REVIEW

Toward a Healthy and Environmentally Sustainable Campus Food Environment: A Scoping Review of Postsecondary Food Interventions

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ABSTRACT

Interventions are urgently needed to transform the food system and shift population eating patterns toward those consistent with human health and environmental sustainability. Postsecondary campuses offer a naturalistic setting to trial interventions to improve the health of students and provide insight into interventions that could be scaled up in other settings. However, the current state of the evidence on interventions to support healthy and environmentally sustainable eating within postsecondary settings is not well understood. A scoping review of food- and nutrition-related interventions implemented and evaluated on postsecondary campuses was conducted to determine the extent to which they integrate considerations related to human health and/or environmental sustainability, as well as to synthesize the nature and effectiveness of interventions and to identify knowledge gaps in the literature. MEDLINE (via PubMed), CINAHL, Scopus, and ERIC were searched to identify articles describing naturalistic campus food interventions published in English from January 2015 to December 2019. Data were extracted from 38 peer-reviewed articles, representing 37 unique interventions, and synthesized according to policy domains within the World Cancer Research Foundation's NOURISHING framework. Most interventions were focused on supporting human health, whereas considerations related to environmental sustainability were minimal. Interventions to support human health primarily sought to increase nutrition knowledge or to make complementary shifts in food environments, such as through nutrition labeling at point of purchase. Interventions to support environmental sustainability often focused on reducing food waste and few emphasized consumption patterns with lower environmental impacts. The implementation of integrated approaches considering the complexity and interconnectivity of human and planetary health is needed. Such approaches must go beyond the individual to alter the structural determinants that shape our food system and eating patterns. *Adv Nutr* 2021;12:1996–2022.

Keywords: healthy eating, environmental sustainability, interventions, nutrition policy, food environments, postsecondary settings, campus settings, young adults, students, scoping review

Introduction

Dietary risk factors are among the leading contributors to morbidity and mortality worldwide (1). Low intake of fruits and vegetables, nuts and seeds, and whole grains, and high intake of sodium, are the largest contributors to diet-related deaths (1). At the same time, there is growing recognition of the negative implications of current eating patterns for the environment through their connection to agricultural production, contributing to large impacts on climate change, nitrogen and phosphorous pollution, and biodiversity loss (2–4). Public health nutrition has traditionally focused on supporting eating patterns consistent with human health, for example, by ameliorating nutrient deficiencies and promoting an appropriate balance of dietary components (5). More recently, the public health nutrition paradigm has shifted toward environmentally sustainable eating patterns as a means to improve both human health and environmental sustainability (5). The UN Sustainable Development Goals (SDGs) likewise recognize the central role food and nutrition play in supporting human health and protecting the planet by prioritizing reducing hunger (SDG2) and improving health and well-being (SDG3) (6). Further, emphasizing sustainable production and consumption (SDG12) (6) will require transformation of the food system.

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The FAO broadly defines sustainable eating patterns as those with low environmental impacts that contribute to the health and food and nutrition security of future generations (7). This definition recognizes an array of interconnected determinants to support sustainable eating patterns pertaining to health and well-being; biodiversity, environment, and climate; equity and fair trade; eco-friendly, local, and seasonal foods; culture and heritage; and food and nutrient security needs (8, 9). This conceptualization was echoed in the report of the EAT–*Lancet* Commission on Healthy Diets from Sustainable Food Systems, which emphasizes policy targets to shift population eating patterns toward those that align with planetary health as a means of achieving health for all (3). Dietary guidance on healthy and environmentally sustainable eating patterns recommends appropriate caloric intake, increased variety of plant-based foods (e.g., nuts and seeds, fruits and vegetables, whole grains), reduced consumption of animal-based foods, and intake of small amounts of highly processed foods and sugars (3, 10). Evidence from modeling studies suggests cobenefits of achieving such eating patterns, including reducing rates of morbidity and mortality from chronic disease and stemming climate change and its negative implications for human health (11).

Currently, there is an unprecedented level of attention globally toward interventions to support eating patterns consistent with human and, perhaps to a lesser extent, planetary health (3, 12, 13). Public health nutrition interventions aim to promote and improve population and planetary health by improving food environments and food systems in ways that can support healthy and sustainable eating patterns (13). Policymakers are interested in understanding the effectiveness of these interventions, evaluated in a variety of settings (14), to inform the allocation of resources to policies and programs. To encourage policy action, the World Cancer Research Fund developed the NOURISHING framework to highlight policy actions needed to promote healthy eating (13). NOURISHING consists of 10 key policy areas within the 3 domains of *1*) modifications to the Food Environment ("NOURIS"), such as economic measures to address food affordability and nutrition labeling standards and regulations; *2*) harnessing the Food System and supply chain ("H"), such as food waste management interventions and supply-chain incentives for production; and *3*) Behavior Change Communication ("ING"), such as media awareness campaigns and nutrition education in work and school settings (13). Although environmental sustainability was not explicitly addressed when NOURISHING was developed in 2013, the framework highlights interventions that may simultaneously support human and planetary health. For example, supply-chain incentives may support food production systems that contribute to improved dietary quality and lower greenhouse gas emissions (15). Similarly, food-based dietary guidelines can provide guidance on shifting to healthy eating patterns that reduce greenhouse gas emissions and water and land use (16, 17). NOURISHING also aligns with the SDGs by supporting health and well-being (SDG3), emphasizing education (SDG4), and contributing to sustainable consumption and production patterns (SDG12). Overall, NOURISHING and other approaches call for a suite of integrated policy interventions to transform the food system and support a shift in eating patterns to optimize human and planetary health (18).

Public and private institutions hold financial power and capacity to support food system transformation (19, 20). In particular, postsecondary institutions offer unique consumer food environments with a variety of campus eateries and offerings, multiple suppliers and other stakeholders, and, often, contracts with multinational corporations (21–23). Such institutions are well-positioned to implement and evaluate a range of interventions to support healthy and environmentally sustainable eating patterns within naturalistic settings (24–26) and to provide insights into interventions that can potentially be scaled up and adapted to other settings. For example, quasi-experimental studies within postsecondary settings allow for real-world evaluations of interventions in which food and beverage selection may be affected by an array of external factors, with application to a range of other settings. Evidence suggests increasing commitment and action among postsecondary institutions to improve the health of their campus communities and reduce their impacts on the planet through food and nutrition (27–31). Recognizing that campuses represent a microcosm of food environments, they can provide a testing ground for "whole-of-systems" approaches to address the complex interconnections among issues related to health and environmental sustainability (32–34). Simultaneously, such approaches can benefit campus communities, particularly students, recognizing that young adulthood is a critical period for establishing eating patterns that may track into later life (35–37).

Prior reviews have synthesized literature on interventions intended to promote healthy eating within postsecondary settings (38, 39). Such reviews have evaluated changes to the availability of nutrition information (e.g., point-of-purchase nutrition labeling) and the affordability and accessibility of particular foods (e.g., fiscal measures) as potentially effective strategies to support healthy eating (38, 39). Reviews focused on food sustainability interventions within postsecondary settings have also been conducted, but have largely focused on sustainability education (40–44). A recent review of governance documents synthesized approaches to supporting sustainable food systems across universities in Australia and New Zealand, demonstrating the capacity of campuses to leverage a "whole-of-systems" approach by implementing strategies beyond education to promote sustainability (45). To date, syntheses of the existing evidence have considered approaches to promote health and sustainability in isolation, but have not considered to what extent a range of interventions are designed to jointly support eating patterns consistent with both human health and environmental sustainability.

To address this gap, we conducted a scoping review to explore the state of evidence on food- and nutrition-related

interventions implemented and evaluated in postsecondary settings. Our objectives were to *1*) determine the extent to which each of health and environmental sustainability were considered, including whether they were addressed in tandem within the same interventions; *2*) synthesize the nature and effectiveness of these interventions; and *3*) identify gaps in the peer-reviewed evidence on interventions to support healthy and sustainable eating patterns on postsecondary campuses.

Methods

Scoping reviews are an iterative approach for determining the coverage and range of literature on a topic (46–48) and are an increasingly common approach to characterize evidence on emerging topics (49). A scoping review was appropriate to synthesize the available evidence on campus interventions that aim to support healthy and environmentally sustainable eating patterns, as well as to identify evidence gaps. Based on prior reviews (38, 39), we anticipated the included interventions and corresponding outcomes would vary and, therefore, a systematic review or meta-analysis focused on specific research outcomes was not appropriate (49).

Similarly to systematic reviews, scoping reviews use systematic searching and screening techniques for transparency and reproducibility. This review draws upon steps outlined in Arksey and O'Malley's (50) framework for scoping reviews. Reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines (51), which identify essential items to be reported.

Evidence acquisition

The search strategy was developed in consultation with 2 research librarians with expertise in searching public health and environmental sciences literature. Research databases relevant to health (MEDLINE via PubMed, CINAHL), environmental sciences (Scopus), and education (ERIC) were searched. Relevant keywords and controlled subject headings (e.g., Medical Subject Headings in MEDLINE) were identified to capture interventions that aimed to address outcomes related to healthy and environmentally sustainable eating patterns within the postsecondary context. The final search strategy (**Supplemental Table 1**) for all databases consisted of keywords and subject headings related to core concepts relevant to the research questions, including food and nutrition; environmental sustainability; interventions; and postsecondary campuses. The search strategy was piloted in MEDLINE to ensure relevant articles were retrieved, and subsequently modified to fit the search parameters of the other databases (e.g., appropriate controlled subject headings were used for each database). The search was limited to January 2015–December 2019. This time frame was defined based on a preliminary search that suggested interventions with a focus on environmental sustainability have become more common since 2015, which coincides with the release of the SDGs (6) and the growing emphasis on environmental sustainability within the nutrition literature (3, 5).

Articles published in English in peer-reviewed journals were considered eligible for inclusion if they met the following criteria: *1*) the article included a description of the implementation and evaluation of an intervention, defined as an organized effort to promote healthy and/or environmentally sustainable eating patterns (52); *2*) the intervention was implemented in a naturalistic environment within a postsecondary setting (13); and *3*) there was a specific focus on supporting healthy and/or environmentally sustainable eating patterns. Studies included may have evaluated outcomes by measuring dietary intake or antecedent factors that influence eating patterns, such as knowledge, skills, and purchasing. The NOURISHING framework was used to inform the universe of interventions considered as well as the synthesis, although the NOURISHING domains are broad, as described above, allowing consideration of a range of intervention types. Given the potential overlap between the Food Environment and Food System policy domains (53), Food Environment interventions were characterized as those aiming to alter the physical campus environment (e.g., labeling in dining halls) and Food System interventions as those that aimed to alter the food supply chain across multiple campus eateries (e.g., changes to waste management systems, campus gardens supplying multiple eateries, fair-trade initiatives) (54). Articles considering interventions focused on other aspects of the food system (e.g., food safety), food-related conditions or behaviors (e.g., disordered eating), or a combination of health behaviors (e.g., healthy eating and physical activity) were excluded.

The records identified through the searches were managed using RefWorks and Covidence, an online Cochrane-recommended tool for supporting reviews (55), and screened according to the inclusion and exclusion criteria. After removing duplicates, 3 study authors (KML, Y-SC, and TEW) screened 100 articles based on titles and abstracts, reaching 81% (KML and Y-SC) and 92% agreement (KML and TEW) on inclusion and exclusion decisions, respectively. Discrepancies were resolved and the inclusion and exclusion criteria clarified. Upon screening a second set of 100 articles based on titles and abstracts, 93% and 92% agreement was reached, respectively. The remaining articles were independently screened by Y-SC and TEW and 95% agreement was reached. Discrepancies were resolved through an independent screen by KML or discussion with the study team.

After review of all titles and abstracts, all full texts were reviewed independently by Y-SC and TEW against the inclusion and exclusion criteria, with 98% agreement. Discrepancies during both stages of screening were resolved by discussing reasons for inclusion or exclusion among the reviewers. Reference lists of eligible articles were also searched for relevant articles. Cohen's κ values were not calculated to express interrater reliability because of a skewed distribution due to a higher number of articles being

excluded than included, as described by Cohen's paradox (56, 57).

Evidence synthesis

A data extraction spreadsheet was developed to capture the location and setting, sample population and size, study objectives, details of the interventions, evaluation design and outcomes, measures, key findings regarding effectiveness, authors' interpretations, and funding sources. Data extraction was conducted by 1 study author (KML), with verification by 1 additional author (Y-SC or TEW). Interventions were characterized according to the NOURISHING Framework, based on the domain that most closely aligned (13). Interventions were also categorized as focused on human health, environmental sustainability, or both. Although an intervention promoting healthy eating could potentially also be considered to promote environmentally sustainable eating patterns, we examined the explicit framing of the intervention within the article and whether there was attention paid to the implications of eating patterns for greenhouse gas emissions, water use, food waste, or other aspects related specifically to environmental sustainability. Other aspects of healthy and sustainable eating patterns, such as social and economic sustainability, were not considered. As is common in scoping reviews, a risk of bias assessment was not performed (50). However, we drew upon limitations and potential biases highlighted by the authors of the included studies to identify potential gaps within the literature and recommendations for future research.

Extracted data were qualitatively synthesized to *1*) characterize the nature of the literature on interventions; *2*) compare and contrast the effectiveness of interventions implemented on postsecondary campuses and their impacts; *3*) interpret implications for supporting healthy and environmentally sustainable eating patterns; and *4*) identify evidence gaps.

Results

Overview

Figure 1 presents the results of the search and study selection process. The initial search yielded 4276 articles, 218 of which were identified as potentially relevant after removing duplicates and screening titles and abstracts. The most frequent reason for exclusion was because the intervention or outcomes were not relevant to the research question. After full-text screening, 37 records met the inclusion criteria and 1 additional record was identified based on the reference lists of the included records. In total, 38 records were included in the review, representing 37 unique intervention studies: 29 interventions were focused on human health, 8 focused on environmental sustainability, and no interventions mutually considered both.

A consistent number of articles were published by year between 2015 and 2017 (~6–7 articles each year), with an increase in 2018 (n = 12) and a decrease in studies published in 2019 (n = 6), potentially indicating growing but varied interest in evaluations of food interventions in postsecondary settings. Although interventions primarily focused on supporting human health, there was an increase in the number of interventions targeting environmental sustainability starting in 2017. Of the 37 unique interventions, 21 were implemented in the United States, 5 were carried out in Canada, 6 in Europe (3 in England, 1 in Belgium, 1 in Germany, and 1 in Portugal), 3 in South America (Peru, Colombia, and Brazil), and 2 in Australia. In terms of postsecondary context, 22 interventions were implemented in foodservice settings (e.g., cafeterias, dining halls, restaurants), 1 was implemented at an on-campus grocery store, 4 interventions were related to vending machines, 7 were campus-wide (e.g., nutrition education program), and 4 were online. Twelve articles were supported by funds from the respective university or college. One article noted funding from the American Dairy Association-Mideast and aimed to increase milk consumption from vending machines using choice architecture (58). For 9 articles, there was no funding source whereas, for another 7, funding disclosures were not included. The funding source for 1 article was unclear (i.e., the authors indicated they did not receive financial support; however, the methods indicated funding was used to support the intervention).

Table 1 demonstrates the 37 interventions categorized by the NOURISHING Framework policy domains and their focus on human health or environmental sustainability. Most interventions utilized strategies in the Food Environment (n = 15) or Behavior Change Communication domains (n = 9). Only 1 intervention explicitly targeted the Food System domain by evaluating the impact of a food waste composting system. Approximately one-third of interventions (n = 12) used strategies from multiple NOURISHING domains. The following sections report on the study designs and observed effectiveness of interventions.

Interventions considering human health

Of the 37 interventions considered, 29 were aimed at supporting human health (**Table 2**). Of these, 14 fit into the Food Environment domain and 7 fit into the Behavior Change Communication domain, whereas there were no interventions in the Food System domain. The remaining 8 interventions utilized strategies from >1 NOURISHING domain. Most evaluations of the interventions considered outcomes related to changes in consumption patterns or improvements in knowledge and understanding of nutrition. The duration of the study periods was generally relatively limited, ranging from 1 wk to 5 mo, as summarized in Table 2. Three interventions used sales data representing a period of ~2 y. Although sales data do not shed light on individual changes in intake, the data are indicative of purchasing behaviors over a long period of time and can help identify potential trade-offs, such as positive health and sustainability outcomes compared with changes in revenue.

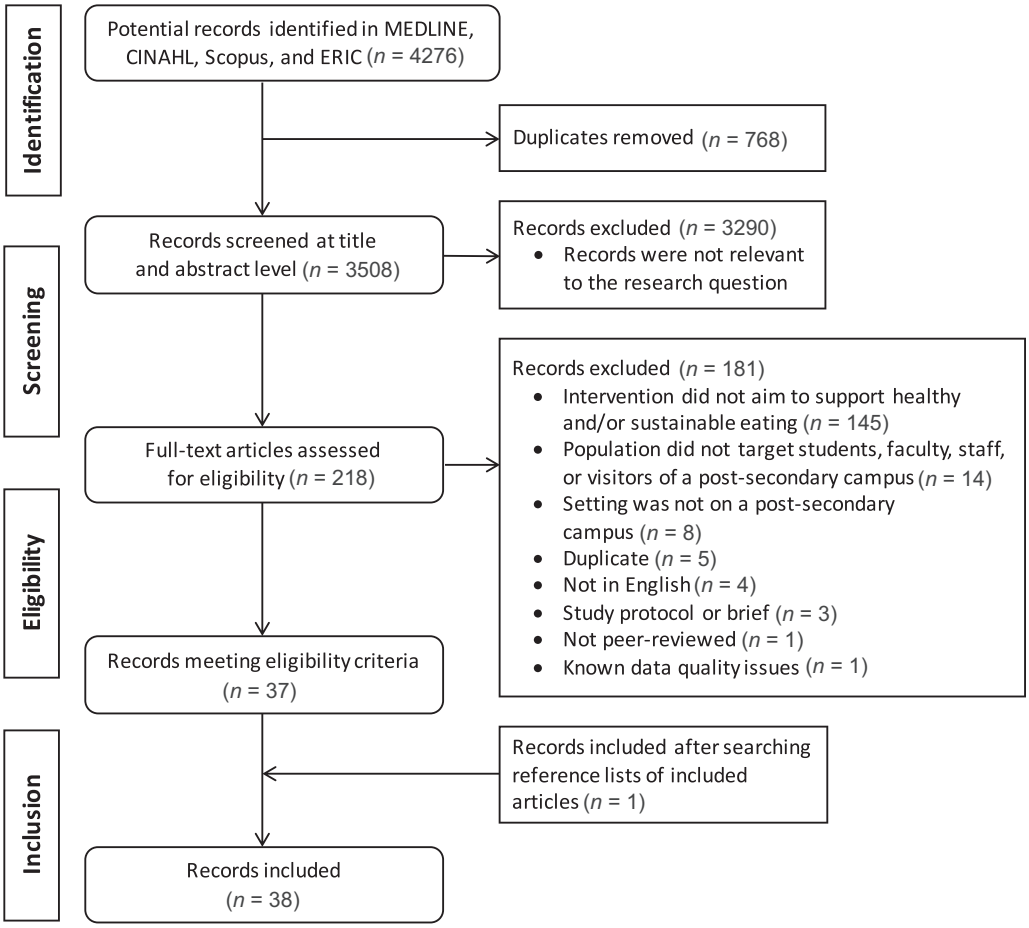

Figure 1 PRISMA flow chart illustrating the search and screening process to identify food interventions implemented on post-secondary campuses.

Food Environment domain.

Fourteen interventions aimed to manipulate the food environment by implementing nutrition labeling ($n = 6$ interventions described in 7 articles) (59–65, 67, 68), setting standards for healthy food offerings ($n = 4$) (58, 66, 67, 68), using economic tools to address food affordability ($n = 1$) (69), or utilizing a combination of food environment strategies (e.g., nutrition labeling and fiscal measures) ($n = 3$) (70–72).

Across nutrition labeling interventions ($n = 6$), outcomes were generally evaluated using surveys to determine label noticing, use, and preferences among consumers and sales data to measure changes in the quality of purchases (e.g., change in mean calories purchased). Overall, nutrition labeling was found to increase consumption of healthy foods (e.g., fruits and vegetables), while also showing decreases in the energy and fat content of foods ordered. Three interventions displayed nutrition information numerically in dining halls (59–62). Christoph and Ellison (60) found that a greater proportion of respondents who used the labels selected fruits, vegetables, and beans, and fewer selected potatoes and French fries, than non–label users. Similarly, Cioffi *et al.* (61) found that nutrition labels led to significant decreases in the energy and fat content of purchases. Hammond *et al.* (62) observed that numeric calorie labels led to a significant decrease in calories ordered and consumed. Labels that use symbols to present nutrition information at a glance were also evaluated. Policastro *et al.* (63) implemented a sandwich order form that indicated healthy ingredients using a star symbol and observed an increase in selection of healthy ingredients and decreased selection of less healthy ingredients. After a mandatory nationwide implementation of the Health Star Rating policy on postsecondary campuses in Australia, Shi *et al.* (64) observed an increase in healthy snacks and beverages offered in vending machines compared with data from 3 y before implementation. A labeling campaign that provided point-of-purchase health messages by Sogari *et al.* (65) found that messages about vitamins and fiber led to a higher proportion of individuals choosing whole-grain pasta than in the condition with no messages.

Interventions that set standards for food offerings used choice architecture strategies, such as relocating healthy options to high-traffic areas ($n = 3$) and changing portion sizes

TABLE 1 Categorizations of included interventions based on the NOURISHING framework[1]

	Food environment						Food system	Behavior change communication		
	N	O	U	R	I	S	H	I	N	G
Authors	Nutrition label standards and regulations on the use of claims/implied claims on food	Offer healthy food and set standards in public institutions and other specific settings	Use economic tools to address food affordability and purchase incentives	Restrict food advertising and other forms of commercial promotion	Improve nutritional quality of the whole food supply	Set incentives and rules to create a healthy retail and food service environment	Harness food supply chain and actions across sectors to ensure coherence with health	Inform people about food and nutrition through public awareness	Nutrition advice and counselling in health care settings	Giving nutrition education and skills
Interventions considering human health ($n = 29$)										
Aboul-Enein and Bernstein (73)										•
Bernardo *et al.* (74)										•
Bevet *et al.* (66)		•								
Biden *et al.* (70)	•		•							
Cárdenas *et al.* (71)		•	•							
Christoph *et al.* (59); Christoph and Ellison[2] (60)	•									
Cioffi *et al.* (61)	•									
Deliens *et al.* (69)			•							
Dingman *et al.* (75)	•							•		
Hammond *et al.* (62)	•									
Hua *et al.* (76)		•	•					•		
Mistura *et al.* (77)		•						•		
Mora-García *et al.* (78)	•							•		
O'Brien and Palfai (79)										•
Policastro *et al.* (63)	•									
Rodgers *et al.* (80)										•
Rose *et al.* (58)		•								
Roy *et al.* (81)	•							•		
Schroeter *et al.* (82)										•
Scourboutakos *et al.* (83)	•							•		
Seward *et al.* (72)	•	•								
Shi *et al.* (64)	•									
Sogari *et al.* (65)	•									
Tallant (84)										•
Valdez *et al.* (85)										•
Vermote *et al.* (67)		•								
Vermote *et al.* (86)	•							•		
Viana *et al.* (87)	•	•	•					•		
Walmsley *et al.* (68)		•								

(*Continued*)

TABLE 1 (*Continued*)

	Food environment						Food system	Behavior change communication		
	N	O	U	R	I	S	H	I	N	G
Authors	Nutrition label standards and regulations on the use of claims/implied claims on food	Offer healthy food and set standards in public institutions and other specific settings	Use economic tools to address food affordability and purchase incentives	Restrict food advertising and other forms of commercial promotion	Improve nutritional quality of the whole food supply	Set incentives and rules to create a healthy retail and food service environment	Harness food supply chain and actions across sectors to ensure coherence with health	Inform people about food and nutrition through public awareness	Nutrition advice and counselling in health care settings	Giving nutrition education and skills
Interventions considering environmental sustainability (*n* = 8)										
Ahmed *et al.* (88)					•			•		•
Duram and Williams (89)		•					•			
Godfrey and Feng (90)	•							•		
Lorenz-Walther *et al.* (91)		•						•		
Monroe *et al.* (92)										•
Mu *et al.* (93)							•			
Pinto *et al.* (94)								•		
Rajbhandari-Thapa *et al.* (95)		•								

[1] *n* = 37 interventions across 38 records.

[2] Different outcomes from the same intervention were presented in 2 separate articles.

This material has been reproduced from the World Cancer Research Fund International NOURISHING framework https://www.wcrf.org/int/policy/policy-databases/nourishing-framework.

(*n* = 1). Such interventions were evaluated by monitoring changes in sales of foods and beverages (e.g., daily total quantity sold) or using survey data to determine consumer preferences. Evaluations of these interventions yielded mixed evidence on effectiveness (58, 66, 68). Walmsley *et al.* (68) relocated fruits and vegetables to the front of the on-campus grocery store and observed an initial significant increase in the percentage of total sales for fruits and vegetables immediately, but the effect was not sustained over a 5-y period. Bevet *et al.* (66) observed an increase in purchases of vegetable-heavy entrées when they were placed at the start of the self-serve line. Rose *et al.* (58) observed no changes in milk and calcium intake after implementation of vending machines with milk cartons in high-traffic areas of a residence building. Vermote *et al.* (67) reduced portion sizes for French fries, finding a reduction in consumption, with no differences in reported satiety and caloric intake, despite mixed consumer perceptions about the intervention.

One intervention used economic tools to address food affordability. Deliens *et al.* (69) increased the price of French fries and reduced the price of fruit and observed a reduction in sales of French fries and an increase in fruit sales during each of the 1-wk intervention periods.

Several interventions utilized a combination of strategies within the Food Environment domain. Interventions that used financial incentives (70, 71) showed an increase in healthy foods sold. Biden *et al.* (70) implemented an interpretive label using a checkmark to indicate healthy options and a reward card program to incentivize fruit and milk purchases. The authors found that healthy items were sold more often, were made less expensive by the food service operating on campus, and appeared more frequently on menus than less healthy items. Cárdenas *et al.* (71) observed a significant increase in fruit sales when phasing in a variety of strategies, including repositioning of fruits to cash registers, implementing posters indicating the health benefits of fruit and vegetable consumption, and lowering the price of fruit by 33%. Seward *et al.* (72) implemented traffic light labeling to indicate healthy options in a residence cafeteria and repositioned healthy foods and beverages to be more accessible. Interviews and surveys revealed that participants wanted nutrition labels and thought the intervention was helpful; however, there were no significant changes in the proportions of red, amber, and green labeled items sold.

Behavior Change Communication domain.

Seven interventions utilized strategies within the Behavior Change Communication policy domain to support healthy eating patterns. Four were primarily evaluated for impact on dietary intake using dietary assessments, including dietary recalls (79, 82, 84) and Food Frequency Questionnaires (80). In 1 study, the impact of the intervention was evaluated based on blood samples to assess changes in cholesterol and glucose (85). Two articles measured changes in behavior using

TABLE 2 Overview of characteristics and key findings of food interventions considering human health in postsecondary campus settings[1]

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Aboul-Enein and Bernstein (73)	Houston, TX, USA	Online	Students; enrolled in undergraduate online nutrition course ($n = 65$)	Online nutrition course about the Mediterranean diet (incorporated assigned readings, article reviews, recipe analysis, weekly discussion forums, asynchronous presentations, writing assignments, exams)	1 semester (~4 mo)	Pretest, posttest experiment (no control)	Survey: perceived quality and value of Mediterranean diet (Mediterranean Diet Quality Index—16-item questionnaire index; score range 0–12, where ≤3 is low, 4–7 is medium, and ≥8 is high)	Compared with scores before the intervention, participants viewed the Mediterranean dietary pattern more positively and demonstrated an increase in understanding of the pattern	Not stated
Bernardo *et al.* (74)	Brazil	University campus	Students ($n = 82$; 41 in intervention and 41 in control)	Cooking class intervention (5 weekly 3-h hands-on cooking sessions) and food selection and purchasing workshop. Sessions included cooking demonstrations, discussions about nutrition, hands-on food preparation, and group meals. Session was conducted in groups of 10–12 students, divided into 2–3 students/bench.	6 wk	Randomized control trial with follow-up at 6 mo	Sample characteristics: demographics, cooking characteristics (e.g., self-reported knowledge, cooking experience, and location). Outcomes related to cooking skills and healthy eating practices using a questionnaire tested for validity: *1*) accessibility and availability of fruits and vegetables at home; *2*) cooking attitudes; *3*) cooking behaviors at home; *4*) cooking behaviors away from home; *5*) produce consumption self-efficacy; *6*) self-efficacy for using basic cooking techniques; *7*) self-efficacy for using fruits, vegetables, and seasonings (while cooking); and *8*) knowledge of cooking terms and techniques.	Survey responses demonstrated an increase in cooking confidence and self-reported knowledge of cooking terms after the intervention. Participants increased the availability of fruits and vegetables at home after the intervention. Effects were sustained at the 6-mo follow-up	Federal Agency for Support and Evaluation of Graduate Education in Brazil; Human Resources Development Program; National Council for Scientific and Technological Development
Bevet *et al.* (66)	Burlington, VT, USA	Cafeteria (buffet-style)	Students ($n = 681$ in pretest; $n = 128$ late-at-night)	Choice architecture 1: vegetable-heavy entrées added to beginning of self-serve line.Choice architecture 2: healthy choices snack bar added to salad bar (e.g., hummus, popcorn, trail mix, yogurt, precut fruit).	~3 wk	Pretest, posttest quasi-experiment (no control)	Pre-survey (to identify preferences for food options among diners at different eating occasions): preference for foods, sociodemographics. At-late-night survey: health score, food choices, satisfaction. Tallied number of students who took food from each intervention station.	Between 54% and 69% of students incorporated a vegetable-heavy entrée into their dining session throughout the week. Significant increase in purchases from the healthy choices snack bar.	University of Vermont Dean of Students Office

(*Continued*)

TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Biden *et al.* (70)	London, Ontario, Canada	Residence cafeterias	Sales from cafeterias. Students were surveyed to provide context to findings (n = 1476).	Point-of-purchase labels using a checkmark indicator based on multinutrient "FRESH" criteria. Those not meeting criteria were classified as non–FRESH approved. FRESH Reward Card program provided students with 1 free fruit/milk after 9 purchases of whole fruit/milk.	~2 y for intervention period	Pretest, posttest ecological study	Sales outcomes: number of items sold, number of fruit and milk items sold, net sales, number of free fruit or milk items redeemed, annual cost of free fruit items redeemed calculated by taking the mean cost of the fruits with the highest sales quantities.	Healthy items were sold more often and made less expensive by the food operating service. Healthy items also appeared more frequently on menus than less healthy items	Authors had no funding to report
Cárdenas *et al.* (71)	Lima, Peru	Cafeteria	Sales from cafeterias (~150 students/d). Students for semistructured interviews (n = 12)	Repositioned fruit next to point of purchase with a sign that said, "Consuming five fruits and vegetables per day prevents many illnesses - World Health Organization" with price per item of fruit. Poster was also placed at entrance of cafeteria. Follow-up intervention where price of fruit was reduced by 33%.	13 wk; 3 wk per intervention period	Pretest, posttest experiment with 2 intervention phases (no control)	Outcomes (collected by salesperson): number of pieces of fruit sold each day; number of full meals sold; fruit ratio of total fruit purchased to total meals sold in the same day. Visible information about each consumer was also collected (e.g., sex, student vs. nonstudent adults). Qualitative interviews: perceptions of marketing strategies of fruit, demographic questions, reasons for purchasing or not purchasing fruit, noticed reduction in price.	Fruit purchasing significantly doubled from phase 1 (repositioning of fruits) to phase 3 (added 33% reduction). There were no differences in fruit sold between the other phases.	National Heart, Lung, and Blood Institute; NIH; US Department of Health and Human Services; Fogarty International Center
Christoph and Ellison (60)	Midwestern USA	Dining hall	Students (n = 1069)	Nutrition label items (with dish title, serving size, number of calories, and grams of fat, carbohydrates, and protein)	~16 wk; data collected at weeks 8 and 12	Cross-sectional	Survey: gender, age, college classification, height, weight, self-perceived eating habits, exercise frequency, enrollment in college-level nutrition courses, and nutrition label use. Dietary intake coding (using pre- and postmeal photographs): coded selection, type, servings, and consumption according to the US Department of Agriculture's MyPlate food categories.	When compared with non–label users, a greater proportion of label users selected fruits, vegetables, and beans. Fewer label users selected fried foods, foods with added sugars, potatoes, and refined grains than nonusers.	US Department of Agriculture; National Institute of Food and Agriculture

(*Continued*)

TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Christoph *et al.* (59)	Midwestern USA	Dining hall	Students ($n = 2729$)	Nutrition label items (with dish title, serving size, number of calories, and grams of fat, carbohydrates, and protein) placed directly in front of food	∼16 wk; data collected at weeks 8 and 12	Cross-sectional (3 waves)	Survey: nutrition label provision, awareness, and use; behavior characteristics (sleep, exercise, food habits); and specific topics (e.g., what types of information the diner would prefer to see, reasons for label nonuse, frequency of dining services mobile application). Sociodemographic variables (age, sex, year in university) and anthropometric variables (height and weight, weight intention) were collected for correlates.	Nutrition label placement did not influence nutrition label awareness.	US Department of Agriculture; National Institute of Food and Agriculture
Cioffi *et al.* (61)	Ithaca, NY, USA	Dining hall	Sales from dining halls	Nutrition labeling on prepackaged food purchases	∼2 y; 1 y for pre- and posttest periods, respectively	Pretest, posttest experiment (no control)	Mean calories purchased per week, sales patterns, change in high- vs. low-calorie and high- vs. low-fat foods.	Food labels led to a 7% reduction of mean total calories purchased per week. Total fat for purchased foods also demonstrated a 7% reduction among labeled foods.	Division of Nutritional Sciences, Cornell University
Deliens *et al.* (69)	Brussels, Belgium	On-campus restaurant	Students for French fries experiment ($n = 2930$ during control week; 2344 during week 1 and 2325 during week 2). Students for fruit experiment ($n = 3235$ during control week; 3802 during week 1 and 3728 during week 2). Students for interviews ($n = 230$ for French fry experiment; $n = 227$ for fruit experiment)	Price increases on French fries by 10% and 20%. Price reductions on fruit purchases by 10% and 20%. Posters and information boards to communicate the price adjustments	5 wk; 1 wk per intervention period	Pretest, posttest quasi-experimental study and qualitative interviews	Data collected at register: student status, chosen menus, whether French fries or fruit was chosen, sex of the student. Interviews: demographics (gender, age, residency, study discipline, height, weight), food choice and whether price manipulation influenced their choice, asked if price adjustment would change their consumption in the long run, asked if they believed it was a good initiative to support healthy eating.	Increasing the price of French fries by 10% and 20% led to a 10.9% and 21.8% reduction in purchases, respectively. Decreasing the price of fruit by 10% and 20% led to a 25.1% and 42.2% increase in fruit purchases, respectively.	Authors had no funding to report

(*Continued*)

TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Dingman *et al.* (75)	North Carolina, USA	Vending machines in residence halls	Vending machines (sales data for $n = 18$ machines; 9 intervention and 9 control sites). Students ($n = 670$).	Poster boards adjacent to each vending machine, listing Nutrition Facts Panel for each product in the vending machine. Five products that met nutrition criteria were highlighted (<200 kcal, ≤2 g saturated fat, 0 g *trans* fat, ≤7 g sugar, 300 mg Na) and labeled as "Better Choice" snacks with an interpretive label. Criteria and promotional messages were described on posters and emails.	8 wk; 4 wk for pre- and posttest periods, respectively	Pretest, posttest, 2 × 2 experimental design	Sales data: the mean calories sold per snack, and the proportion of snacks that contained fewer calories and less saturated fat, sugar, and sodium than the usual snacks (i.e., Better Choice snacks). Used sex and year of schooling as covariates in models.	Compared with the 4-wk pretest period, there were no significant differences in calories sold.	Not stated
Hammond *et al.* (62)	Ontario, Canada	Residence cafeterias	Students ($n = 159$)	Numeric calorie labels	2 wk; 1 wk for pre- and posttest periods, respectively	Pretest, posttest naturalistic cohort	Demographic information: sex, race, self-reported health status, BMI, weight perceptions and aspirations. Exit surveys: noticing information, what types of information, when they saw it, use of information, calories ordered and consumed.	Compared with the pretest period, calorie labels led to significant increases in noticing and use of nutrition information to guide food purchases. The calorie content of foods purchased and estimated amount of calories consumed decreased after the intervention.	Canadian Cancer Society Research Institute; Canadian Institutes of Health Research

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TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Hua *et al.* (76)	New Haven, CT, USA	Vending machines	Vending machines ($n = 56$)	Improved availability of healthier snacks (using "FitPick" criteria of ≤250 kcal, ≤20 g sugar, ≤230 mg Na, ≤10 g fat, ≤3 g saturated fat, and no *trans* fat). Water and other beverages (≤25 kcal/237 mL) were classified as healthy. Reduced price for healthy items by 25%. Water reduced price to $1. 3. Promotional signage to indicate price change and labels to indicate healthy items. Signs promoted water consumption.	5 mo	2 × 2 × 2 balanced factorial experiment	Sales and revenue data: total number of units sold and total revenue, stratified by type of vending machine (i.e., snacks or beverages).	The interaction between improving the availability of healthier options and promotional signage increased revenue of healthier snacks. Price reductions alone did not affect consumer choice. The interaction of all 3 interventions did not increase purchasing of healthier snacks. Compared with the pretest period, there was an overall increase in healthier snack purchasing across all intervention machines.	None to report
Mistura *et al.* (77)	Victoria, British Columbia, Canada	Residence cafeterias	Students for surveys ($n = 340$)	Improved availability and appearance of vegetables. Poster at eye level to indicate vegetable option and with a character/message.	∼11 wk; 3 wk per intervention phase	Pretest, posttest quasi-experiment (no control)	Tallied number of students observed purchasing a vegetable option compared with the total count of students that purchased from the hot table. Counts were recorded by sex.	Compared with the 2-wk pretest period, there was no change in the mean number of vegetables purchased.	British Columbia Ministry of Health
Mora-García *et al.* (78)	Bogota, Colombia	Cafeteria	Consumers ($n = 228$ for control; $n = 257$ for intervention)	Randomly informed people about the existence of the front-of-package Nutri-Score labeling system.	4 wk	Pretest, posttest randomized controlled trial	Receipts: products bought, price of product. Survey: anthropometric and demographic characteristics, using the system, physical activity measurements.	The intervention led to an increase in total expenditure of $0.18. Spending on healthier items was 21% or $0.26 higher than purchases made during the pretest period, with no change for less healthy items. Compared with those in the control, customers were 10% more likely to buy healthier items.	Apoyo de Proyectos Interdisciplinarios de Investigación

(*Continued*)

TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
O'Brien and Palfai (79)	Northeastern USA	Online	Students ($n = 148$; $n = 49$ for control group, $n = 50$ in web-only group; $n = 49$ in web and mobile group)	Online nutrition course (on-screen, open-response prompts, writing task, personalized feedback on healthy eating) only. Online nutrition course intervention and daily messages for behavior planning.	4 wk	Pretest, posttest randomized controlled trial	Dietary habits survey: vegetable and fruit consumption (three 7-d recall items). Healthy food choices: how often students selected university-sponsored healthy items (Sargent Choice selection).	Compared with the control group and the group that received the online nutrition course, those who received the online course and daily messaging demonstrated a significant increase in the likelihood of improving vegetable consumption and were 3 times more likely to meet dietary guideline standards. However, the intervention did not significantly change fruit consumption.	Not stated
Policastro *et al.* (63)	NJ, USA	Dining hall (take-out line)	Students ($n = 9765$)	Modified sandwich order form where healthier ingredients were listed first within each category, printed in bold and larger font, and designated with a star symbol.	8 d of data collection over 8-wk study period	Pretest, posttest experiment (no control)	Participants' choice of ingredients and measures for calories, fat, sodium, and fiber for each order.	When compared with orders using the unmodified sandwich order form, the modified form led to an increase in selection of healthier ingredients and decreased selection of less healthy ingredients.	None to report
Rodgers *et al.* (80)	Northeastern USA	Online	Students ($n = 43$)	Online intervention which included taking photographs of every meal and text messages to encourage healthy eating (3 times/d at mealtimes).	10 wk; 3 wk for intervention period	Pretest, posttest experiment (no control)	Demographic survey: age, year in school, housing status, weight and height using scale to calculate BMI. Food Frequency Questionnaire: fruit and vegetable intake. Beverage Intake Questionnaire: caloric intake from sugar-sweetened beverages. Drive for Thinness (subscale from Eating Disorder Inventory): 7 items, such as preoccupation with thinness.	There was a significant increase in fruit and vegetable consumption among those in a higher BMI category. There were no significant changes in vegetable consumption and a decrease in fruit consumption was observed among those in a lower BMI category.	None to report

(*Continued*)

TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Rose *et al.* (58)	Columbus, OH, USA	Vending machines (campus dorms)	Students ($n = 128$)	Vending machines with milk installed in high-traffic areas and near other vending machines.	2 mo	Pretest, posttest experiment (no control)	Healthy Habits Survey: vending purchasing habits, motivators and barriers to consuming calcium-rich foods. Calcium consumption questionnaire: assessed calcium and milk intake from foods and beverages.	No changes in milk and calcium intake.	American Dairy Association-Mideast
Roy *et al.* (81)	Australia	Food outlet	Students ($n = 713$)	Calorie labeling placed adjacent to items on menus and contextual statement. Social marketing campaign with comprehensive website/interactive calculators, advertising slides for digital screens, and banners. Dietitians were also available during lunch hours and stood next to banners.	10 wk; 5 wk/intervention	Pretest, posttest experiment (no control)	Sales data: change in itemized food sales data (also compared with the same weeks during the same period the year prior). Intercept interviews: customer attitudes, awareness of knowledge, and use.	There were no differences in sales between the calorie labeling with social marketing campaign and calorie labeling alone. Of participants, 30% were aware of the calorie labels on the menus and 75% were accepting of the labeling intervention after they were made aware of the changes. Participants selected meals with lower mean calories after the social marketing intervention, despite most participants claiming that the campaign would not influence their food and beverage purchases.	None to report; corresponding author received Australian Government, Department of Education support
Schroeter *et al.* (82)	USA	University campus	Students ($n = 57$; $n = 18$ for control group; $n = 8$ for incentive and education group; $n = 31$ for education group)	Four-week educational session on 5 food groups outlined in US Department of Agriculture's MyPlate, including 1-h lessons with 3–4 quiz questions, interactive style, and with tailored personalized suggestions at the end of the lessons. Education and incentive if Healthy Eating Index score was improved by 5%.	6 wk; 4 wk for intervention	Pretest, posttest randomized controlled trial	Survey: demographics, media behavior (self-rated), nutrition knowledge (self-rated), health behavior, and dietary recalls using the Automated Self-Administered 24-Hour Dietary Assessment Tool.	Dietary quality scores increased by 15% among those who received either intervention, whereas the control group increased by 8%.	Cornell Center for Behavioral Economics in Child Nutrition; California Polytechnic State University College of Agriculture, Food, and Environmental Sciences

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TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Scourboutakos *et al.* (83)	Toronto, Ontario, Canada	Residence cafeteria (buffet style)	Students ($n = 368$–510)	Education campaigns for beverages and fruits and vegetables (e.g., healthy eating plate infographic). Physical activity calorie equivalent labeling for sugar-sweetened beverages.	5 mo; 2 mo for pretest and 3 mo for intervention period	Pretest, posttest quasi-experiment (no control)	Beverage choices and fruit and vegetable choices.	The proportion of students who purchased fruit significantly increased from 30% to 36%. The proportion of students who purchased sugar-sweetened beverages significantly decreased from 49% to 41%.	Cancer Care Ontario; Canadian Institutes of Health Research; University of Toronto
Seward *et al.* (72)	Cambridge, MA, USA	Residence cafeterias	Students ($n = 1329$)	Traffic light labeling and healthy-plate stickers. Healthy foods and beverages moved to high-traffic and accessible areas.	13 wk; 6 wk for pretest and 7 wk for intervention period	Pretest, posttest quasi-experiment (no control)	Cafeteria servings: change in proportions of red, yellow, and green items (overall and by subgroups of food categories). Online surveys: how and whether students used the nutrition information to guide choices and whether they wanted to have nutritional labels/what information should be on those labels.	Of postintervention students who noticed the traffic-light labels, 59% thought they were helpful and 73% said that they should continue to be used after the study. No significant changes in proportions of red-, amber-, and green-labeled items sold.	Harvard College Museum of Comparative Zoology; National Heart, Lung, and Blood Institute
Shi *et al.* (64)	Australia	University campus	Vending machines ($n = 60$ across 7 campuses; $n = 27$ snack machines, $n = 33$ beverage machines, $n = 11$ with both)	Health Star Rating (voluntary front-of-package labeling system; ranging from half a star to 5 stars where more stars indicate a healthier choice).	Not applicable	Cross-sectional	Audits: name, weight, volume of items; promotions. Nutritional quality: energy, positive nutrients, risk nutrients.	Compared with preimplementation data ~3 y prior, there was an increase in the proportion of snacks and beverages rated 3.5 stars or higher offered in the vending machines.	None to report
Sogari *et al.* (65)	USA	Dining hall	Consumers ($n = 3734$)	Messages about the nutritional benefits for whole-grain pastas.	18 d over 9-wk study period	Pretest, posttest quasi-experiment	Number of diners who selected whole-grain pasta vs. other types of pasta.	Compared with the nonmessage condition, messages about vitamin benefits demonstrated a 7.4% increase in the probability of selecting whole-grain pastas.	European Union's Horizon 2020 Research and Innovation Programme

(*Continued*)

TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Tallant (84)	USA	University campus	Students ($n = 33$)	Nutrition education course focused on self-efficacy, nutrition behavior skill-building, and nutrients and lifestyle behaviors. Lecture on food labels was also provided.	16 wk	Pretest, posttest quasi-experiment	Survey: food label use; healthy food choices; modified survey instrument from the United States Department of Agriculture Diet and Health Knowledge survey measuring perceptions on diet adequacy, nutrition knowledge, nutrition self-efficacy, and perceptions for a peer nutrition education component. Dietary self-assessment. Scores for food label reading.	Compared with the pretest period, the intervention led to a significant increase in food label–reading behavior and food choice behavior. Of students, 27% practiced food label reading more frequently at the posttest period and 29% indicated choosing healthier options more frequently.	Not stated
Valdez *et al.* (85)	Tuscan, AZ, USA	University campus	Students ($n = 10$)	Experiential learning course: value of whole foods plant-based diet (and nutrition) for chronic conditions, provided meals.	10 d	Pretest, posttest quasi-experiment using mixed methods	Qualitative questionnaire: perspectives on whole foods plant-based diets. Blood samples for cholesterol and glucose.	The intervention improved participant understanding of how plant-based diets can affect chronic disease. Compared with the pretest period, there was an observed mean change in total cholesterol of −26 mg/dL, HDL cholesterol of −6.1 mg/dL, and LDL cholesterol of −21.6 mg/dL.	Authors stated that they did not receive financial support; however, the article stated that grant funding was secured to cover the costs of meals
Vermote *et al.* (67)	Brussels, Belgium	On-campus restaurant	Students ($n = 2056$ at pretest; $n = 2175$ at posttest). Students and employees for interviews and dietary recall ($n = 296$).	Reduced portion sizes for French fries (∼20%)	1 wk	Pretest, posttest quasi-experiment	Consumption and plate waste. Interviews: satiety and caloric intake; food recall for meal, side, dessert, and beverage; sociodemographics. Noticing of portion sizes and estimates for how much and if portion size was sufficient.	Reduced portion size was effective in reducing consumption and plate waste, with no differences in satiety and caloric intake. Mixed consumer perceptions regarding portion size changes.	Not stated
Vermote *et al.* (86)	Brussels, Belgium	On-campus restaurant	Students ($n = 556$)	Food labeling (interpretive) at point of purchase and information campaign (posters).	35 wk; interventions were phased in ranging from 1 to 23 wk in duration	Pretest, posttest quasi-experiment using mixed methods	Sales data: amount sold for desserts. Interviews: demographics, visibility of intervention, influence and use, feasibility for long-term use.	Compared with the pretest period, there was a significant increase in fruit purchasing. The effect was sustained over a 35-wk study period.	Not stated

(*Continued*)

TABLE 2 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Viana *et al.* (87)	Los Angeles, CA, USA	Vending machines	Vending machines ($n = 3$). Consumers ($n = 100$).	Information campaign using Healthy Campus Initiative label (included web address for more nutritional information). Interpretive labeling for healthy products. Healthy products were grouped at eye level.	2 mo	Pretest, posttest quasi-experiment	Sales reports: revenue, profit, number of total products sold, and healthier products sold. Survey: demographics, typical frequency of vending machine purchasing.	Compared with the pretest period, intervention machines demonstrated an increase in profits of healthier items. Revenue was not compromised after the intervention.	Not stated
Walmsley *et al.* (68)	Coventry, England	On-campus grocery store	Not applicable	Moving fruits and vegetables from the back of the store to the front and moving beverages.	5 y; 2 y per intervention period	Pretest, posttest experiment (no control)	Sales data: daily total quantity sold for each product, description, price, profit, barcode, unit size, and food category.	The rearrangement of the shop led to an increase in the percentage of total fruit and vegetable sales. There was a decline in sales of fruits and vegetables over a 5-y period.	None to report; corresponding authors supported by University of Warwick; National Institute of Health Research

[1] $n = 29$ interventions across 30 records.

questionnaires and scoring indexes specifically developed for evaluating the intervention (73, 74).

Three interventions were provided online, using strategies such as online educational modules, messaging with personalized feedback, and self-monitoring strategies (73, 79, 80). Aboul-Enein and Bernstein (73) implemented an online nutrition course on the Mediterranean dietary pattern and found that participants viewed the dietary pattern more positively and demonstrated an increase in knowledge of it afterward. O'Brien and Palfai (79) implemented an online nutrition course and messaging intervention, and observed higher vegetable consumption and no difference in fruit consumption among participants when compared with those who received no intervention and those who only received the nutrition course. In an evaluation of a text-messaging and self-monitoring intervention implemented by Rodgers *et al.* (80), there was an increase in fruit and vegetable consumption observed among those in a higher BMI category. The intervention did not significantly change vegetable consumption and decreased fruit consumption among those in a lower BMI category.

The remaining 4 Behavior Change Communication interventions were in-person courses with a focus on improving self-efficacy and understanding of nutrition knowledge (74, 82, 84, 85). All utilized survey measures to evaluate the impact of the interventions on attitudes toward healthy eating behaviors (e.g., self-efficacy to cook with fruits or vegetables) or knowledge (e.g., understanding impact on chronic disease risk). Bernardo *et al.* (74) implemented a cooking class and observed an increase in cooking confidence and self-reported knowledge of cooking terms after the intervention, as well as an increase in the availability and accessibility of fruits and vegetables. These effects were also demonstrated at a 6-mo follow-up. Schroeter *et al.* (82) implemented an educational session on the US Dietary Guidelines MyPlate, with 1 intervention group receiving education and a financial incentive, a second intervention group receiving only education, and a control group receiving no intervention. Dietary quality scores, measured using the US Healthy Eating Index, increased by 15% among those in the intervention groups, whereas scores in the control group increased by 8%. An intervention by Valdez *et al.* (85) that aimed to improve knowledge of a whole foods plant-based diet found participants improved their understanding of the impact of nutrition on chronic health conditions. Similarly, Tallant (84) observed a significant increase in label use after an intervention on food label reading. Participants also indicated choosing healthier food options more frequently after the intervention.

Combination of domains.

Eight interventions incorporated both the Food Environment and Behavior Change Communication domains. Sales data and survey measures were used across interventions to evaluate the impacts on food and beverage selections.

Five interventions used point-of-purchase nutrition labeling, with awareness campaigns to teach consumers how to use the labels (75, 78, 81, 83, 86). Across the 5 interventions, findings on the impact of nutrition labels and education were mixed. Vermote *et al.* (86) found a significant increase in fruit purchases and the effect was sustained in a campus restaurant. Scourboutakos *et al.* (83) observed an increase in fruit purchases, as well as a decrease in the proportion of students purchasing sugar-sweetened beverages, after calorie labeling. Hua *et al.* (76) randomly assigned a range of strategies to different vending machines across campus, including improving the availability and prices of healthy options and promotional signage to signal the changes. The combination of improving availability of healthy products and implementing promotional signs led to increases in revenue for healthier snacks, whereas price reductions alone did not change purchasing. Viana *et al.* (87) also focused on vending machines and combined nutrition labeling and choice architecture strategies with an information campaign. The authors observed increased profits from healthier items with no compromise in revenue when compared with the previous year. In contrast, Dingman *et al.* (75) observed no change in purchasing after implementing Nutrition Facts panels, interpretive labels to highlight healthy options, and promotional signage in vending machines in residence dining halls. Mistura *et al.* (77) increased the availability of vegetable options and displayed promotional signage to indicate the added options, observing no change in the mean number of vegetable servings purchased when compared with the 2-wk baseline period.

Interventions considering environmental sustainability

Eight interventions focused on supporting environmentally sustainable eating patterns (**Table 3**). One intervention fit into the Food Environment domain, 1 aligned with the Food System domain, 2 fit into the Behavior Change Communication domain, and 4 used strategies from a combination of NOURISHING domains. A variety of outcomes were measured across domains, including food waste, consumer perceptions of the intervention, and changes in eating patterns. Intervention periods were typically short-term, ranging from 1 to 6 wk in duration.

Food Environment domain.

In an intervention by Rajbhandari-Thapa *et al.* (95), trays were removed from a dining hall to encourage consumers to minimize plate waste by reducing portion sizes. The authors observed that students in the intervention dining hall self-selected fewer servings of lunch entrée items and drinks than in the control. Further, in cafeterias without the trays, food waste appeared to be reduced, based on less food left over.

Food System domain.

Mu *et al.* (93) implemented a composting system, a strategy considered to align with the Food System domain by supporting the food supply chain, to collect food and other organic waste across a campus. Using life cycle assessments to measure the environmental impact, the food waste composting system performed well for several environmental indicators (e.g., lower greenhouse gas emissions, smog formation, fossil fuel use, eutrophication) when compared with a landfill waste system.

Behavior Change Communication domain.

An intervention by Pinto *et al.* (94) incorporated an education awareness campaign aimed at reducing food waste. Compared with the pretest period, a reduction in plate waste of ∼15% was observed. The awareness campaign was initially well-received, but participants' interest declined as the intervention continued. Further, the authors observed initial collaboration to reduce food waste by staff but collaboration declined during busy mealtime hours.

An online intervention by Monroe *et al.* (92) aimed to educate participants about "green eating" behaviors, such as eating local, reducing waste, and reducing consumption of red meats. Using a scoring index to evaluate intention to engage in environmentally sustainable eating behaviors (e.g., shopping locally), the authors found an improvement in scores (indicative of more sustainable behaviors) from baseline in the intervention group when compared with the control.

Combination of domains.

One intervention by Duram and Williams (89) used strategies aligning with the Food Environment and Food System domains by implementing a campus garden as a means to support food service procurement and ingredient use. The authors documented the experience of implementing a student-led campus garden over 3 y and highlighted the potential for student initiatives to engage in the food system and the local food movement.

Three interventions used strategies from the Food Environment and Behavior Change Communication domains and showed mixed results. Ahmed *et al.* (88) implemented changes to food service standards (e.g., reduced portion sizes and providing smaller serving tools) and a messaging campaign led by students to raise awareness about food waste. A 17% reduction in total food waste was observed; however, this reduction was not statistically significant. Students reported the intervention made them think more about food waste and supported campus-wide efforts to address food waste through composting. Lorenz-Walther *et al.* (91) reduced portion sizes of meat entrées to minimize food waste over several data collection phases, with an educational campaign on food waste implemented during the final 6-wk period. The authors observed a small, but significant, decrease in food consumption and waste after the intervention. Further, those who indicated the informational campaign influenced their decisions to eat all the food on their plate had less leftovers than those who indicated the campaign did not influence their decisions. Finally, Godfrey and Feng (90) categorized and labeled foods in a dining hall according to small, medium, and large

TABLE 3 Overview of characteristics and key findings of food interventions considering environmental sustainability in postsecondary campus settings[1]

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Ahmed *et al.* (88)	Bozeman, MO, USA (Montana State University)	Dining hall	Students ($n = 249$ for survey)	Reduced portion size of all entrées by at least one-quarter. Serving utensils were replaced by smaller tongs, spoons, and ladles (leading to multiple scoops being required to serve the same amount of food). Messaging campaign to raise awareness on food waste; posters demonstrated strategies to reduce waste (e.g., mindful portion sizes, coming back for seconds, exploring all food options in the dining hall). Teach students to develop, implement, and evaluate a food waste intervention.	3 wk	Pretest, posttest experiment (no control)	Food waste measurements: weighted food and nonfood waste for 3 d pre- and post-intervention. Plate waste measurement: visual estimates of amount of food waste on scale of 1–4 (less than one-quarter to more than three-quarters of the plate) and frequency of food item wasted. Survey (intercept technique): 5 questions on diner attitudes toward food waste. Participant reflections by research team: evaluating effectiveness of experiential learning project (focused more on teaching pedagogy; therefore, not included in data charting).	Although not statistically significant, the intervention demonstrated a 17% reduction in total food waste. Participants self-reported that the intervention made them think more about food waste and supported campus-wide efforts to address food waste through composting. Students reported that they would feel more concerned about food waste if the efforts allowed them to save money.	National Institute of General Medical Sciences of the NIH; Montana State University's Campus Sustainability Council and Montana Institute on Ecosystems
Duram and Williams (89)	Carbondale, IL, USA	University campus	Students ($n = 9$)	Campus garden (led by students) to promote sustainability education; later helped to supply campus dining halls and campus farmer's markets.	3-y evaluation	Case study using mixed methods (interviews, budget analysis)	Qualitative assessment of growth of garden and future recommendations.	Campus gardens were driven by student leadership and were committed to projects that aimed to improve campus food systems. Process of implementing the campus garden was documented.	Southern Illinois University (Green Fund)
Godfrey and Feng (90)	Calgary, Alberta, Canada	Dining hall	Students for interviews ($n = 10$). Students for pre- and posttest survey ($n = 32$).	Communication campaign on water footprints. Foods were categorized into easy-to-understand posters and labels to identify small, medium, and large water footprints. Low-water-footprint meals were recommended in the second week.	3 wk	Pretest, posttest experiment (no control) using mixed methods	Production reports and sales report: behavior change (i.e., increase in proportion of low-water-footprint meals sold). price, lifestyle image, and food appearance; measure of belief; emotional response to using water footprint information). Interviews: food choices, how students perceived concepts of environmentally sustainable food and food choices, reactions and interpretations of water footprint signage.	Interviews demonstrated that students perceived environmentally sustainable foods as providing greater health benefits. Students also indicated that they opt for convenience over choosing environmentally sustainable foods. Compared with the pre-intervention period, there were no significant changes in consumption after the intervention.	Canadian Social Sciences and Humanities Research Council; University of Calgary Students Union Sustainability Fund

(*Continued*)

TABLE 3 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Lorenz-Walther *et al.* (91)	Germany	Canteen	Consumers ($n = 503$ at pretest; 377 at posttest)	Posters to raise awareness of food waste and provided strategies on how to avoid food waste (e.g., reminder to only take so much food and to choose more side dishes, invitation to ask for a smaller portion of a dish). Reduce portion size: for meat entrées, portion sizes were reduced from 140 g to 120 g or smaller scoops were used for sauces that contained meat (decreased from 100 g to 83 g sauce).	30 wk; one 6-wk period for pretest and five 6-wk periods for posttest	Pretest, posttest quasi-experiment	Survey: cognitive attitude toward finishing food, perceived behavioral control over having plate leftovers, perceived subjective norms in finishing all food, portion size ratings, taste ratings. Plate leftovers (observed by videotaping of returned trays): leftovers were visually estimated.	Compared with the pretest period, there was a small decrease in food consumption and waste. Participants who indicated the informational campaign influenced their decisions to eat all the food on their plate had less leftovers than those who indicated that the campaign did not influence their decisions.	German Federal Ministry of Education and Research
Monroe *et al.* (92)	Northeastern USA	Online	Students for intervention group ($n = 241$ at pretest; $n = 187$ at posttest). Students for control group ($n = 367$ at pretest; $n = 304$ at posttest).	Four modules (1/wk) with topics on green eating behaviors, eating local, reducing waste, choosing environmentally friendly proteins. Modules included information displayed in text, pictures, and video clips, and included interactive questions/quizzes.	5 wk	Pretest, posttest randomized controlled trial	Survey: "green eating" behavior scale (6 items related to pro-environmental food choices, shopping at farmer's markets, organic/fair-trade foods, meals without antibiotics or hormones, and frequency of purchasing meat or poultry labeled free range; decisional balance; self-efficacy at home and school; stage of change; knowledge assessment; readiness to change behavior based on module variables; confidence, relevance, attention, and satisfaction with program).	Compared with the pretest period, scores for "green eating" behavior increased among those who received the intervention.	University of Rhode Island

(*Continued*)

TABLE 3 (*Continued*)

Authors	Location	Setting	Sample size	Intervention	Duration	Study design	Outcomes and measures	Summary of findings	Funding
Mu *et al.* (93)	Union, NJ, NY, USA	University campus	None	Food waste composting system (in-vessel composting technology).	Not applicable	Cross-sectional	Plant growth, life cycle assessment (environmental impact), cost–benefit analysis.	The food waste composting system lowered greenhouse gas emissions, smog formation, fossil fuel use, and eutrophication when compared with a landfill waste system.	Kean University
Pinto *et al.* (94)	Lisbon, Portugal	Cafeteria	Cafeteria (∼240 students/d)	Posters about food waste. Students were trained to provide information on how to reduce plate waste and the social impact of food waste.	4 wk; 10 d for pre- and posttest periods, respectively	Pretest, posttest ecologic study (no control)	Inorganic and organic waste from trays. Plate waste based on mean serving size. Monetary loss assessment. Waste consumption index to calculate amount of consumption and per capita waste consumption.	Compared with the pretest period, there was a ∼15% reduction in plate waste during the intervention. The information campaign was initially well-received by staff and students; however, interest in food waste declined as the intervention continued.	European Union Horizon 2020 research
Rajbhandari-Thapa *et al.* (95)	Southern USA	Dining halls	Students ($n = 3153$; $n = 1564$ in control group and $n = 1589$ in intervention group)	Removed trays to encourage reduced portions.	1 wk	Pretest, posttest quasi-experiment (with control)	Number of lunch entrée servings; number of drink servings; number of salad servings; number of dessert servings; number of lunch entrées, salads, and dessert servings with at least one-quarter left over; and number of lunch entrée servings with at least one-quarter left over.	Compared with the control group, students in the dining hall without trays self-selected fewer servings of lunch entrée and drink items. Cafeterias without trays demonstrated fewer servings with leftovers.	None to report

[1] $n = 8$ interventions across 8 records.

water footprint. Data from interviews demonstrated students connected environmentally sustainable foods with health benefits; however, students often made trade-offs between choosing sustainable foods and convenience. Consumption patterns did not change significantly as a result of the intervention.

Discussion

Postsecondary campuses are uniquely positioned to demonstrate leadership by committing to actions that support health and environmental sustainability and offering real-world experimental settings in which to evaluate interventions to improve population and planetary health. This review examined 37 food interventions, described in 38 articles. A majority of the interventions focused on supporting human health, whereas fewer were focused on environmental sustainability and no interventions explicitly addressed both. This is perhaps not surprising given the relatively novel focus on supporting eating patterns that are healthy and environmentally sustainable (3, 5, 16), although the implications of the food system and our eating patterns for the planet have long been recognized (96). More recently, the SDGs have helped to focus attention on the importance of integrated thinking regarding human health and environmental sustainability. The findings of this scoping review indicate there is substantial progress to be made in terms of addressing calls for integrated interventions to protect human and planetary health (3, 97–99).

Among interventions solely focused on supporting human health, the intervention types were concentrated in the Food Environment and Behavior Change Communication domains of the NOURISHING framework, with none aligning with the Food System domain. Similar to a prior review of postsecondary food interventions focused on healthy eating (100), a majority of food environment interventions consisted of nutrition labeling at the point of purchase, typically using interpretive symbols (e.g., checkmark, star rating system) to indicate healthier options. Consistent with existing reviews on point-of-purchase nutrition labeling, we found mixed evidence on the effectiveness of labels in supporting healthy eating patterns (101–107) given differences in observed outcomes and data collection instruments. Interventions utilizing choice architecture strategies also demonstrated mixed effectiveness when implemented alone; however, some interventions demonstrated the potential of choice architecture strategies when paired with other strategies such as nutrition labeling (71, 87). Interventions using economic tools, such as price changes or reward programs, demonstrated significant increases in purchases of targeted foods and beverages (e.g., fruit, milk) and decreases in purchases of less healthy foods (e.g., French fries) (70, 71, 69). A small number of evaluations of such interventions were identified, although a large body of literature supports the salience of pricing to food purchasing decisions (108–111). Findings from the included Behavior Change Communication interventions demonstrated effectiveness in improving knowledge; however, changes to behavior were minimal, aligning with suggestions for multiple intervention strategies that include modifications to the food environment rather than education alone (112). The fact that some interventions incorporated a combination of strategies is promising given evidence suggesting that using multiple interventions increases the potential to support healthy eating patterns (112). However, our findings align with prior reviews indicating room for growth in terms of "whole-of-systems" approaches (45).

Interventions related to environmental sustainability were often implemented and evaluated with the intention of reducing food waste whereas a focus on altering dietary intake, such as increasing plant-based proteins and reducing red meat, was minimal. This finding echoes a recent review by Grech *et al.* (45), suggesting that environmental sustainability strategies primarily prioritized sustainable waste management and prevention. Food waste interventions used strategies aligning with the Food Environment and Behavior Change Communication domains, such as reducing portion sizes of meals and implementing awareness campaigns to minimize plate waste. The emphasis on food waste is unsurprising given the growing body of literature demonstrating that consumers perceive minimizing food waste and packaging as having the greatest impact on reducing the environmental footprint of eating patterns (113–115), despite evidence that interventions targeting the production phase show the greatest potential to reduce the overall environmental impact of food service operations (116). Most interventions focused on food waste used labeling or educational campaigns and although survey responses to the interventions indicated increases in awareness, there was little to no long-term reduction in food waste (88, 90, 91, 94). Although the literature on food waste interventions is emerging, interventions that incorporated Food Environment strategies (e.g., reducing portion sizes) demonstrated potential to reduce food waste (88, 91). This finding aligns with literature focused on human health that suggests interventions that modify food environments are needed to change behavior (112).

This review did not find any interventions that jointly considered human and planetary health, demonstrating that nutrition and environmental sustainability are being addressed in isolation. Notably, interventions utilizing strategies from the Food Environment (e.g., nudges) and Behavior Change Communication (e.g., education) domains, which were the predominant intervention types included, are likely insufficient on their own to support a transition toward healthy and sustainable eating patterns (117). Strategies that utilize a systems lens (118, 119), ideally targeting multiple domains in a joined-up manner, are needed for the joint promotion of health and environmental sustainability. Several authors drew parallels between healthy and environmentally sustainable eating patterns when interpreting their findings (67, 88, 89, 91–93, 95). For example, in an article describing a food waste reduction intervention, Ahmed *et al.* (88) highlighted the detrimental consequences of food waste on water and land usage, as well as the potential nutrient loss

from wasted food, with implications for human nutrition. Similarly, Vermote *et al.* (67) focused on reducing portion sizes from a health perspective, but noted the potential for reducing greenhouse gas emissions by minimizing waste. These interpretations suggest growing interest in understanding the potential cobenefits and trade-offs of interventions for health and environmental sustainability. Relatedly, the need for research that measures compensatory food behaviors was identified (63, 67, 86, 91, 95). For example, several articles describing interventions that aimed to reduce food waste speculated whether consumers may have responded to the intervention by consuming their entire portion (i.e., increasing caloric intake) rather than reducing their self-served portion sizes (91, 95).

Most interventions were evaluated using a quasi-experimental design and collected pre- and posttest data with no comparison to a control group. There is a need for trials with control groups to address confounders, allowing for stronger inferences about an intervention's effectiveness (120, 121). In addition, most interventions were of limited duration and had short follow-up periods, echoing prior reviews demonstrating a paucity of evidence on the long-term impacts of interventions (38, 39). Limitations were also noted in the extent of outcomes studied and the strategies used to measure them. Many evaluations were based on self-reported consumer perceptions of the interventions and aggregate sales data (e.g., change in sales of fruits). Appropriately evaluating interventions to support healthy and environmentally sustainable eating patterns will require expanded data collection tools and analytic methods that can measure implications for both. There is a growing body of evidence that uses a combination of diet quality indexes (122, 123) and data on the environmental sustainability of foods (10, 124–126), for example, drawing upon life cycle assessment (10, 126). Life cycle assessment incorporates consideration of the full food supply chain by addressing whether an intervention that creates positive health and environmental outcomes at the food consumption stage may have negative health and environmental impacts at other parts of the supply chain.

Work to consider how interventions affect the healthfulness and sustainability of the food system and eating patterns, as well as trade-offs between human and planetary health, is made complex by the multidimensionality of healthy and environmentally sustainable eating. Further work is needed to delineate which aspects are most relevant to measure and how best to measure them (127). Systematic approaches to evaluation could contribute to a more comparable body of literature: for example, using tools from implementation science to evaluate the impact of interventions on similar outcomes in a variety of settings (128). Further, only 1 article (89) described a process evaluation of an intervention. Process evaluations provide insight into the implementation of interventions (129, 130) and are valuable for understanding whether the intervention was implemented as intended and how it interacted with contextual factors, such as student engagement and other interventions in place. Given the variation in the interventions included in this review and the call for multistrategy approaches, process evaluations can provide campus stakeholders with an understanding of how to design and implement interventions that are best tailored to their context. Relatedly, several articles demonstrated the value of students and food service operators being involved in the implementation and evaluation of interventions (88, 89, 94), speaking to the need for collaborative partnerships among students, faculty, staff, and campus stakeholders. Of note, no studies provided information on the structure of their campus food service operations (e.g., food delivered by food service chains compared with self-operated); such information would be valuable for further understanding influences on the types and impacts of interventions conducted and evaluated in postsecondary settings.

This review was limited to peer-reviewed literature and excluded gray literature, likely missing recent efforts on campuses that have not yet been published, as well as those potentially undertaken by campus stakeholders such as food services without the involvement of academic researchers. University food service operations are increasingly committing to initiatives such as the Association for the Advancement of Sustainability in Higher Education and Menus of Change (131, 132), potentially indicative of an increasing amount of activity related to actions promoting health and sustainability in campus settings. Associated internal reports may include information not considered in this review about how campuses are attempting to improve human health and environmental sustainability. Given the lack of peer-reviewed literature identified on interventions that jointly addressed health and sustainability, examining the gray literature is an important next step. In addition, future systematic reviews could focus on the impacts of specific intervention types (e.g., economic tools) by limiting inclusion to study designs that support inferences about causality (e.g., experimental studies with pre- and posttest periods and control groups). However, systems-informed approaches that consider interactions among interventions are also needed.

The findings of this review may be affected by publication bias, with articles that show null effects not appearing in the published literature. As well, the potential for author bias when interpreting the literature is inherent to scoping reviews. However, we aimed to maintain objectivity and transparency in our synthesis and reporting by using a consistent data extraction strategy for each article and conducting independent validation of the extraction by a second reviewer (50).

In conclusion, existing peer-reviewed evidence suggests interventions to support both healthy and environmentally sustainable eating patterns within postsecondary contexts are currently limited and there is a greater emphasis on human health than on environmental sustainability. Interventions that aim to modify cues within the food environment either in isolation or in combination with other strategies demonstrate the greatest potential in effectively supporting human health and environmental sustainability. Specifically,

interventions utilizing economic tools, such as price adjustments, show potential in improving dietary intake but are understudied within the literature. Further, interventions that focused on environmental sustainability primarily focused on food waste, suggesting an opportunity to integrate interventions from other domains within the NOURISHING framework in "whole-of-systems" approaches. Clear operational definitions and robust and standardized measures of healthy and environmentally sustainable eating will be valuable for measuring progress toward global targets for human and planetary health.

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