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Strategies for reducing meat consumption within college and university settings: A systematic review and meta-analysis

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Introduction: Despite the considerable public and planetary health benefits associated with reducing the amount of meat consumed in high-income countries, there is a limited empirical understanding of how these voluntary changes in food choice can be effectively facilitated across different settings. While prior reviews have given us broad insights into the varying capacities of behavior change strategies to promote meaningful reductions in meat consumption, none have compared how they perform relative to each other within a uniform dining context.

Methods: To address this gap in the literature, we synthesized the available research on university-implemented meat reduction interventions and examined the variations in the success rates and effect estimates associated with each of the three approaches identified in our systematic review.

Results: From our analyses of the 31 studies that met our criteria for inclusion ($n = 31$), we found that most were successful in reducing the amount of meat consumed within university settings. Moreover, independent of the number of individual strategies being used, multimodal interventions were found to be more reliable and effective in facilitating these changes in food choice than interventions targeting the choice architecture of the retail environment or conscious decision-making processes alone.

Discussion: In addition to demonstrating the overall value of behavior change initiatives in advancing more sustainable dining practices on college and university campuses, this study lends further insights into the merits and mechanics underlying strategically integrated approaches to dietary change. Further investigations exploring the persistence and generalizability of these effects and intervention design principles are needed.

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KEYWORDS

dietary change, health promotion, systematic review, universities and higher education institutions, behavioral interventions, meat reduction, meta-analysis, sustainable nutrition

1. Introduction

Dietary change has been cited as a necessary measure for achieving a variety of international sustainability targets (Springmann et al., 2018; Clark et al., 2020; Chen et al., 2022). In particular, there has been an emphasis on the co-benefits of reducing excess meat consumption among adolescents and adults living in high-income countries (HICs) (Yip et al., 2013; Aleksandrowicz et al., 2016; Springmann et al., 2016), specifically with regard to the advantages these population-level shifts would present for human health, climate change, and the global ecology (Godfray et al., 2018; Willett et al., 2019; Parlasca and Qaim, 2022).

Programs aimed at limiting the sale and consumption of meat have therefore become an important object of interest among food systems researchers (De Boer et al., 2014; Garnett et al., 2015; Wellesley et al., 2015; Jiang et al., 2020; Rust et al., 2020), with evidence to suggest that actualizing these transitions within HICs could reduce agricultural emissions, water use, and land appropriation by more than half (Aleksandrowicz et al., 2016; Sun et al., 2022), all while avoiding millions of diet-related deaths each year (Wang et al., 2016; Willett et al., 2019; Zhang et al., 2021).

Due to pervasive public resistance to programs restricting individual choice (Sievert et al., 2020; Ewald et al., 2021; Pechey et al., 2022), much of this research has focused on the value of behavior change strategies in promoting voluntary shifts in food choice (Bianchi et al., 2018a,b; Graça et al., 2019). Within the context of meat reduction interventions, common strategies include those that (1) modify the presentation and arrangement of items on menus, (2) add to the existing set of meal options, (3) manipulate the layouts of dining areas, (4) utilize promotional messaging, and (5) introduce pricing incentives.

Each of these strategies leverage different behavior change principles to motivate individuals toward more sustainable food choices without actively limiting the options available to them. Dual-process accounts of conditional reasoning (Evans, 2011; Kahneman, 2011) provide us with a useful framework for classifying these differences, with some strategies targeting more implicit decision-making processes and others focusing instead on the more deliberate aspects of cognition.

Using this operating principle, we can group the existing set of meat reduction interventions into three categories (referred to as "approaches" hereafter) based on the cognitive systems being targeted by their individual strategies. More specifically, we specify between (1) interventions that target the choice architecture of the retail environment (i.e., interventions that modify the presentation and arrangement of items on menus, add to the existing set of meal options, and/or manipulate the layouts of dining areas), (2) interventions that target conscious decision-making processes (i.e., interventions that utilize promotional messaging and/or introduce pricing incentives), and (3) interventions that target both systems simultaneously (i.e., interventions that involve at least two strategies corresponding to each of the initial two approaches; referred to as "multimodal interventions" hereafter) (see Figure 1).

While prior reviews have given us broad insights into the value of dietary change interventions in shifting attitudes (Hartmann and Siegrist, 2017; Sanchez-Sabate and Sabaté, 2019; Valli et al., 2019) and behaviors (Bianchi et al., 2018a,b; Harguess et al., 2020; Kwasny et al., 2022) related to meat consumption, none have compared how these approaches perform relative to each other within a uniform dining context—information that could meaningfully inform the underlying theory and design of setting-specific policies and interventions. In the health promotion literature, settings-based evaluation techniques are frequently used to identify overlapping traits between high-performing interventions, allowing researchers to isolate the strategic components that are most valuably contributing to the behavioral changes being observed with that context (Whitelaw et al., 2001; Dooris, 2009; Bloch et al., 2014).

Due to the high mitigation potential associated with lowering the resource requirements tied to institutional foodservice operations (Jones et al., 2019; Bull et al., 2022; Sherry and Tivona, 2022) and the developing interest in improving the sustainability of college and university environments (Leal Filho et al., 2018; Amaral et al., 2020; Ruiz-Mallén and Heras, 2020), we elected to apply these techniques toward the subset of meat reduction interventions that have been implemented within higher education institutions (HEIs) (referred to as "university settings" hereafter). In particular, we wanted to leverage this existing evidence base to (1) determine whether meat reduction interventions have been successful in reducing the amount of meat consumed within university settings and (2) identify which of the three investigated approaches has generated the most favorable dietary change outcomes.

To accomplish this, we synthesized the existing research on university meat reduction and examined the variations in the success rates and effect estimates between interventions targeting the choice architecture of the retail environment, interventions targeting conscious decision-making processes, and multimodal interventions. Based on these analyses, we found that the majority of included interventions were successful in reducing the amount of meat consumed within university settings, and that multimodal interventions were more reliable and effective in facilitating these changes than either of the remaining two approaches, regardless of the number of individual strategies being used. Further insights regarding the state of the literature and its possible future directions are also provided.

2. Materials and methods

This paper has been presented in accordance with the guidelines stipulated by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (see Supplementary Table 1). For further information on our methodologies, a more detailed version of this previously registered protocol can be viewed alongside a record of its revisions at https://osf.io/zhg5b/.

2.1. Search strategy

To identify the relevant literature published between January 1, 2000, and June 3, 2021, we consulted seven electronic databases: ERIC, PsycINFO, PubAg, PubMed, SCOPUS, Sociological Abstracts, and Web of Science. For each database, we used a combination of keywords and controlled vocabulary operationalizing our three principal search concepts: behavior change, meat consumption, and college and university settings.

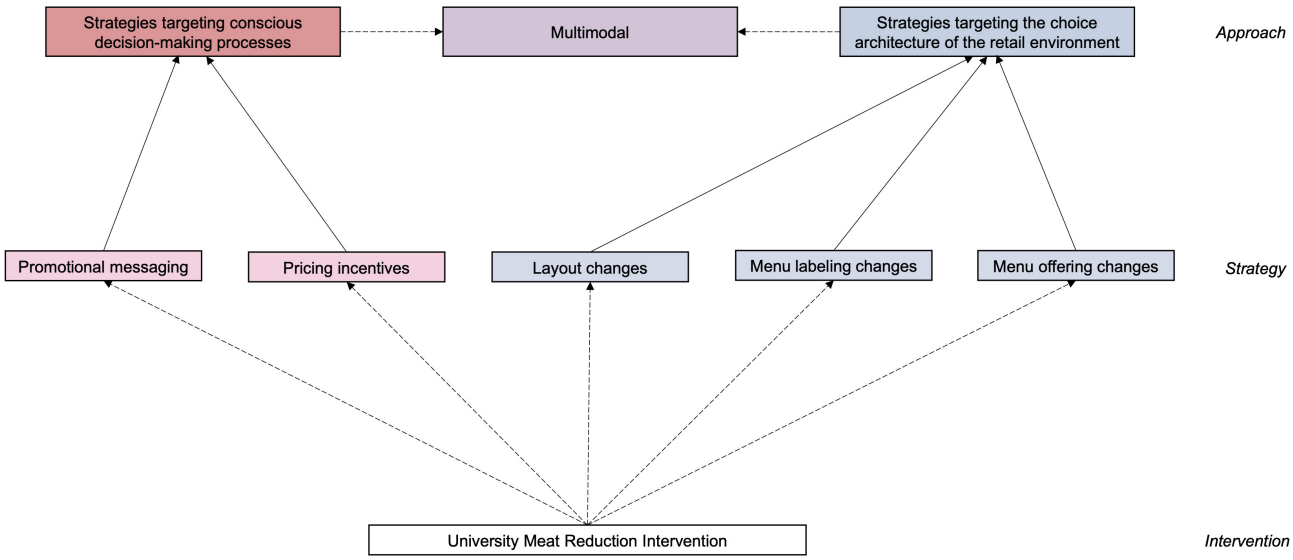

FIGURE 1
Flow diagram outlining the organizing principles of our intervention classification scheme. Interventions are considered "multimodal" if they involved two or more strategies corresponding to each of the remaining two approach styles. Therefore, at minimum, multimodal interventions must include at least one strategy targeting the choice architecture of the retail environment and at least one strategy targeting conscious decision-making processes.

To develop these searches, we generated an initial base strategy for the PubMed database using the Yale Medical Subject Heading (MeSH) Analyzer to create a list of terms represented across 11 previously identified seed articles. After filtering these terms based on their relevance to our search concepts, we translated the resulting base strategy across the remaining six databases. These searches are provided in full in Supplementary Table 2.

2.2. Selection criteria

Prior to implementing our search strategy, we developed a set of selection criteria based on our research objectives and pre-existing knowledge of the literature. These specifications were designed to parameterize our analyses by qualifying eligible studies based on (1) the populations that were sampled, (2) the settings that were investigated, (3) the outcome variables that were assessed, and (4) the evaluation methods that were used. We elaborate on these criteria in greater detail below.

2.2.1. Population

Studies were required to sample members of the hosting university's student body. To allow exploration into the effects of interventions on the broader university environment, we elected to retain instances where members of the faculty and staff were sampled alongside university students.

2.2.2. Setting

Studies were required to report on interventions that had been conducted naturalistically within physical university dining environments. Records documenting laboratory-based, artificial choice experiments were excluded.

2.2.3. Evaluation method

Studies were required to evaluate the effects of a campaign, program, or initiative in at least one of two ways: (1) by comparing behavioral measures before and after the implementation of an intervention or (2) by making comparisons between treatment and control groups. Studies utilizing cross-sectional data were excluded.

2.2.4. Outcome variables

Studies were required to use at least one of the following three measures to evaluate the effect of the intervention on food choice: (1) intended changes in meat consumption, (2) self-reported changes in meat consumption, and (3) observed changes in meat consumption. Studies using alternate measures of food choice were excluded.

2.3. Screening procedure

After importing the records into a citation management system (Clarivate, 2020), we documented the total volume of search results before removing duplicate entries. Non-duplicate records were then transferred to an online web-based program for screening (Veritas Health Innovation, 2021).

Our screening procedure was conducted successively by two independent reviewers, with a third designated to settle arising conflicts in voting. The initial stage of title-and-abstract screening

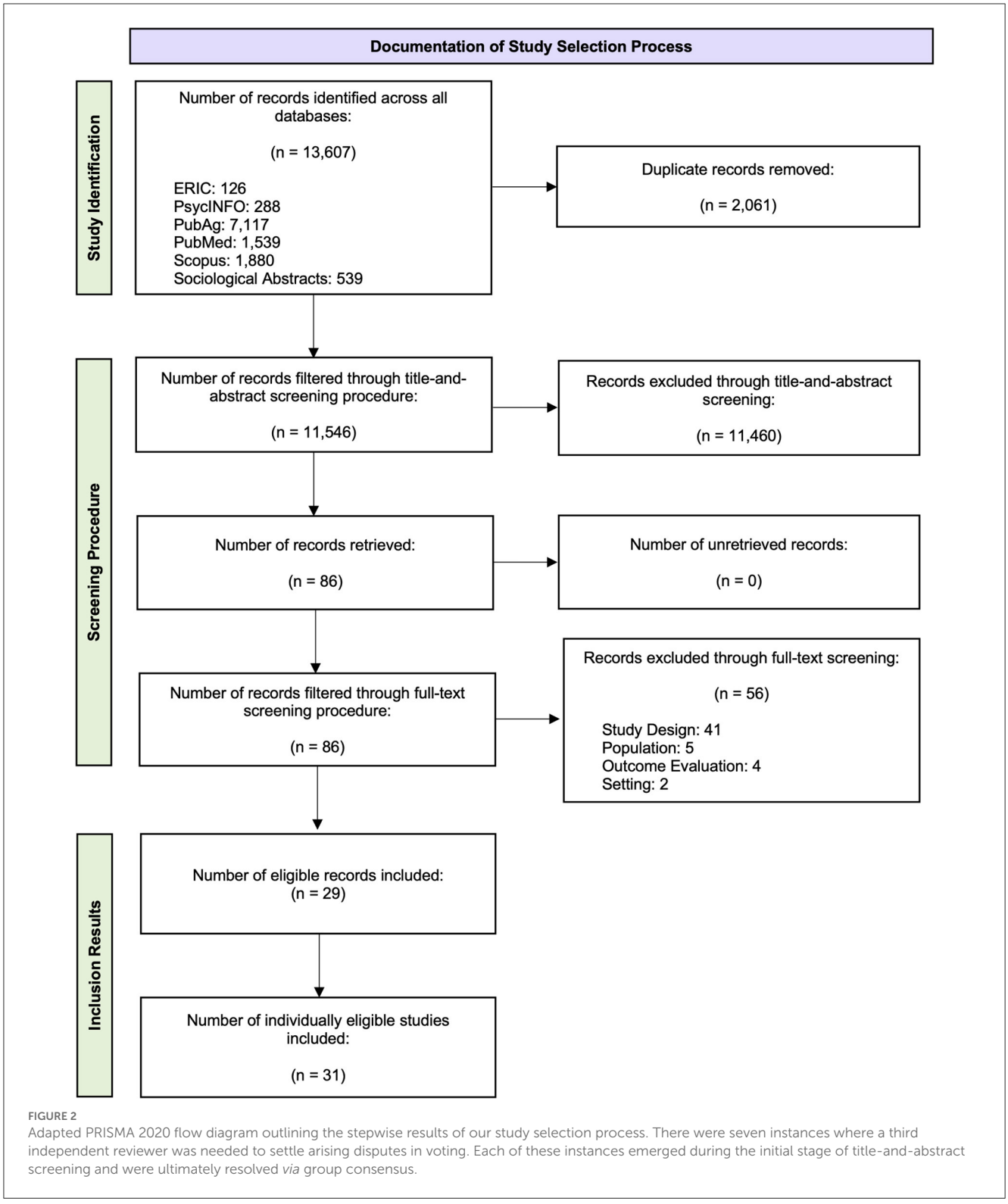

FIGURE 2
Adapted PRISMA 2020 flow diagram outlining the stepwise results of our study selection process. There were seven instances where a third independent reviewer was needed to settle arising disputes in voting. Each of these instances emerged during the initial stage of title-and-abstract screening and were ultimately resolved *via* group consensus.

was used to sort non-duplicate records according to their potential relevance, with all decisions being based around whether the readable contents met any of our four exclusion criteria. By contrast, during the final stage of full-text review, records were only included if the readable contents met all four of our inclusion criteria (see Figure 2).

2.4. Data extraction

For each included record, data on the article's author(s), title, publication year, and implementation year were collected alongside information describing the university and country in which the intervention was implemented. Using the classification scheme

described in Figure 1, we typified included interventions based on the strategies they used and the larger approach category they fell under. Information on their evaluation methods, outcome measures, and targeted meat types were also extracted.

To standardize how significance was determined across studies, we also collected the relevant data used to interpret the intervention's effect on meat consumption. This involved extracting study-level information on mean outcomes, group sample sizes, and error. All extracted variables were exported to and compiled in Microsoft Excel (see Table 1) (Microsoft Corporation, 2018).

2.5. Quality assessment

We used the Evidence Project's Risk of Bias Tool to establish a minimum standard for our analyses (Viswanathan et al., 2018; Kennedy et al., 2019), such that each included study needed to meet at least one of the eight specified criteria for inclusion. This was done to ensure that studies were of sufficient rigor and appropriately accounted for common sources of bias.

Studies were therefore required to satisfy at least one of the following eight criteria: (1) monitor a cohort over time, (2) involve the use of a control or comparison group, (3) use pre-post intervention data, (4) use random assignment, (5) use random selection, (6) report a rate of attrition below 20 percent, (7) demonstrate equivalency across sociodemographic variables, or (8) demonstrate equivalency across outcome variable of interest (Kennedy et al., 2019).

2.6. Main analyses

Our main analyses were divided into three parts, with the first evaluating differences in the success rates across interventions, the second comparing mean differences in their effect estimates, and the third examining changes in performance over time.

2.6.1. Success rates

As a function of both the direction and significance of an intervention's effect on meat consumption, we used success rates to compare the capacities of the three investigated approaches to facilitate changes in food choice. These values were calculated by dividing the number of interventions reporting significant reductions in meat consumption within an approach category by the total number of interventions that used that particular approach.

To standardize how significance was determined across studies, we used a consistent set of methods to internally calculate changes in behavior resulting from the intervention. For studies inferring change based on the differences in the sample means reported between control and treatment conditions, we used two-tailed *t*-tests, and for those inferring change based on proportional differences in sales, we used chi-square tests. In both cases, we set an alpha of 0.05 and depicted these results visually using Boon and Thomson (2021) revised methods for visualizing patterns, which leverage the "<>," "∧," and "∨" symbols to represent neutral, positive, and negative effects, respectively.

2.6.2. Effect estimates

In addition to using success rates to understand the relative frequency with which interventions significantly reduced the amount of meat consumed within university settings, we also calculated the associated odds ratios to evaluate how the magnitudes of these effects varied across approaches. For the studies using mean differences to form these comparisons, we calculated these effect estimates using the means and standard deviations of the control and interventions groups, and for those using differences in sales proportions, effect estimates were calculated using the frequency distributions derived from the sample sizes and proportional shares of control and intervention groups.

To perform these calculations, we used the Practical Meta-Analysis Calculator from Lipsey and Wilson (2001) and later verified these initial results using the "effectsize" (Ben-Shachar et al., 2020) and "metafor" (Schwarzer, 2022) packages within RStudio (RStudio Team, 2021).

2.6.3. Time series

Prior research has indicated that there has been increasing concern and awareness surrounding how diets influence different processes related to global environmental change (Macidarmid et al., 2016; Jürkenbeck et al., 2021). To determine whether this phenomenon has contributed to differences in the performance of interventions over time, we used Sturge's rule to construct equal-sized time intervals and compared the success rates and effect estimates of interventions conducted between 2001 and 2007, 2008 and 2014, and 2015 and 2021.

3. Results

3.1. Study selection

Of the 11,546 unique records screened for their relevance and eligibility, a total of 29 research articles documenting 31 independently eligible studies met the necessary criteria for inclusion (see Figure 2).

3.2. Study characteristics

3.2.1. Time and place

The 31 studies included in our analyses were all conducted and published between 2001 and 2021, with each cumulative frequency distribution increasing exponentially over time ($R^2 = 0.97$, $R^2 = 0.96$) (see Figure 3A). The studies were conducted at a total of 33 different intervention sites spanning 24 colleges and universities, nine countries, and two continents (see Figure 3B). More than half were conducted in the United States (51.5%) while the remaining 16 were implemented at colleges and universities in England (16.1%),

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TABLE 1 Summary table outlining the study-level characteristics associated with each of the 31 interventions included in our analyses.

Study ($n = 31$)	Article title	Country	Year conducted	Method of evaluation	Approach category	Strategies implemented	Reported outcome variable	Targeted meat types	Direction of effect	Odds ratio (95 % CI)
Andersson and Nelander (2021)	Nudge the lunch: A field experiment testing menu-primacy effects on lunch choices	Sweden	2019	Between-subjects comparisons	Multimodal	(1) Informational messaging (2) Change in menu presentation	Observed changes in meal purchasing behaviors	All meat	^	2.78 (1.00, 7.75)
Brunner et al. (2018)	Carbon label at a university restaurant: Label implementation and evaluation	Sweden	2016	Pre-post	Multimodal	(1) Informational messaging (2) Change in menu presentation	Observed changes in meal purchasing behaviors	Ruminant meat	^	1.09 (1.01, 1.18)
Campbell-Arvai (2011)	Motivating pro-environmental food choices: The role of value orientation, information provision, and a default behavioral intervention	USA	2010	Between-subjects comparisons	Multimodal	(1) Informational messaging (2) Change in menu presentation	Intentions to change meal purchasing behaviors	All meat	^	12.19 (8.90, 16.68)
Carfora et al. (2019)	How to reduce red and processed meat consumption by daily text messages targeting environment or health benefits	Italy	2018	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	Red and processed meat	^	2.59 (1.35, 4.97)
Carfora et al. (2016)	Randomized controlled trial of a text messaging intervention for reducing processed meat consumption: The mediating roles of anticipated regret and intention	Italy	2016	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	Processed meat	^	3.49 (1.75, 6.96)

(Continued)

TABLE 1 (Continued)

Study ($n = 31$)	Article title	Country	Year conducted	Method of evaluation	Approach category	Strategies implemented	Reported outcome variable	Targeted meat types	Direction of effect	Odds ratio (95 % CI)
Carfora et al. (2017)	Correlational study and randomized controlled trial for understanding and changing red meat consumption: The role of identities	Italy	2015	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	Red meat	^	3.73 (2.29, 6.06)
Cerezo-Prieto and Frutos-Esteban (2021)	Toward healthy routes: Effects of nutritional labels on eating behaviors in a university cafeteria	Spain	2020	Pre-post	Multimodal	(1) Informational messaging (2) Change in menu presentation	Observed changes in meal purchasing behaviors	Red meat	^	1.71 (1.37, 2.12)
Dissen and Crowell (2020)	We are what we eat: Assessing the use of a documentary film as an educational tool to change students' nutritional attitudes and behaviors	USA	2019	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	Beef, pork, poultry	^	3.20 (1.68, 6.08)
Garnett et al. (2021)	Price of change: Does a small alteration to the price of meat and vegetarian options affect their sales	England	2018	Between-subjects comparisons	Interventions targeting conscious decision-making processes	(1) Financial incentive	Observed changes in meal purchasing behaviors	All meat	<>	1.07 (1.01, 1.14)
Garnett et al. (2020)	Order of meals at the counter and distance between options affect student cafeteria vegetarian sales	England	2017	Between-subjects comparisons	Interventions targeting aspects of the built environment	(1) Change in dining area layout	Observed changes in meal purchasing behaviors	All meat	<>	0.82 (0.78, 0.88)
Garnett et al. (2020)	Order of meals at the counter and distance between options affect student cafeteria vegetarian sales	England	2018	Between-subjects comparisons	Interventions targeting aspects of the built environment	(1) Change in dining area layout	Observed changes in meal purchasing behaviors	All meat	^	3.64 (3.51, 3.77)
Garnett et al. (2019)	Impact of increasing vegetarian availability on meal selection and sales in cafeterias	England	2017	Pre-post	Interventions targeting aspects of the built environment	(1) Change in menu offerings	Observed changes in meal purchasing behaviors	All meat	^	1.52 (1.40, 1.64)

(Continued)

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TABLE 1 (Continued)

Study ($n = 31$)	Article title	Country	Year conducted	Method of evaluation	Approach category	Strategies implemented	Reported outcome variable	Targeted meat types	Direction of effect	Odds ratio (95 % CI)
Hormes et al. (2013)	Reading a book can change your mind, but only some changes last for a year: Food attitude changes in readers of The Omnivore's Dilemma	USA	2007	Between-subjects comparisons	Interventions targeting conscious decision-making processes	(1) Informational messaging	Intentions to change meal purchasing behaviors	All meat	^	1.75 (1.30, 2.35)
Jalil et al. (2020)	Eating to save the planet: Evidence from a randomized controlled trial using individual-level food purchase data	USA	2019	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Observed changes in meal purchasing behaviors	All meat	<>	1.57 (0.97, 2.56)
Jay et al. (2019)	Reduction of the carbon footprint of college freshman diets after a food-based environmental science course	USA	2017	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	Ruminant meat	<>	1.71 (0.97, 3.00)
Kurz (2018)	Nudging to reduce meat consumption: Immediate and persistent effects of an intervention at a university restaurant	Sweden	2015	Both	Interventions targeting aspects of the built environment	(1) Change in menu presentation (2) Change in dining area layout	Observed changes in meal purchasing behaviors	All meat	<>	1.44 (0.70, 2.99)
Larner et al. (2021)	Reaction to a low-carbon footprint food logo and other sustainable diet promotions in a UK University's Student Union "Living Lab"	England	2019	Pre-post	Multimodal	(1) Informational messaging (2) Change in menu presentation (3) Financial incentive	Observed changes in meal purchasing behaviors	Ruminant meat	^	1.41 (1.36, 1.46)

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TABLE 1 (Continued)

Study ($n = 31$)	Article title	Country	Year conducted	Method of evaluation	Approach category	Strategies implemented	Reported outcome variable	Targeted meat types	Direction of effect	Odds ratio (95 % CI)
Malan (2020)	Swap the meat, save the planet: A community-based participatory approach to promoting healthy, sustainable food in a university setting	USA	2019	Both	Multimodal	(1) Informational messaging (2) Change in menu offerings	Observed changes in meal purchasing behaviors	All meat	^	1.39 (1.34, 1.44)
Malan et al. (2020)	Impact of a scalable, multi-campus "Foodprint" seminar on college students' dietary intake and dietary carbon footprint	USA	2018	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	All meat	<>	1.41 (0.83, 2.41)
McClain et al. (2013)	Incorporating prototyping and iteration into intervention development: A case study of a dining hall-based intervention	USA	2011	Both	Multimodal	(1) Informational messaging (2) Change in menu presentation	Self-reported changes in meal purchasing behaviors	Red and processed meat	^	1.50 (0.94, 2.40)
McDonough (2012)	Modifying students' intentions to eat sustainably	Canada	2010	Pre-post	Interventions targeting conscious decision-making processes	(1) Informational messaging	Intentions to change meal purchasing behaviors	All meat	<>	1.53 (0.83, 2.82)
Michels et al. (2008)	A study of the importance of education and cost incentives on individual food choices at the Harvard School of Public Health cafeteria	USA	2001	Pre-post	Interventions targeting conscious decision-making processes	(1) Informational messaging (2) Financial incentive	Observed changes in meal purchasing behaviors	Red and processed meat	^	2.82 (2.57, 3.10)

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TABLE 1 (Continued)

Study ($n = 31$)	Article title	Country	Year conducted	Method of evaluation	Approach category	Strategies implemented	Reported outcome variable	Targeted meat types	Direction of effect	Odds ratio (95 % CI)
Nash (2014)	The green eating project: Web-based intervention to promote environmentally conscious eating behaviors	USA	2013	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Intentions to change meal purchasing behaviors	All meat	<>	1.33 (0.92, 1.91)
Papadaki and Scott (2005)	The Mediterranean Eating in Scotland Experience project: Evaluation of an internet-based intervention promoting the Mediterranean diet	Scotland	2003	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	All meat	<>	0.61 (0.23, 1.58)
Piester et al. (2020)	"I'll try the veggie burger": Increasing purchases of sustainable foods with information about sustainability and taste	USA	2019	Between-subjects comparisons	Multimodal	(1) Informational messaging (2) Change in menu presentation	Observed changes in meal purchasing behaviors	All meat	^	1.87 (1.08, 3.24)
Piester et al. (2020)	"I'll try the veggie burger": Increasing purchases of sustainable foods with information about sustainability and taste	USA	2019	Between-subjects comparisons	Multimodal	(1) Informational messaging (2) Change in menu presentation	Observed changes in meal purchasing behaviors	All meat	^	2.13 (1.47, 3.09)

(Continued)

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TABLE 1 (Continued)

Study ($n = 31$)	Article title	Country	Year conducted	Method of evaluation	Approach category	Strategies implemented	Reported outcome variable	Targeted meat types	Direction of effect	Odds ratio (95 % CI)
Ring et al. (2019)	Cooking up health: A novel culinary medicine and service-learning elective for health professional students	USA	2017	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	All meat	^	17.97 (9.60, 33.63)
Schwitzgebel et al. (2020)	Do ethics classes influence student behavior? Case study: Teaching the ethics of eating meat	USA	2017	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Observed changes in meal purchasing behaviors	All meat	^	1.27 (1.16, 1.40)
Slapø and Karevold (2019)	Simple eco-labels to nudge customers toward the most environmentally friendly warm dishes: An empirical study in a cafeteria setting	Norway	2018	Pre-post	Multimodal	(1) Informational messaging (2) Change in menu presentation	Observed changes in meal purchasing behaviors	All meat	^	2.70 (1.04, 7.00)
Turnwald and Crum (2019)	Smart food policy for healthy food labeling: Leading with taste, not healthiness, to shift consumption and enjoyment of healthy foods	USA	2017	Between-subjects comparisons	Interventions targeting aspects of the built environment	(1) Change in menu presentation	Observed changes in meal purchasing behaviors	All meat	<>	1.68 (1.46, 1.92)
Wolstenholme et al. (2020)	Two birds, one stone: The effectiveness of health and environmental messages to reduce meat consumption and encourage pro-environmental behavioral spillover	Wales	2020	Both	Interventions targeting conscious decision-making processes	(1) Informational messaging	Self-reported changes in meal purchasing behaviors	Red and processed meat	^	5.21 (2.66, 10.20)

The "^," "<>," and "v" symbols were adapted from Boon and Thomson's (2021) revised methods for visualizing patterns and used to represent whether the intervention had a positive, neutral, or negative effect, respectively, on the outcome of interest.

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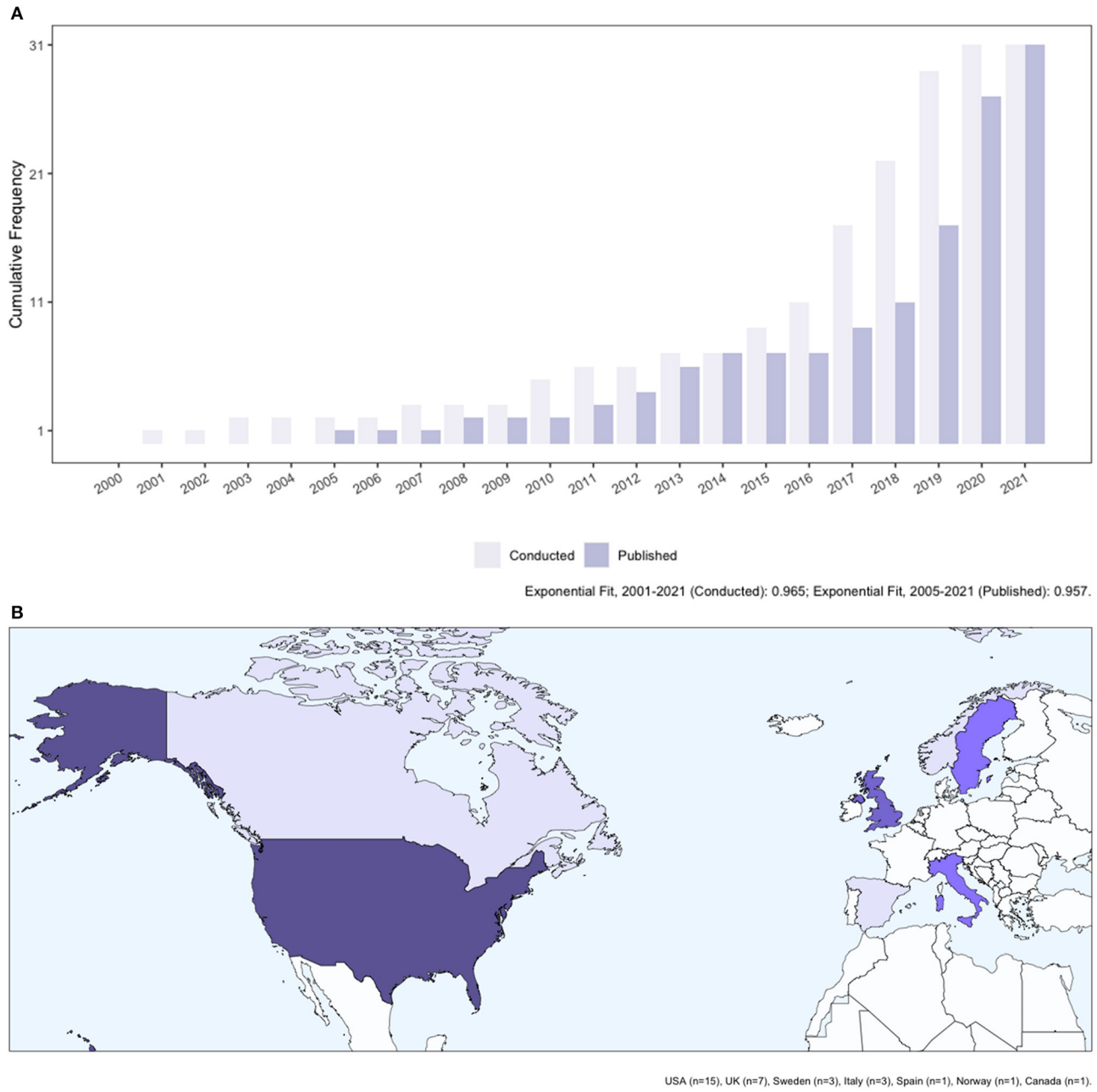

FIGURE 3
(A) Grouped bar graph plotting the annual increases in the number of meat reduction interventions implemented within university settings between 2000 and 2021. **(B)** Choropleth map illustrating the countries where, and frequency with which, included interventions were conducted between 2000 and 2021.

Italy (9.1%), Sweden (9.1%), Canada (3.0%), Spain (3.0%), Norway (3.0%), Scotland (3.0%), and Wales (3.0%).

3.2.2. Strategies and approaches

In total 51.6% of interventions targeted conscious decision-making processes ($n = 16$) while the remaining 48.4% targeted either the choice architecture of the retail environment ($n = 5$) or both drivers simultaneously ($n = 10$). Of the five strategies identified in our systematic review, promotional messaging was the most prominently used (80.6%), followed by strategies that modified the presentation and arrangement of items on menus (35.5%), manipulated the layouts of dining areas (9.7%), introduced pricing incentives (9.7%), and added to the existing set of meal options (8.3%).

In total, 61.3% of interventions utilized a single strategy in isolation while the remaining 12 used at least two in combination (38.7%). Among this latter group, promotional messaging was the most commonly integrated strategy (91.7%), followed by strategies that modified the presentation and arrangement of items on menus

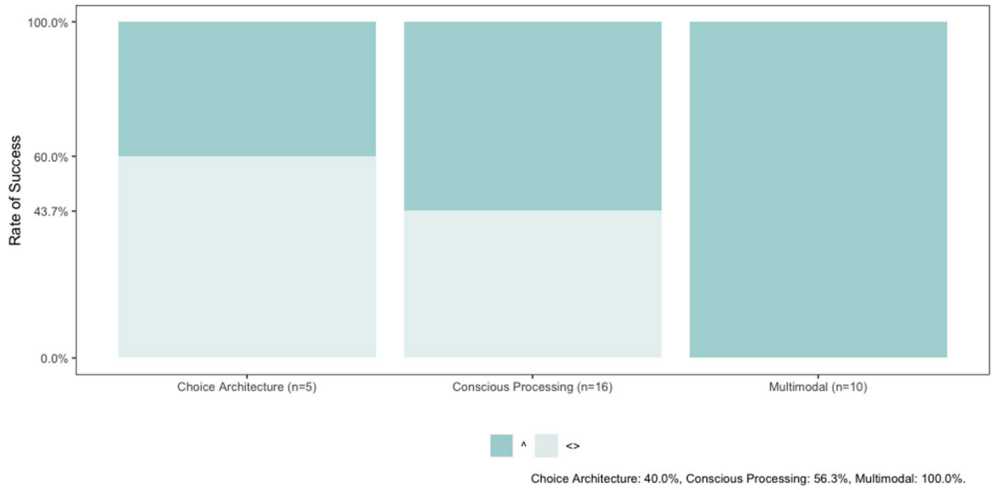

FIGURE 4
Grouped bar graph comparing the proportion of interventions associated with significant reductions in meat consumption across each investigated approach. Relative to other approaches, multimodal interventions were more likely to lead to significant reductions in the amount of meat consumed within university settings ($p = 0.029$). No increases in meat consumption were reported.

(83.3%), introduced pricing incentives (16.7%), manipulated the layouts of dining areas (8.3%), and added to the existing set of meal options (8.3%).

Interventions that manipulated the layouts of dining areas were the least likely to be implemented alongside at least one other strategy (33.3%). By contrast, interventions that utilized promotional messaging (44.0%), modified the presentation and arrangement of items on menus (90.9%), introduced pricing incentives (66.7%), and added to the existing set of meal options (50.0%) were all more likely to be integrated alongside another strategy.

3.2.3. Outcome variables and evaluation methods

Among the included interventions, differences in meat consumption were most often measured observationally (54.8%), with self-reported measures (32.3%) and measures of intention (12.9%) being used at a lower relative frequency. In tracking these changes, nine studies used between-group comparisons when estimating the effects of the intervention on food choice while the remaining 22 either evaluated within-group differences over time (22.6%) or used both evaluation methods concurrently (48.4%).

Over two-thirds of interventions targeted reductions in all types of meat (67.7%) while four focused on reductions in red and process meats (12.9%), three focused on reductions in ruminant meats (9.7%), two focused on red meat alone (6.5%), and one focused on processed meat alone (3.2%).

3.3. Quality assessment

All of the included studies satisfied at least one of the eight criteria specified by the Risk of Bias Tool, meaning that each study met the minimum standard of rigor for our main analyses (see Table 2). The mean summary score across all included studies was 3.19 ($sd = 2.17$), indicating a high degree of study-level variation. Among the evaluated criteria, 90.3% used a control or comparison group, 51.6% collected pre- and post-intervention data, 38.7% assessed equivalence between groups at baseline, 32.3% assessed equivalence across potentially relevant sociodemographic characteristics, 29.0% had a follow-up rate of at least 80%, and 25.8% randomly assigned participants for assessment. No study randomly selected participants for assessment.

The least applicable items were those assessing attrition (51.6%) and equivalence across potentially relevant sociodemographic factors (3.2%). The items that were most relevant to our studies, on the other hand, were those assessing equivalence across potentially relevant sociodemographic factors (61.3%) and equivalence between groups at baseline on disclosure (58.1%).

3.4. Main analyses

3.4.1. Success rate variations

Over two-thirds of the included interventions were associated with significant reductions in meat consumption (67.7%). The remaining interventions yielded no differences in behavior (32.3%), with none of the included studies reporting any increases in meat consumption resulting from negative reactance or rebound effects.

Between the three investigated approaches, multimodal interventions were significantly more likely to be associated with reductions in meat consumption than those targeting conscious decision-making processes or the choice architecture of the retail environment alone ($p = 0.029$) (see Figure 4). There was no

TABLE 2 Table summarizing the results of our quality assessment and risk of bias analysis.

Study ($n = 31$)	Cohort	Control or comparison group	Pre/post intervention data	Random assignment of participants to the intervention	Random selection of participants for assessment	Follow-up rate of 80% or more	Comparison groups equivalent on sociodemographics	Comparison groups equivalent at baseline on disclosure
Andersson and Nelander (2021)	N	Y	N	N	N	NA	NR	NR
Brunner et al. (2018)	Y	Y	Y	N	N	NA	Y	Y
Campbell-Arvai (2011)	N	Y	N	Y	N	NA	NR	NR
Carfora et al. (2019)	Y	Y	Y	Y	N	Y	NR	Y
Carfora et al. (2016)	Y	Y	Y	Y	N	Y	Y	Y
Carfora et al. (2017)	Y	Y	Y	Y	N	Y	NR	Y
Cerezo-Prieto and Frutos-Esteban (2021)	Y	Y	N	N	N	NA	Y	NR
Dissen and Crowell (2020)	Y	Y	Y	N	N	Y	Y	Y
Garnett et al. (2021)	N	Y	N	N	N	NA	NR	NR
Garnett et al. (2020)	N	Y	N	N	N	NA	NR	NR
Garnett et al. (2020)	N	Y	N	N	N	NA	NR	NR
Garnett et al. (2019)	N	Y	N	N	N	NA	NR	NR
Hormes et al. (2013)	Y	Y	N	N	N	NA	NR	NR
Jalil et al. (2020)	Y	Y	Y	N	N	Y	Y	Y
Jay et al. (2019)	Y	Y	Y	N	N	Y	NR	Y
Kurz (2018)	N	Y	N	N	N	NA	NR	NR
Larner et al. (2021)	N	Y	N	N	N	NA	NR	NR
Malan (2020)	N	Y	N	N	N	NA	NR	NR
Malan et al. (2020)	Y	Y	Y	N	N	N	Y	N
McClain et al. (2013)	N	Y	N	N	N	N	NR	NR
McDonough (2012)	Y	N	Y	N	N	N	NR	NR
Michels et al. (2008)	N	N	Y	N	N	N	NR	NR
Nash (2014)	Y	Y	Y	Y	N	Y	N	Y
Papadaki and Scott (2005)	Y	Y	Y	N	N	N	Y	Y
Piester et al. (2020)	N	Y	N	Y	N	NA	Y	NR

(Continued)

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TABLE 2 (Continued)

Study ($n = 31$)	Cohort	Control or comparison group	Pre/post intervention data	Random assignment of participants to the intervention	Random selection of participants for assessment	Follow-up rate of 80% or more	Comparison groups equivalent on sociodemographics	Comparison groups equivalent at baseline on disclosure
Piester et al. (2020)	N	Y	N	Y	N	NA	Y	NR
Ring et al. (2019)	Y	Y	Y	N	N	Y	NR	Y
Schwitzgebel et al. (2020)	Y	Y	Y	N	N	Y	NR	Y
Slapø and Karevold (2019)	N	N	Y	N	N	NA	NA	NA
Turnwald and Crum (2019)	N	Y	N	N	N	NA	NR	NR
Wolstenholme et al. (2020)	Y	Y	Y	Y	N	N	Y	Y

difference in the rate of success across interventions targeting the choice architecture of the retail environment and conscious decision-making process.

Interventions using at least two strategies concurrently were also more likely to be associated with reductions in meat consumption than interventions using a single strategy in isolation ($p = 0.024$), though both sets of interventions significantly reduced the amount of meat consumed within university settings on at least half of the evaluated occasions. Interventions that used promotional messaging strategies, in particular, were successful 57.1% of the time when used in isolation and 76.0% of the time when used in combination with other strategies ($p = 0.029$).

When comparing the performance between multimodal interventions and unimodal interventions leveraging two or more strategies, multimodal interventions were associated with a higher rate of success (100%, compared to 50.0%) and a greater overall effect on food choice ($OR = 2.88$ [1.95, 4.64]), compared to ($OR = 2.13$ [1.64, 3.05]).

There were no significant differences in the success rates associated with interventions conducted in Europe and North America ($p = 0.28$).

3.4.2. Effect size variations

The effect estimates associated with the included studies ranged from 17.97 [9.60, 33.63] to 0.61 [0.23, 1.58], with a mean standardized effect of 2.88 [1.85, 4.77], indicating that the included interventions reduced the overall odds of consuming meat within these settings by an average of 187.5%.

However, due to the heterogeneity in the mean effect estimates associated with studies using self-reported ($OR = 4.20$ [2.99, 5.88]) and intended ($OR = 4.14$ [2.23, 7.73]) measures of change, relative to those using observational measures of change ($OR = 1.82$ [1.37, 2.75]) (see Figure 5), we elected to use a fixed-effect model for our meta-analysis, limiting our comparisons to the 17 studies ($n = 17$) that used observational methods to evaluate changes in meat consumption (see Figure 6).

From this analysis, we found that interventions targeting the choice architecture of the retail environment had a greater mean effect on meat consumption ($OR = 1.82$ [1.57, 2.24]) than interventions targeting people's conscious decision-making processes ($OR = 1.68$ [1.43, 2.05]), though both approaches had a smaller average effect on meat consumption than multimodal interventions ($OR = 1.89$ [1.21, 3.41]) (see Figure 7). Across all approaches, this narrower set of interventions reduced the overall odds of consuming meat within university settings by 81.8%.

3.4.3. Time series variations

No significant differences were found in intervention performance over time.

4. Discussion

Prior research has indicated that organizational change can play a unique role in advancing sustainable development (Krabbe et al., 2015; Hamam et al., 2021; Garnett and Balmford, 2022; Nielsen,

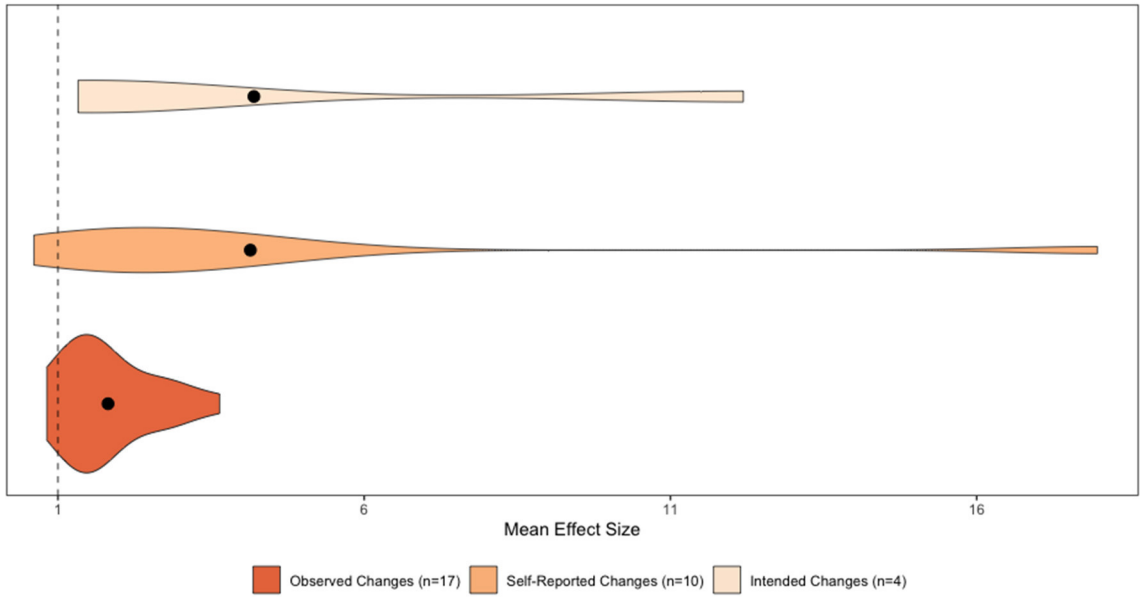

FIGURE 5
Violin plot comparing the effect size distributions for each of the three included evaluation methods. The differences in the magnitude of these effect estimates suggest some level of effect size heterogeneity across the three included methods of evaluation, with observational methods yielding smaller and more precise measurements of dietary behavior.

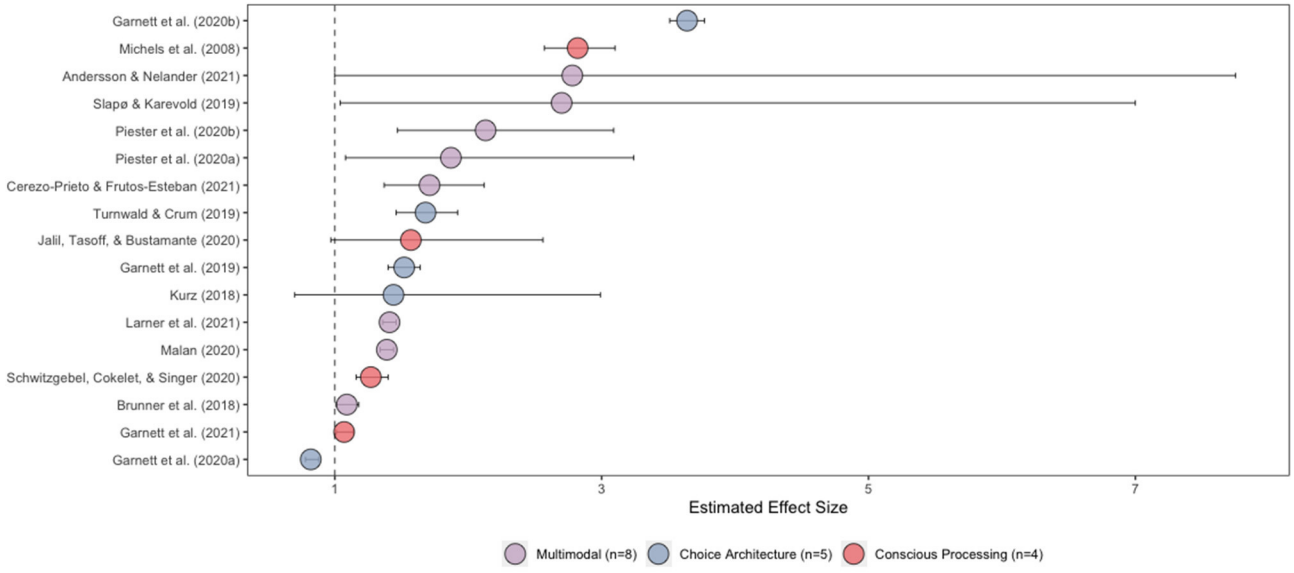

FIGURE 6
Forest plot comparing the effect estimates of the 17 studies included in the fixed effect model. Effects sizes are given as odds ratios, with error bars denoting 95% confidence intervals.

2023). In particular, there is an interest in understanding how HEIs can contribute to this larger effort by reducing the amount of meat consumed within campus environments (Ruiz-Mallén and Heras, 2020; Sherry and Tivona, 2022; Taylor et al., 2023). Despite the empirical progress that has been made over the last two decades, there has been little research to date reflecting on how useful these interventions have been in promoting voluntary changes in food choice within university settings. To address this gap in the literature, we synthesized the evidence on university-implemented meat reduction interventions to determine whether these interventions have been generally effective in promoting behavior change, and identify whether there are any relevant approach-dependent differences in intervention performance within these dining contexts. A summary of our findings and their implications

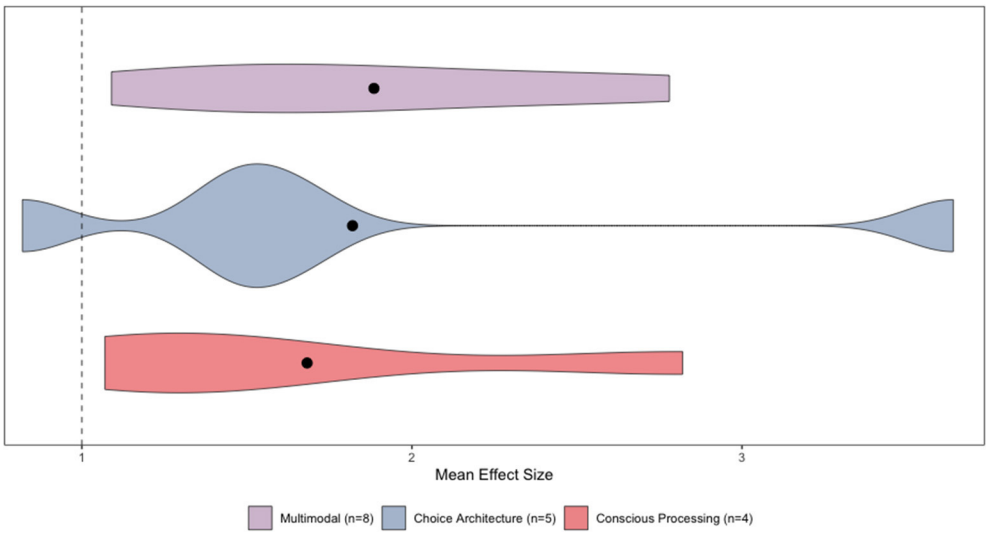

FIGURE 7
Violin plot comparing the effect size distributions of the three investigated approaches. Compared to the other two approaches, multimodal interventions had a greater overall effect on meat consumption.

for intervention design and dietary change research are given below.

4.1. Summary of main findings

In this systematic review of the university meat reduction literature, we identified and analyzed 31 dietary change interventions that had been implemented over the course of 21 years across 24 universities, nine countries, and two continents (see Figure 3). Of these interventions, over two-thirds led to significant changes in food choice (see Figure 4), lowering the overall odds of consuming meat within college and university settings by an average of 82% (see Figure 6).

Between the three approaches investigated in this systematic review (see Figure 1), multimodal interventions were found to be more reliable and effective in reducing meat consumption than interventions targeting the choice architecture of the retail environment or conscious decision-making processes alone (see Figure 7). This remained true even after controlling for the the number of individual strategies being used, indicating that these performance-related advantages were a function of more than just strategic volume. As such, from an intervention design standpoint, there may be inherent value in understanding how strategies can be integrated to exert influence on both implicit and deliberate decision-making processes.

The remaining two unimodal approaches were equally successful in reducing the amount of meat consumed within university settings (see Figure 3), though interventions exclusively targeting the choice architecture of the retail environment were found to have a greater mean effect on food choice than interventions targeting conscious decision-making alone (see Figure 7).

Over the evaluated 21-year period, there was an exponential increase in the amount of research that was conducted and published on university-implemented meat reduction interventions (see Figure 3). Despite this proliferation, time series analysis revealed no salient improvements in intervention performance over time, highlighting a possible need for more effective, setting-specific guidelines for reducing meat consumption within university settings.

Our findings on the overall success of university-implemented meat reduction interventions were largely consistent with prior research examining the value of behavior change strategies in promoting reductions in meat consumption (Bianchi et al., 2018a,b; Harguess et al., 2020; Kwasny et al., 2022; Ronto et al., 2022). However, the comparatively higher rate of success observed in this study relative to previously published reviews could be attributed to the differences in the populations being targeted by included interventions, with earlier reviews investigating the broader effects of behavior change strategies on the general population and ours focusing instead on changes in food choice among mostly young adults and adolescents, who have been found to be more receptive to plant-rich diets and dietary change interventions, more broadly (de Villiers and Faber, 2019; Hargreaves et al., 2021; Jürkenbeck et al., 2021).

Our comparisons of the three approaches investigated in this study provide an intuitive, decision-centered framework for implementing meat reduction interventions within university settings. More specifically, our study contrasts earlier work on the subject by using dual-process accounts of conditional reasoning to typify interventions based on the cognitive processes targeted by their strategies (Evans, 2011; Kahneman, 2011), rather than the various sources of influence involved in dietary decision making (i.e., intrapersonal-, interpersonal-, organizational-, community-, and policy-level factors). While socioecological perspectives

provide a useful method of conceptualizing how different contextual factors interact to influence food choice at a systems level (Robinson, 2008; Townsend and Foster, 2013), they tend to be less instructive for intervention design when the desired changes in behavior (i.e., reductions in meat consumption) are voluntary and the dining context (i.e., university cafeterias) is fixed (Schölmerich and Kawachi, 2016). The classification scheme used in this study circumvents these limitations by focusing instead on how common meat reduction strategies differentially inform decision-making processes at the individual level.

The results from our joint analysis were mostly consistent with earlier research supporting the value of integrated approaches to meat reduction (Kahn-Marshall and Gallant, 2012; Gittelsohn and Lee, 2013; Vo et al., 2019; Ramsing et al., 2021). In addition to replicating these general findings, we were also able to use our novel classification scheme to distinguish between three different types of meat reduction approaches, with multimodal interventions outperforming interventions targeting the choice architecture of the retail environment and conscious decision-making processes alone, independent of the number of strategies involved. While past research has suggested that the advantages to integrated approaches are a result of probability (Kahn-Marshall and Gallant, 2012) and focused efforts to leverage links between socioecological levels (Schölmerich and Kawachi, 2016), our findings seem to suggest an alternative explanation—that the benefits to performance are a function of both the number of strategies used and the nature of how those strategies coalesce to exert influence on relevant decision-making processes.

With respect to the remaining two approach categories, our findings on interventions targeting the choice architecture of the retail environment were consistent with prior research supporting nudging interventions as an effective way of promoting dietary change (Bucher et al., 2016; Byerly et al., 2018; Vandenbroele et al., 2020; Ensaff, 2021; Mertens et al., 2022). However, for interventions targeting conscious decision-making processes, the research has been more mixed (Worsley, 2002; Bianchi et al., 2018a; Thakur and Mathur, 2021), with some doubts being raised about the sufficiency of education-based strategies in influencing actual behavior within applied contexts (Kaur et al., 2017). Despite the salience of these concerns, we did not find evidence of this in our analyses, (see Figure 4), with interventions targeting conscious decision-making processes yielding significant changes in intention as well as behavior in 56% of cases. However, we did find that interventions targeting conscious decision-making processes did tend to perform better when they were combined with at least one other strategy.

Finally, the exponential increase reported in the number of university-implemented meat reduction interventions mirrors the increase in meat reduction interventions that have been implemented more generally over the last several decades (Kwasny et al., 2022). It is therefore unclear how much of this can be attributed to the establishment of institutional network programs, like the Association for the Advancement of Sustainability in Higher Education (AASHE) and the United Nation's Higher Education Sustainability Initiative (HESI), and how much can be attributed to increasing public concern and awareness surrounding the environmental, climate, and health implications of food (Macidarmid et al., 2016; Jürkenbeck et al., 2021). Despite the increasing awareness of the interactions between agriculture, diet, public health, and the global ecology, we found no evidence pointing to any increases in the relative performance of university-implemented meat reduction interventions over time.

4.2. Strengths and limitations

To the best of our knowledge, our study is the first to critically examine the value of university-implemented meat reduction interventions, and the first to jointly analyze the relative merits between these three approaches to dietary change. We accomplished this using a novel, theory-informed classification scheme that typifies interventions according to the decision-making processes targeted by their individual strategies, allowing us to make nuanced comparisons between interventions that consciously incentivize individuals to make more sustainable food choices, interventions that manipulate the physical environment in ways that make those choices easier, and interventions that do both simultaneously. In doing so, we were able to identify which approach was most effective in promoting dietary change within these settings while also providing supporting, evidence-based explanations highlighting the behavioral mechanisms that could be involved in driving these observed effects. In addition, our evaluations of these meat reduction approaches made use of two distinct performance-related outcomes: one focused on the capacity of interventions to generate significant reductions in meat consumption and one focused on measuring the degree to which change occurred within these university environments. By distinguishing between these outcomes, we were able to leverage the existing evidence to compare the performance of these interventions across multiple dimensions. Finally, by undertaking this exercise, we were also demonstrate how settings-based evaluation techniques can be used to meaningfully inform the design of setting-specific interventions and policies.

However, within the context of this study, we were unable to evaluate the long-term effects of university meat reduction efforts on food choice. Due to the limited duration of the included studies' evaluation periods, we were unable to assess the how long these changes in behavior persisted within these environments, and whether their persistence was at all contingent on the type of approach used. This limitation is especially salient given the existing empirical concerns surrounding the durability of nudging individuals toward healthier food options (Van Rookhuijzen et al., 2021). For the same reasons, we were also unable to evaluate whether these interventions were associated with any rebound effects resulting from psychological reactance (Osman, 2020). Furthermore, because the included studies evaluated behaviors that were specific to university environments, it is also unclear whether the benefits of implementing these types of interventions within university environment led to meaningful instances of contextual spillover (Verfuerth et al., 2021), or if they induced change across other desirable pro-environmental behaviors (Carrico, 2021). Finally, while we identified meat reduction interventions that had been implemented in universities across nine different countries, all of these countries are situated in either Europe or North America. Therefore, it remains unclear whether these findings are generalizable across other cultural contexts.

4.3. Recommendations for future research

To better account for the asymmetries in the effect sizes associated with each of the three included outcome measures, future investigations should prioritize using observational methods to track changes in dietary behaviors where possible. In addition to providing more precise approximations of changes in food choice (Webb and Sheeran, 2006; Loy et al., 2016; Meyer and Simons, 2021) and minimizing the risks of bias that stem from the so-called "intention-behavior gap," collecting observational data has the additional benefit of equipping institutional policymakers and foodservice providers with a practical means of making complementary supply-side changes based on information that is collected at the point of purchase. Furthermore, to allow for a better sense of whether the investigated approaches can lead to lasting changes in behavior, researchers should endeavor to evaluate the effects of these initiatives more frequently and over longer intervals of time. In addition to allowing investigations to be more sensitive to instances of reactance, higher monitoring frequency may also allow researchers to pick up on uninvestigated patterns in meat consumption, like those resulting from seasonality, that may inform how these types of meat reduction interventions could be more strategically timed. Furthermore, researchers could additionally use survey items to understand whether these approaches are associated with meaningful contextual spillover effects, or if they lead individuals to engage in other pro-environmental behaviors unrelated to meat consumption. Finally, the question of how generalizable these effects are across other cultural contexts and institutional settings remains unanswered. Future research should therefore investigate whether settings-based evaluation techniques may prove useful across similar dining contexts (Moore et al., 2013; Hertwig and Grüne-Yanoff, 2017), such as in hospital and workplace cafeterias, and whether these findings can be replicated in universities that stand to benefit from these interventions that are situated outside of a Western context, such as in China and Brazil.

5. Conclusions

The results from this systematic and meta-analysis provide compelling evidence in favor of university-implemented meat reduction interventions and their value in promoting dietary change within university settings. Through our comparisons of the different approaches that have been used within these environments, we were able to identify a number of strategic advantages associated with using multimodal interventions to facilitate these desired changes in food choice. Institutional stakeholders interested in engaging in these types of sustainable dining initiatives should therefore consider incorporating these design principles into future interventions. Despite the promise of these initial findings, further research is still needed to understand how long these effects endure within university environments, and whether these design principles are generalizable across other settings and cultural contexts.

Data availability statement

The datasets presented in this study can be found in the following online repositories: [link 1] and https://github.com/kenjinc/university-meat-reduction-srma/blob/main/markdowns/visuals.md.

Author contributions

KC initiated and conceptualized the project. LR designed and implemented the search strategy with assistance from KC and AW. KC and AW conducted the relevant screening procedures with assistance from DA-J and RR. KC synthesized the extracted data, conducted the relevant analyses, and drafted the manuscript. RR acquired funding for the project and provided administrative support and supervision throughout. All authors reviewed the final version of the manuscript prior to submission.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1103060/full#supplementary-material

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