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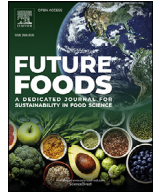
Interventions that influence animal-product consumption: A meta-review

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ABSTRACT

Transitioning toward plant-based diets can alleviate health and sustainability challenges. However, research on interventions that influence animal-product consumption remains fragmented and inaccessible to researchers and practitioners. We conducted an overview of systematic reviews, also known as a meta-review. We searched five databases for reviews that examined interventions that influence (increase or decrease) the consumption of animal products. We quantitatively summarised results using individual studies' directions of effect because reviews rarely reported effect sizes of primary studies. Eighteen reviews met inclusion criteria, 12 of which examined interventions intended to decrease animal-product consumption and 6 of which examined interventions intended to increase animal-product consumption. In total, only two reviews conducted quantitative meta-analyses. Across all reviews, vote counting indicated that providing information on the environmental impact of meat consumption may reduce consumption, with 10 of 11 estimates suggesting reduced consumption (91%, 95% CI [62.3%, 98.4%]; $p = .012$). Providing information on the health consequences, emphasising social norms, and reducing meat portion sizes also appeared promising, albeit with more limited evidence. Reviews examining interventions that decreased consumption predominately focused on meat (10/12 reviews). Future reviews should conduct quantitative syntheses where appropriate and examine interventions that influence the consumption of animal products other than meat.

1. Introduction

There is growing consensus that a transition toward a primarily plant-based diet would benefit public health, food security, the conservation of biodiversity, the climate, and animal welfare (Aiking, 2011; Allen et al., 2019; Clark and Tilman, 2017; IARC, 2015; Kahleova et al., 2018; Lacroix, 2018; Leip et al., 2015; Poore and Nemecek, 2018; Willett et al., 2019). Plant protein intake is associated with reduced mortality and cardiovascular disease risk (Huang et al., 2020), whereas consumption of red and processed meat is associated with increased risk of several major chronic diseases (Rouhani et al., 2014; Wolk, 2017). Environmentally, animal agriculture is estimated to demand 2–25 times more natural resources than plant agriculture, and 20–100 times more

for ruminant animals such as cattle (Clark and Tilman, 2017). Further, it is widely accepted that factory farming causes severe, extensive, and potentially unethical animal suffering (Broom, 2007; Bryant, 2019; Proctor et al., 2013; Wagner et al., 2015), and there is substantial public support for a ban on factory farming in countries such as the USA (Norwood and Murray, 2018; Reese, 2017). The EAT-lancet commission report calls for a "Great Food Transformation" and a paradigm shift in our food systems (Willett et al., 2019). Adoption of planetary health diets that optimise health and environmental sustainability, while reducing suffering, will require interventions that stimulate a range of actions from both individuals and organisations.

Yet, encouraging people to substitute plant-based foods for animal-product foods in their diets is difficult and changing the food habits of millions of people has been identified as a key research area requiring more attention (Béné et al. 2020). Demand for animal products worldwide is increasing (FAO, 2017), a trend that is projected to continue as the world population grows, affluence increases (Aiking, 2011), and more countries (especially those with large populations such as China and India) adopt a Western-style diet (FAO, 2017; Slingo et al., 2005). Diets can also be difficult to change because driving forces—such as taste preferences, social context, familiarity, habit, and cultural tradition—are complex, interacting, and sometimes immutable (Sanchez-Sabate and Sabaté, 2019; Valli et al., 2019). For example, reasons for low willingness to reduce meat consumption include a lack of cooking skills, lack of information, enjoyment of dishes rich in animal products, and the belief that meat is essential to a healthy diet (Graça et al., 2019; Valli et al., 2019).

There is increasing research on how to reduce animal-product consumption. Literature has identified several personal, socio-cultural, and environmental factors that influence the consumption of animal products and there is a growing focus on interventions—actions taken by individuals, businesses, or governments—which incorporate these factors (e.g., Bianchi et al., 2018b; Graça et al., 2019; Harguess et al., 2020; Taufik et al., 2019). Existing reviews draw on disciplines such as environmental sustainability (e.g., Wynes et al., 2018) and health promotion (e.g., Valli et al., 2019). Compared with primary studies, systematic reviews often provide stronger indications of what interventions work and when they work (Higgins et al., 2019), and offer insights into the reproducibility of key findings (Stanley et al., 2018). However, reviews typically have a narrow focus, such as interventions addressing consumption of only one type of animal product (e.g., meat but not eggs, or vice versa) or consumption in only one context (e.g., supermarkets; Hartmann-Boyce et al., 2018). In cases like these, where multiple systematic reviews are available regarding a range of interventions affecting the same outcome, collating and comparing those reviews allows for researchers, practitioners, and policymakers to identify and act upon the most robust evidence (Becker and Oxman, 2011).

To provide a parsimonious and accessible synthesis of the available evidence in a single source, we conduct a systematic review of systematic reviews (hereafter 'meta-review') of interventions that influence (increase or decrease) intended or actual consumption of animal products (a.k.a. an "umbrella review" or "overview of reviews"; Becker and Oxman, 2011; Grant and Booth, 2009; Higgins et al., 2019; Khangura et al., 2012; World Health Organisation, 2017). Meta-reviews are particularly effective for making review-level evidence useful and accessible for researchers, practitioners, and policymakers (Khangura et al., 2012; World Health Organisation, 2017). The approach enables evidence to be summarised across a broader range of research fields and perspectives than would be practical for a systematic review focused on primary studies (Becker and Oxman, 2011). We include factors found to increase animal-product consumption (e.g., subsidising chicken farmers) because of the potential that the same mechanism could be targeted to decrease consumption (e.g., removing subsidies).

2. Methods

2.1. Protocol and registration

Our methods were based on best-practice guidelines for conducting meta-reviews (Johnson & Hennessy, 2019; Hennessy et al., 2019). The protocol was registered in advance using the Open Science Framework (bit.ly/OSF-meta-review).

2.2. Eligibility criteria

The inclusion and exclusion criteria are presented in Table 1.

2.3. Search strategy

To broaden the reach and utility of the review, our expert advisory board of health and animal welfare researchers (DR, MW, ST, MM, KZ, AH, CB, DM, PP, DW, JP) and practitioners (JH) assessed the proposed search terms, inclusion and exclusion criteria, and database sources. Our search strategy comprised two stages; in stage 1 we searched both peer reviewed and grey literature to identify relevant articles. Stage 2 involved forwards and backwards searching to identify any additional eligible articles. The two stages are described below.

2.3.1. Database and grey literature searching

A search strategy was developed in collaboration with an academic reference librarian. Five databases—Medline, Scopus, PsycINFO (Ovid), Web of Science, and Proquest Dissertations and Theses—were searched on 21 February, 2020 for peer-reviewed articles published from 1990, due to very few systematic reviews being conducted before then (Smith et al., 2011). Terms used for identifying the type of study were informed by a comprehensive typology of review methods (Grant and Booth, 2009) and included: meta-anal*, "systematic review", meta-regress*, "rapid review", "scoping review", "state-of-the-art review", and "mapping review". Terms used to indicate interventions included: influenc*, nudg*, "behavio*r change", educat*, encourag*, and interven*. Terms targeting animal-product consumption as outcomes included: "animal product*", animal-based, vegan*, vegetarian*, meat, and plant-based. An example search string is provided in our pre-registered protocol (bit.ly/OSF-meta-review). No terms, subject areas, or languages were excluded. Only papers which were found electronically were included, given that this approach expedites the review without influencing conclusions (Ganann et al., 2010). No papers were excluded based on this requirement, as all reviews found were available electronically.

To avoid missing relevant research, and to help mitigate publication bias, we searched the grey literature for eligible reviews using the process outlined by Stansfield and colleagues (2016). This involved using the team's knowledge of relevant resources to generate a list of websites to search (e.g., Food Climate Research Network and Animal Charity Evaluators) and recording details such as the date searched, the pathways followed, any search terms used, and relevant records found. These details were recorded in two spreadsheets (a summary of the search; Supplementary file 1, and the data extraction; Supplementary file 2) by the 11 authors involved in this process (AD, AR, AS, EG, HA, JL, KW, NF, PS, SC, TH).

2.3.2. Forward and backward citation searching

Following the completion of searches and full-text screening, forwards and backwards searching was undertaken using Scopus (Hinde and Spackman, 2015). Backwards searching involved reviewing all citations of articles included in Stage 1. The forwards search involved searching for all articles that cited an included article. These articles were then screened following the process outlined below. Following completion of all full-text screening, included articles were circulated to the expert advisory board to solicit any relevant omissions.

Table 1

Inclusion and exclusion criteria.

	Inclusion criteria	Exclusion criteria
Types of reviews	• Systematic reviews published in academic journals or grey literature (with or without quantitative meta-analyses) • Similar reviews including reproducible search and filtering strategies (Grant & Booth, 2009)	• Non-systematic reviews or meta-analyses; primary research papers; theory papers; narrative reviews
Types of participants	• Any population of participants	
Types of interventions	• Reviews assessing interventions intended to influence (increase or decrease) consumption or purchase of animal products • Reviews including non-interventional studies (e.g., observational research) or irrelevant intervention studies (e.g., examining another food group) were eligible if they also included relevant interventional studies	• No exclusion criteria regarding source of intervention (e.g., restaurants), method of persuasion (e.g., flyers), or communication channel (e.g., face-to-face) • Reviews solely exploring factors associated with consumption (e.g., personality) were excluded
Types of outcome measures	• Reviews measuring intentions or behaviours regarding animal-product consumption. Measurements of intentions included (but not limited to) purchasing behaviour; choosing animal products vs. non-animal products in discrete choice experiments; actual or intended consumption • Reviews could concern dietary products from any animal(s)	• Excluded outcomes regarding non-dietary use of animal products (e.g., leather) and reviews of plant-based alternatives (e.g., meat substitutes, tofu, soy milk) that did not measure consumption of animal products • Given our focus on immediate drivers of behaviour, we excluded reviews which focused solely on knowledge of or affective responses to animal products without assessing consumption • Willingness to pay for animal products was originally included in the protocol as an acceptable proxy for intended consumption but was excluded following advice from our advisory board around difficulty of interpretation

2.3.3. Screening and selection of reviews

Fifteen reviewers were involved in screening (NF, RG, KW, PS, AS, AD, JL, AM, HA, AR, SC, TH, EG, LF, MZ). Titles and abstracts of records were independently screened by two reviewers against the inclusion and exclusion criteria. An article progressed to full-text screening if either or both reviewers voted to include it. During full-text screening, two reviewers independently evaluated inclusion criteria in detail. Disagreements at the full-text screening stage resulted in the decision being made by a senior member of the team, not involved in the initial decision (EG, MZ, AS, or PS).

2.4. Data extraction, synthesis, and quality appraisal

Fifteen reviewers were involved in data extraction (NF, SC, EG, KW, HA, RG, AM, AD, TH, AR, LF, JL, MZ, PS, AS). A data extraction spreadsheet was developed to capture the following information: review question(s); methods; number of studies and participants; key findings; effect size estimates; key conclusions, and limitations. This spreadsheet was refined after pilot-testing and extractor calibration on three randomly selected articles. Data extraction was conducted in duplicate, with one author (EG) resolving inconsistencies in extraction. A context mapping spreadsheet was also developed to categorise contextual variations in the interventions identified by reviews (Slattery et al., 2020). This captured i) the source(s) of the intervention(s) that reviews examined, ii) the method(s) of intervention(s), iii) the channel(s) transmitting the intervention(s), iv) the receiver(s) of the intervention(s), v) the outcomes(s) of the intervention(s) and vi) the data collection techniques used. Further detail on context mapping is provided in Supplementary file 3.

We planned to convert effect sizes from reviews to a common metric and conduct meta-meta-analyses, however we needed to deviate from our protocol because so few reviews reported effect sizes of primary studies. Instead, we undertook vote counting based on direction of effect—an acceptable statistical synthesis method for when meta-analysis of effect estimates is not possible and consistent effect measures or data are not reported across studies (McKenzie and Brennan, 2020). We performed vote counting by assessing, for each review, the percentage of individual study estimates whose signs suggested reduced rather than increased consumption in the intervention group, regardless of the effect sizes or statistical significance. Statistical significance was

not considered because underpowered studies in vote counting can produce misleading conclusions (McKenzie and Brennan, 2020). As recommended, confidence intervals for these percentages of estimates suggesting reduced consumption were calculated using Wilson interval methods (Brown et al., 2001), and we tested the null hypothesis that only 50% of estimates suggested reduced consumption using a two-tailed binomial test (McKenzie and Brennan, 2020). Vote counting based on direction of effect was not implemented to replace a meta-analysis as it neglects factors like sample size and effect size (Borenstein et al., 2009). Considering this paper's focus on interventions that are intended to reduce animal-product consumption, vote counting was not undertaken with interventions intended to increase consumption. Instead, we provided a qualitative synthesis of those results.

Quality assessment of all included articles was conducted in duplicate by two trained authors (KW, TH) using the Assessing the Methodological Quality of Systematic Reviews checklist 2 (AMSTAR 2; Shea et al. 2017). Systematic reviews vary widely in quality, so it is important to critically evaluate the methods and reporting, and their potential impact on the findings (Shea et al., 2017). For assessing the quality of reviews, comparative studies have shown AMSTAR 2 to be more reliable and equally valid compared with other tools (Lorenz et al., 2019). These assessments, in addition to all data and materials, are available on the Open Science Framework for transparency (bit.ly/OSF-meta-review).

3. Results

3.1. Results of search process

Fig. 1 is a PRISMA diagram illustrating the search results. After removing duplicates, we screened 11,989 articles in total: 11,666 articles from academic databases, 36 from the grey literature search, 283 from forwards and backwards searching, and 4 from the expert advisory board. Of these articles, we assessed the full text of 72. A total of 18 articles met the eligibility criteria and all were included.

3.2. Characteristics of included reviews

Table 2 provides a summary of included reviews. The 18 reviews synthesised the literature on interventions influencing animal product consumption in various ways. Five posed a research question regarding

Table 2

Summary of included reviews; review questions, method, key results, and author conclusions

Review	Review Question	Review Scope Summary	K	N	Summary of Results	Author Conclusions	Animal Products Focus	AMSTAR 2 total score
Bianchi and colleagues (2018a)	Which interventions targeting conscious determinants of human behaviour are effective at reducing meat demand?	• Included: studies of interventions targeting conscious determinants of human behaviour; objective or self-reported demand for meat • Excluded: studies requiring specific meat consumption; general dietary interventions • Search: 6 databases; 7 search strings	29	25,477	• Reduced meat consumption: self-monitoring interventions, individual lifestyle counselling • Reduced intended meat consumption in virtual settings, but no evidence for actual behaviour: providing information on environmental, health, socio-political, animal welfare consequences • Not effective: interventions implicitly highlighting animal suffering; tailored education (limited research) • Mixed results: information on multiple consequences of eating meat	Impact of interventions targeting conscious determinants of human behaviour was modest. Effective interventions included: self-monitoring of meat consumption; lifestyle counselling; information about health, environment, animal welfare consequences of meat consumption.	All included studies evaluated interventions that influence meat consumption	7
Bianchi and colleagues (2018b)	Are interventions that restructure physical micro-environments effective at reducing the demand for meat?	• Included: studies of interventions restructuring physical micro-environments meat demand • Excluded: general dietary interventions; interventions not featuring environmental restructuring; non-experimental studies • Search: 6 databases	18	11,290	• Reduced actual / intended meat consumption: reducing meat serving portion sizes; providing meat alternatives along with supporting educational material; changing the sensory properties of meat / meat alternatives • May reduce consumption: repositioning meat products to reduce prominence at point-of-purchase • Limited evidence: manipulating description of meat / meat alternatives; pricing interventions.	Physical micro-environment interventions could reduce meat consumption (e.g., reducing meat serving portion sizes, providing meat alternatives, changing the sensory properties of meat/meat alternatives). No evidence for other interventions (e.g., manipulating the verbal description of meat/meat alternatives).	All included studies evaluated interventions that influence meat consumption	7
Byerly and colleagues (2018)	Which interventions successfully alter human behaviour in six domains where decisions have major environmental impacts?	• Included: experiments focused on pro-environmental behavior changes that reported statistical inferences. • Search: 3 databases; 18 terms (relevant to this review)	72	NR	• Small number of included studies targeting meat consumption • Mixed evidence: education interventions • Reduced consumption: changing the default cafeteria menu to be vegetarian; commitments to reduce consumption	Promising evidence that using commitments (writing down intentions to reduce meat consumption) and defaults (having default vegetarian menus) can reduce meat consumption. Evidence for education is mixed.	4/72 studies targeted meat consumption. The remainder related to water use, transportational choices, family planning, waste production, and land management.	1.5
Graça and colleagues (2019)	What variables are associated with meat curtailment, meat substitution and adherence to plant-based diets?	• Included: English-language, peer-reviewed primary research articles that reported facilitators / barriers of plant-based diets • Excluded: studies not focused on food practices, consumer choice, or behaviour; studies focused only on physiological / clinical aspects; entomophagy studies. • Search: 11 databases; 19 terms.	110	NR	• Reduced actual / intended meat consumption: dynamic norms; implementing changes in collective meal contexts; emphasising environmental impact and animal-origins of meat; positive representations of plant-based diets; reminders to reduce meat consumption; health, environmental, and autonomy-supportive frames • Barrier to reducing consumption: believing meat consumption is healthy and necessary	There is evidence on how to successfully manipulate variables affecting motivational processes in following more plant-based diets. Findings experimentally reinforce that consumer perceptions and reactions towards animals used for meat production are important.	19/110 of included quantitative studies were experiments or RCTs.	1.5

Table 2 (*continued*)

Review	Review Question	Review Scope Summary	K	N	Summary of Results	Author Conclusions	Animal Products Focus	AMSTAR 2 total score
Harguess and colleagues (2020)	What factors are associated with reduced meat consumption; what experiments have reduced meat consumption?	• Included: English-language studies measuring variables related to meat consumption; experimental or quasi-experimental designs • Search: 4 databases; 34 terms.	22	9420	• Reduced actual / intended meat consumption: providing information on environmental, health, animal welfare consequences; visual depiction with emotionally provocative messaging • Not effective: adjusting framing for recipient values	Factors that influence meat consumption include values, knowledge, emotions, perceived behavioral control, social norms, and the food environment. Emotionally provocative health-information strategies may be effective in reducing meat consumption. Several factors that have been identified in correlational studies have not been tested experimentally	All included studies evaluated interventions that influence meat consumption	3
Hartmann and Siegrist (2017)	Are consumers aware that meat consumption has a large environmental impact? Are they willing to reduce meat consumption or substitute meat?	• Included: English-language studies on reducing meat consumption. • Excluded: studies not related to consumer behaviour; not reporting on primary quantitative results; wild-animal focus, physiological focus • Search: 1 database; 11 terms	38	NR	• Only two experimental studies were found. • Reduced meat consumption: providing meat-free options; providing information about environmental consequences (small effects)	There is a lack of experimental studies and further investigations should focus on strategies (e.g., nudging interventions) that could motivate environmentally friendly consumption behaviour	2/38 included studies assessed interventions and were relevant	5
Hartmann-Boyce and colleagues (2018)	How effective are grocery store interventions at changing food purchasing behaviour?	• Included: RCTs of interventions designed to change food purchasing behaviour; implemented in real/simulated grocery stores; compared interventions or had a control; reported purchasing at the individual / store level • Search: 13 databases; 150 terms	35	20,156	• Reduced high-fat meat and dairy purchases; custom computer program suggesting healthy alternatives • No impact on cottage cheese sales: signage; recipes; brochures • No impact on canned seafood sales: Product reorganisation and shelf rearrangement • Increased milk sales: climate-related store signage • Increased skim milk and chicken nugget sales: changing food placement; signage; taste testings	Conclusions regarding animal products are not provided. Authors note that interventions in grocery stores that manipulate price, provide suggestions for alternatives, and perhaps impact item availability, appear to have the greatest effect on altering purchase behaviour.	5/34 studies examined animal products	5
Hendrie and colleagues (2013)	What are the characteristics of effective interventions that increase dairy and calcium consumption in primary-school aged children?	• Included: English-language studies; last 20 years; interventions aimed to increase Ca / dairy intake in children / parents; measured Ca / dairy intake • Excluded: studies targeting specific subgroups; topics including Ca supplementation, pregnancy, and food science research • Search: 6 databases; 130 terms	14		• Most effective techniques: taste exposure; prompting practice of the behaviour • Majority of interventions were effective • Effective interventions: higher in intensity; number of behaviour change techniques was not important • Most prevalent technique: general nutrition education	Providing nutrition education is common, but not clearly effective. Higher intensity interventions targeting Ca / dairy consumption were more effective, with taste exposure and prompting practice being important to incorporate	All included studies evaluated interventions that influence (increase) dairy consumption	4.5

Table 2 (*continued*)

Review	Review Question	Review Scope Summary	K	N	Summary of Results	Author Conclusions	Animal Products Focus	AMSTAR 2 total score
Jung and colleagues (2016)	What interventions can increase the calcium intake of pregnant, lactating, or postpartum women?	• Included: English-language studies; interventions targeting Ca / dairy intake of pregnant, postpartum, or lactating women • Excluded: studies focused on Ca supplementation • Search: 5 databases; backwards searching	5	NR	• Increased dairy consumption: reviewing behavioural goals. • Not effective: encouraging overall health nutrition; nutrition education • Not important: number of behavioural techniques used	Education does not appear to be effective for increasing Ca / dairy intake but goal-setting may be.	4/5 included studies appear to be relevant, as they target dairy consumption rather than calcium intake more broadly.	3
Marquez and colleagues (2015)	What are the characteristics of effective interventions that increase dairy and calcium consumption in adolescents?	• Included: English-language studies; interventions designed to modify Ca / dairy intake in adolescents; reported at individual / group level • Search: 8 databases; backwards searching; grey literature	17	NR	• Increased dairy consumption: higher in intensity; longer in duration; general encouragement, instruction, self-monitoring behaviour, feedback; social comparison, stress management, motivational interviewing supplements, prescribed diet. • Not strong predictor: number of behaviour change techniques; highly personalised contact; parental support (limited evidence)	Effective interventions were higher in intensity and longer in duration. Several behavioural change techniques can increase dairy consumption, but the number is not important. Targeting subjects at a group level (e.g., in school) is sufficient for modifying dairy intake - individual contact with adolescents is not necessary.	All included studies evaluated interventions that influence (increase) dairy consumption	5.5
Nisa and colleagues (2019)	Which interventions are effective in promoting climate change mitigation by individuals and households?	• Included: randomised field controlled trials; interventions on climate change mitigation behaviours (related to energy consumption, animal-product consumptions, water use, transportation, food waste, or recycling). • Excluded: quasi-experimental or pre-posttest studies without a control group; papers with insufficient statistics; papers that did not link group-level changes to individual-level behaviour change. • Search: 4 databases; 80 terms; grey literature	83	3,092,763	• Few studies relevant to our review; relevant studies used nudges and social comparison • Average magnitude of relevant effect sizes is larger compared to interventions targeting water, transportation, or energy • A randomly selected individual from the experimental group has a 16.9% higher probability of reducing meat consumption than an individual selected from the control group • Behaviour interventions overall have a very small effect on climate change mitigation ($d = -0.093$).	No specific conclusion was provided relating to animal product consumption. Authors note that when considering all interventions, not just those concerning animal products, nudges and social comparison had the highest behavioural plasticity potential. There is no evidence that interventions produce lasting changes with regards to climate change mitigation.	7/84 studies examined meat consumption, and the remainder targeted energy consumption, transportation, food waste, water consumption, and recycling.	9
Rouf and colleagues (2018)	What is the efficacy of interventions promoting calcium or dairy consumption among young adults?	• Inclusion: English-language studies; interventions promoting Ca / dairy intake; experimental, quasi-experimental, before/after study design; adults • Search: 8 databases; 57 terms	16	2434	• Most common interventions: face-to face; education • Not important: higher intensity interventions • Effect of successful interventions was small	There is some evidence that interventions can significantly increase dairy or calcium intake but the effect size is small.	8/16 included studies provided results on dairy intake.	6.5

(*continued on next page*)

Table 2 (*continued*)

Review	Review Question	Review Scope Summary	K	N	Summary of Results	Author Conclusions	Animal Products Focus	AMSTAR 2 total score
Sanchez-Sabate and Sabaté (2019)	(1) Are people aware of the environmental impact of meat production and consumption? (2) Are people willing to stop or reduce meat consumption based on environmental concerns? (3) Have ecological/environmental concerns been the motivation for people who have altered their meat consumption?	• Included: focus on consumer awareness of the environmental impact of meat consumption; consumer willingness to reduce meat consumption because of environmental impact; consumer environmental reasons to have reduced meat consumption • Search: 1 database	34	NR	• Reduce intended meat consumption: providing information on environmental consequences of meat consumption; environmental messages appealing to emotions/values reduced intentions to eat meat • Most papers reviewed present environmental problems in a rational and detached manner.	Providing consumers with information about environmental consequences may reduce consumption. However, there is significant disparity in findings regarding this.	Reports mainly on surveys rather than interventions. It is unclear which findings are from intervention studies.	2.5
Srbely and colleagues (2019)	What are the characteristics of effective interventions that increase dairy and calcium consumption in preschool aged children?	• Included: English-language; last 20 years; interventions increasing Ca / dairy intake in children (1.5-5 yrs) / parents; measured Ca / dairy intake at individual / group level • Excluded: clinical populations; changing the type of dairy consumption; allergies; Ca supplementation; breast-feeding • Search: 6 databases; backwards searching; grey literature	14	10383	• More likely to increase dairy consumption: environmental restructuring (62.5% efficacy); prompts/cues (57.1%); delivering interventions in one setting/environment • Not important: behaviour change technique	Most interventions were ineffective. Delivering interventions in one setting (preschool), using environmental restructuring and prompts/cues, and targeting both parent and child appear to be associated with overall intervention effectiveness. Factors not associated with effective interventions included intervention duration, frequency of contact, and level of personalisation.	13/14 included studies targeted dairy intake and one study targeted calcium intake	6.5
Taufik and colleagues (2019)	Which factors are best to target in order to increase plant-based and/or reduce animal-based food consumption?	• Included: English-language studies; tested single-component interventions; real-life settings; measured actual change in plant-based / animal-product consumption • Excluded: children; non-human targets; biomedical topics. • Search: 2 databases; > 100 terms	51	NR	• Effective techniques: instructing participants to substitute sweetened beverages for water; doubling vegetable servings while reducing meat portion sizes in restaurants; text message reminders to reduce red meat consumption; smaller meat portion sizes in stores, dynamic norms • Not effective: traffic light label system; financial incentives, implementation intentions	Targeting individual or environmental determinants appear to be most effective at promoting more plant-based and less animal-based food consumption. Relatively few real-life intervention studies have been conducted that focus on a decrease in animal-based food consumption.	8/51 studies examined how interventions could reduce the consumption of animal products. The remaining studies examined how plant-based food consumption could be increased.	6.5
Valli and colleagues (2019)	How do people's health-related values and preferences affect meat consumption?	• Included: quantitative, qualitative, mixed methods; adults; Europe, Australia, Canada, the United States, and New Zealand; health-related values / preferences on meat consumption • Excluded: focus on meat alternatives, quality, safety, industry consumer trends, and specific populations • Search: 6 databases	54	72,981	• Unclear which studies tested intervention • Studies suggested health concerns don't prompt participants to reduce meat consumption • Not effective: providing information on health risks (participants mistrusted information provided)	Low-certainty evidence highlights that omnivores are attached to meat consumption and being faced with potentially undesirable health effects does not affect willingness to change this behaviour, especially if the evidence is uncertain.	9/54 studies addressed willingness to reduce meat consumption. The remainder focused on reasons for meat consumption.	9

Table 2 (*continued*)

Review	Review Question	Review Scope Summary	K	N	Summary of Results	Author Conclusions	Animal Products Focus	AMSTAR 2 total score
Veul (2018)	Which interventions can reduce the consumption of meat in OECD countries, and why are they successful? What interventions would be effective at reducing meat consumption in the Netherlands?	• Included: OECD countries; last 10 years; reference to meat (or synonyms) in title, and food intake / intervention (or synonyms) in title / abstract • Excluded: food safety; animal treatment; efficiency of meat production; health effects • Search: 2 databases; 65 terms; forwards, backwards searching; grey literature	43	NR	• Common intervention components: choice architecture; point-of-purchase actions; campaigns; financial • Less common: raising awareness; governmental actions • Differences in intervention effectiveness are related to socio-demographic and cultural differences. • Effective strategies: health-issue framing; presenting 'meat skeptics' with health and environmental information; Whatsapp reminders to reduce red meat consumption; mental contrasting with implementation intentions; default plant-based menus; reducing meat portion sizes • Mixed results: price interventions; confronting people with cognitive dissonance • Not effective: labelling (e.g., environmental impact; can be confusing)	Effective interventions include health-benefits framing and targeting practice (e.g., changing portion sizes) and self-efficacy / attitude determinants (e.g., implementation intentions). Financial measures show limited impact and low public acceptability. Intervention effectiveness differs between socio-demographic and cultural groups, and gender.		1.5
Wynes and colleagues (2018)	What emissions reductions are reported from a variety of behavioural interventions across high-emitting domains (i.e., personal vehicles, diet, household energy use, and air travel)?	• Included: English-language; after 1990; interventions focused on pro-environmental behaviours or positive health outcomes relating to personal vehicles, diet, household energy use, air travel; sufficient information for emissions calculations • Excluded: very young / sick participants; food waste • Search: 1 database; 21 terms (relevant to this review)	40	886576	• Most effective: including 'nudges' in cafeterias / restaurants • Some effect: 'carbon-labelling' on meat products; text message reminders to reduce red meat consumption; providing information when goal setting • No effect: providing education and instructions by itself • Backfire effect: providing all information to individuals as opposed to tailored information	Effectiveness of interventions ranged from having a backfiring effect to substantially decreasing consumption. The most effective intervention was nudging. Eco-labels on products can provide an opportunity to reach consumers outside of schools, workplaces and restaurants, and can prompt them to make more sustainable choices.	6/40 included studies examined diet. Focus was on interventions that reduced carbon emissions, but this implied interventions that reduced meat consumption.	1.5

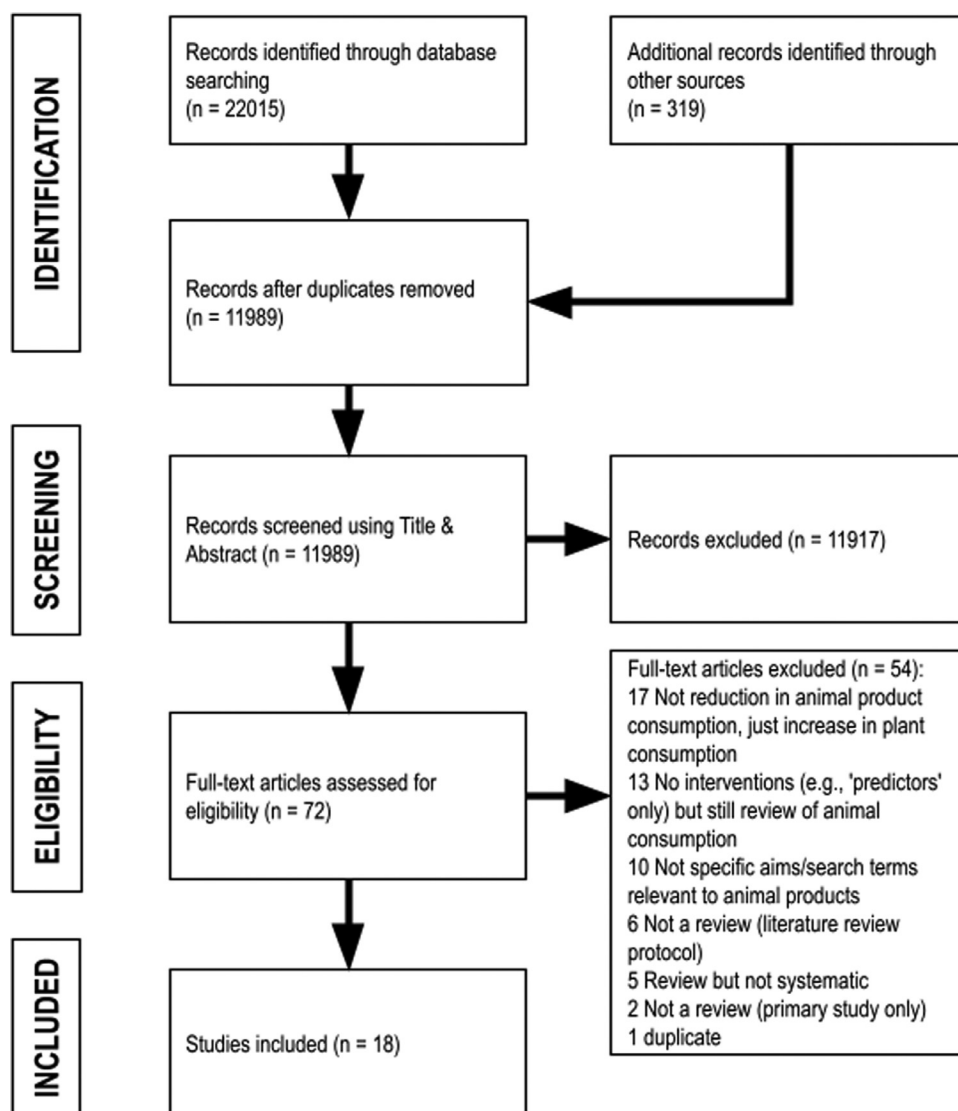*Note. K* = Total number of studies included in the review. *N* = Total number of participants included in the review.

specific types of interventions or contexts (e.g., the effect of interventions in grocery stores). The remaining 13 conducted a broad search for any interventions relating to one or more specific animal product(s). Ten reviews examined interventions targeting meat consumption, five focused on dairy, and three focused on animal products in general. In total, only two reviews conducted meta-analyses and pooled estimates of effect sizes (Nisa et al., 2019; Rouf et al., 2018). The remaining 16 reviews used qualitative methods of synthesis, and rarely reported the effect sizes of their included primary studies. Of the 18 reviews, 12 examined interventions intended to decrease animal-product consumption, and six examined interventions intended to increase animal-product consumption. Where available, all pooled effect sizes reported by each review are described in Table 2. The contexts covered by the included reviews are summarised in Supplementary file 3.

3.3. Quality assessment

We assessed the quality of included reviews using the criteria set out by AMSTAR 2 (see Supplementary file 4). While these are stringent, gold-standard processes for conducting a comprehensive and reliable systematic review, not all criteria have been shown to decrease bias in conclusions. For example, in many cases, large meta-analyses may to some extent mitigate publication bias without explicitly correcting for it

(Mathur and VanderWeele, 2020b). Nevertheless, all are 'good practice' and conclusions should be drawn in light of the quality of the reviews. Fewer than half of the reviews (7/18) conceptualised their search in terms of the specific participants, interventions, comparisons, and outcomes they sought to identify. Only one provided an adequately detailed prospective registration with justification for modifications (Valli et al., 2019). In most reviews (13/18), there was no rationale for the type of studies eligible for inclusion (e.g., randomised trials only, randomised and non-randomised trials, all designs). The AMSTAR2 criteria for a 'comprehensive search' are stringent but most reviews (10/18) failed to meet even the 'partial' criteria (i.e., > 2 databases, keywords provided, restrictions justified). More than half conducted study selection (11/18) and data extraction (11/18) in duplicate. Only one listed the excluded studies with reasons (Valli et al., 2019). Most described included studies in either full detail (6/18) or some detail (6/18), but well-described meta-analyses were rare (2/18; Nisa et al., 2019; Rouf et al., 2018). Nevertheless, many reviews attempted to explain systematic patterns that may have explained heterogeneity in study findings (8/18). Most reviews failed to assess risk of bias (11/18) and most did not use risk judgements in assessing the conclusions drawn from their included studies (14/18). More information on reviews' assessments of the quality of their included studies and their study designs is included in our extraction table in Supplementary file 4. Only one assessed whether risk of bias

influenced pooled effect size estimates (Nisa et al., 2019). Most reviews declared any conflicts of interest and had strategies for mitigating biases (12/18), but we did not find any that reported on funding of included studies.

In general, higher quality reviews (AMSTAR score ≥ 5) did not appear to differ from lower quality reviews (AMSTAR score < 5) in their focus. One exception was that three of the higher quality reviews focused on dairy and calcium consumption in young adults compared to only one in the lower quality reviews.

3.4. Vote counting based on direction of effect

Table 3 summarises the vote counting results from the relevant studies within the 12 reviews that assessed interventions intended to decrease animal-product consumption and the implications of those findings. Relevant data from studies that were extracted from the reviews is available in Supplementary file 5. Two types of interventions appeared particularly promising, in that (i) a high proportion of estimates suggested reduced consumption; and (ii) there was a moderately large number of relevant studies (at least 10). First, regarding interventions that provided information on the environmental impact of eating meat, 10 of 11 studies (91%, 95% CI [62.3%, 98.4%]; $p = .012$) had estimates suggesting reduced consumption. Second, regarding interventions that provided information on the health consequences of meat consumption, 8 of 10 studies (80%, 95% CI [49%, 94.3%]; $p = .11$) had estimates suggesting reduced consumption. Emphasising social norms was also among the more reliable interventions (4/4 estimates suggesting reducing consumption, 100%, 95% CI [51%, 100%]; $p = .125$), as was reducing meat portion sizes (4/4; 100%, 95% CI [51%, 100%]; $p = .125$). Reviews only cited one unique study for several interventions, including images of cows before slaughter, emphasising the social consequences of eating meat, informing consumers that the consumption of meat is associated with social dominance, and providing default plant-based meals.

3.5. Qualitative synthesis of interventions intended to increase animal-product consumption

Six reviews discussed the evidence for interventions intended to increase animal-product consumption or related intentions. All six reviews focused on dairy consumption. Providing dairy products or tastings was a reliable intervention for increasing consumption (Hartmann-Boyce et al., 2018). Although the most prevalent behaviour change technique regarding dairy consumption was general nutrition education, this did not reliably increase consumption (Hendrie et al., 2013; Jung et al., 2016; Rouf et al., 2018). One of the two meta-analyses identified in our search found that educational interventions increased dairy consumption ($d = .31$, 95% CI [.11, .50], $k = 4$), but the high risk of bias in included studies led reviewers to have low confidence in this estimate (Rouf et al., 2018). There is mixed evidence for changes to food placement or signage (Hartmann-Boyce et al., 2018), providing recipes and brochures (Hartmann-Boyce et al., 2018), and whether increasing dairy or calcium consumption alone is more effective than targeting general health behaviour (Hendrie et al., 2013; Jung et al., 2016; Marquez et al., 2015).

4. Discussion

This paper is, to our knowledge, the first meta-review to synthesise this research area and provide an accessible synthesis of interventions that reduce animal-product consumption. To simplify the breakdown of these results, we will use sections suggested by the Individual, Social, Material (ISM) Tool (Darnton and Horne, 2013). We describe how animal-product consumption can be addressed in three contexts: the individual (factors held by an individual affecting the choices they make), the social (factors relating to social groups), and the material (factors relating to the wider environment). Following this breakdown, we discuss

what we can learn from interventions that increase animal-product consumption, limitations of included reviews, and limitations of our meta-review.

4.1. The individual context

The individual context includes an individual's skills, knowledge, values, attitudes, and evaluations (Darnton and Horne, 2013). Interventions targeting the individual included providing information about the consequences of animal-product consumption, assisting with goal setting and implementation intentions, personalised messaging, individual lifestyle counselling, and emphasising animal welfare.

4.1.1. Providing information on consumption consequences is a promising intervention

Interventions that provide information typically involve presenting the environmental, health, and animal welfare arguments for reducing animal-product consumption, or a combination of these.

Emphasising environmental consequences. Interventions that provided information about the negative environmental consequences of meat consumption had estimates that consistently suggested reduced meat consumption. This aligns with retrospective research suggesting that 4-19% of consumers who report reducing intake were motivated by environmental concerns (Sanchez-Sabate and Sabaté, 2019). This tactic also appears to target a gap in education—consumers tend to be unaware of the environmental impact of the production of meat (Hartmann and Siegrist, 2017; Sanchez-Sabate and Sabaté, 2019). Individuals consider meat reduction to be one of the least effective methods for alleviating climate change when compared to other options (such as driving cars less), despite shifting to a plant-based diet being one of the highest impact actions that can be taken by an individual to reduce emissions (de Boer et al., 2013; Wellesley et al., 2015; Wynes et al., 2018).

When presenting information on the environmental consequences of animal-product consumption, several factors should be considered. First, this intervention may be especially effective when considering particular populations such as university students (Sanchez-Sabate and Sabaté, 2019). Second, the intervention effect may be moderated by prior belief—environmental messages may change meat consumption amongst individuals who already hold negative attitudes towards meat consumption, but not among those who believe it is healthy and climate friendly (Vainio et al., 2018). Third, framing environmental messages so they appeal to emotions and values can be especially effective (Sanchez-Sabate and Sabaté, 2019). Environmental appeals are often presented in a detached and unemotional manner (Sanchez-Sabate and Sabaté, 2019). Framing animal-product consumption as an environmental issue can be "a bridge too far" (p. 28) for consumers if no direct personal relevance is emphasised (de Boer et al., 2013), especially considering that negative consequences are often long-term (Aschemann-Witzel, 2015), complicated, vague, and lacking urgency (de Boer et al., 2013; Wellesley et al., 2015). Further research is needed to ascertain how this argument can be emotively assimilated in an informational intervention (de Boer et al., 2013; Wellesley et al., 2015).

Emphasising health consequences. We found some supporting evidence for interventions that emphasise health consequences. When informed about undesirable health consequences, most omnivores report low willingness to change their meat consumption (Valli et al., 2019). Resistance to change can be generated by beliefs that meat is healthy and necessary (Graça et al., 2019; Valli et al., 2019), that the consequences of consumption are trivial, and the belief that individuals have already reduced consumption in the past (Valli et al., 2019). Yet, interventions can successfully influence the intentions of older consumers or those with pre-existing negative perceptions of meat consumption (Graça et al., 2019). Health concerns also appear to be a primary motivation for many vegetarians (Valli et al., 2019) and are the most common motive for non-vegetarians to consider plant-based diets (Hopwood et al., 2020). Therefore, health concerns may be a driver among the health literate,

Table 3

Vote counting results of interventions to decrease animal-product consumption.

Intervention	Sub-category (if applicable)	Review findings	Commentary/implications
Providing information	Information on environmental impact	Three reviews[1,2,3] cited 11 unique studies. A statistically significant majority of results were in favour of the intervention (10/11; 91%, 95% CI [62.3%, 98.4%]; $p = .012$).	Promising strategies include: - Providing information about the environmental consequences of eating meat - Considering whether the recipient has existing positive or negative beliefs about meat consumption. This strategy may be more effective for those who have negative beliefs and are already concerned about the environment
	Health impact	Five reviews[1,2,4,5,6] cited 10 unique studies. Majority of results were in favour of the intervention (8/10; 80%, 95% CI [49%, 94.3%]; $p = .11$).	Promising strategies include: - Providing information about the health consequences of eating meat
	Animal welfare impact	Two reviews[1,2] cited 2 unique studies. Results were consistently in favour of the intervention (2/2; 100%, 95% CI [34.2%, 100%]; $p = .5$).	Promising strategies include: - Providing information about the animal welfare consequences of eating meat
	Providing multiple arguments	Five reviews[1,2,4,7,8] cited 16 unique studies. Results were mixed, with over half being in favour of the intervention (11/16; 68.75%, 95% CI [44.4%, 85.8%]; $p = .21$).	Mixed results for strategies including: - Providing information about multiple reasons to reduce animal-product consumption (e.g., health and environmental arguments)
Implicitly emphasising animal welfare	Meat with head attached	Three reviews[1,5,10] cited 3 unique studies. Results were consistently in favour of the intervention (3/3; 100%, 95% CI [43.9%, 100%]; $p = .25$).	Promising strategies include: - Reminding consumers of the animal origins of meat through displaying meat with the head attached
	Animals in advertisements / next to recipes	Two reviews[1,5] cited 3 unique studies. Results were consistently in favour of the intervention (3/3; 100%, 95% CI [43.9%, 100%]; $p = .25$).	Promising strategies include: - Showing cute/live animals in meat advertisements or next to meat recipes
	Cow heading to slaughter	Three reviews[1,2,5] cited 1 unique study. Results were in favour of the intervention (1/1; 100%, 95% CI [20.7%, 100%]; $p = 1$).	Potentially promising strategies include: - Reminding consumers of the animal origins of meat through images of cows heading to slaughter
Goal-setting and self-monitoring	Text message reminders	Six reviews[1,2,4,5,7,8] cited 2 unique studies. Results were consistently in favour of the intervention (2/2; 100%;,95% CI [34.2%, 100%]; $p = .5$).	Promising strategies include: - Digital notifications reminding individuals to monitor their red or processed meat consumption
	Implementation intentions	Five reviews[1,2,4,7,8] cited 2 unique studies. Results were consistently in favour of the intervention (2/2; 100%, 95% CI [34.2%, 100%]; $p = .5$).	Promising strategies include: - Creating implementation intentions (e.g., intentions to consume meat-free meals in specific circumstances, imagining barriers and solutions)
Social consequences of eating meat	Norms	Five reviews[1,5,7,8,9] cited 4 unique studies. Results were consistently in favour of the intervention (4/4; 100%, 95% CI [51%, 100%]; $p = .125$).	Promising strategies include: - Emphasising how the amount of people following plant-based diets is growing - Conveying positive representations of plant-based diets through popular TV shows
	Social image	Three reviews[1,2,11] cited 1 unique study. Results were in favour of the intervention (1/1; 100%, 95% CI [20.7%, 100%]; $p = 1$).	Potentially promising strategies include: - Telling people about negative social consequences of eating meat (e.g., popularity, poorer social image)
	Social dominance meaning	Two reviews[1,2] cited 1 unique study. Results were not in favour of the intervention (0/1; 0%, 95% CI [0%, 79.3%]; $p = 1$).	Unsupported strategies include: - Telling people who reject social dominance that those who are more socially dominant eat more meat
Default plant-based meals		Five reviews[1,3,4,8,12] cited 1 unique study. Results were in favour of the intervention (1/1; 100%, 95% CI [20.7%, 100%]; $p = 1$).	Potentially promising strategies include: - Offer plant-based meals and menus as the default option at restaurants
Providing meat alternatives		One review[10] cited 3 unique studies. Results were consistently in favour of the intervention (3/3; 100%, 95% CI [43.9%, 100%]; $p = .25$).	Promising strategies include: - Providing people with meat alternatives to try (e.g., mycoprotein products)
Description of meat / meat alternatives	Description of meat	Two reviews[1,10] cited 2 unique studies. Results were consistently in favour of the intervention (2/2; 100%, 95% CI [34.2%, 100%]; $p = .5$).	Promising strategies include: - Labelling meat options as "meat" instead of "standard" or "normal" in cafeterias - Referring to "beef" and "pork" dishes as "cow" and "pig"
	Description of meat alternatives	One review[10] cited 3 unique studies. Majority of results were not in favour of the intervention (1/3; 33.34%, 95% CI [6.1%, 79.2%]; $p = 1$).	Mixed results for strategies including: - Changing name of meat-free meals to more appealing alternatives - Highlighting a plant-based meal as the "Chef's recommendation"

Table 3 (*continued*)

Intervention	Sub-category (if applicable)	Review findings	Commentary/implications
Economic interventions		Two reviews[7,10] cited two unique studies. Results were consistently not in favour of the intervention (0/2; 0%, 95% CI [0%, 65.8%]; $p = .5$).	Unsupported strategies: - Providing financial incentives for healthy food/drink purchases - Changing prices of different meat serving portions from decreasing price per unit with increasing portion size to stable price per unit across portion sizes
Personalised messaging		Two reviews[1,2] cited 10 unique studies. Results were mixed, with just over half of studies being in favour of the intervention (6/10; 60%; 95% CI [31.3%, 83.2%]; $p = .75$).	Mixed results for strategies including: - Tailoring messaging based on the receivers state of change, animal-product intake levels, or personality
Individual lifestyle counselling		One review[2] cited 8 unique studies. Majority of results were in favour of the intervention (6/8; 75%; 95% CI [40.9%, 92.9%]; $p = .29$).	Promising strategies include: - Providing individualised supporting material such as information on barriers to change, feedback, and support to prompt behaviour change
Reducing meat portion sizes		Three reviews[4,7,10] cited 4 unique studies conducted in lab and field (restaurant, stores) settings. Results were consistently in favour of the intervention (4/4; 100%; 95% CI [51%, 100%]; $p = .125$).	Promising strategies include: - Supermarkets offering the option of smaller meat portion sizes - Restaurants reducing meat portion sizes but maintaining dish volume by increasing vegetable servings

Note.
[1] Harguess and colleagues (2020)
[2] Bianchi and colleagues (2018)
[3] Hartmann and Siegrist (2017)
[4] Veul (2018)
[5] Graça and colleagues (2019)
[6] Valli and colleagues (2019)
[7] Taufik and colleagues (2019)
[8] Wynes and colleagues (2018)
[9] Nisa and colleagues (2019)
[10] Bianchi and colleagues (2018b)
[11] Sanchez-Sabate and Sabaté (2019)
[12] Byerly and colleagues (2018)

but a barrier for those who believe that plant-based diets are inadequate (Dibb & Fitzpatrick, 2014).

Emphasising animal welfare consequences. Although Bryant and Barnett (2018) note that "the most commonly perceived benefit of cultured meat was in terms of animal welfare" (p. 16), emphasising animal welfare had relatively little supporting evidence compared to environmental or health messages, partly reflecting the smaller number of studies examining animal welfare interventions. There is some supporting evidence behind implicitly emphasising animal welfare through presenting images of cows heading to slaughter, meat with the head attached, or animals next to recipes.

Providing information on multiple consequences. The effect of educating individuals on multiple consequences of eating meat, rather than targeting a specific framing, is unclear with estimates being in mixed directions. Integrating several food-related values (e.g., health and environmental) into the approach, rather than presenting it as an isolated issue (e.g., only emphasising environmental considerations), may help to mitigate resistance generated by particular approaches (de Boer et al., 2013). At the other extreme, providing excessive information, as opposed to tailored information, may sometimes have a backfiring effect and increase consumption, potentially through text and images triggering unconscious cravings (Klöckner and Ofstad, 2017).

4.1.2. Personalised messaging

We found mixed support for tailoring interventions to the receiver (e.g., animal-product intake levels, personality, self-schema, or values). Research suggests that the same intervention is not always as effective for all individuals and populations. For example, although some consumer groups are more affected by health concerns, it should not be the go-to approach in all circumstances (Veul, 2018). Younger consumers, people belonging to lower socioeconomic status groups, and those who follow unhealthy diets may be less sensitive to this approach (Pribis et al., 2010; Veul, 2018). Further, people who are 'meat believers' (those who are convinced that meat is essential for a healthy diet) may respond negatively to the cognitive dissonance invoked by health appeals (Veul, 2018). Similarly, suggestions that meat-free meals are a potential option for addressing environmental issues can trigger detrimental responses in climate-change skeptics (de Boer et al., 2013). Therefore, those advocating for a plant-based diet may consider not only what they are saying, and how they are saying it, but who they are saying it to.

4.1.3. Individualised lifestyle counselling

Estimates were fairly consistently in favour of individualised lifestyle counselling as an intervention. Although these interventions were often successful in reducing red or processed meat consumption, they seemed to involve substantial investment to conduct (e.g., telephone counselling with health advisors and providing tailored supporting material such as information on barriers to change, feedback, and support to prompt behaviour change). Therefore, it may be difficult to scale this intervention and to disentangle the driving factors of behaviour change from all the components involved.

4.1.4. Goal setting and self-monitoring

This meta-review found estimates consistently in favour of goal setting and self-monitoring interventions. Digital notifications reminding individuals to monitor their red or processed meat consumption appear to be promising (Carfora et al., 2017), but more research is needed to solidify these findings. Further, creating implementation intentions (e.g., creating an intention to consume a meat-alternative in a specific circumstance) may be a reliable tool for reducing meat consumption (Loy et al., 2016; Rees et al., 2018).

4.1.5. Implicitly highlighting animal suffering

There is some evidence to suggest that different methods of implicitly highlighting animal suffering may reduce intended meat consumption. These interventions, which typically involve reminding consumers

of the animal origins of meat (e.g., with cute pictures, photos of meat with the head attached, or images of cows heading to slaughter), often aim to induce emotionally charged states such as empathy, disgust, and cognitive dissonance (Harguess et al., 2020). Confronting consumers with their contradicting desires to consume meat but not harm animals (the "meat paradox"; Loughnan et al., 2010) can prompt them to resolve this discomfort by reducing consumption (Tian et al., 2016). Care must be taken when presenting animal welfare appeals to ensure that confronting consumers with their cognitive dissonance is not harmful and does not induce defense mechanisms that maintain—or even increase—animal-product consumption (Veul, 2018). Further research is needed on how to help individuals who consume animal products overcome defence mechanisms that are employed to reduce discomfort such as avoidance and denial of animal pain (Rothgerber, 2014).

4.2. The social context

The social context includes the norms, institutions, roles, relationships, and leaders that an individual is exposed to (Darnton and Horne, 2013). Interventions targeting the social context that were discussed by included reviews included emphasising norms and connotations of meat consumption.

4.2.1. Emphasising social norms

There is some evidence that portraying positive social norms regarding plant-based diets can reduce meat consumption (e.g., through popular TV shows discussing vegetarianism; Byrd-Bredbenner et al., 2010). Although vegetarians and vegans represent a minority of the population in Western countries (Leitzmann, 2014; Sanchez-Sabate and Sabaté, 2019), and these diets may differ substantially from current norms (Béné et al. 2020), communicating *dynamic* norms may reduce consumption (Sparkman and Walton, 2017). This involves emphasising how the amount of people following plant-based diets is growing, which prompts pre-conformity due to believing that meat consumption will be lower in future and reducing consumption matters to others. Given that perceptions of social expectations and norms may influence the likelihood of following more plant-based diets (Wyker and Davison, 2010), reference to these could be incorporated when relevant and encouraging.

4.2.2. Social implications of meat consumption

Two studies were cited by included reviews that assessed how being informed of potential social consequences of meat consumption affected intentions. Cordts and colleagues (2014) found that conveying that meat consumption may harm an individual's personal image (e.g., through reduced popularity and cooperative skills) reduced intentions to eat meat. However, Allen and Baines (2002) found no evidence of an effect of manipulating the symbolic meaning of meat (by telling participants that more socially dominant individuals eat more meat).

4.3. The material context

The material context includes the infrastructure, rules and regulations, technologies, and objects that surround an individual (Darnton and Horne, 2013). Interventions targeting the material context that included reviews discussed were nudges, provision of meat alternatives, description of meat or meat alternatives, and economic interventions.

4.3.1. Nudges

Nudges—aspects of choice architecture which alter behaviour in a predictable way without forbidding options or changing economic incentives (Thaler and Sunstein, 2009)—can be used to prompt dietary behaviour change (Bucher et al., 2016). Several reviews attest to the popularity and impact of nudges to reduce animal-product consumption (e.g., Bianchi et al., 2018; Harguess et al., 2020; Taufik et al., 2019; Veul, 2018). Our meta-review found estimates supporting interventions

which reduce meat portion sizes (e.g., Reinders et al., 2017; Rolls et al., 2010) and involve default meat-free menus (e.g., Campbell-Arvai et al., 2014). These strategies may be effective as they do not require the consumer to actively and voluntarily change their behaviour, or even realise the need for behaviour change (Veul, 2018). This has been supported in previous research on healthy eating choices—as eating is mostly habitual, and is vulnerable to self-regulation failures, changing the food environment is often more successful than strategies which attempt to directly change what people think or feel (Duckworth et al., 2016; Wansink and Chandon, 2014).

4.3.2. Provision of meat alternatives

Another aspect of changing the environment is providing appealing alternatives. We found some evidence of an effect of providing people with meat alternatives to try (e.g., mycoprotein products). This intervention may be promising—especially considering that the enjoyment derived from eating meat is a key motivator behind meat consumption and that a lack of food alternatives is a reported barrier to reduction (Valli et al., 2019). Alternatives such as cultivated meat may be particularly poised to address these barriers, yet our meta-review found no reviews that focused on how the provision of cultivated meat would impact the consumption of traditional meat. Although achieving mimicry and efficiency presents a significant challenge for the growing field before it can become accepted, industrialised, and economically feasible (Post, 2012), research is needed to examine consumer willingness to substitute cultivated meat for traditional meat.

4.3.3. Description of meat and meat alternatives

There is some evidence that there is an effect of changing the description of meat meals, but mixed evidence on altering the description of plant-based meals. Highlighting the animal origins of a meal (e.g., referring to "beef" and "pork" dishes as "cow" and "pig"; Kunst and Hohle, 2016), and pushing back on implicit suggestions of meat-eating norms (Stewart et al., 2016), show some promise. Yet, the outcome of changing the name of meat-free meals to more appealing alternatives, or of highlighting a plant-based meal as the "Chef's recommendation", is unclear (Bacon and Krpan, 2018).

4.3.4. Pricing interventions

No estimates we found demonstrated that financial incentives decreased animal-product consumption. Neither providing financial incentives for healthy purchases nor changing the price of different meat serving portions produced results in the desired direction.

4.4. Interventions that increase animal-product consumption

4.4.1. Techniques to increase dairy intake can also provide insights into how to decrease it

The most prevalent behaviour change technique assessed by individual studies in this space was nutrition education, but those interventions did not robustly increase dairy consumption (Hendrie et al., 2013; Jung et al., 2016; Rouf et al., 2018). Techniques that have been found to increase dairy consumption include delivering interventions in a single environment (e.g., school), delivering interventions at the group level (i.e., not personalised), and involving taste exposure (e.g., providing dairy foods). Given the efficiency and cost-effectiveness of these interventions, it suggests group-setting interventions such as school milk programs could also involve plant-based alternatives (e.g., soy milk). We speculate that offering free tastings of plant-based substitutes might also reduce the demand for animal products, given the effectiveness of taste exposure and increasing familiarity with products (Hartmann-Boyce et al., 2018). Together, the evidence from these reviews summarise what interventions increase dairy consumption and may guide us toward strategies to promote plant-based alternatives.

4.5. Limitations of included reviews and directions for future research

While well-conducted systematic reviews of rigorous studies can provide robust evidence (Higgins et al., 2019), the reviews we identified failed to meet a number of recommendations that generally lead to robust, causal findings (Shea et al., 2017). None of the reviews used best-practice methods for assessing quality of primary studies, assessed whether the quality of the included studies influenced their conclusions, or explored the funding in the included studies, and few reviews assessed publication bias.

In general, future reviews would benefit from improved methodology to provide more robust findings. First, many reviews did not implement transparent reporting. As a result, using even a simple reporting checklist like PRISMA (Moher et al., 2010; Page et al., 2020) would increase the transparency of future reviews. Second, most studies did not conduct a quantitative synthesis. Quantitative meta-analyses can be conducted across heterogeneous participants, interventions, comparisons, and outcomes. Using analysis methods that quantify evidence strength across these measured sources of heterogeneity as well as unmeasured sources could help identify the settings in which these interventions may be effective (Hedges et al., 2020; Mathur and VanderWeele, 2019). Meta-analyses are possible—indeed recommended—when there are even just two comparable studies (Ioannidis et al., 2008), as was often the case in our included reviews. Adding a meta-analysis allows for a more robust exploration of heterogeneity and a better quantification of publication bias (Pustejovsky and Rodgers, 2019).

Most reviews focused on reducing meat consumption, and few addressed other animal products, like eggs or dairy. The reviews which examined dairy focused on interventions to *increase* consumption. One review conducted a broad search of behavioural interventions to encourage more plant-based diets generally (Taufik et al., 2019). Yet, all studies found were focused on meat, except one which examined dairy. This suggests that there is either a lack of primary studies, or that they are not detected by the search strategies in the reviews.

Most of the literature examined focused on Western, educated, industrialized, rich and democratic (WEIRD) populations. This may limit the generalisability of the findings due to differences in population perceptions and norms, as well as different needs. For example, increased consumption of meat in Africa may be necessary considering micronutrient deficiencies (e.g., zinc, iron, etc.) or financial stability (e.g., owning a cow or goat).

Context mapping revealed several limitations of included reviews. Firstly, they did not compare differences in how the source of information influences intervention outcomes. Future research could determine to what extent people are more persuaded by similar people or whether messages attributed to government or health organisations are more effective than animal activists. Several reviews compared the effectiveness of different channels, primarily in examining dairy consumption, and focused on comparing levels of personalisation (e.g., (Hendrie et al., 2013; Marquez et al., 2015). Given the growth in social media use and influence, future research should explore how mediated communication (e.g., Facebook adverts) perform versus face to face, and whether the scale and cost benefits of mediated communication outweigh the presumed downside of less interpersonal connection. Reviews also did not assess if outcome types or study methodology were associated with effect sizes (e.g., if self-reported data led to larger estimates than purchase data, or if non-randomised studies reported smaller estimates than randomised studies). Findings on the intention-behaviour gap (Faries, 2016), and differences between field and lab studies (Dubois et al., 2020), suggest that there may be value in future research which addresses both of these questions.

The included studies themselves are also fraught with a series of limitations. Many relied on self-report measures and intended consumption rather than observable behaviours and actual consumption (Harguess et al., 2020). This means that some of the findings may be driven by socially desirable responding. Similarly, the reviews that did

rate the risk of bias in the included studies often found a preponderance of high-risk designs that are susceptible to bias (e.g., Valli et al., 2019). Primary studies on this topic would therefore also benefit from improved methodology and reporting. Specifically, a large number of criteria for risk of bias require better reporting or prospective registration of methods (Higgins et al., 2019). If primary studies consult research quality information sources such as the EQUATOR network and use the standardised reporting checklist relevant for their design, then the field can increase transparency, reproducibility, and validity of their conclusions (Simera et al., 2010).

Given randomised trials of dietary change interventions are often difficult to conduct, the field could still benefit from conducting quasi-experiments rather than correlational studies, more robust techniques for finding causal evidence from observational data (e.g., propensity score matching, IPTW, structural causal models, or directed acyclic graphs; Pearl, 2009), and meta-analysis methods that characterise the robustness of findings to potential unmeasured confounding (Mathur and VanderWeele, 2020a).

There are a variety of interventions that have been identified in correlational studies but have not been experimentally tested or systematically reviewed (Hartmann and Siegrist, 2017). Behaviour change interventions that could promote sustainable diets and the adoption of more plant-based meals have been suggested by the World Resources Institute (Attwood et al., 2020) and the Behavioural Insights Team (2020). Although these reports did not meet our inclusion criteria due to their unsystematic searches, they provide an indication of interventions that could be assessed. Exploring interventions that are known to be effective with other dietary behaviours (e.g., healthy eating) may also be a promising avenue.

Shah (2020) draws on best practice in health and global development research to argue that there could be considerable value in developing: i) a theory of change for influencing animal-product consumption, ii) the cost effectiveness of different interventions to influence consumption of animal products, iii) an information model to prioritise research, and iv) sector wide evidence grading standards. Future researchers and reviewers could consider implementing many of these suggestions.

4.6. Limitations of our overview of reviews

The findings of our meta-review are contingent on the quality of the included reviews and the quality of the studies included in those reviews, discussed above. Moreover, this review is limited to reviews with a systematic, reproducible method. Evidence regarding other interventions may be available in the form of non-systematic reviews, and primary studies not included in systematic reviews. For example, a review by Animal Charity Evaluators (2017) found that leafleting does not have a significant effect on reducing animal product consumption. Yet, as their review lacked a systematic, reproducible search strategy, it was not included. Similarly, the Playbook for Guiding Diners Toward Plant-Rich Dishes in Food Service provides 23 behaviour change interventions that could be implemented in the food service sector to encourage diners to select more plant-rich dishes (Attwood et al., 2020). However, this report was excluded as the review results are not explicitly discussed (but are used to inform their recommendations).

There are also limitations regarding our quality appraisal and intervention categorisation. AMSTAR2 was developed to assess the quality of systematic reviews of interventions (Shea et al., 2017). Although most of our included reviews were focused on interventions, some had a broader focus on exploring variables (e.g., Sanchez-Sabate and Sabate, 2019; Valli et al., 2019). Other quality appraisal tools may have been better suited to evaluating those few reviews. We also note that we did not use an established behaviour change technique taxonomy (e.g., Michie et al. 2013; Teixeira et al. 2020) to categorise interventions found in included reviews. Although this would have been ideal, we judged that many included interventions were not well described by those taxonomies; for example, information about health and environmental consequences might be classified as the same behaviour change technique under established frameworks but are important to separate for this review.

5. Conclusion

Reducing animal-product consumption could provide numerous benefits to society, from helping to address environmental destruction to reducing animal suffering to optimising health. Despite limitations in the quality of reviews available, there is some promising evidence that informing consumers about environmental consequences reduces meat consumption. Discussing health impacts, implicitly emphasising animal welfare, encouraging goal-setting and self-monitoring, and conveying positive social norms around plant-based diets are also promising strategies, albeit with a more limited evidence base. Future reviews should conduct quantitative syntheses where appropriate and examine interventions that influence animal-product consumption other than meat. Investigating and adopting interventions to reduce animal-product consumption is one important factor in safeguarding planetary health (Willett et al., 2019).

Declaration of Competing Interest

None.

CRediT authorship contribution statement

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Ethics approval

Ethics approval was not sought for this review given that this is a review of existing research.

Data availability

The protocol and data for this review are available on the Open Science Framework: bit.ly/OSF-meta-review

Supplementary materials

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