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TOPICAL REVIEW

Are interventions for environmentally sustainable dietary behaviours effective? A review

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Abstract

In the face of growing environmental pressures, understanding how governance can promote more sustainable dietary behaviours is increasingly critical. However, a synthesis of available intervention strategies for behavioural change is currently missing. This umbrella review synthesizes findings from 29 reviews published between 2018–2024, assessing effectiveness of governance interventions aimed at reducing consumer-level food waste and shifting diets toward more environmentally sustainable patterns, particularly reducing meat consumption and increasing the uptake of more sustainably produced foods. Using a dual-method approach, combining narrative synthesis and effect direction analysis, we evaluated interventions through the lens of behavioural change theory. A majority of interventions demonstrated positive effects, especially those targeting food waste, which tend to face fewer cultural and motivational barriers than dietary changes such as meat reduction. Information-based interventions were most commonly studied. While they effectively raise awareness and influence attitudes, there is broad consensus that they are insufficient in isolation to drive substantial behaviour change. Interventions that restructure the decision-making context, such as setting vegetarian meals as default, removing trays in canteens, or reducing portion sizes, consistently showed positive effects. Written and verbal cues were effective in reducing food waste, while results were more mixed for meat reduction. Feedback and goal-setting strategies appear promising, but have been evaluated mostly through stated, rather than observed, behaviours. Fewer studies examined incentivising, coercive, or training-based interventions, though these approaches may offer higher impact if implemented appropriately. Overall, the findings highlight the need to combine intervention types to target the full range of behavioural determinants: capability, opportunity, and motivation. We also highlight the need for more rigorous, long-term, and context-sensitive research. Finally, we offer recommendations for policy makers and researchers, emphasizing that consumer-focused efforts must be integrated into a broader, cross-sectoral policy strategy, spanning health, agriculture, environment, and education, to enable substantial change in food consumption behaviours.

1. Introduction

Alleviating environmental pressures from food systems requires improvements in production, but also changes in food consumption, primarily a shift from animal to plant-based products and reductions in food waste [1–3]. However, altering dietary patterns is difficult [4], even when it may bring personal health benefits [5]. Hence, interventions that help consumers make more sustainable choices are needed [6].

Here we focus on governance interventions, defined as any course of action, programme or activity either undertaken directly or mandated by governance actors. With governance actors we here mean a broad array of actors in the complex multi-actor food system including, for example, courts, regulatory agencies, regional or local governments [7]. Governance interventions may include public policy instruments such as taxes and subsidies, regulation of marketing and a range of information-based interventions, including labelling and information campaigns. Interventions may also be initiated by food system private actors, such as retailers and restaurants, and include restructuring of menus, restricting plate size, etc. [8].

Several food policies promoting public health have already been adopted by policy makers, but few policies specifically aimed at promoting environmentally sustainable food consumption have been implemented [9]. Such policies are likely to encounter societal resistance since they may conflict with (perceived) short-term consumer self-interests and since food habits tend to be viewed as private, closely linked to identity and culture [10]. Understanding how governance interventions can be designed to be effective is crucial to increase their legitimacy and avoid wasting political capital on ineffective measures [11].

A wide range of behaviour change interventions aiming to promote more sustainable consumption patterns is available to policy makers [8]. The evidence base investigating the effectiveness of these interventions has expanded significantly recently. Systematic reviews and knowledge syntheses have discussed the effectiveness of interventions for more sustainable food consumption broadly, and summarised for different intervention categories [12], or focused on specific types of intervention, like nudges (e.g. [13–15]) or information campaigns [16]. Others have focused only on one type of outcome, for example, reducing consumption of meat (e.g. [15, 17, 18]), animal-based products (e.g. [19, 20]), or consumer food waste [21–24]. However, there is a lack of a comprehensive synthesis and analysis of the available intervention strategies across outcomes such as reduced food waste and lower meat consumption. This paper seeks to address that gap by synthesising existing evidence and highlighting key considerations for effective policy design.

We present an umbrella review, a systematic approach to collects and evaluate information from multiple reviews and meta-analysis [25], of governance interventions aimed at promoting more environmentally sustainable dietary behaviour. We synthesise the evidence using the behaviour change wheel (BCW) [26], which is a practical analytical tool that creates a link between interventions and behaviour, to better understand intervention effectiveness. Identifying determinants of relevant behaviours, e.g. knowledge or norms, targeted by an intervention allows links between effectiveness and behavioural determinants to be traced and conclusions to be drawn on why different interventions may work or not [27].

Interventions for environmentally sustainable food consumption vary substantially in design, implementation, and context, target different outcomes (e.g. reduced meat consumption, reduced food waste, promotion of more sustainably produced foods) which limits the feasibility of conducting a meta-analysis. We synthesize this scattered evidence by combining two approaches. First, we conduct a narrative analysis of the evidence, a comprehensive review method used to provide an overview of a wide variety of studies, including elements of analysis and critique [28]. We complement this narrative synthesis with an effect direction analysis of eligible intervention (positive, negative or no effects), a standardized method in systematic reviews enabling synthesis of diverse measures of effect [29]. The effect direction analysis is conducted for three different categories of outcomes: dietary shifts between food groups (e.g. from meat to more plant-based food), dietary shifts within food groups (i.e. towards more sustainably produced food, e.g. organic foods), and reduced consumer food waste. In consumer food waste we include food wasted by consumers in households and restaurants.

We categorize interventions inductively to different common intervention types (e.g. labelling, information-based etc.) and discuss effectiveness of these types in relation to intervention function in the BCW and discuss how differences in the behavioural mechanisms triggered by different interventions explain differences in effect. To enhance scientific rigour, transparency, and comprehensiveness, this umbrella review incorporated careful planning (as described in the study protocol [30]), comprehensive searches, consistency checks during screening and data extraction, and a critical appraisal of the included evidence (see supplementary data A.4).

2. Methods

2.1. Literature review

This umbrella review aims to answer the question: What evidence exists on the effectiveness of different governance interventions aiming to reduce the negative environmental impact from food consumption or food waste (at the consumption stage)? We collate and narratively synthesize conclusions from existing reviews to provide a comprehensive overview of the current evidence base. We followed a systematic review methodology, with the exception of only including reviews published between 2018 and 2025 (searched on 27th of January 2025). We used the AMSTAR 2 tool [31] for critical appraisal of included reviews that consists of randomised and non-randomised studies of interventions with some adaptations to accommodate for the study designs present in our evidence base (see supplementary data A.4). Our protocol was preregistered and is available in the PROCEED registry (PROCEED-23-00097) [30]. EPPI-Reviewer Web [32], a review management software, supported the majority of the review process (including assembling a library of search results, deduplication, screening, and critical appraisal).

We decided to focus on more recent review studies, published after 2018 as a previous systematic mapping exercise [8] showed that the majority of studies on interventions for more sustainable food consumption were published after 2018. However, as the reviews include older primary research we capture evidence before 2018 as well. For reviews to be eligible they had to focus, directly or indirectly, on influencing consumer choice or consumer food waste behaviour through governance interventions and present data on measured effects of individual interventions. Eligible populations were consumers in any geographic or economic settings and eligible interventions were governance interventions that have been or could be implemented by a governance actor with the explicit aim to change consumption patterns (eating or wasting) or that shift consumption within food product groups for environmental reasons. Peer-reviewed articles as well as unpublished material are included in the review.

Literature was collected from three sources [30]: (1) relevant reviews identified in the comprehensive search via a systematic mapping of governance interventions for environmentally sustainable food consumption (with the same scope as this study but without interventions for reductions in consumer food waste) [8], (2) an update of this search in Scopus and Web of Science Core Collections (WoSCC) from the year 2022–2025 (searched on 27th of January 2025)), and (3) bibliographic searches on Scopus and WoSCC for food waste reviews. We limited our searches to English. Search strings for food waste literature were developed in a series of iterations. The comprehensiveness of the search was tested via a list of benchmark studies. Search strings are provided in supplementary data tables A.1 and A.2 and the search strategy is described in detail in supplementary data A.3.

Screening was conducted on title and abstract, followed by the full text (with consistency checking at both screening levels). Consistency check for title and abstract screening was performed by all seven reviewers on a subset of 392 out of 4091 records. All disagreements were resolved in discussion, ensuring all reviewers interpreted eligibility criteria consistently. The consistency exercise was finalised after four rounds and to interrater agreement of above 80%, indicating high consistency. At full text level, consistency checking was conducted on a subset of 20 (out of 299) records and the same records were screened by six reviewers until reaching an interrater agreement of above 80%, which was reached after two rounds. All disagreements were resolved in discussion. After ensuring consistency between reviewers, the screening process continued independently by six reviewers and is further described in supplementary data A and figure A.1. Studies included and excluded at title and abstract and full text are listed in supplementary data B.

After full text screening, a critical appraisal of review quality and methodological rigour was performed by a total of six reviewers (in pairs) using an adapted version of the AMSTAR2 [31] (see supplementary data A.4 and tables A.3 for appraisal results). Data extraction was also conducted in pairs by six reviewers using a predesigned data extraction sheet (see supplementary data C). In case of missing data or discrepancies in extractions we consulted the original source studies (primary research). As per Pieper *et al* [33] we have reported on the overlap (or duplication) between primary research studies within each intervention category (see details in the supplementary data E) [34]. Duplicated primary research studies were removed in the effect direction analysis.

2.2. Theory

In this umbrella review we applied elements from the BCW [26] framework, a theory-based method for characterizing and designing behaviour interventions, in discussing the evidence. The framework identifies nine intervention functions that might be applied to influence behaviour (table 1): education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling and enablement. These aim to address deficits in all or any of the three key components for a behaviour to take place; capability, opportunity and motivation (referred to as the COM-B system, which forms the centre of the

Table 1. List of the nine intervention functions and their definitions adapted from the behaviour change wheel (BCW) [26] illustrated with examples of interventions for a more sustainable food consumption or reduced food waste. Adapted from the behaviour change wheel (BCW) [26].

Intervention function	Definition	Example of intervention to promote more sustainable food consumption or reduce food waste
Education	Increasing knowledge or understanding	A leaflet with information about the consequences of food waste
Persuasion	Using communication to induce positive or negative feelings or stimulate action	Poster at waste station to remind actors to waste less food
Enablement	Increasing means or reducing barriers to increase capability (beyond education and training) or opportunity (beyond environmental restructuring)	Social support group that shares recipes of vegetarian dishes and how to waste less food
Modelling	Providing an example for people to aspire or imitate	Using social comparison of, for example, influencers that promote a vegetarian lifestyle
Training	Imparting skills	Cooking class to learn how to cook tasty vegetarian meals
Coercion	Creating expectation of punishment or cost	Tax on meat
Incentivisation	Creating expectation of reward	Price change of vegetarian dish
Environmental restructuring	Change the physical or social context	Increasing the number of vegetarian offers on a menu
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours)	All vegetarian conference meal buffet

BCW [26]) [35]. Capability is defined as an individual's physical and psychological capacity to engage in the desired behaviour. Examples include having knowledge of nutrition and environmental impact to have the psychological capability to engage in the necessary thought process of, for example reasoning and comprehension. Physical capability includes having cooking skills to cook and plan desirable meals [26]. Opportunity means all factors that lies outside the individual and enables or prompts the behaviour, comprising of physical (e.g. having access to storage for leftover food) and social opportunities (e.g. a supportive social environment) [26, 35]. Motivation is defined as the thought process that energise and direct the behaviour, including reflective, conscious decision-making and automatic decision-making which involves habits, values and emotions [26, 36]

2.3. Synthesis approach

We synthesised the evidence using two different approaches. First, we summarised the key conclusions, policy and research recommendations from each review study as expressed by the review authors to help preserve the meaning, nuance, and context of each study (supplementary data D.1). This allowed for a transparent comparison and respects the authors' framing of their findings. Second, we provided a narrative synthesis, by drawing overarching conclusions acknowledging the quality of the review and the amounts of studies they cover presented in section 3.1).

We complemented this synthesis, with an effect direction analysis that reported on direction of effect of individual studies of interventions from the primary research studies across reviews (section 3.2). For each study of an intervention effect we extracted data on intervention(s) type, effect direction (positive, no effect, negative) and type of outcome measured (stated preference, a hypothetically estimated preference illustrated by a stated behaviour or, real revealed preference, which is based on actual records of behaviour [37]) (supplementary data A and E). We then inductively categorised identified interventions into groups based on their type (e.g. labelling, information-based, written and verbal cues etc.) and we discuss these based on the BCW intervention functions they typically apply, and their connection to the key components of COM-B [26].

It was not possible to perform quantitative synthesis or comparison of intervention effects due to high heterogeneity in outcomes (and outcome measures), intervention design and implementation setting. In addition, most reviews did not report such details. The effect direction synthesis method is limited and provides no information on the magnitude of effects and cannot account for differences in the relative

sample sizes of the studies (Cochrane handbook, 2nd edition [38]). We visualised the effect direction analysis using an effect direction plot [29] for each intervention category and across outcomes (supplementary data E). All identified interventions are listed in supplementary data D.2. For further limitations on the methodology and the evidence base, see supplementary data A.7.

3. Results

3.1. Literature overview and narrative synthesis of review studies

We identified 49 reviews that were eligible for inclusion. After critical appraisal, 20 reviews were excluded from data analysis as 19 received a critical appraisal score of "critically low" and one did not include data at the required resolution (see further details of the critical appraisal and search findings in supplementary data A.4, A.5 and table A.4).

Out of the 29 included reviews (table 2), 11 focused on dietary shifts between and in food groups, 8 focused on food waste, and 10 focused on both dietary shifts and food waste. The eligible reviews were published between 2018–2024 with the majority published after 2020 (79%). Five reviews included meta-analyses and the remaining were narrative (21) or scoping reviews (3). Overall, the following patterns emerged: most reviews only include studies in English, and were conducted in a high-income setting. Only ten out of 29 reviews included both peer-reviewed and unpublished material, seven studies were restricted to university settings and eight to food service settings while the remainder mostly focused on consumers more generally.

The review validity was generally higher for studies focusing on diet shifts from meat to plant-based food and lowest for shifting within groups, e.g. to organic food. Note that we have only assessed the quality of the review studies, thus, the primary studies of interventions can still be of high quality, although included in a low-quality review.

In the following sections we narratively summarise key findings from the reviews that focused solemnly on dietary shifts (including reduced meat consumption and better food choices) (section 3.1.1), only on reduced food waste (section 3.1.2), and reviews including studies of both these outcomes (section 3.1.3).

3.1.1. Dietary shifts

We identified nine review studies that focused exclusively on reducing the consumption of meat or other animal-sourced foods [15, 17–20, 39–41, 56] and two additional studies on mainly choosing more sustainable food products, specifically certified products [43, 44] (table 2).

From these reviews, we conclude that there is strong evidence that information-based interventions often show positive effect on intentions to reduce meat consumption, however, the effect tends to be weak and intentions not translating into behaviour. This conclusion was drawn in several reviews [17–20, 39, 42] including one high quality meta-analysis of randomised control trials of interventions aimed at enhancing knowledge (Hedges's $g < 0.2$ in most studies included in the meta-analysis) [41]. By emphasizing health and evoking strong emotional response, information-based interventions seem to have greater potential than interventions only highlighting the environmental impact associated with consumption of animal soured foods [41, 42]. Information-based interventions that go beyond providing information also show more promise, e.g. self-monitoring and individual lifestyle counselling [42].

Further, we conclude that there is moderate evidence, primarily drawn from one high quality systematic review [15], supporting the effectiveness of default nudges as a promising intervention strategy. Default nudges involve having a particular choice pre-set to simplify and steer decisions, e.g. providing a meat-free meal as the pre-selected choice when signing up to a conference, or reducing the meat content in a meal. Important contextual moderators for default nudges include the invasiveness of the default, the recognisability and presentation of the alternative, and the setting in which the consumer makes the choice. The largest reduction occurred when the meat-free control alternative was presented as a subordinate option to the default options, for example, mentioned at the bottom of a menu or as an option per request.

Kwasny *et al* [17], Wynes *et al* [39], and Taufik *et al* [19] examined interventions aimed at reducing meat consumption across various contexts. Kwasny *et al* [17] concluded that there is strong evidence supporting the effectiveness of interventions that are persuasive, enabling, or involve training. These include factual and emotional messaging, information linking meat to living animals, cooking education, and increasing the visibility of vegetarian options. However, Kwasny *et al*'s conclusion regarding the effectiveness of animal welfare messaging is based on few studies. Di Gennaro *et al* [41], drawing on a different set of studies, found that messages focused on health and environmental impacts were substantially more effective than those related to animal welfare. This indicates that the evidence for animal welfare messaging as an effective strategy to reduce meat consumption remains mixed. Nevertheless, both Kwasny *et al* [17] and Di Gennaro

Table 2. Summary of included reviews: eligible interventions, publication year, study setting, number of studies reviewed, whether meta-analysis or not, and critical appraisal score (high quality, moderate quality and low quality).

Eligible interventions	Authors	Pub. year	Title	Study setting	No of studies	Meta-analysis	Critical appraisal score
Dietary shifts							
Reduced meat consumption							
All	Kwasny *et al* [17]	2022	Towards reduced meat consumption: a systematic literature review of intervention effectiveness, 2001–2019	General	99	No	Moderate
All	Taufik *et al* [19]	2019	Determinants of real-life behavioural interventions to stimulate more plant-based and less animal-based diets: a systematic review	General	51	No	High
All	Wynes *et al* [39]	2018	Measuring what works: Quantifying greenhouse gas emission reductions of behavioural interventions to reduce driving, meat consumption, and household energy use	General	40	No	Low
All	Greene *et al* [40]	2023	How to entice restaurant patrons to order low-emissions meals? A meta-analysis and research agenda	Food service sector	26	Yes	Moderate
All	Stiles *et al* [20]	2022	Effectiveness of strategies to decrease animal-sourced protein and/or increase plant-sourced protein in foodservice settings: a systematic literature review	Food service sector	28	No	Moderate
All	Chang *et al* [18]	2023	Strategies for reducing meat consumption within college and university settings: a systematic review and meta-analysis	University	31	Yes	Low
Information	Di Gennaro *et al* [41]	2024	How may we effectively motivate people to reduce the consumption of meat? Results of a meta-analysis of randomized clinical trials	General	14	Yes	High

(Continued.)

Table 2. (Continued.)

Eligible interventions	Authors	Pub. year	Title	Study setting	No of studies	Meta-analysis	Critical appraisal score
Information, counselling and self-monitoring	Bianchi *et al* [42]	2018	Interventions targeting conscious determinants of human behaviour to reduce the demand for meat: a systematic review with qualitative comparative analysis	General	29	No	Moderate
Default	Meier *et al* [15]	2022	Review: do green defaults reduce meat consumption?	General	12	No	High
Better food choice							
Labelling	Majer *et al* [43]	2022	The effects of visual sustainability labels on consumer perception and behaviour: a systematic review of the empirical literature	General	26	No	Moderate
Nudges	Souza-Neto *et al* [44]	2023	Lowering the harm of tourist activities: a systematic literature review on nudges	Food service sector	45	No	Low
Reduced food waste							
All	Liechti *et al* [22]	2024	A systematic literature review of impactful food waste interventions at the consumer level	General	49	No	Low
All	Simões *et al* [21]	2022	How to influence consumer food waste behaviour with interventions? A systematic literature review	Households	96	No	Low
All	Jobson *et al* [23]	2024	A systematic review of pre-post studies testing behaviour change interventions to reduce consumer food waste in the household	Households	16	No	Low
All	Carino *et al* [45]	2020	Environmental sustainability of hospital foodservices across the food supply chain: a systematic review	Hospitals	104	No	Moderate
All	Manimaran *et al* [24]	2023	Strategies to reduce the rate of plate waste in hospitalized patients: a scoping review	Hospitals (only plate waste)	9	No	Moderate
Information/ education	Guimarães *et al* [46]	2024	From plate to planet: a systematic review and meta-analysis on strategies to reduce plate food waste at food services	Food service sector	18	Yes	Moderate
Information/ education	Jenkins *et al* [16]	2022	Exploring the application of social media in food waste campaigns and interventions: a systematic scoping review of the academic and grey literature	General	15	No	High

(Continued.)

Table 2. (Continued.)

All	Radhakrishnan *et al* [47]	2024	Interventions for reducing food waste and behavioural change among students in higher education institutions: a systematic review	University	16		High
Nudges	Barker *et al* [13]	2021	What nudge techniques work for food waste behaviour change at the consumer level? A systematic review	Households	18	No	Low
Dietary shift and reduced food waste							
All	Wadi *et al* [48]	2024	Investigating intervention components and their effectiveness in promoting environmentally sustainable diets: a systematic review	General	13	No	Low
All	Sullivan *et al* [49]	2021	Consumer expectation and responses to environmental sustainability initiatives and their impact in foodservice operations: a systematic review	Food service sector	33	No	High
All	Herrera Burstein and Goñi Avila [50]	2024	Promoting sustainable consumption among university students: a systematic literature review	University	34	No	Low
All	Lee *et al* [51]	2021	Toward a healthy and environmentally sustainable campus food environment: a scoping review of postsecondary food interventions	University	38	No	Moderate
Information/ education	Ghammachi *et al* [52]	2022	Investigating web-based nutrition education interventions for promoting sustainable and healthy diets in young adults: a systematic literature review	Young adults	22	No	High
Nudges	Ferrari *et al* [53]	2019	Can nudging improve the environmental impact of food supply chain? A systematic review	General	25	No	Low
Nudges	Pandey *et al* [14]	2023	Nudging toward sustainable food consumption at university canteens: a systematic review and meta-analysis	University	14	Yes	Low
Nudges	Byerly *et al* [54]	2018	Nudging pro-environmental behaviour: evidence and opportunities	University	72	No	Low
Digital behaviour change interventions	Hedin *et al* [55]	2019	A systematic review of digital behaviour change interventions for more sustainable food consumption	Households	15	No	Low

et al [41] agree that health-related messaging is generally more effective than messaging focused on the environmental impacts of meat consumption.

Taufik *et al* [19] conclude that interventions targeting environmental determinants, such as economic incentives and adjusting portion sizes, demonstrate the highest effectiveness (interventions successful in 65% of cases). However, efforts to enhance food availability showed mixed results: verbal prompts and free samples are beneficial, while changes in product placement or outlet density show limited impact in this study. Individual-focused strategies, such as self-regulation, are also similarly effective (60% success rate). Other individual-focussed interventions, including those aimed at inducing emotions, promoting food knowledge and skills through providing feedback, or prompting health-related thinking, present varied outcomes. Taufik *et al* [19] conclude that due to the variability in determinants, settings, and target populations, establishing generalizable results and recommendations for effective interventions is highly challenging.

Two of the reviews on interventions aimed at reducing meat consumption focused on interventions implemented in food services in general [20, 40] while one review focussed specifically on university canteens [18]. Greene *et al* [40] and Chang *et al* [18] include a meta-analysis of the included studies. Chang *et al* [18] found that 70% of interventions showed significant reductions in meat consumption (odds ratio of 1.82 [1.37, 2.75] for revealed behaviours), while the rest showed no effect (there were no negative effects reported). Combined interventions were significantly more likely to be associated with reductions in meat consumption than those targeting reflective motivation (conscious decision-making) and physical opportunity (like the decision-making context) alone. Interventions exclusively targeting the decision-making context had a greater mean effect than interventions targeting conscious decision-making alone. Greene *et al* [40] found that overall, increasing the visibility of target meals, descriptive labels, and leveraging social norms are ineffective. Effective interventions were those that increased the enjoyment consumers associated with the target meal (i.e., hedonic enhancements) or altered decision context, with increasing the availability and convenience of target meals being highly effective. Stiles *et al* [20] found that most studies reviewed (79%) demonstrated effectiveness. Menu redesign, recipe redesign, service redesign, menu labelling, and prompting at the point of sale resulted in increased uptake of target foods in most studies.

Both Kwasny *et al* [17], Greene *et al* [40] and Taufik *et al* [19] conclude that there is less evidence supporting the effectiveness of interventions that focus on socio-cultural factors, such as shaping social norms (e.g. social comparison messages or norm statements). The success of interventions also varies across consumer groups, depending on their socio-demographic and socio-cultural backgrounds, personality traits, values, and meat-related lifestyles [17, 40].

There was a substantial difference between studies that measured stated or intended behaviour change and those that assessed actual (revealed) behaviour change [18, 42, 43]. For example, information-based interventions, including labelling and educational efforts, were primarily evaluated using self-reported or intended behaviour, with the majority showing positive effects. In contrast, studies that measured real behaviour generally found no significant effect [18, 40]. Therefore, although Majer *et al* [43] reported significant positive outcomes in 25 out of the 26 studies on the use of products and menu labels, the review contributes limited evidence regarding the effectiveness of these interventions in changing actual behaviours, as only two studies measured real-world outcomes such as purchases or food consumption.

3.1.2. Reduced food waste

Nine reviews looked at interventions to reduce food waste [13, 16, 21–24, 45–47] (table 2).

Three studies on household food waste all found that the most commonly studied interventions were information provisioning and campaigns, or more persuasive information interventions, like written and verbal cues, feedback and goal-setting. Most showed a potential to reduce food waste [13, 21, 23]. Consistent with the literature on information-based interventions for dietary shifts (see section 3.1.1), the reviews found that information alone had limited effectiveness. Jobson *et al* [23] found that only one-third of the studies measured food waste quantities or behaviours at multiple time points following the intervention, which limits the ability to assess whether the effects were sustained over time.

Liechti *et al* [22], who reviewed 49 studies on consumer food waste, both in households and food services, found that intervention effects ranged from 7% to a 79% reduction. Multi-component interventions had a higher potential to reduce food waste than single-component interventions.

The review by Jenkins *et al* [16] focused on interventions using social media to reduce food waste and found them to show mostly positive effects on raising awareness. The authors identified that social media campaigns, simply by showing individuals their waste, could evoke feelings of guilt and create a sense of social pressure to reduce food waste. However, most interventions in the study by Jenkins and colleagues [16] relied on self-reported food waste measurements, or only assessed the participants' perceptions of their food

waste, which hinders the possibility to draw conclusions of how the social media campaigns affected actual food waste behaviour.

Across the four reviews on consumer food waste in food services, there was strong evidence that customer-centred interventions, particularly those enhancing the ability to choose foods and portion sizes, showed the greatest potential [24, 45–47]. Guimarães and colleagues [46] found that removing trays and moving away from self-service systems in schools, proved effective. A high quality review by Radhakrishnan *et al* [47], who reviewed interventions in universities, also found removing trays and reducing portions sizes to be the most promising interventions. For hospitals, Manimaran *et al* [24] and Carino *et al* [45] conclude that the most effective strategies to reduce patient food waste were those that provided patient choice and reduced the time between ordering and eating, such as a room service model [24, 45].

In contrast to studies on dietary shifts, the majority of food waste studies measured actual behaviour rather than relying on self-reported data (see figure 2).

3.1.3. Dietary shift and reduced food waste

Nine reviews were broad in scope and included studies on both reducing food waste and dietary shift, in particular, reducing meat and promoting plant-based alternatives [14, 48–55].

The findings from these studies corroborate the findings from reviews only focusing on food waste or reducing meat consumption. For example, reviews in this category also conclude that tray-less dining and reducing portion size seems effective to reduce food waste, and that menu modification to promote plant-based options in restaurants show positive results on reduced meat consumption, with reports in increased sales of vegetarian meals by 41%–79% [14, 54].

Byerly *et al* [54], Herrera Burstein and Goñi Avila *et al* [50] and Lee *et al* [51] who study interventions in university settings, all conclude that interventions changing the decision-making context, like increasing number of vegetarian options or changed food service system outperformed information-based interventions. Results from Sullivan *et al* [49], Byerly *et al* [54] and Herrera Burstein and Goñi Avila [50] support the conclusions from other studies, as stated above, that information alone shows limited potential to change behaviour and that interventions such as menu redesign and defaults show more promise. Sullivan *et al* [49] repeat that, although information can change consumer attitudes and satisfaction, this does not commonly translate into behaviour change.

Results from nudging interventions show mixed outcomes. Nudges that alter the decision-making context, such as menu modifications and smaller buffet plate sizes, were consistently found effective across three systematic reviews on nudging, however, several studies included in the nudging reviews indicated weak or negligible effects of nudging interventions [14, 53, 54].

The review by Wadi *et al* [48], which examined a broad range of interventions promoting environmentally sustainable diets, found that most interventions included were based on increasing knowledge, such as educational courses for students, or posters and text messages, informing about the environmental impacts of certain behaviours. However, these informational interventions were often implemented alongside other strategies. Consistent with the findings of Liechti *et al* [22] on food waste reduction, Wadi *et al* [48] concluded that information-based interventions were most effective when combined with other strategies targeting additional behavioural functions. More specifically, Wadi *et al* [48] found that opportunity-enhancing interventions, such as environmental restructuring, tended to have smaller effects when integrated into multicomponent approaches compared to others. For example, in the context of reducing meat consumption, combining education with interactive intervention functions such as training, modelling or persuasion, resulted in roughly double the reduction compared to combining education with environmental restructuring.

3.2. Identified interventions and effect direction

Across the 29 reviews, we identified 289 studies from primary research papers investigating intervention effects (figures 1, 2 and supplementary data D and E). In figure 1, interventions are organised in the emerging intervention categories, and related to intervention functions from the BCW [26]. Figure 2 present a summary of the direction of measured effect for each intervention type and outcome.

Education and persuasion functions were covered by most interventions (61% of studies), and included labels, feedback and goal setting, and written and verbal cues. Environmental restructuring was also covered by many interventions (27% of studies), including how plant-based options are displayed and distributed. Less covered intervention functions were enablement, e.g. social support and feedback and goal setting (8% of studies), modelling, e.g. exposure to social norm messages (5% of studies), restriction (2% of studies), e.g. removal of meat, incentivisation (<1% of studies), for example via price changes, coercion (<1% of studies), e.g. by introduction of taxes, and training (<1% of studies).

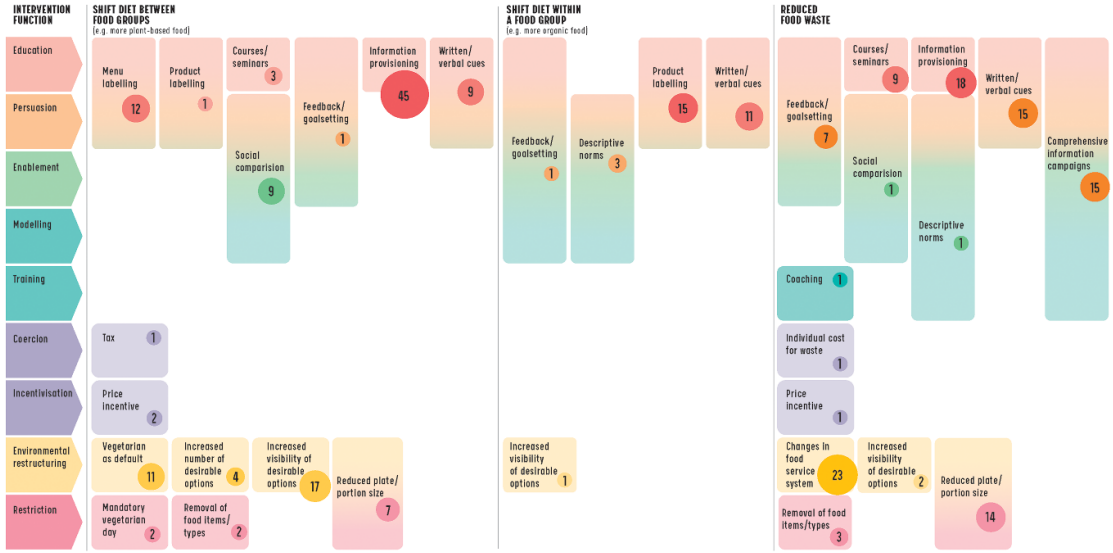

Figure 1. Reviewed interventions grouped by emerging intervention types and categorised for each of the measured outcomes and intervention functions. Derived from the behaviour change wheel [26]. Graphics: Susanne Flodin Studio.

Interventions to reduce food waste and shift within food groups (often to purchase more organic food) generally had positive effects, while interventions that aims to stimulate a shift between food groups, primarily from meat to plant-based, showed more mixed results (figure 2).

3.2.1. Information-based interventions, education programs and coaching

Information-based interventions, in which we include basic information provisioning and more comprehensive information campaigns, were tested in 78 studies (supplementary data D). Interventions in the information provisioning category included providing information using brochures, articles and websites, often without being provided at the moment when the behaviour or decision-making occurs. Comprehensive information campaigns typically combine several information-based interventions and use multiple communication channels across time. In the context of food waste reduction, this category of interventions showed a predominantly positive effect direction, with 79% of studies reporting favourable outcomes. In contrast, for reduced meat consumption, only about one-third of studies demonstrated a positive direction of effect (figure 2; supplementary data D and E). When considering only studies that measured revealed preferences, the pattern remained: 80% of food waste studies (21 in total) showed positive effects, whereas just 17% of meat reduction studies (6 in total) did so.

Information-based interventions rely on the behavioural function of education and typically also include elements of persuasion, targeting psychological capability and reflective motivation to encourage the desired behaviour [26]. These interventions aim to influence behaviour by increasing knowledge, shaping beliefs about the potential benefits or drawbacks of the behaviour, enhancing perceptions of the likelihood that the behaviour will lead to specific outcomes, and shifting attitudes toward the behaviour [57]. However, even when information successfully changes beliefs and attitudes, potentially motivating behavioural change, strong existing habits, prevailing social norms, or automatic motivations such as taste preferences can override the intention to act.

For information-based interventions to work, consumers must process the information they receive, convert it into knowledge and ultimately act on the knowledge [58, 59]. There are two barriers to consumers turning information into knowledge; (i) lack of capability, and (ii) lack of motivation to process information. Likewise, there are two barriers to consumers turning knowledge into behaviour; (i) lack of motivation, and (ii) lack of opportunity to make desired choices [60]. Carefully designed information campaigns can help address these barriers. Campaigns that combine educational and persuasive functions tend to be more effective than those relying solely on information provision [16, 17, 21, 52]. Repeated educational efforts can lower the threshold for converting information into knowledge [16], while simultaneously targeting psychological capability as well as both reflective and automatic motivation. This comprehensive approach strengthens the foundation for behaviour change by addressing multiple components within the COM-B system [26]. However, these barriers can differ and, for example, be more difficult to overcome in regard to shifting to more plant-based food compared to reducing food waste [61].

Figure 2. Effect direction per outcome and targeted intervention function (coloured dots) derived from the behaviour change wheel [26]. We only account for the same intervention once and exclude any overlaps between studies included in multiple reviews. The figure shows effect direction (positive as upwards pointing arrow, no effect as square, negative as downwards pointing arrow) and if the effect was measured by revealed (top) or stated (bottom) preference. Two interventions are not represented here since one is mixing revealed and stated preferences and the other is mixing all outcomes.

Awareness of environmental impacts also affects effectiveness of information-based interventions. For example, an information campaign aiming to inform about negative consequences associated with a specific behaviour, for example eating meat, is more effective when lack of such knowledge is the barrier towards engaging in a new behaviour, e.g. eating less meat [27]. Newly gained awareness of environmental

consequences may however not be enough to alter consumer food choices, since other barriers, e.g. lack of opportunity and/or motivation to engage in a new dietary behaviour, are not addressed.

The evidence base included 13 studies of educational programmes such as courses or seminars out of which all but one showed a positive effect direction. Education interventions aim to help people translate information into knowledge to overcome capability and motivation barriers to perform a certain behaviour. University courses and seminars, including discussion and engaging with audience queries, presumably translate information into knowledge more effectively than one-directional information-based interventions like labels or leaflets.

Only one study focused on coaching and the intervention function training, which imparts skills and address both psychological and physical capability in contrast to the other information-based interventions that only address psychological capability [26].

3.2.2. Product and menu labels

Labels are presented to consumers at the point of purchase, typically on the food product or on a menu. The labels tested in the evidence base (28 studies) were carbon footprint labels and eco-certification labels (labels for organic farming, Rainforest Alliance, Marine Stewardship Council, Aquaculture Stewardship Council). Carbon footprint labels typically aim to steer consumers towards lower-impact foods across broad categories (e.g. from meat to plant-based options), while eco-certifications direct consumers to a potentially better option within a certain product category (e.g. organically vs. conventionally produced foods). Out of the 28 studies, 16 were of product labels and 12 of menu labelling. Product labels all showed positive outcomes, however, all but one were studied by stated preferences, commonly in choice experiments. Menu labelling showed more mixed outcomes; for studies using revealed preferences half of the interventions showed no effect.

Labels are designed to encourage behaviour change primarily by informing and prompting consumers to make more sustainable choices. They typically convey concise information, such as comparative figures or traffic light designs, that highlight the environmental (or health) consequences of a product. Labels function as both educative and persuasive tools, targeting psychological capability by increasing awareness, and reflective motivation by influencing attitudes and beliefs. They also serve as persuasive cues, especially at the point of decision-making, where they act as immediate visual or written prompts to nudge consumer choices. However, translating label information into action often requires consumers to have prior knowledge and motivation.

Research suggests that the effectiveness of labels in converting information into actionable knowledge can be enhanced through improved design (e.g. [17]). A commonly studied labelling formats is the traffic light design, often applied to illustrate the carbon footprint of foods or meals. Traffic light labels can be seen as a form of feedback on behavioural outcomes, helping consumers quickly identify which food items are less climate-impacting than others. Label designs can also leverage social comparison, particularly when products are positioned as better relative to alternatives [62]. However, evidence on the effectiveness of the use of traffic light labels remains mixed [63–66].

By combining elements of feedback, comparison, and emotional framing, as highlighted above in regard to informational intervention effects, well-designed labels can play a role in shaping behaviour but its effect in isolation is likely to remain limited.

3.2.3. Written and verbal cues

Interventions that use written or verbal cues, such as messages on stickers, in stores, via text messages, or on menus, to remind consumers of sustainable behaviours have been examined in 36 studies within the evidence base. These cues are often placed at the point of decision-making, such as in supermarkets, canteens, or on refrigerators in the context of food waste. Examples include a refrigerator magnet reminding users not to waste food [67], written or verbal prompts to encourage organic food purchases [62], and a milk guide at a dispensing station promoting plant-based alternatives [68]. These interventions aim to address the barrier of forgetting by serving as timely prompts, targeting psychological capability, as well as both reflective and automatic motivation. They can also function in an educative role, such as posters before the serving station in a canteen explaining the environmental impact of certain food choices, or a persuasive one, like stickers on waste bins encouraging food-saving behaviour [69].

An interesting example is provided in the study by Jagau and Vyrastekova [70] who introduced cues prompting guests to reflect on their level of hunger before taking food. This intervention can encourage internal reflection, stimulating reflective motivation and leading guests to make more mindful, waste-conscious choices.

To be effective, cues must be noticeable and self-explanatory [69]. Overall, most studies using written and verbal cues reported positive effects (figure 2, supplementary data E), with 68% of interventions

evaluated based on actual, revealed behaviour. Interventions targeting food waste reduction and shifts toward more sustainable dietary choices, such as purchasing organic products, generally showed positive outcomes [21, 49, 53]. In contrast, a larger proportion of interventions aimed at reducing meat consumption showed no effect. This may be because such cues do not directly influence motivation and are therefore more effective when a baseline level of motivation is already present. Motivation tends to be stronger for reducing food waste or buying sustainably produced food than for eating less meat [61].

3.2.4. Exposure to norm statements

Exposure to social norms and norm appeals draws on the intervention functions of modelling, persuasion, and education to trigger automatic and reflective motivation for the desired behaviour. By providing social support, through groups sharing tips and recipes for instance, it can also serve an enablement function [26], addressing both physical and social opportunity for actors to engage in the desired behaviour. Descriptive norms are used to help individuals compare their own behaviour to that of others, highlighting what is commonly done or approved of (i.e. the 'norm') [69]. In contrast, personal norms appeal to an individual's internal sense of moral obligation, such as the responsibility to act in an environmentally friendly way [27].

The findings from 14 studies examining social norms and norm appeal interventions show mixed results (figure 2, supplementary data E). Most of these studies focused on reducing meat consumption and measured both stated (57%) and revealed behaviour (43%). Among the studies assessing actual behaviour, half reported either no effect or a negative effect. Results from social comparison interventions were similarly inconclusive. For instance, one study found that social norm messages had no impact when real behaviour was measured [71], whereas two other studies, however based on self-reported behaviour, reported positive outcomes [72]. Notably, one study found that dynamic descriptive norms messages highlighting how others' behaviour has changed over time, were more effective in promoting behaviour change than static norms [73]. This may be because dynamic norms are especially persuasive for behaviours that are not yet widely adopted, such as reducing meat consumption [27].

3.2.5. Providing feedback and setting goals

Nine studies investigated interventions involving feedback on past behaviour, goal setting, and progress monitoring. Most of these relied on self-reported outcomes (78%) and all reported positive effects (figure 2, supplementary data E).

Feedback interventions are most effective when linked to goal-setting and supplemented with additional strategies [69]. These interventions typically incorporate educative, persuasive, and enablment elements, allowing them to address all three components of behaviour change: capability, opportunity, and motivation. Their effectiveness depends on the presence of a pre-existing motivation to change, or on delivering feedback in a way that stimulates action, such as through competitions or social comparison.

Several studies have shown that providing individuals with feedback on their performance in reducing food waste can enhance motivation to improve further. For example, two studies that visualised food waste for students, based on observed behaviour, reported positive results [74, 75]. In another study with positive outcome, participants were asked whether they intended to reduce meat consumption in the following week [76]. Those who answered yes were then asked to write down this goal, effectively committing to it. The findings suggest that combining goal-setting with a written commitment or implementation plan can increase the likelihood of engaging in the desired behaviour.

3.2.6. Changing the decision context

Interventions targeting automatic and heuristic decision-making processes by changing the decision context, but without restricting consumer choices, focus on creating both physical and social opportunity to engage in behaviour change by environmental restructuring [26].

In total 58 studies of interventions that change the decision context were found in the evidence base; most found positive effects (87%) and almost 80% of the studies measured outcomes as revealed preference. However, sample size was generally small, and studies often carried out in a specific context (e.g. hospital ward, university canteen), making findings difficult to generalise outside the specific setting. Interventions that alter the decision-making context include increasing the availability of desirable options (e.g. more vegetarian meals [77]), setting sustainable choices as the default [78], or changing how food is served to reduce waste [45]. These changes, such as adjusting menus, food presentation, or portion sizes, often target protein choices, with over half (32 out of 58) aiming to encourage selection of vegetarian, vegan, or more sustainable options [27], consistent with the narrative synthesis on dietary shift, identifying default nudges as having potential to reduce meat consumption.

3.2.7. Restrictions in offerings, and plate and portion size reduction

Studied interventions of restrictions in offerings include limiting meat consumption in schools, such as introducing mandatory vegetarian days [79] or removing meat dishes as an option [80], or eliminating certain types of food to reduce food waste [81]. These interventions aim to reduce both physical and social opportunities to engage in undesired behaviours, thereby encouraging behaviour change. The evidence base for such interventions is limited, comprising only seven studies, often with small sample sizes and being performed in specific contextual settings (figure 2, supplementary data E). Most studies assessed revealed preferences, typically in real-world environments, and nearly all reported positive effects. Restrictive interventions can also involve reducing plate or portion size in restaurants or canteens. All sixteen studies of plate and portion size reductions reported positive results, i.e. reduced meat consumption or food waste.

Restrictions in offerings are likely to be effective as they limit opportunities to engage in undesired behaviour, particularly at key moments like food selection or meal service. However, the evidence base contained some negative effects of this type of intervention. For example, in one case, a mandatory vegetarian day led some individuals to avoid the lunch canteen altogether [82], suggesting that while capability and opportunity may have increased, motivation to change behaviour was lacking. Additionally, unintended consequences remain a concern, as most studies do not assess potential secondary behaviours that may arise as a result of implementing restrictive measures.

3.2.8. Economic coercion and economic incentives

Very few studies on fiscal interventions were identified in the reviews. However, we found three interventions that tested the effects of price reduction or economic incentives [83, 84], and two interventions that, in contrast, functioned coercive and imposed higher costs on individuals for engaging in undesired behaviours [72, 85]. Fiscal measures aim to enhance both automatic and reflective motivation by serving as reinforcements and by strengthening individuals' beliefs about the consequences of their actions [26, 57].

3.2.9. Combined interventions

A total of 19 studies tested combinations of intervention. Examples of combined interventions include: a multicomponent approach targeting five mechanisms: social norms, information, fear appeals, empathy through anthropomorphism, and goal setting [86]; a strategy combining information, communication, product design, processes, and consumer needs [87]; and an intervention involving product hampers, tailored advice, expert webinars, and cook-alongs [88]. Another study combined fiscal tools, taxes, subsidies, and labelling, to influence consumer choices [72]. Overall, 84% of these studies reported positive effects, verifying the findings from the narrative synthesis of reviews where multi-component interventions were identified as the most promising interventions for improving dietary behaviours. However, most findings on combined interventions (84%) relied on stated behaviour measures. Combinations interventions are more likely to effectively address all components of the COM-B model, capability, opportunity, and motivation, especially when applied across different settings and over time, thereby increasing the likelihood of sustained behaviour change.

4. Discussion

Our umbrella review of reviews revealed that interventions targeting education, persuasion and environmental restructuring functions were most commonly studied, which is in accordance with other review of review studies and mapping exercises [12, 89]. Overall, most studies of interventions found positive effects. However, interventions aiming to stimulate a dietary shift, commonly from meat to more plant-based food, showed more mixed results than interventions aiming to reduce food waste or stimulate a dietary shift within food groups towards more sustainable options, such as organic foods (figure 2). This seems to be a consequence of a greater effectiveness of information-based interventions targeting food waste reduction and within food group dietary shifts in translating to knowledge, belief about consequences and attitudes into enhanced capability, and, finally, motivation for behaviour change. In contrast, interventions aimed at reducing meat consumption face greater attitudinal and motivational barriers, limiting their impact [4]. Interventions aiming to change or restrict the decision-making context generally showed positive effects.

For certain types of interventions, such as labels, information provision, coaching, and feedback and goal setting, effectiveness has mostly been evaluated through stated preferences rather than revealed preferences. The well-established attitude–behaviour gap suggests that positive effects observed in self-reported behaviour tend to be overestimated compared to actual behaviour; in other words, consumers often say one thing but do another [90, 91]. Several reviews included in this analysis confirm this pattern. For example, Chang *et al* [18], in their study on strategies to reduce meat consumption in college and university settings, reported substantial discrepancies between observed and self-reported behaviour change. In contrast, other

intervention types, such as changes to the decision context, restrictions in offerings, and written or verbal cues, are more often tested through revealed preferences. Many of these interventions (e.g. [63, 66, 68, 79, 81, 82, 92, 93]) and reviews (e.g. [18, 20, 24, 45, 47, 52]) have been conducted in specific environments such as hospitals or university canteens. Generalising the effectiveness of these interventions across broader populations should be done with caution.

Consumers in different settings vary in their capability, opportunity, and motivation to change food consumption behaviours for environmental reasons. For instance, university students may already possess the knowledge (capability) about the environmental impacts of meat consumption, making them more receptive to interventions like menu labelling that provide the opportunity to act. This may not be the case for other groups, such as primary school children, who may lack the same level of understanding or autonomy [82]. Similarly, interventions involving norm-setting, goal-setting, and feedback can support behaviour change among motivated individuals [94], but motivation is subjective and can vary significantly by context. As several reviews point out [95, 96], context is critical in determining when and how interventions are effective. Therefore, careful consideration of the target population and setting is essential in the design and implementation of governance strategies aimed at shifting food behaviours. The effect of interventions can also materialise over time considering that eating patterns are shaped by automatic and heuristic behaviours which are difficult to change [97]. Hence, effects of interventions that aim to build social norms and feedback structures, shaping automatic decision-making, may not become apparent for years [27], while changing the decision-making context, e.g. using a nudge, may trigger automatic motivation to change a behaviour at the point of decision, but may not have a long-lasting effect [98].

Considering the evidence base as a whole (29 reviews, 289 studies of interventions), there is substantial evidence that governance interventions can be used to decrease the environmental pressures that are associated with food consumption. Some interventions can be considered low-cost and low-risk, i.e. they carry small political risk, are relatively inexpensive to implement, and are presumably more acceptable to consumers (e.g. [12, 99, 100]). These include certain well-designed information and education interventions, written and verbal cues, and changes to the decision context, aiming to influence consumer (psychological) capability, reflective and automatic motivation, and physical and social opportunity to engage in more sustainable food behaviours [26]. Our synthesis clearly show that information alone cannot change behaviour to the extent needed [16, 21, 22]. However, we agree with Jenkins *et al* [16], Di Gennaro *et al* [41] and others that, we still need information-based interventions to change attitudes, raise awareness and increase acceptance of other and multi-component interventions [16, 41, 42]. As is often said, information is necessary but not sufficient.

Another important aspect to consider is the actual change in environmental impacts from implementing interventions. For example, although interventions to reduce food waste generally had positive effects, food waste reductions may be less effective in reducing environmental impacts than dietary change. For example, halving food waste could reduce the climate impact of food by 8%–9% [101, 102], while substituting half of the main animal products by 2050 could reduce land use greenhouse gas emissions by up to 20% [103]. Although synthesis of the review findings revealed that low-cost and low-risk interventions may generate desired results, these interventions will not be sufficient on their own to transform food consumption behaviours to the extent necessary to reach environmental targets [1]. More intrusive and effective interventions are therefore needed, in combination with other types of interventions [6, 12, 99].

Several reviews highlighted methodological limitations in the evidence base. Common issues included small sample sizes, limited contextual relevance, short follow-up periods, and a reliance on self-reported rather than observed behaviour change [19, 23, 52]. Our critical appraisal showed that many of the reviews also lacked methodological transparency, affecting replicability and interpretation. These weaknesses are further discussed in the limitations section (supplementary data A.7). Additionally, the potential for publication bias should be considered, as studies showing positive effects may be more likely to be published than those reporting null or negative results.

Our synthesis of review studies, using a behavioural theory lens, analysed intervention types based on their intervention functions and how they target the different key components that are needed for a behaviour to occur. Such analysis can improve predictions of what will work in a particular setting and, importantly, increase understanding of why a specific intervention may not work in a certain context or why a specific combination of intervention functions is necessary. When designing policy to reduce the environmental impact from food consumption, it is also important to draw on the immense knowledge gained in other fields of research on interventions to change eating behaviour, e.g. interventions to stimulate healthier eating patterns (e.g. [104–106]) or targeting the food environment (e.g. [6, 107]), which were only partly covered in our evidence base.

Shifting food consumption toward more sustainable patterns is an urgent but complex challenge, situated within a broader food system and must also address a range of other issues such as public health, fair

Table 3. Recommendations for policy makers, food system actors and the research community.

Recommendation	Explanation
Recommendations to policy makers and food-system actors	
Promote tailored multi-component interventions	Combine intervention functions, for example, education using information provisioning combined with, for example, training, modelling or persuasion to effectively overcome multiple barriers.
Tailor interventions to specific groups	Use behavioural insights and pre-assessment tools to design culturally relevant and demographically targeted strategies that reflect diverse needs, motivations, and barriers.
Use nudges strategically	Apply low-cost nudges like defaults and reminders, preferably in combination with other interventions.
Strengthen food environment design	Restructure food settings by increasing the visibility and availability of plant-based options, serving meals on plates instead of trays, and reducing portion sizes.
Enhance education and training	Go beyond awareness by providing practical skills, cooking education, and emotional messaging tailored to health and sustainability goals.
Support meat reduction through structural and informational policies	Regulate meat advertising, and consider fiscal policies (e.g. taxes or subsidies) to shift consumption patterns, while supporting producers in transitioning to sustainable alternatives.
Engage key stakeholders across the food system	Collaborate with retailers, food providers, and public institutions to scale up effective interventions, implement sustainable procurement, and improve access to sustainable options.
Recommendations to the research community	
Improve methodological rigour	Use robust, long-term study designs with diverse samples, objective measures, and rigorous evaluation methods to better assess lasting behaviour change.
Focus on real-world and understudied contexts	Conduct more research in real-life settings and across diverse cultural contexts.
Broaden the scope of interventions studied	Explore underused strategies and their combinations, such as gamification, incentives, and habit disrupting strategies.
Design within theoretical frameworks	Ground interventions in strong behaviour change theories and consider underlying social practices and emotional drivers to enhance effectiveness and long-term impact.
Engage in interdisciplinary and cross-sector collaboration	Design studies that integrate multiple outcomes, involve cross-disciplinary collaboration, assess feasibility, policy relevance, and satisfaction, and include both qualitative and quantitative methodologies.

livelihoods for producers, social protections for vulnerable populations, ensuring animal welfare and many more. Coordinated and coherent policy making across multiple domains, including health, agriculture, environment, education, and industry is needed. Within this broader food system landscape, consumer-focused interventions to facilitate more sustainable eating play a vital but complementary role. Policy makers, but also other food system actors such as food industry, food services and retail have a critical role to play in creating environments that make sustainable choices more accessible, attractive, and achievable for all. When well-coordinated, such measures not only improve outcomes but also build public support for more ambitious policy efforts. In table 3, we present key policy recommendations drawn from the 29 included reviews (see supplementary data D.1), supplemented by our own analysis, to support effective and responsible policy development.

5. Conclusions

This umbrella review demonstrates that governance interventions can support meaningful shifts toward more environmentally sustainable food consumption, particularly through reductions in meat intake and food waste. While many interventions show positive effects, their effectiveness varies depending on the behaviour targeted, the intervention type, and the context in which they are implemented.

Information-based and environmental restructuring interventions are the most commonly studied, but often need to be combined with other strategies to generate substantial sustained change in real life situations. Interventions that alter the decision-making context, such as defaults, portion sizes, or food presentation, consistently show promise.

To enhance the effectiveness and legitimacy of food consumption policies, interventions must address all three components needed for a behaviour to take place, capability, opportunity, and motivation, and be designed with sensitivity to the specific contexts and populations they aim to influence. Achieving this requires coordinated action across policy domains, sectors, and actors throughout the food system. While no single solution exists, a combination of well-designed, evidence-informed interventions has the potential to reduce the environmental pressures of food consumption and contribute to broader sustainability and public health.

Data availability statement

The data that supports the findings of this study are openly available in the supplementary data of this article.

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Conflict of interest

The authors declare that they have no known competing interests.

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