley, E., Buckley, J. D., & Bogomolova, S. (2016). Nudging healthier food and beverage choices through salience and priming. Evidence from a systematic review [Review]. *Food Quality and Preference*, *51*, 47-64. https://doi.org/10.1016/j.foodqual.2016.02.009

Wright, B., & Bragge, P. (2018). Interventions to promote healthy eating choices when dining out: A systematic review of reviews. *British Journal of Health Psychology*, *23*(2), 278-295. https://doi.org/10.1111/bjhp.12285

Wyse, R., Jackson, J. K., Delaney, T., Grady, A., Stacey, F., Wolfenden, L., Barnes, C., McLaughlin, M., & Yoong, S. L. (2021). The Effectiveness of Interventions Delivered Using Digital Food Environments to Encourage Healthy Food Choices: A Systematic Review and Meta-Analysis [Review]. *Nutrients*, *13*(7), Article 2255. https://doi.org/10.3390/nu13072255

1029 Table 1 General characteristics of included reviews

ID	Author and date	RF	Sco	Population	Timeframe	N	Product	CI
1	Allan et al. (2017)	Both	H	Employees	1946 to Nov 2014 (Search) 1976 to 2014 (Pub)	22	Not specific	N
2	An et al. (2021)	Both	H	Eight studies recruited people aged 15 years and older, whereas the other studies did not report age distribution.	Inception to December 1 2019 (Search) 2009 to 2019 (Pub)	15	Not specific	N
3[b]	Bianchi et al. (2018)	Both	B	Generic population	Inception to Aug 31 2017 (Search) 2005 to 2018 (Pub)	18	Meat	N
4	Chambers et al. (2021)	Both	H	Children <18 years of age	January 1994 to January 2019 (Search)	137	Fruit and vegetables, healthy and unhealthy meals, snacks, sides and beverages	Y
5	Croker et al. (2020)	Both	H	Generic population	2016 to 2019 (Search) 2017 to 2019 (Pub)	14	Prepackaged foods	N
6	Gynell et al. (2022)	Both	H	Generic population	Inception to December 2021 (Search) 2008 to 2022 (Pub)	23	Healthy food	N
7	Harbers et al. (2020)	Both	H	Adults	Inception to Jan 31, 2018 (Search) 1984 to 2018 (Pub)	75	Not specific	N
8	Kay et al. (2025)	Both	H	Generic population	Inception to March 2024 (Search) 1975 to 2024 (Pub)		Food and beverage	Y
9	Laiou et al. (2021)	Both	H	Cafeteria users/ customers/sales/ investigator observations	January 2003 to October 2020 (Search) 2011 to 2020 (Pub)	60	Healthy food; high-calorie food items	N
10	Lindstrom et al. (2023)	Both	H	Adults	April 2009 to July 2020 (Search) 2012 to 2020 (Pub)	33	Fruits, vegetables, packaged foods, and restaurant menu items.	Y
11	Sapio and Vecchio (2024)	Both	H	Low SEP population	2018 to Jan 2024 (Search) 2018 to 2023 (Pub)	43	Food and drinks	Y
12	Schruff-Lim et al. (2023)	Both	H	Generic population	Inception to July 2022 (Search)	62	Not specific	Y
13	Slapo et al. (2021)	Both	H	Consumers of stores	Inception to April 2020 (Search) 1982 to 2019 (Pub)	36	Healthy food (non-specific)	Y
14	Song et al. (2021)	Both	H	Adults	1990 to 24 May 2021 (Search)	156	Foods and drinks	N

					1998 to 2021 (Pub)			
					Inception to Feb 2022 (Search)			
15	Valencic et al. (2023)	Both	H	Healthy population	2006 to 2021 (Pub)	15	Not specific	N
					Inception to October 2020 (Search)			
16	Wyse et al. (2021)	Both	H	Generic population	2006 to 2020 (Pub)	11	Not specific	Y
	Al-Khudairy et al.							
17	(2019)	DCs	H	National Health Service (NHS) staff	Inception to May 2017 (Search)	18	Food and drinks	Y
					2008 to October 2022 (Search)			
18	Almeida et al. (2024)	DCs	H	Generic population	2009 to 2022 (Pub)	39	Fruit, Vegetables	N
	Arno and Thomas			Adults: a minimum of 18 years to a maximum 65				
19	(2016)	DCs	H	years of age.	2004 to 2014 (Search & Pub)	42	Not mentioned the details	N
					Inception to 2016 (Search)			
20	Broers et al. (2017)	DCs	H	NM	2005 to 2016 (Pub)	23	Fruit and/or vegetables	N
				1 study on children; 10 studies with university students or staff, and 5 studies on customers of	Inception to February 2015 (Search)			
21	Bucher et al. (2016)	DCs	H	hospital cafeterias.	1976 to 2014 (Pub)	18	Healthy or unhealthy items	N
	Crocketta et al.				1945 to 2017 (Search)			
22	(2018)	DCs	H	Generic population	1984 to 2017 (Pub)	28	Food or drinks	N
					October 2010 to October 2019 (Search)			
23	Fergus et al. (2021)	DCs	H	Generic people (including children and elders)	2011 to 2019 (Pub)	46	Not specific	N
				Preschool/kindergarten-aged children (44%), elementary (37%) and secondary school-aged	January 1996 and October 2015 (Search)		Food consumption and/or selection and fruit and/or	
24	Lycett et al. (2017)	DCs	H	children (20%).	2000 to 2015 (Pub)	40	vegetable intake	N
					Inception to December 2020 (Search)			
25[e]	Meier et al. (2022)	DCs	E	Individual consumers	2012 to 2020 (Pub)	12	Meat consumption	Y
				School children in grades Kindergarten – 12	Inception to 2018 (Search)			
26	Metcalfe et al. (2020)	DCs	H	(primary and secondary school students)	2005 to 2018 (Pub)	29	Milk, fruit, vegetable and water	N
	Nornberg et al.				Inception to 2013 (Search)			
27	(2016)	DCs	H	Disease-free adolescents (aged 11 to 19 years)	2001 to 2012 (Pub)	12	Vegetable	N
					2011 to 2021 (Search)			
28[e]	Pandey et al. (2023)	DCs	E	Generic population	2013 to 2021 (Pub)	14	Not specific	N
					1998 to 2014 (Search)		Food and drinks (healthy or	
29	Roy et al. (2015)	DCs	H	Young adults in tertiary education settings	2001 to 2014 (Pub)	15	unhealthy)	Y
30	Schulte et al. (2023)	DCs	H	Population in secondary school	Inception to October 2021 (Search)	14	Food and/or drinks	N

31	Shaw et al. (2020)	DCs	H	Individuals aged 18+ years	2005 to 2020 (Pub) 2005 to 2019 (Search & Pub)	39	Food/ beverage items	Y
32	Vecchio and Cavallo (2019)	DCs	H	Generic healthy population	2015 to 2018 (Search) 2016 to 2018 (Pub)	26	NM	N
33	Cadario and Chandon (2020)	NM	H	Generic population	Inception to 2017 (Search)	96	Not specific	N
34	Ikonen et al. (2020)	NM	H	NM	Inception to 2018 (Search) 1996 to 2018 (Pub)	130	Not specific	N
35	Skov et al. (2013)	NM	H	Ranging from school children aged 4 to 18 to working-age adults	Inception to Mar 2012 (Search) 1984 to 2012 (Pub)	12	Not specific	N
36	Wilson et al. (2016)	NM	H	Adult humans	Inception to 2014 (Search) 2010 to 2014 (Pub)	26	Food and drinks	N

Note: CI: The combination of nudges and other non-nudges interventions like education or financial interventions; ID: Identification number of each review. The three IDs marked with superscripts (3^{b}, 25^{e}, 28^{e}) refer to systematic reviews that are in the scope of environmentally friendly food choices; N: number of primary studies; NM: Not mentioned. RF: Regional focus of the countries included: Both: Developed and developing countries; DCs: Developed countries (Source: UNCTADstat – Classifications. Retrieved 30 April 2024: https://unctadstat.unctad.org/EN/Classifications.html); Sco: The scope of the review discussion on food choices: B: Both healthy and environmentally friendly food choices; E: environmentally friendly food choices; H: Healthy food choices. Timeframe: Pub: The timeframe during which the primary studies included in the review were originally published; Search: The timeframe during which the literature searches were conducted to identify studies for the review.

1037 Table 2 Methodological issues of primary studies

Methodological issues	IDs
Not mentioned the quality appraisal of primary studies	11, 15, 19, 28[e], 33, 34
Only list the quality distribution without the accompanying compilation and discussion	3[b], 5, 6, 7, 10, 14, 23, 25[e], 29, 30, 31, 36
For RCTS: Attrition bias (Incomplete outcome data)	4, 9, 16
For RCTS: Knowledge of allocation (Blinding)	4, 13, 18, 22, 27
For RCTS: Randomisation procedure (Insufficient detail to determine whether randomisation had been appropriately performed)	4, 8, 13, 16, 17, 22, 24
For RCTS: Selective outcome reporting	9
Baseline group comparability (Whether intervention and control groups were comparable at baseline)	8
Blinding of outcome assessors	8, 9, 22
Confounding	9, 12, 20, 27
Data Transparency (Open Data)	12
Do not use population-based sampling	2
Inaccurate outcome measurement tools	35
Incentive compatibility (majority used hypothetical choices)	12
Inclusion/exclusion criteria reporting	9
Lack of descriptive information	27, 35
Lack of intervention fidelity checks	26
Low external validity	32
Non-validated measures	24
Pre-registration	12
Sample Size Bias	2, 27, 35
Selection bias of non-RCT studies	1, 12, 13, 16, 24
Short implementation durations	27, 35
Study design (e.g., pre-post designs without control groups)	12
Unclear about different biases due to insufficient reporting	1, 9, 13, 21, 22, 27

1038

1039

1040

1041

1042

1043

1044 Table 3 The nudge frameworks

Authors	Categories	N of nudge types	Review ID
Ensaff (2021)	Default, Placement, Availability, Contrast, Presentation, Semiotics, Prompts and Descriptives.	8	11
Cadario and Chandon (2020)	1. Cognitively oriented: descriptive nutritional labelling, evaluative nutritional labelling, or visibility enhancements; 2. Affectively oriented: hedonic enhancements or healthy eating calls 3. Behaviour-oriented: convenience enhancements or size enhancements.	7	11, 33
Bauer and Reisch (2019)	(1) Provision of information; (2) Use of salience and social norms; (3) Changes in the defaults; (4) Changes to the physical environment; and (5) Incentives and preplanning	5	4
Kraak et al. (2017)	Place, profile, portion, pricing, promotion, healthy default picks, prompting or priming and proximity	8	13
Hollands et al. (2017)	TIPPME 1. Placement: availability, position 2. Properties: functionality, presentation, size and information.	6	7, 18, 22, 28[e], 30, 31
Muenscher et al. (2016)	1. Decision information: translate information, make information visible, provide social reference point 2. Decision structure: change choice defaults, change option-related effort, change range or composition of options, change option consequences 3. Decision assistance: provide reminders, facilitate commitment	9	16, 32
Hollands et al. (2013)	1. Alter the properties: ambience, functional design, labelling, presentation and sizing. 2. Alter the placement: availability and proximity. 3. Alter both the properties and placement: priming and prompting.	9	1, 9, 13, 17, 19, 20, 21, 24
Blumenthal-Barby and Burroughs (2012)	Incentives, Defaults, Salience and affect, Norms and messenger, Subconscious priming, Commitments and ego preservation	6	10, 36
Dolan et al. (2012)	MINDSPACE: Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitments, Ego	9	23

1045 Note: The ID numbers correspond to the review information provided in Table 1.

1046

1047

Table 4 The extended TIPPME framework

Category	Type	Description	Review ID	N of reviews
Placement	Availability	Add or remove (some or all) products or objects to increase, decrease, or alter their range, variety or number.	1, 9, 11, 17, 18, 19, 20, 24, 27, 28[e], 29, 31, 36 ratios: 6	14
	Position	Alter the position, proximity or accessibility of products or objects.	1, 6, 7, 9, 11, 13, 15, 17, 18, 20, 21 (E), 26, 28[e], 30, 31, 32, 33, 36 salience: 22	20
Properties	Functionality	Alter functionality or design of products or objects to change how they work, or guide or constrain how people use or physically interact with them.	7, 9, 18	3
	Presentation	Alter visual, tactile, auditory or olfactory properties of products, objects or stimuli.	1, 3[b], 7, 9, 18, 19, 20, 24, 28[e], 30, 33 priming: 6, 8 (E), 10, 19, 20, 23, 24, 32 affect: 11, 23, 33 environmental cues: 32 salience: 4, 15 naming: 6	18
	Size	Alter the size or shape of products or objects.	1, 3[b], 7, 8, 12, 16, 17, 18, 19, 23, 25[e], 27, 31, 32, 34	15
	Information	Add, remove or change words, symbols, numbers or pictures that convey information about the product or object or its use.	1, 2 (E), 3, 4, 5 (E), 6, 7, 9, 10, 11, 12 (E), 14 (E), 15, 16, 17, 18, 19, 20, 22 (E), 28[e], 29, 30, 33, 34 (E), 35, 36 norms and messenger: 4, 10, 23 prompting:1, 9, 13, 24	29
Additional type	Default	Default work through inertia or status quo bias, nudging people to stick with pre-set options.	4, 6, 10, 11, 15, 16, 23, 25[e] (E), 32	9
Combined nudges		Different types of nudges	10, 11, 15, 17, 20, 36	6
Combined interventions (incl. nudges)		Other non-nudges interventions (like education) combined with nudges	4, 10, 11, 12, 13, 17, 23, 25[e], 29	9

Note: The ID numbers correspond to the review information provided in Table 1; The descriptions for Placement and Properties subcategories are defined by Hollands et al. (2017); Duplicate IDs within the same category were counted only once in the last column (N of reviews); E, exclusive, the review focuses only on that type of nudge;

Saliences mentioned in different reviews can be categorised into either “Position” or “Presentation”, based on how they are explicitly defined within each respective study.

Table 5 Overall findings from the included systematic reviews

Nudge types	Regional focus	NR	NREff	Overall quality assessment (Review ID)	Direction of results (Review ID)
Availability	Both	4	2	M (1, 9); L (6); CL (11)	I (6, 9)
	Developed	9	5	M (17, 18, 24, 31); L (20, 27, 29); CL (19, 28[e])	P (24, 27, 28[e], 29); I (18, 31)
	NS	1	0	L (36)	/
Position	Both	8	5	M (1, 7, 9, 16); L (6, 13); CL (11, 15)	P (6, 7, 9, 15, 16)
	Developed	10	7	M (17, 18, 21, 31); L (20, 23, 26); CL (28[e], 30, 32)	P (17, 18, 21, 23, 28[e], 30); I (31)
	NS	2	0	M (33); L (36)	/
Functionality	Both	2	2	M (7, 9)	P (7); I (9)
	Developed	1	1	M (18)	I (18)
Presentation	Both	9	6	M (1, 3[b], 4, 7, 9); L (6, 8); CL (10, 11, 15)	P (3[b], 4, 8, 9, 10, 15); I (6)
	Developed	7	4	M (24); L (20, 23); CL (19, 28[e], 30, 32)	P (24, 28[e], 30); I (23)
	NS	1	0	M (33)	/
Size	Both	5	2	M (1, 3, 7, 9); L (13)	P (3[b]); I (9)
	Developed	8	3	M (17, 18, 24); L (20, 26); CL (19, 28[e], 32)	P (17, 24); I (18)
	NS	2	1	M (33); CL (35)	I (35)
Information	Both	15	12	M (1, 3[b], 4, 5, 7, 9, 12, 14, 16); L (6, 13); CL (2, 10, 11, 15)	P (5, 7, 10, 13, 14, 15, 16); N (3[b], 4, 6); I (2, 9)
	Developed	10	8	M (17, 18, 24); L (20, 23, 29); CL (19, 28[e], 30); H (22)	P (18, 23, 24, 28[e], 30); N (17); I (22, 29)
	NS	4	2	M (33); L (36); CL (34, 35)	I (34, 35)
Default	Both	7	6	M (4, 16); L (6, 13); CL (10, 11, 15)	P (4, 6, 10, 13, 15, 16)
	Developed	2	1	M (25[e]); CL (32)	P (25[e])

Note: The ID numbers correspond to the review information provided in Table 1; Direction of Results: P: Positive effect, N: No effect, I: Inconclusive effect. NR: Number of reviews; NREff: Number of reviews with effectiveness conclusions; Overall Quality assessment of included reviews: H: High; M: Moderate; L: Low; CL: Critical low; NS: Not specified.

1080 Table 6 Overall findings on nudging effects from meta-analyses

Authors (Year)	N of studies	Nudge types	Overall effect
Arno and Thomas (2016)	42	Availability, presentation, size, information	On average, nudge interventions led to a 15.3% (95% CI: 7.58, 23.0) rise in healthier consumption decisions, either based on the frequency of healthy selections or the overall intake.
Broers et al. (2017)	14	Availability, position, presentation, size, information	A medium (SMD = 0.30) significant effect was shown.
Cadario and Chandon (2020)	96	Position, presentation, size, Information	The meta-analysis yielded a SMD of 0.23, equivalent to −124 kcal/day.
Crocketta et al. (2018)	3	Information	A meta-analysis of three RCTs that examined energy labelling on restaurant menus found a statistically significant reduction of 47 kcal in energy purchased (SMD = 46.72 kcal, 95% CI: 78.35, 15.10, N = 1877).
Croker et al. (2020)	11	Information	The sugar and sodium content of purchased products was lower when FOPLs were present compared to when they were absent (-0.40 g sugar per 100 g, P < 0.01; -24.482 mg sodium per 100 g, P = 0.012). Additionally, there was a trend toward reduced energy (-2.03 kcal per 100 g, P = 0.08) and saturated fat content (-0.154 g saturated fat per 100 g, P = 0.091).
Ikonen et al. (2020)	114	Information	While FOPLs helped consumers identify healthier products, their effectiveness in encouraging consumers toward healthier choices is more limited.
Kay et al. (2025)	66	Presentation	Seven meta-analyses indicated that visual cues and primes can effectively influence consumption-related behaviours, though the effects are generally small.
Pandey et al. (2023)	9	Availability, position, presentation, size, information	Nudging by altering the properties showed a small effect size (SMD = 0.16), and nudging through changes in placement demonstrated a medium effect size (SMD = 0.21).
Slapo et al. (2021)	30	Information, default	Small but significant effect on food purchases: SMD = 0.17.
Song et al. (2021)	134	Information	The traffic light labelling system is effective overall.
Wyse et al. (2021)	7	Position, information, default	Effective in reducing the energy content of online food purchases (SMD = -0.34, p = 0.01).

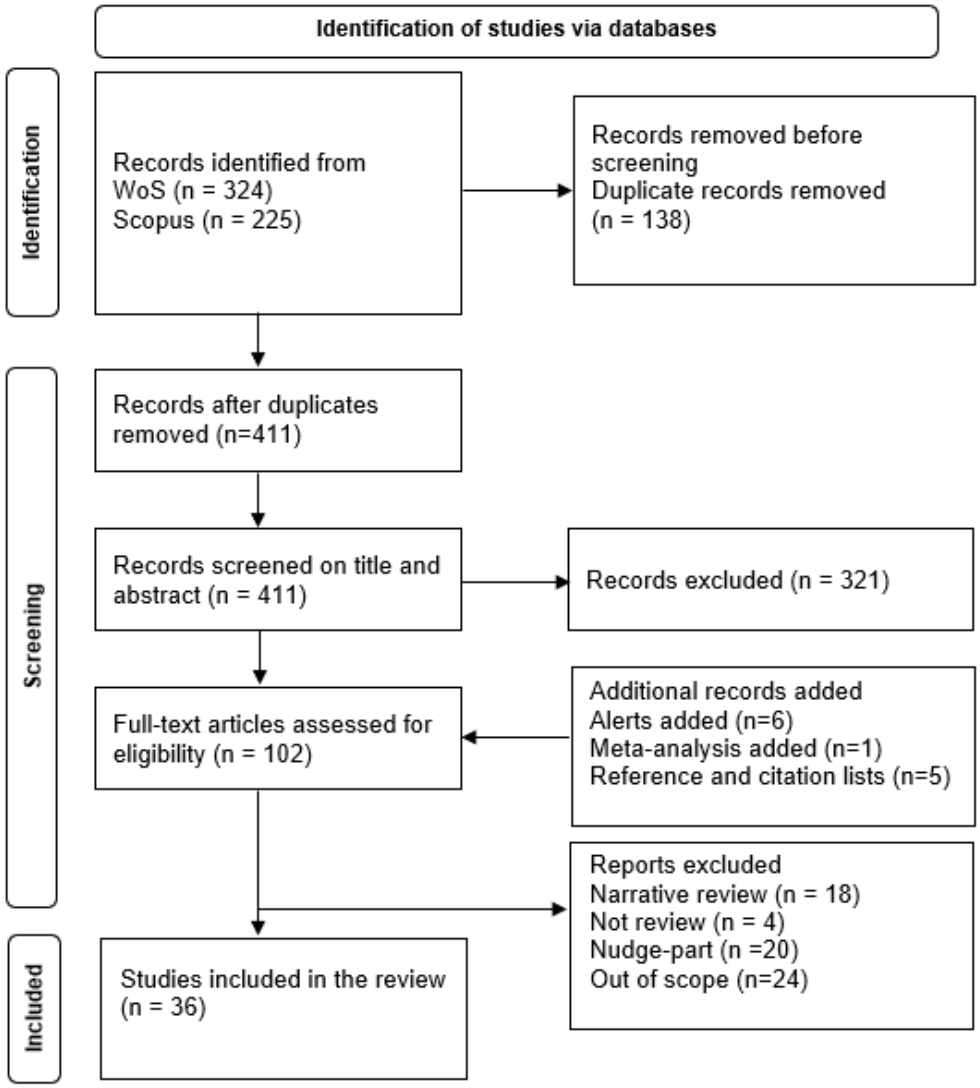
Note: CI: Confidence interval; FOPLs: Front-of-package labels; N: Total number of observations; RCTs: Randomised controlled trials; SMD: Standardised mean difference.

Table 7 Future research recommendations reported in the included systematic reviews

Methodological advancements in empirical study design
• Prioritise randomised controlled trials (RCTs), factorial designs, and cluster-randomised studies in real-world settings (Lindstrom et al., 2023; Metcalfe et al., 2020; Slapo et al., 2021). • Use laboratory studies alongside field experiments to explore psychological mechanisms (e.g., "dodge effects") and refine real-world interventions (Gynell et al., 2022; Kay et al., 2025; Meier et al., 2022). • Examine how nudges interact with other interventions like pricing strategies to enhance effectiveness (Metcalfe et al., 2020; Pandey et al., 2023; Slapo et al., 2021). • Assess long-term efficacy, sustainability of behaviour change, and compensatory behaviours (An et al., 2021; Chambers et al., 2021; Harbers et al., 2020; Ikonen et al., 2020; Meier et al., 2022; Metcalfe et al., 2020; Sapio & Vecchio, 2024; Schruff-Lim et al., 2023; Schulte et al., 2023). • Use digital tracking (e.g., loyalty cards) to monitor individual purchasing behaviour (Harbers et al., 2020; Slapo et al., 2021; Valencic et al., 2023). • Include effect sizes, randomisation details, and subgroup analyses by demographics (e.g., age, SES, ethnicity) (Chambers et al., 2021; Metcalfe et al., 2020; Slapo et al., 2021).
Contextual and demographic adaptations
• Test interventions and design strategies for specific groups (e.g., low-income households, ethnic minorities) for different food purchasing contexts to address health equity gaps (Chambers et al., 2021; Fergus et al., 2021; Gynell et al., 2022; Lindstrom et al., 2023; Metcalfe et al., 2020).
Economic and ethical considerations
• Investigate intervention costs, scalability, and feasibility for policymakers (Chambers et al., 2021; Metcalfe et al., 2020; Pandey et al., 2023; Wyse et al., 2021). • Assess autonomy concerns, psychological costs, and stakeholder acceptability (e.g., retailers, consumers) (Harbers et al., 2020; Ikonen et al., 2020; Meier et al., 2022; Valencic et al., 2023).
Stakeholder engagement and policy integration
• Involve policymakers, retailers, and schools in intervention development to ensure ethical and practical implementation (Harbers et al., 2020; Metcalfe et al., 2020). • Track adherence to nudges in real-world settings (e.g., school cafeterias) and refine strategies using stakeholder feedback (Metcalfe et al., 2020). • Policymakers should ensure that nudges complement, rather than replace traditional public health interventions, such as integrating front-of-package labels (FOPLs) with complementary interventions (e.g., taxation, education campaigns) to align consumer perceptions with actual dietary behaviour and mitigate the halo effect. (Her & Seo, 2017)

Table 8 Recommendations for review conduct

• Use quality assessment tools such as AMSTAR 2 as a reference to improve the quality of the review.
• Incorporate the analysis of combined interventions and compare the effectiveness of different forms of integration.
• Ensure systematic reporting of study regions to analyse cultural, economic, and regulatory influences on nudge effectiveness. Cross-country comparisons could reveal contextual moderators.
• Ensure clear reporting of the publication time frame of the included primary studies and the time frame of the literature search.
• Adopt standardised frameworks when classifying nudges, ensuring consistency in categorisation and comparison across studies.
• Explicitly define the scope by specifying whether it targets health, environmental objectives, or both and address the current imbalance by prioritising reviews on environmental nudges and comparing the results when both objectives are involved to identify synergies or trade-offs.
• Instead of only reporting overall effects, reviews should report effect sizes for each nudge subcategory if applicable and assess which are most impactful in different settings and populations, as overall effects provide limited practical guidance for real-world implementation.



1128 Fig. 1. Flow chart of the article selection