

COMPREHENSIVE REVIEW

Interventions based on sensory-hedonic strategies and on nudging to facilitate vegetable and pulses consumption in the school environment

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Abstract

Childhood and adolescence shape lifelong taste preferences and dietary habits, making them crucial periods for promoting healthy and sustainable eating. As students consume up to half of their daily energy intake at school, school interventions can have a significant impact on promoting plant-based diets. Although the benefits of promoting plant-based diets on children's and adolescents' health and environmental sustainability are well established and various studies report promising effects of interventions based on sensory-hedonic strategies and on nudging in promoting vegetables and pulses in schools, a comprehensive collection of those reports is lacking. Therefore, this systematic review aims to collect published literature on the above interventions in schools that focus on promoting the consumption of vegetables and pulses to children and adolescents. Three databases—PubMed, Scopus, and Web of Science—were searched over all years until March 2022 using pre-specified terms. From the 10,488 studies identified, a total of 57 studies reporting sensory-hedonic (e.g., manipulating food sensory properties or their hedonic value) or nudging (e.g., changing the presentation) interventions targeting children and/or adolescents in schools and aiming at promoting vegetables and/or pulses were included. Overall, interventions based on sensory-hedonic strategies (either enhancing the perception of well-accepted flavor and texture or manipulating their hedonic value) and on nudging (through incentives and prompts) are effective in promoting vegetables and pulses. A gap in the literature was identified for interventions targeting adolescents and pro-

Abbreviations: FAO, Food and Agriculture Organization; FD, Food Dudes; NCDs, Non-communicable diseases; WHO, World Health Organization.

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moting pulses. Finally, multicomponent interventions, rather than using one strategy alone, could be more successful.

KEYWORDS

health, nudges, nutrition, school, sensory strategies, sustainability

1 | INTRODUCTION

1.1 | The shift toward sustainable diets

Childhood and adolescence are crucial to support healthy and sustainable eating as lifelong taste preferences and dietary habits are shaped during these periods (Larson et al., 2008). All children have the right to a healthy diet and a sustainable environment. Among the factors accounting for climate change and environmental degradation are today's diets. They contribute to the perpetuation of a food production system that drives the climate and biodiversity crises and reinforces social inequalities (FAO et al., 2021; Tilman & Clark, 2014).

Because of these environmental concerns but also considering all other direct health benefits, the transition toward more sustainable diets, which are characterized by alternative sources of proteins, is at the center of 21st-century research (FAO et al., 2021). The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) define these diets as “*dietary patterns that promote all dimensions of individuals' health and well-being; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable*” (WHO & FAO, 2019). More specifically, the EAT-Lancet Commission report describes plant-forward diets, as diets comprising a greater proportion of vegetables, fruits, legumes, whole grains, and nuts (Willett et al., 2019).

Recognizing the importance of a holistic approach to a sustainable food system, the European Commission has launched a proposal for a legislative Framework for Sustainable Food Systems (European Commission, 2022), aiming at making this transition faster and easier. To facilitate this transition, a better understanding of how eating habits are established is needed. Results from a European survey revealed that consumers are becoming more willing to shift to more sustainable eating, but factors such as price, lack of information, limited availability, and difficulty identifying sustainable foods are perceived as barriers to this shift (BEUC, 2020). Moreover, consumers are also becoming more aware of the health benefits of the change to sustainable eating. For example, prospective cohort studies have found associations between the consumption

of plant-based foods, mainly legumes, beans, bread, cereals, pasta, and nuts, with a lower risk for all-cause mortality (Song et al., 2016b), lower risk of type 2 diabetes, cardiovascular diseases, hypertension, metabolic syndrome, and obesity (Dinu et al., 2017; Kim et al., 2019; Satija et al., 2016, 2017; Yokoyama et al., 2014). On top of that, a global modeling analysis found that replacing animal-source foods with plant-based ones was effective in both, reducing premature mortality by 22% and reducing the environmental impact (e.g., greenhouse gas emissions, nitrogen applications, etc.) (Springmann et al., 2018). As not all plant-based diets are equally healthy and environmentally sustainable, emphasis should be given to those diets rich in vegetables, legumes, whole grains, fruits, and nuts, instead of those rich in refined grains and added sugars (Musicus et al., 2022). Therefore, the promotion of healthy plant-based diets is a strategy not only to help the reduction of environmental degradation and climate change but also to improve the population's health and reduce the burden of non-communicable diseases (NCDs) (Clark et al., 2019). This is important as the consequences of the growing burden of obesity, and in particular of childhood obesity, together with the diet-related NCDs, are expected to result in high costs not only for the individuals but also for the society as a whole (EAT and UNICEF, 2020).

1.2 | The formation of children's dietary habits

The importance of tackling childhood obesity is also highlighted by the fact that obesity tends to persist into adulthood and children and adolescents living with obesity have higher risks of adult obesity and mortality (Engeland et al., 2004). Among the drivers of childhood obesity are unhealthy eating patterns (IARC Working Group Reports, 2017). The importance of eating patterns during adolescence has been highlighted, as they set the foundation for a healthy life. However, many factors influence adolescents' food choices (Neufeld et al., 2022). Among them is the family environment, which plays a key role in forming their dietary habits. For instance, low parental education and socio-economic status have been associated with low vegetable intake in adolescents (Peltzer & Pengpid, 2010),

as well as the low availability of and encouragement to eat vegetables (Middlestadt et al., 2013; Peltzer & Pengpid, 2010) and the low parental consumption of these foods (Draxten et al., 2014).

A factor influencing adolescents' food choices is their transition from being primarily dependent on their caregivers to acquiring responsibilities related to food purchase, preparation, and consumption. As adolescents grow older and gain more autonomy over their eating behavior, they are more likely to make unhealthy food choices and skip meals. This is confirmed by data from the Health Behaviour in School-aged Children study, which indicates that during this transition, fruit and vegetable intake declines and most adolescents are failing to meet current nutritional recommendations, undermining their capacity for healthy development (WHO, 2020). Despite the well-documented health benefits associated with fruit and vegetable consumption (Middlestadt et al., 2013) for the reduction of all-cause mortality (Oyebode et al., 2014; Wang et al., 2014), reduced mortality from cardiovascular disease (Oyebode et al., 2014; Wang et al., 2014), coronary heart disease and stroke (He et al., 2006; Satija et al., 2017), reduced risk of hypertension (Savica et al., 2010), osteoporosis (Lanham-New Susan A, 2006), mental health (dementia and cognitive decline (Lamport et al., 2014; Loef & Walach, 2012), and a number of cancers (WCRF & AICR, 2018), still almost half of the adolescents (48%) eat neither fruits nor vegetables on a daily basis (Appleton et al., 2019; WHO, 2020).

1.3 | Factors influencing vegetable consumption

In particular, for the case of vegetables, the aversion toward their consumption can be attributed to their sensory properties, for example, their bitter and undesirable taste, which serves as a major barrier to their acceptance and consumption, especially in young children and adolescents (Brug et al., 2008; Dinehart et al., 2006; Dinnella et al., 2016; Wardle et al., 2003). Dinnella and colleagues, in a cross-cultural study exploring the sensory determinants of liking for vegetables, found that liked tastes such as sweet and umami, delicate flavors, and bright appealing colors are associated with a higher liking for vegetables, whereas bitter taste and objectionable flavors are associated with children's rejection (Dinnella et al., 2016). A recent study showed that attentional bias was higher for vegetables with critical sensory properties (such as bitterness and astringency) supporting the idea that negative sensory properties can act as barriers to the acceptability of vegetables (Agovi et al., 2022). On top of that, it has been reported that individual differences in taste respon-

siveness and genetic variations that account for the ability to perceive the bitter thiourea compounds (PROP taster status) may be associated with a decreased intake and acceptance of the bitter-tasting vegetables (Bell & Tepper, 2006; Dinehart et al., 2006; Duffy et al., 2010).

Moreover, food neophobia, defined as the reluctance to eat or avoidance of novel foods, acts as another factor that leads children to reject foods with bitter taste, objectionable flavors, or poor appearance and texture, characteristics present in many vegetables (Dovey et al., 2008). A cross-national study comparing food neophobia among school-age children in five European countries reported that food neophobia was negatively associated with the consumption frequency of vegetables (Proserpio et al., 2020). This neophobic behavior in childhood is typically transferred into adulthood and is associated with adults' low vegetable acceptance and consumption (Goldring et al., 2009; Knaapila et al., 2011; Törnwall et al., 2014). The transfer of childhood eating habits and preferences into adulthood is well documented, and childhood experiences are often related to adult vegetable intake (Larson et al., 2008; Lien et al., 2001). For this reason, early interventions focusing on promoting vegetable consumption could maximize health benefits (Perry et al., 1998) and could have promising results in establishing eating habits that extend into adulthood (Larson et al., 2008; Wardle et al., 2003).

Familiarity has a key role in the development of food preferences and mere (repeated) exposure to foods has been indicated as one of the most diffuse strategies to develop food preferences, including for vegetables (Appleton et al., 2018). Increasing children's familiarization with vegetables has been central in many interventions, both in the case of familiarizing with the taste (through tasting) and in the case of familiarizing with the vegetables as physical objects (through touching, sensing, etc.) and cognitively (getting to know how the plant grows, etc.).

1.4 | Interventions in the school environment

Given that many children and adolescents consume up to half of their daily energy intake at school (Briefel et al., 2009), school-based interventions can be a promising strategy for establishing healthy eating habits in these age groups. For years, school educational programs have been the main strategy for encouraging healthy dietary habits and discouraging unhealthy ones, but findings show that an increase in the knowledge is not necessarily associated with a change in behavior and willingness to shift toward healthy eating (O'Brien & Davies, 2007). On the other hand, consistent longitudinal associations between

taste preferences and intake of fruits and vegetables during young adulthood were found, and it was proposed that nutrition programs providing adolescents with more opportunities to taste and be exposed to a variety of vegetables and fruits (such as the Fresh Fruit and Vegetable Program (USDA, 2022)) could be a feasible strategy to establish positive taste preferences for these foods (Larson et al., 2008).

Thus, interventions in school environments that promote early exposure to vegetables and pulses, thereby forecasting their regular consumption also in adulthood, are gaining attention. In the past years, changes in the choice architecture, which refers to the environment or setting where choices are made, have gained increased attention. This is particularly the case of nudging interventions, which focus on changing the design of the choice architecture in a way that better choices are induced by maintaining the freedom of choice. Thaler and Sunstein define nudge as “any aspect of the choice architecture that alters people’s behavior predictably without forbidding any options or significantly changing their economic incentives” (Thaler & Sunstein, 2008). One example is the positioning of vegetables in the school cafeteria line in a way that increases their accessibility and the likelihood of being selected by the students. This nudging intervention uses a small change in one’s decision context, without excluding access to other options and shows how people’s choices can be influenced by the position and order of the items in the decision space.

Interventions using sensory-hedonic strategies have also gained increased attention. The prominent role of food sensory properties in preference development and in shaping the overall food hedonic judgment is widely recognized with food characterized by well-accepted sensory properties liked and consumed the most (Appleton et al., 2019, Forde & de Graaf, 2022). Different types of interventions can be considered as sensory hedonic. This is the case of food transformation interventions aimed at improving the sensory appeal of plant-based dishes through modifications of food appearance, taste, and texture. Other types of sensory-hedonic interventions have been adopted which are based on the manipulation of the hedonic valence of food sensory properties to increase the acceptance of a target food (Prescott, 2012), as in the case of hedonic contrast and conditioning studies. Hedonic contrast describes how preference and liking for one food are influenced by the recent experience of other foods which differ in hedonic valence, whereas evaluative conditioning describes the effect of contingently presenting neutrally liked foods with other foods with a strong valence, positive or negative. “Hedonic Contrast,” is a specific context effect in which a food is judged “less good” when presented after a “bet-

ter” one and judged better when presented after a “not so good” food (Zellner et al, 2003). Conditioning studies based on repeated exposure showed that initially less accepted food, characterized by unfamiliar and objectionable flavor, gained a positive/neutral valence when this was paired with a neutral/liked flavor (Havermans & Jansen, 2007a; Yeomans, 2006).

Interventions using multi-modal sensory elements could be particularly useful for highly neophobic children, who tend to reject vegetables based on their visual appearance or texture (Nekitsing et al., 2018). A recent review suggested that interventions focusing on both taste exposure and non-taste sensory experience, including sight and touch, have an increased impact in promoting the consumption of unfamiliar vegetables compared to familiar ones (Nekitsing et al., 2018).

1.5 | Objective

Although the benefits of promoting plant-based diets on both children’s and adolescents’ health and environmental sustainability are well established and various studies report promising effects of interventions in promoting vegetables and pulses in school settings, a comprehensive collection of those reports is still lacking. Such insight could be very important for future research. Therefore, the purpose of this work was to systematically review the published literature on school-based interventions using sensory-hedonic strategies and nudging to increase children’s and adolescents’ vegetable and pulses consumption.

2 | MATERIALS AND METHODS

The studies were identified using a search strategy and analyzed against inclusion criteria.

2.1 | Search strategy

This systematic review was conducted in March 2022. To identify all the relevant literature, three databases—Pubmed, Scopus, and Web of Science—were searched using the following search terms in the title or abstract of the papers and were adapted according to the requirements of individual databases:

(vegetable* OR legume* OR pulses) AND (child* OR adolescent* OR teenager* OR student*) AND (school* OR class*) AND (“choice architecture” OR “architectural choice” OR intervention OR nudge* OR consumption OR sensory)

2.2 | Language and date restrictions

To identify all the relevant published literature, a search over all years of records was conducted (up until March 2022) and was limited to literature published in the English language.

2.3 | Selection criteria

Studies were included if they reported either a sensory-hedonic or nudging intervention taking place in a school setting, focusing on children and/or adolescents, and measuring a change in behavior, such as selection, consumption, and purchasing of vegetables and/or pulses. Studies that measured only a change in liking or knowledge, intentions, or attitudes and those reporting the use of education and familiarization with tasting but not behavioral changes were excluded from the scope of this systematic review. The same applies to interventions purely focusing on the use of repeated exposure; however, multi-component interventions using mere exposure as one of their compounds were included if at least one sensory-hedonic or nudging strategy was reported. To be included, studies should consider vegetables as a separate food group. The review was limited only to primary studies whose full article was available; therefore, unpublished literature, reviews, conference abstracts, and gray literature were not included. The systematic review included studies regardless of the use or not of a control or a comparison group.

2.4 | Selection process

The selection process is shown in Figure 1. A total of 10,488 studies were retrieved from the three databases (2,344 from PUBMED, 5,334 from Scopus, and 2,810 from Web of Science). One review author (MK) conducted the search, checked for duplicates using the Rayyan web application (Ouzzani et al., 2016), and excluded 5,464 records. MK assessed the remaining 5,024 studies first based on the relevance of the titles and then the abstracts and excluded 4,874 records. The full text of the remaining 150 studies was reviewed against the inclusion criteria by MK, and the abstracts of all 150 studies were subsequently reviewed by two review authors (CD or SS), resulting in the final number of 57 studies included in this systematic review.

The extracted information from all the included studies is provided under the “Results” section. Due to the high heterogeneity between study methodologies, the risk of bias was not assessed, nor a meta-analysis was conducted. The review was undertaken following the PRISMA

guidelines, and the outcomes of the review process are illustrated using the PRISMA diagram in Figure 1.

3 | RESULTS

The results of the search are presented in Figure 1. In total, 57 studies reporting an intervention based on sensory elements or on nudging targeting children and/or adolescents in the school environment and aiming at promoting vegetables and/or pulses were identified. For this review, sensory-hedonic interventions are considered those that focus on the sensory characteristics of the foods (improving or changing food taste and texture and/or texture) and those based on modifications of the hedonic valence of food sensory properties (pairing different foods/flavors, eventually coupled with repeated exposure). Nudging interventions are those that focus on changing the environment where food are served (e.g., changes in their presentation style, portion size, placement, defaults, and using informative labels or stickers, as well as through incentives and prompts). Many selected interventions focus on more than one age group of students: 68% are targeted at children (<9 years old), 89% at pre-adolescents (9–12 years old), and 40% at adolescents (13–19 years old) (WHO, 2022). Details of the sensory-hedonic strategies and nudging interventions are presented in Tables 1 and 2 respectively.

3.1 | Sensory-hedonic interventions

This systematic review identified 12 sensory-hedonic interventions aimed at increasing acceptance and consumption of foods containing vegetables or pulses (Table 1). Such cases include: (1) the improvement of sensory appeal by flavor (D’Adamo et al., 2021; Just et al., 2014; Zellner & Cobuzzi, 2017), appearance and texture modifications (Burgess-Champoux et al., 2018; Chung & Fong, 2018; Chung et al., 2020; Cohen et al., 2012, 2015; Mistura et al., 2019) coupled with repeated exposure; (2) valence manipulation by the use of evaluative conditioning (Johnston et al., 2011; Olsen et al., 2012;) and hedonic contrast (Zellner & Cobuzzi, 2016).

3.1.1 | Improving the taste with flavor, appearance, and texture modifications and new recipes

Some positive findings came from interventions using food transformation, for example, changing food’s original shape, texture, and appearance. For instance, incorpo-

TABLE 1 Details of included studies using sensory-hedonic interventions.

Authors	Title	Aim	Population	Target food	Intervention	Control	Outcome	Results	Conclusions	Type of strategy
Burgess-Champoux et al. (2018)	Modifying School Meal Entrées to Improve Child Legume Intake	To determine if modifying school meal entrées to include legumes would increase the selection and consumption of legumes by K-6th grade children.	CHL, PRE $n = 508$ $F = 48\%$ (School 1) $n = 454$ $F = 52\%$ (School 2) $n = 581$ $F = 48\%$ (School 3)	V, L	Five entrée items were modified to include legumes and were served in three schools. Students selected two to three entrée options offered on the cafeteria line including a cold item (sandwich or salad). Comparisons were made between original and modified entrée items for the number of children eating school lunch who selected entrées and for intake.	No	Intake	The selection of modified and original items was similar for most entrées in all schools; consumption was lower for two modified entrées in two schools compared to original entrées. Macaroni and cheese with added white beans in two schools and Mandarin Chicken with added black-eyed peas in one school. Overall, selection and consumption varied by entrée type and school.	Entrée selection and intake varied possibly based on changes in appearance, familiarity, and taste or liking. Incorporating legumes into school meal entrées can increase legume consumption by children depending on entrée type.	Food modification and new recipes
Chung and Fong (2018)	Appearance Alteration of Fruits and Vegetables to Increase Their Appeal to and Consumption by School-Age Children: A Pilot Study	(1) To investigate the effectiveness of enhancing the visual appeal of FV to increase children's liking and consumption. (2) To compare the effectiveness of repeated exposure to the visual appeal of transformed FV for enhancing children's liking and consumption.	CHL, PRE $n = 17$ $F = 58.8\%$ (original food) $n = 18$ $F = 55.6\%$ (transformed food)	V	In the first 4 weeks, children in each intervention group were served a pairing of one fruit and one vegetable every afternoon (same for the two groups). Five distinct pairings of FV were served in 1 week, and this FV pattern was repeated in the first 4 weeks for both groups, with the children tasting the same FV but in different physical forms each time for the experimental group. In week 5, the same pattern and food forms were served to the children in both groups; however, those in the transformed food (TF) group were required to participate in a workshop session before each pairing was served. In week 6, only the original foods (OFs) were served to the children in both groups, and the pairing pattern remained the same as before. Each child tried all 10 FV in five pairings per week for 6 consecutive weeks.	Yes—only exposure	Liking and consumption	For transformed vegetables, there was a non-significant difference in the children's liking of sweet potato, pumpkin, spinach, carrot, and aubergine between the groups. An increase in liking was observed for pumpkin in only its original form after 6 weeks ($z = -2.745, p < .01$). Mean % consumption at week 6 was lower versus week 1 for the vegetable samples in both groups. Between the groups, the mean % of vegetable consumption in the experimental group was higher versus control group, at week 1. At week 6, the mean % of vegetable consumption in the TF group was higher versus the OF group, except for aubergine. Significant differences in the consumption of pumpkin, sweet potato, spinach, carrot, and aubergine were observed between the two groups. Appearance transformation increased vegetable consumption at the 1st and 6th attempts.	Mere exposure was sufficiently powerful to affect the willingness of children to try foods that they dislike. This pilot study confirmed that exposing children six times to disliked apple and pumpkin was sufficient to increase their liking. Mere exposure was effective in enhancing vegetable acceptance, regardless of their appearance; however, appearance transformation alone also increased vegetable consumption.	Improving the taste and new recipes
Chung et al. (2020)	Using Physical Food Transformation to Enhance the Sensory Approval of Children With Autism Spectrum Disorders for Consuming Fruits and Vegetables	To evaluate the effect of physical transformation of FV to snacks to enhance Autistic spectrum disorders (ASD) children's sensory approval for eating them.	CHL, PRE, ADL $n = 56$ (children with ASD) $F = 12.5\%$	V	The intervention lasted 4 weeks with three episodes of FV exposure to the ASD children per week. In each week, six foods (three fruits and three vegetables) were used. For each episode, one fruit and one vegetable were prepared and served to the children. Food transformation constituted changing bananas into ice-cream, zucchinis and sweet potatoes into chips, apples and kiwis into popsicles, and carrots into juice.	No	Acceptance and habitual consumption	No significant increase was observed in vegetable consumption. For habitual consumption, parents reported increased frequency of consumption in two out of three vegetables (1.9 vs. 2.5 for zucchini, 1.8 vs. 2.4 for sweet potatoes).	Physical changes in foods may improve the impaired sensory processing of ASD children to promote their vegetable acceptance.	Improving the taste and new recipes

(Continues)

TABLE 1 (Continued)

Authors	Title	Aim	Population	Target food	Intervention	Control	Outcome	Results	Conclusions	Type of strategy
Cohen et al. (2012)	Long-term Impact of a Chef on School Lunch Consumption: Findings from a 2-Year Pilot Study in Boston Middle Schools	To test the effectiveness of a chef-based model on student's selection and consumption of school lunches.	PRE, ADL $n = 1609$ (intervention) $n = 1440$ (control)	V	A professional chef trained cafeteria staff to prepare healthier school lunches (i.e., more whole grains, fresh/frozen FV, and less sugar, salt, saturated fats, and trans fats). The chef created new menus that resembled the standard Boston Public Schools menus but were modified to improve the healthiness and palatability of all meal components (meals included entrees, grain-based sides, FV, and milk).	Yes—standard school lunch	Selection and consumption	Overall, the Chef Initiative schools provided healthier lunches and the percentage of foods consumed at Chef Initiative and control schools were similar (61.6% vs. 57.3%; $p = .63$). Of the areas targeted, there was greater vegetable consumption; students consumed 0.36 more vegetable servings/day ($p = .01$) at Chef Initiative schools.	Overall, the selection and consumption of foods at Chef Initiative schools were similar to those of students in control schools.	Improving the taste and new recipes
Cohen et al. (2015)	Effects of Choice Architecture and Chef-Enhanced Meals on the Selection and Consumption of Healthier School Foods: A Randomized Clinical Trial	To evaluate the short- and long-term effects of chef-enhanced meals and extended exposure to choice architecture on healthier school food selection and consumption.	CHL, PRE, ADL $n = 672$ $F = 50.7\%$ (Chef + Smart Café schools) $n = 651$ $F = 56\%$ (Smart Café school) $n = 379$ $F = 52.8\%$ (Chef school) $n = 936$ $F = 54.9\%$ (control)	V	Schools were randomized to receive a professional chef to improve school meal palatability (chef schools) or to a delayed intervention (control group). To encourage vegetable selection, participating schools offered them at the beginning of the lunch line. Signage and images promoting vegetables were prominently displayed. To assess the effect of choice architecture (smart café), all schools after 3 months were then randomized to the smart café intervention or the control group.	Yes—delayed intervention	Selection and consumption	After 3 months, vegetable selection increased in chef versus control schools (odds ratio [OR], 1.75; 95% confidence interval [CI], 1.36–2.24), with no effect on the selection of other components or meal consumption. Vegetable selection increased in the chef (OR, 2.54; 95%CI, 1.83–3.54), smart café (OR, 1.91; 95%CI, 1.46–2.50), and chef plus smart café schools (OR, 7.38; 95%CI, 5.26–10.35) compared with the control schools, and consumption also increased in the chef (0.16; 95%CI, 0.09–0.22 cups/d) and chef plus smart café (0.13; 95%CI, 0.05–0.19 cups/d) schools. The smart café intervention alone had no effect on consumption.	Chefs focusing on school food quality, palatability, and variety is an effective method to improve vegetable selection and consumption over time. Choice architecture may be a good short-term strategy to increase consumption—it does not appear to be successful in the long-term. Repeated exposure to new foods is important.	Improving the taste and new recipes
D'Adamo et al. (2021)	The Addition of Spices and Herbs to Vegetables in the National School Lunch Program Increased Vegetable Intake at an Urban, Economically Underserved, and Predominantly African-American High School	To explore whether stakeholder-informed addition of spices and herbs to National School Lunch Program (NSLP) V would increase intake at an urban, economically underserved, and predominantly African-American high school in Baltimore, Maryland.	CHL, PRE, ADL $n = 29$ $F = 55\%$	V, L	A two-phase, controlled intervention was conducted at a high school. The stakeholder engagement phase included the assessment of NSLP V attitudes/preferences among 43 school stakeholders and subsequent student sensory testing. The 2nd phase was conducted in the school cafeteria and consisted of 8 weeks comparing student intake of typical V recipes versus otherwise identical recipes with spices and herbs.	No	Intake and willingness to try	Total V intake was 18.2% higher (8.22 g per meal, $p < .0001$) with spices and herbs versus the typical recipes. Five V had a higher intake with spices and herbs (steamed carrots, broccoli, California medley, green beans, raw carrots) and two had a higher intake with typical recipes (peas, black beans, and corn). No difference in V trying (typical = 76.5%, spices and herbs = 74.2%, $p = .07$). More students tried typical V without student-led advocacy (typical = 24.2%, spices and herbs = 69.69%, $p > .0001$) and more students tried V with spices and herbs in with student-led advocacy (typical = 67.5%, spices and herbs = 78.88%, $p > .0001$).	The addition of spices and herbs to V in the NSLP was feasible and associated with small increases in V intake at an urban, economically underserved, and predominantly African-American high school.	Improving the taste and new recipes

(Continues)

TABLE 1 (Continued)

Authors	Title	Aim	Population	Target food	Intervention	Control	Outcome	Results	Conclusions	Type of strategy
Johnston et al. (2011)	Increasing Vegetable Intake in Mexican-American Youth: A Randomized Controlled Trial	To assess the effect of multiple exposures to vegetables, and pairing vegetables with a preferred taste, of increasing vegetable consumption for children who reported being resistant to eating or trying vegetables (evaluative conditioning).	PRE, ADL N = 40 F = 47.5% (pairing) N = 38 F = 57.9% (exposure only)	V	Pairing condition: Children were provided a preferred taste (peanut butter) paired with vegetables weekly at school during a nutrition class for 4 months. Exposure-only condition: Children received vegetables weekly during a nutrition class that covered the same material as the pairing condition.	No	Consumption	After 4 months, the pairing condition participants demonstrated significant increases in vegetable consumption (F = 13.40, <i>p</i> < .001) as well as a variety of vegetables eaten (F = 13.69, <i>p</i> < .001) when compared to those in the exposure-only condition. When peanut butter was paired with vegetables, intake of celery increased significantly (<i>t</i> = -3.7, <i>p</i> = .001), whereas consumption of broccoli and carrots remained constant (<i>t</i> = -1.74, not significant, <i>t</i> = 0.87, not significant).	The findings of this study suggest that the pairing of vegetables with a preferred taste, such as peanut butter, may be an effective technique in increasing consumption, especially in children who report being resistant to eating vegetables.	Manipulating valence
Just et al. (2014)	Chefs Move to Schools. A Pilot Examination of How Chef-Created Dishes Can Increase School Lunch Participation and Fruit and Vegetable Intake	To gauge the feasibility of the "Chefs Move to Schools" (CMTS) program and response through lunch sales and food consumption.	CHL, PRE, ADL n = 10,674	V	Three types of pizza were always offered: cheese, garlic, and pepperoni, but each Thursday, the school would prepare a specialty pizza. The chef developed recipes for three types of pizza (meat taco, bean taco, and garlic spinach pizza) and a ranch-flavored hamburger. In addition to these dishes, the chef prepared three additional items: a meat lover's pizza, a mozzarella burger, and a prepackaged salad which was served as a side item. Sides of FV were served daily.	Yes—no change in the menu	Lunch sales, consumption, and waste	57.6% more students took a vegetable (<i>p</i> = .002). There was a 7% point decrease in the selection of cooked vegetables (<i>p</i> = .01) and a 21% point increase in the selection of salad (<i>p</i> < .001). Vegetable consumption increased by 16.5% (<i>p</i> = .005), which was completely driven by increased salad consumption.	The program was successful in increasing vegetable consumption. Findings suggest that offering a vegetable that complements the available main dishes can have a significant impact on vegetable consumption.	Improving the taste and new recipes
Mistura et al. (2019)	Examining the Efficacy of a "Feasible" Nudge Intervention to Increase the Purchase of Vegetables by First-Year University Students (17–19 years of age) in British Columbia. A Pilot Study	To examine the impact of a contextually feasible evidence-informed nudge intervention on the food purchasing behavior of older adolescents (1st-year students) in a university residence cafeteria in British Columbia, Canada.	ADL n = 5098 F = 40% (baseline 1) n = 6173 F = 41.6% (intervention) n = 5754 F = 43% (baseline 2) n = 7385 F = 41.5% (intervention 2)	V	The nudges were placement nudges that involved altering the properties of the vegetable to enhance freshness and appearance. This was implemented by adding an option of fresh, raw vegetables to the existing cooked vegetable option, in combination with an environmental cue (sensory and cognitive) in the form of a small poster displayed at eye level, highlighting the addition of the fresh vegetable option with a colorful character and a health message.	No	Number of students purchasing one of the vegetables	Visual inspection showed neither intervention had an effect on the mean proportion of vegetables purchased or females or males analyzed separately.	More research is needed. Nudges in real-life settings, rather than laboratories, need to have more controls in place.	Improving the taste and new recipes

(Continues)

TABLE 1 (Continued)

Authors	Title	Aim	Population	Target food	Intervention	Control	Outcome	Results	Conclusions	Type of strategy
Olsen et al. (2012)	Children's Liking and Intake of Vegetables: A School-Based Intervention Study	To investigate the effects on vegetable liking and intake gained from exposing children to servings of mixed snack vegetables of different liking levels in a classroom setting (evaluative conditioning)	PRE <i>n</i> = 220 <i>F</i> = 43.2% (intervention) <i>n</i> = 73 <i>F</i> = 49% (control)	V	The intervention consisted of two exposure periods. 1st, children were either exposed to a neutrally liked vegetable (cauliflower), a mixture of a neutrally liked and a liked (sugar snap peas) vegetable, or a mixture of a neutrally liked and a disliked (celery) vegetable. In the 2nd period, all children received the same servings; a mixture of disliked, neutral, and liked vegetables.	Yes	Liking and intake	Liking for most vegetables decreased during the exposure periods but tended to recover somewhat during follow-up. Intake of all vegetables was either stable or decreased during the intervention, no increases were observed. Intake levels depended on the type of vegetable servings: When served with a liked vegetable, children consumed more of a neutrally liked vegetable than when served alone (<i>p</i> = .0005) or together with a disliked vegetable (<i>p</i> = .005).	Classifying vegetables based on liking and serving them in a manner where neutral or disliked vegetables are always served along with better-liked vegetables might be a way of increasing both total consumption and consumption of less-liked vegetables.	Manipulating valence
Zellmer and Cobuzzi (2016)	Just Dessert: Serving Fruit as a Separate "Dessert" Course Increases Vegetable Consumption in a School Lunch	To investigate the impact of serving a well-liked fruit course at the same time as or after the less-liked vegetable in a school lunch, served family-style (hedonic contrast)	CHL, PRE <i>n</i> = 47	V	On two different days, the same meal, which included a vegetable (kale salad) served in one serving dish and a fruit (apple-berry medley) served in another serving dish, was observed. On the first observation day, the fruit/dessert component was served after the meal. On the second observation day, the fruit/dessert was served at the same time as the rest of the meal. Consumption of and liking for the vegetable were measured.	No	Consumption and liking	Results showed that 40% of children ate none of the kale when the fruit/dessert was served at the same time as the rest of the meal whereas, all of the children ate kale when the fruit/dessert was served after the main part of the meal. More children ate all of the kale put on their plate or had seconds (55%) when the fruit/dessert was served after the rest of the meal than when fruit/dessert was served at the same time (20%). No difference in the distribution of the hedonic ratings given to the kale under the two conditions	Serving the fruit/dessert component of the meal after the rest of the meal, which includes a vegetable, is an effective way to increase the vegetable intake of students in a school lunch.	Manipulating valence
Zellmer and Cobuzzi (2017)	Eat your Veggies: A Chef-Prepared, Family-Style School Lunch Increases Vegetable Liking and Consumption in Elementary School Students	To investigate the effect of a chef-involved school lunch program (Eatiquette program) on liking for and consumption of vegetables in both the short-term and over the course of a school year.	CHL, PRE <i>n</i> = 24–26 (School A) <i>n</i> = 60–84 (School B)	V	Two schools, one with a traditional lunch service (School B) and the other (School A) devoted 1 day/week to the "Eatiquette Program," which incorporates chef-prepared food, non-disposable plates and cutlery, and family-style service including an adult at each table. In School A, the food in the Eatiquette meals, served 1 day/week, was made from scratch with fresh ingredients. School A consisted of fresh cauliflower florets coated in canola/olive oil, seasoned with salt and pepper, and roasted. In School B, the cauliflower was steamed with unseasoned florets. The sweet potato fries in the Eatiquette preparation were fresh sweet potatoes cut into slices, coated with olive oil, seasoned with cinnamon, cumin, salt, and pepper, and baked.	Yes—traditional lunch service	Consumption, liking, and ability to identify V	Consumption increased from the beginning to the end of the school year for children eating the Eatiquette lunch. Liking for and ranking of cauliflower increased from the beginning to the end of the year for the children in the Eatiquette (<i>n</i> = 6) program but not for those eating the traditional lunch (<i>n</i> = 22).	The Eatiquette program increased consumption of and liking for V. Aspects of the Eatiquette program including food palatability and the presence of an adult at each table may be responsible for these increases.	Improving taste and new recipes

Note: Population groups considered are the following: children (CHL) < 9, pre-adolescents (PRE) 9–12, and adolescents (ADL) 13–18. The food groups are vegetables (V), legumes (L), and fruit and vegetables (FV). The gender groups are female (F) and male (M).

TABLE 2 Details of included studies using nudging interventions.

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Ansa et al. (2021)	Fruit and Vegetable Intake at and Away From School During Participation in the FIT Game	To examine children's FV intake away from school while participating in the FIT Game program at school.	CHL, PRE $n = 37$ $F = 68\%$	V	The FIT Game features fictional teenage heroes who try to stop the villains from doing evil and the episodes are displayed at school cafeteria while students select and eat their lunch. To access new episodes, students need to eat more FV than what they normally do.	No	Consumption	Vegetable consumption increased by 88% during the final 3 days of playing the FIT Game versus baseline (0.16 vs. 0.30, $p = .01$). No change in the consumption of vegetables away from school versus baseline (0.69 vs. 0.67, $p = .83$).	The FIT Game increased vegetable consumption at school, but a modest non-significant decrease was observed at home.	Incentives
Adams et al. (2005)	Salad Bars and Fruit and Vegetable Consumption in Elementary Schools: A Plate Waste Study	To use plate waste weighing to determine if elementary school students with self-service salad bars consume more FV compared with students served pre-portioned amounts determined by cafeteria staff.	CHL, PRE $n = 288$ $F = 54\%$	V	One district used daily salad bars and the other used pre-portioned FV servings. One salad bar and one pre-portioned school were sampled on a Monday and the other two schools on Friday to control for any day-of-week effects.	No	Consumption	A salad bar was not associated with greater vegetable consumption. Vegetable consumption was + related to the number of vegetables offered at salad bars ($p < .05$), adjusting for sex and grade. Salad bar schools offered four and seven vegetables each, and Pre-portioned schools offered five vegetables each. Students consumed on average 4g of vegetables more with a salad bar vs students using pre-portioned servings, but the difference was not significant.	Providing a self-service salad bar is not sufficient to improve elementary school children's vegetable intake. However, salad bars with more variety were associated with higher intakes.	Presentation and availability
Bean et al. (2018)	Salad Bars Increased Selection and Decreased Consumption of Fruits and Vegetables 1 Month After Installation in Title I Elementary Schools: A Plate Waste Study	To evaluate the 1-month impact of salad bars on FV selection, intake, and waste	CHL, PRE $n = 282$ $F = 53\%$ (baseline) $n = 443$ $F = 49\%$ (post)	V	Digital imagery plate waste assessments were conducted before salad bars were installed (baseline) and 1 month afterward (post). Post-surveys examined student perceptions of salad bars.	No	Selection, consumption, and waste	At post, students selected more types of vegetables (0.9–1.5; $p < .001$), although vegetable consumption decreased by 0.27 cups ($p < .001$). Less vegetable waste (0.24 cups; $p < .001$) at post. Students liked the ability to choose vegetables from salad bars. Salad bars increased the number of vegetables selected but decreased the overall amount consumed, compared with when vegetables were pre-portioned.	Short-term exposure to salad bars increased the number of vegetables chosen but decreased consumption. Additional strategies are needed to increase consumption. Future longitudinal research should include a comparison of schools serving pre-portioned vegetables only.	Availability
Bergamaschi et al. (2016)	Variety in Snack Servings as Determinant for Acceptance in School Children	To investigate if the classical variety (CV) and perceived variety (PV) influence acceptance and intake of snack servings in a similar way in Danish school-aged children.	PRE $n = 153$ $F = 47.7\%$	V	Children were exposed to vegetables, fruits, and nut snacks during a school break. Two sets of stimuli were used in a within-subject design: (1) CV—number of different foods varied; (2) PV—only serving styles and shape of green apple and carrot were varied. For each set, three levels of variety in the servings were tested: low (two stimuli), medium (four stimuli), and high variety (six stimuli).	No	Intake and liking for each serving set	Intake in the CV set decreased according to the level of variety. PV set only showed an increase of liking with increasing levels of variety. No differences in intake in the PV set among levels of variety. Intake in low level of the CV set—containing the same stimuli cut in different ways (carrot chunks and carrot sticks)—was higher than in the PV set. For the CV set, the highest intake was observed in the serving with the lowest variety.	Intake does not increase according to the level of variety. Adding more variations of products appeared to be less successful in consumption despite changing the liking—maybe consumption is more affected by acceptability and familiarity with the stimuli than by variety.	Availability and presentation

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Birnbaum et al. (2002)	Are Differences in Exposure to a Multicomponent School-Based Intervention Associated With Varying Dietary Outcomes in Adolescents?	To examine the outcomes on students' eating patterns after exposure to the 7th-grade intervention and to assess whether different outcomes were associated with different levels of exposure (dose-response).	ADL <i>n</i> = 1748 <i>F</i> = 50% (intervention) <i>n</i> = 1755 <i>F</i> = 48.7% (control)	V	Conducted in 16 schools; 50% were randomly assigned to the intervention condition versus control. The Teens Eating for Energy and Nutrition in Schools (TEENS) intervention consists of: (1) a control group, (2) school environment interventions only, (3) classroom plus environment interventions, and (4) peer leaders plus classroom plus environment interventions. Intervention activities included taste testing of fruits, vegetables, and lower-fat foods; increasing FV availability on the lunch line; increasing availability of lower-fat snacks on the à la carte line; displaying posters for à la carte lines and vending machines comparing fat and sugar in snack choices; displaying table tents and posters promoting FV and lower fat foods; holding prize raffles for students taking FV on the lunch line.	Yes—no intervention	Consumption and usual food choices	<ul style="list-style-type: none"> Dose responses were observed, with peer leaders reporting the largest increases in vegetable consumption. Classroom plus environment improved vegetable consumption, versus students exposed only to school environment interventions—no change in vegetable intake. Control students' choices remained stable. No change in daily vegetable servings from baseline to end of 7th grade in students exposed only to the school environment interventions (<i>p</i> = .300) or students in control schools (<i>p</i> = .895). 	A possible dose-response pattern in the intervention effects, but the response of the environment-only exposure group was unexpected and did not fit the usual dose-response model.	Availability, incentives, and modeling
Boehm et al. (2020)	Removing Competitive Foods v. Nudging and Marketing School Meals: A Pilot Study in High-School Cafeterias	(1) To compare federally reimbursable school meals served when competitive foods are removed and when marketing and nudging strategies are used in school cafeterias operating the National School Lunch Program (NSLP). (2) To determine how marketing and nudging strategies influence competitive food sales.	ADL <i>n</i> = 1177 (Healthy Choices School) <i>n</i> = 2140 (Healthy Nudging School) <i>n</i> = 1297 (control)	V	Three high schools were assigned to one of the three conditions: (1) Healthy Choices School: all competitive foods were removed; (2) Healthy Nudging School: a collection of marketing and nudging ("Smarter Lunchroom") interventions was implemented; no changes to the availability of competitive foods. (3) Comparison School made no changes.	Yes—no changes	The share of meals containing a vegetable and total daily sales of competitive foods	<ul style="list-style-type: none"> The Healthy Nudging School served more meals with vegetable sides versus the Comparison and Healthy Choices Schools. The only significant change in meal component selection was a 6% (SE0-02) higher rate of vegetable servings in the Healthy Choices School compared with the control school. Healthy Nudging School's competitive food sales did not change. 	Both strategies—removing competitive foods and marketing and nudging—may increase school meal participation. There was no evidence that promoting school meals decreased competitive food sales.	Availability

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Chinchana Chokhai et al. (2022)	Impact of Teacher Encouragement on Children's Consumption and Non-Eating Behaviour in a Wisconsin Elementary School Vegetable Snack Programme	To examine the impact of teacher encouragement on the consumption of raw vegetables served through a non-FFVP elementary school snack program.	CHL, $n = 217$ $F = 46\%$ (total) $n = 73$ (control)	V	Teachers and children were randomly assigned to one of the three conditions: (1) no encouragement (control); (2) moderate encouragement; (3) high encouragement. Three vegetables were served eight times each, with teachers in both intervention conditions encouraging the first six servings of each vegetable. All encouragement was discontinued during the final two servings of each vegetable.	Yes—no encouragement	Average consumption and non-eating behavior	<ul style="list-style-type: none"> Moderate and high teacher encouragement significantly increased children's consumption of vegetables compared to the control. Both encouragement conditions significantly reduced the likelihood of non-eating behavior. The positive encouragement impacts persisted in the short term even when teacher encouragement had ceased, especially for the high encouragement condition. 	Low-cost teacher encouragement can decrease non-eating behavior and increase children's consumption of vegetable snacks served in elementary schools.	Prompts
Cohen et al. (2014)	Impact of the New U.S. Department of Agriculture School Meal Standards on Food Selection, Consumption, and Waste	To assess the school meal selection, consumption, and waste before and after implementation of the new school meal standards.	CHL, PRE, ADL, $n = 1030$ $F = 54.4\%$	V	The standards increased the availability of whole grains, FV, increased the portion sizes of FV offered, and required the selection of a fruit or vegetable. Additionally, grade-specific limits were placed on the total calories and sodium contents of the meals, and trans fats were removed.	No	Selection and consumption	<ul style="list-style-type: none"> After the new standards were implemented, vegetable selection remained unchanged. Additionally, post-implementation vegetable consumption increased by 16.2%. 	<ul style="list-style-type: none"> High food waste levels both pre- and post-implementation. The new guidelines increased the consumption of vegetables. 	Presentation and availability
Cohen et al. (2015)	Effects of Choice Architecture and Chef-Enhanced Meals on the Selection and Consumption of Healthier School Foods: A Randomized Clinical Trial	To evaluate the short- and long-term effects of chef-enhanced meals and extended exposure to choice architecture on healthier school food selection and consumption.	CHL, PRE, ADL, $n = 672$ $F = 50.7\%$ (Chef + Smart Café schools) $n = 651$ $F = 56\%$ (Smart Café school) $n = 379$ $F = 52.8\%$ (Chef school) $n = 936$ $F = 54.9\%$ (control)	V	Schools were randomized to receive a professional chef to improve school meal palatability (chef schools) or to a delayed intervention (control group). To encourage vegetable selection, participating schools offered them at the beginning of the lunch line. Signage and images promoting vegetables were prominently displayed. To assess the effect of choice architecture (smart café), all schools after 3 months were then randomized to the smart café intervention or the control group.	Yes—delayed intervention	Selection and consumption	<ul style="list-style-type: none"> After 3 months, vegetable selection increased in chef versus control schools (odds ratio [OR], 1.75; 95%CI, 1.36–2.24); no effect on the selection of other components or meal consumption. Vegetable selection increased in the chef (OR, 2.54; 95%CI, 1.83–3.54), smart café (OR, 1.91; 95%CI, 1.46–2.50), and chef plus smart café schools (OR, 7.38; 95%CI, 5.26–10.35) compared with the control schools, and consumption also increased in the chef (0.16; 95%CI, 0.09–0.22 cups/d) and chef plus smart café (0.13; 95%CI, 0.05–0.19 cups/d) schools. The smart café intervention alone had no effect on consumption. 	<ul style="list-style-type: none"> Choice architecture may be a good short-term strategy to increase consumption; it does not appear to be successful in the long-term. Chefs focusing on school food quality, palatability, and variety is an effective method to improve vegetable selection and consumption over time. Repeated exposure to new foods is important. 	Placement, and cafeteria redesign
Dave et al. (2015)	Outcome Evaluation of a Pilot Study Using "Nudges"	To integrate "nudges" or cues from the cafeteria staff, school, and parents to promote healthy student food choices in the cafeteria.	CHL, PRE, ADL, $n = 379$ $F = 52.8\%$ (Chef school) $n = 936$ $F = 54.9\%$ (control)	V	A pilot study was conducted in six intervention and two control schools. A behavioral economics-based intervention was conducted using "nudges" or cues from the cafeteria (staff encouragement to select FV, food labels, "Harvest of the Month" posters), school (morning announcement messages, prompts regarding cafeteria food selections), and parents (school newsletter articles, parent listserve messages) to promote students' selection of FV in the school cafeteria.	Yes—no intervention	Selection	<ul style="list-style-type: none"> No significant differences in the number of servings of vegetables served per student per day averaged over the study period. Process data revealed low implementation of the intervention components. 	<ul style="list-style-type: none"> Low implementation of nudges led to nonsignificant results. Minimal cost interventions should be explored to facilitate the successful implementation of new school meal guidelines. 	Advertisements, prompts, labels, images, and names

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
De Marchi et al. (2020)	Incentivizing Vegetable Consumption in School-Aged Children: Evidence from a Field Experiment	(1) To explore to what extent children in different age classes respond to nonmonetary incentives. (2) To test the longer-term effect of incentive provision on vegetable consumption. (3) To investigate the role of children's food neophobia in their vegetable consumption.	CHL, PRE, ADL <i>n</i> = 370 <i>F</i> = 60%	V	Children were told that they would receive a prize at the end of the week if they finished the whole portion of vegetables served each day to them from Monday to Friday, including both salad and cooked vegetables.	Yes—no incentives	Consumption	For T1 (from weeks 5 to 8), the incentives were effective in reducing vegetable leftovers compared to the control group in the same period (<i>p</i> = .001). Significant differences were found between the two groups, also at T2 after the incentives were removed (<i>p</i> = .008). The follow-up data collected at T3 indicate that leftovers of the incentive group remained lower than the baseline and lower relative to the leftovers of children in the control group. 9- and 10-year-old children ate more vegetables compared to others. High neophobia scores were associated with higher vegetable leftovers.	Results suggest that the incentives are effective in increasing vegetable consumption and that this effect persisted several weeks after the provision of the incentives ended.	Incentives
Dial and Musher-Eizenman (2020)	Power of Packaging: Evaluations of Packaged Fruits and Vegetables by School-Age Children in the U.S.	(1) To examine how the visual presentation of packaged FV (e.g., fun packaging, healthy packaging, plain packaging, and un-packaged) impacts children's (a) health and taste evaluations and (b) willingness to try these foods.	CHL <i>n</i> = 30 <i>F</i> = 53%	V	Ask children to rate packaged foods on health and taste and indicate how much they would like to try these foods. Images selected depicted four vegetables (snap peas, kale, carrot, and sweet potato). Each food was packaged in four different ways: fun package, healthy package, plain package, and un-packaged. Images were printed in color, laminated, and presented one at a time.	No	Health and taste evaluations, willingness to try the foods	Children rated foods in healthy packaging (<i>M</i> = 4.1, <i>SD</i> = 0.5; <i>p</i> < .01) and fun packaging (<i>M</i> = 4.0, <i>SD</i> = 0.6; <i>p</i> = .04) as healthier than plain packaged foods (<i>M</i> = 3.8, <i>SD</i> = 0.6) and foods in fun packaging (<i>M</i> = 4.0, <i>SD</i> = 0.6; <i>p</i> = .01) healthier than un-packaged foods (<i>M</i> = 3.9, <i>SD</i> = 0.6). Foods in healthy packaging did not differ from those in fun packaging or un-packaged foods on health ratings. Foods in fun packaging were rated as tastier (<i>M</i> = 3.7, <i>SD</i> = 0.7) than plain packaged foods (<i>M</i> = 3.4, <i>SD</i> = 0.7; <i>p</i> < .01) and un-packaged foods (<i>M</i> = 3.5, <i>SD</i> = 0.8; <i>p</i> = .04). Healthy packaged foods were not rated tastier than plain packaged foods, fun packaged foods, or un-packaged foods. Children were more willing to try foods in a fun package (<i>M</i> = 3.5, <i>SD</i> = 0.6) than a fun package (<i>M</i> = 3.3, <i>SD</i> = 0.6) (<i>F</i> (3, 30) = 3.0; <i>p</i> = .03) and un-packaged packaged foods (<i>M</i> = 3.3, <i>SD</i> = 0.7; <i>p</i> = .02).	Packaging influences food ratings among 6–9-year-old children. Children seem to enjoy fun packaged foods, but they also seem partial to some nutrition information and health messages. Children rated healthy and fun packaging similarly, suggesting that more information on packaging is more appealing to children in most cases.	Presentation, labels, images, and names

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Eisbernd et al. (2016)	Serving Vegetables First: A Strategy to Increase Vegetable Consumption in Elementary School Cafeterias	To determine if serving bell peppers to elementary school students before other meal components were available would increase the overall consumption of vegetables at the school lunch meal.	CHL, PRE <i>n</i> = 500 (intervention) <i>n</i> = 511 (intervention 2) <i>n</i> = 575 (intervention 3) <i>n</i> = 532 (control) <i>n</i> = 534 (follow up)	V	Students were served a small portion (26–33 g) of a raw vegetable (red and yellow bell peppers) while they waited in line to receive the rest of their lunch meal. They then had the option to take more of the bell peppers, a different vegetable, or no vegetable from the lunch line.	Yes—without vegetables first	Consumption	Intervention days resulted in greater consumption of peppers by weight (mean = ¼ 4.1 g per child eating school lunch) versus control (mean = 1.4 g). Consumption of cooked carrots was higher on control and follow-up versus intervention (2.8 vs. 1.3 g). Total consumption of vegetables was higher on intervention than on control and follow-up (mean = 5.4 vs. 4.0 g). No increase in pepper (or total vegetable) consumption from control to intervention days. There was an increasing linear trend in the consumption of peppers ($F = 51.3$, $p < .001$) and total vegetables ($F = 34.4$, $p < .0001$) over the five occasions.	Serving vegetables before other meal components increased the proportion of students taking and eating vegetables in an elementary school cafeteria.	Presentation
Ensaiff et al. (2015)	Food Choice Architecture: An Intervention in a Secondary School and Its Impact on Students' Plant-Based Food Choices	To test whether a set of complementary changes to the choice architecture could effectively shift a school population's food choice toward more plant-based foods.	PRE, ADL <i>n</i> = 980 (intervention) <i>n</i> = 1132 (control)	V	The intervention included: (1) Freshly prepared vegetables daily specials; disposable pots/trays, pre-filled pots/trays, poster displayed in a holder, and window sticker in a display unit. (2) Sandwiches containing salad; Stickers on sandwich packaging, end of shelf label, and poster displayed in a holder.	Yes, Control school—no intervention and comparison of the same period the year before	Food selection	Selection of designated food items increased during the intervention and post-intervention periods, versus baseline, $p < .001$. Selection of the vegetable daily specials increased from 0.2% of "main" foods to 0.6% during the intervention, $p < .001$. The selection of sandwiches containing salad increased from 0.06% to 1.36%, $p < .001$.	The choice architecture successfully shifted food choice toward more plant-based foods, and students were three times as likely to choose vegetables or salad items during the intervention.	Placement, Labels, images and names, Presentation, Advertisement
Erjavec et al. (2021)	Nudge With Caution: Targeting Fruit and Vegetable Consumption in Primary Schools	To increase children's consumption of FV by presenting the foods more attractively and conveniently as a part of the school lunch.	CHL, PRE <i>n</i> = 67 $F = 56.7\%$ (intervention) <i>n</i> = 40 $F = 52.5\%$ (control)	V	The choice architecture intervention, implemented over 3 consecutive weeks in each school, included nudges: improved presentation and provision (salad vegetables were served in colorful reusable pots, arranged on a cake stand); attractive advertisements (prominent posters announcing vegetables of the day, placed in the canteen); attractive labeling of vegetables (e.g., Dinosaur Tree Broccoli; Ringing Bell Peppers); and prompting by staff. Nudges were presented simultaneously.	Yes—brought their lunch boxes from home	Vegetable serving and consumption	For children who ate school lunch, the selection of vegetables did not change over time and their consumption either remained unchanged or declined. No changes were observed in the comparison group. For children who brought their lunch boxes from home, there was no difference between baseline and follow-up. The servings of vegetables remained unchanged after the intervention implementation for children eating school lunches ($F = 1.1$, $p = .101$, $r = -.20$).	The intervention failed to increase either children's servings or their consumption of vegetables. Offering and labeling the cooked vegetable more prominently and supplementing the available choice with salad pots did not increase children's selection or their eating.	Presentation, labels, images and names, prompts, and advertisement

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Goh et al. (2017)	An Investigation of Sensory Specific Satiety and Food Size When Children Consume a Whole or Diced Vegetable	To explore the development of sensory-specific satiety (SSS) as a result of children's consumption of a fresh vegetable (carrots) in a diced and whole format.	CHI, PRE <i>n</i> = 72 <i>F</i> = 54.1%	V	Children participated in two sessions spread out over 2 separate days. One day they were presented with whole carrots and cucumbers and on the other day with diced carrots and cucumbers. Children were asked to consume either whole or diced carrots for a maximum period of 10 min from a 500-g box. Cucumber was used as a control (only tasted, not consumed ad libitum). Children's liking of carrots and cucumber was measured prior to and after carrot consumption.	No	Liking and consumption	In comparison to cucumber, liking for neither diced (<i>p</i> = .57) nor whole carrots (<i>p</i> = .18) changed during ad libitum consumption of carrots, indicating that SSS did not occur. However, children (<i>n</i> = 36) who finished eating carrots within the 10-min time limit spent more time eating the whole carrots compared to the diced carrots (<i>p</i> < .05), which tended to result in higher consumption of whole carrots (<i>p</i> < .06).	To increase vegetable consumption, it is better to present children with whole rather than diced vegetables.	Presentation
Hamdi et al. (2020)	Implementation of a Multi-Component School Lunch Environmental Change Intervention to Improve Child Fruit and Vegetable Intake: A Mixed-Methods Study	(1) To understand the effectiveness of a multi-component nudge intervention on FV selection and consumption. (2) To evaluate implementation metrics of nudge interventions, with a focus on acceptability, feasibility, and fidelity.	CHI, PRE, ADL <i>n</i> = 760 <i>F</i> = 49%	V	The study consisted of up to four intervention components (cafeteria decorations, creative names, social norming taste tests, and flavor). Schools 1 and 2 operated a serve-only lunch service (i.e., students have no choice in meal components) and School 3 had offer versus serve (OVS), allowing students to select or decline some meal components. Nudge interventions targeted V (green peas at School 1 and broccoli at Schools 2 and 3) and F.	No	Selection and consumption at lunch	The odds of selecting a vegetable at School 3 were three times higher than baseline during the taste test intervention (OR, 3.0; 95%CI, 1.3–6.5). Cafeteria decorations and taste tests had higher reported implementation metrics for acceptability and feasibility. In School 2, vegetable consumption (%) was lower during the creative names intervention versus baseline. Vegetable consumption (%) was higher in School 2 during the first taste test month versus the month prior to the taste test ($\beta = 19.3, p < .001$), corresponding to a 15.1 g reduction in vegetable wasted per student. Mean percent vegetable selection improved throughout the study, with the highest averages occurring over the social norming taste test intervention at School 3.	<ul style="list-style-type: none"> Some nudges were associated with inconsistent improvements in vegetable consumption. Implementation metric ratings for feasibility and acceptability were consistently higher for cafeteria decorations and social norming taste tests versus other intervention components. 	Cafeteria redesign, labels, images, and names
Hanks et al. (2013)	Smarter Lunchrooms Can Address New School Lunchroom Guidelines and Childhood Obesity	To investigate how small changes to school cafeterias, suggested by the principles of libertarian paternalism, can influence the choice and consumption of healthy foods.	PRE, ADL	V	Multiple interventions (smarter lunchroom makeover) were implemented: (a) Improving the convenience of FV; (b) improving the attractiveness of FV relative to other options; (c) making the selection of FV seem normative.	No	Selection and likelihood of consuming one-half or all of a serving of vegetables	The makeover, students were 13.4% (<i>p</i> = .012) more likely to take a F and 23% (<i>p</i> < .001) more likely to take a vegetable. Vegetable consumption increased by 25% (<i>p</i> < .001). In addition, students were 10% more likely to eat an entire serving of vegetables (<i>p</i> = .022).	Small changes in cafeterias and lunchrooms can have a significant influence in guiding students toward healthier behaviors.	Presentation, Placement, Labels, images and names, Prompts

(Continues)

TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Hanks et al. (2016)	Marketing Vegetables in Elementary School Cafeterias to Increase Uptake	To measure the impact that daily exposure to branded vegetable characters has on vegetable selection among boys and girls in elementary schools.	CHL, PRE <i>n</i> = 275	V	Elementary schools in the intervention group were randomly assigned to one of three treatment conditions: (1) a vinyl banner displaying vegetable characters that was fastened around the base of the salad bar; (2) short television segments with health education delivered by vegetable characters; or (3) a combination of the vinyl banner and television segments. In all the intervention schools, small decals printed with the vegetable characters were placed on the floor to direct traffic to the salad bars.	Yes—no intervention	(1) Number of students taking vegetables from the salad bar when exposed to the vinyl banner only, and 239.2% (from 10.2% to 34.6%, <i>p</i> < .001) more students visited the salad bar when exposed to both the television segments and vinyl banners. Both boys and girls responded positively to the vinyl banners (<i>p</i> < .05 in both cases).	Results show that 90.5% (from 12.6% to 24.0%; <i>p</i> = .04) more students took vegetables from the salad bar when exposed to the vinyl banner only, and 239.2% (from 10.2% to 34.6%, <i>p</i> < .001) more students visited the salad bar when exposed to both the television segments and vinyl banners. Both boys and girls responded positively to the vinyl banners (<i>p</i> < .05 in both cases).	This study highlights the positive impact of branded media on children's vegetable selection in the school cafeteria and suggests potential opportunities for using branded media to encourage healthier choices for children.	Advertisement
Hendy et al. (2007)	Overweight and Average-Weight Children Equally Responsive to "Kids Choice Program" to Increase Fruit and Vegetable Consumption	To examine whether the Kids Choice Program produced increases in FV consumption and avoidance of "over justification effects" for overweight and average-weight children.	CHL, PRE <i>n</i> = 275 <i>F</i> = 46.1%	V	The Kids Choice Program included one four-meal block under baseline conditions and three four-meal blocks under reinforcement conditions. During reinforcement conditions, half the children from each grade were randomly assigned to receive token reinforcement either for eating fruits or vegetables.	No	Consumption	For vegetable consumption, a significant food type reinforced study phase interaction was found. No difference in baseline vegetable consumption for children later reinforced for eating vegetables (<i>t</i> (152) = .14, <i>p</i> < .888) was found.	Both average-weight and overweight children are responsive to the program and demonstrate significant increases in the number of meals they consume vegetables.	Incentives and prompts
Hoffman et al. (2010)	Longitudinal Behavioral Effects of a School-Based Fruit and Vegetable Promotion Program	To examine the impact of a multi-year, multi-component, school-based FV promotion program on students' FV consumption during school lunch.	CHL <i>n</i> = 149 <i>F</i> = 49% (intervention) <i>n</i> = 148 <i>F</i> = 49% (control)	V	Program components included influential role models deliver consistent information across multiple settings. The school-wide component included loudspeaker announcements providing an interesting fact about the FV of the day." The lunchtime component involved hanging cafeteria posters reflecting the FV of the day, and lunch aides "catching" students eating FV by giving them verbal praise and a sticker contingent on one bite of these foods. The cafeteria posters, which changed daily to reflect the FV being served that day in the school lunch, were placed as close to the cafeteria line as possible.	Yes	Consumption	Children in the experimental group consumed 6 g more vegetables per lunch (95%CI: 2–11 g, <i>p</i> < .00) at the end of year 1 compared with children in the control group. At the end of year 2, children in the experimental group did not consume more vegetables compared with children in the control group.	The intervention resulted in increased vegetable consumption but results did not remain at year 2.	Modeling, prompts, and advertisement

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Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Horne et al. (2009)	Increasing Parental Provision and Children's Consumption of Lunchbox Fruit and Vegetables in Ireland: The Food Dudes Intervention	To evaluate the effectiveness of the Food Dudes (FD) intervention in Ireland where school meals are not provided and children bring food to school in lunchboxes.	CHL, PRE <i>n</i> = 228 (intervention) <i>n</i> = 207 (control)	V	During the 16-day intervention, children watched video adventures featuring the heroic Food Dudes and received small rewards for eating FV provided. In both schools, parental provision and children's consumption of FV in the lunchboxes were assessed at baseline and 12-month follow-up. FV were provided in both schools over an 8-day baseline phase and the 16-day intervention, and children's consumption was measured.	Yes—no Food Dudes intervention, only FV provision	Parental provision of vegetables in children's lunchboxes and children's consumption	During the last 4 days of the intervention phase, children in the experimental school consumed more vegetables than the control school over the same time period (<i>t</i> = 13.6, <i>p</i> < .001). In the experimental school, consumption of both vegetables was higher in the last 4 days of the intervention compared to the baseline (<i>t</i> = 15.0, <i>p</i> < .001), whereas in the control school, vegetable consumption was lower over the same time period than at baseline (<i>t</i> = 4.1, <i>p</i> < .001).	The Food Dudes intervention was effective in changing parental provision and children's consumption of lunchbox vegetables in Ireland.	Incentives and modeling
Hubbard et al. (2015)	Impact of a Smarter Lunchroom Intervention on Food Selection and Consumption Among Adolescents and Young Adults With Intellectual and Developmental Disabilities in a Residential School Setting	To assess whether a Smarter Lunchroom intervention based on behavioral economics and adapted for students with intellectual and developmental disabilities would increase the selection and consumption of fruit, vegetables, and whole grains, and reduce the selection and consumption of refined grains.	PRE, ADL <i>n</i> = 43 (Students with intellectual and developmental disabilities)	V	The intervention included environmental changes to enhance the students' experience of making choices in the serving line. Communication of the menu choices was enhanced by supplementing the Picture Communication Symbols with real food photos. Peanut butter and jelly sandwiches were moved to the back counter and made available only by request. The healthiest entrée was placed earlier in line, followed by side dishes. Side dishes and entrees were unbundled. Activities to support the intervention included: (i) prompting by "celebrity servers"; (ii) the creation of FV-inspired artwork for the dining hall; (iii) classroom-based taste-testing activities; and (iv) logo naming and branding activities. Side dishes (i.e., pretzels and vegetable side dishes) were "bundled" with the entrée.	No	Selection, consumption, and plate waste	Daily selection of vegetable servings did not change. Significant variability in daily mean serving changes was observed for vegetable selection (likelihood ratio test, <i>p</i> < .001). The rate of selection of all vegetable side dishes did not change significantly from baseline to follow-up. Daily vegetable servings consumed did not change. Vegetable (<i>p</i> = .03) plate waste decreased.	Nudge approaches may be effective for improving the food selection and consumption habits of adolescents and young adults with intellectual and developmental disabilities.	Placement, cafeteria redesign, modeling, defaults, and prompts
Hudgens et al. (2017)	Small Prizes Improve Food Selection in a School Cafeteria Without Increasing Waste	To measure changes in food waste when the Power Plate (PP) program is implemented.	CHL, PRE <i>n</i> = 111 (before intervention) <i>F</i> = 96 (after intervention)	V	The "Power Plate" (PP) intervention was conducted at an elementary school. Green smiley-face emoticons were placed next to the preferred foods in the cafeteria. Students were given a small prize (wrist band, sticker, or temporary tattoo) if they selected the PP. The PP consisted of a fruit, vegetable, and plain fat-free milk (PFFM) along with an entrée and whole grain.	No	Power Plate selection and food waste	Vegetable selection went from 22% to 82% (<i>p</i> < .0001). For food waste, pre and post PP implementation showed that there was no significant difference in food waste before and after the intervention with regards to vegetables (44% before, 36% after).	When children are given small incentives, they will select healthier food items while preserving personal choice. Emoticons coupled with small prizes as incentives for better food selection lead to better food choice and no significant change in food waste.	Incentives

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Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Joyner et al. (2017)	The FIT Game III: Reducing the Operating Expenses of a Game-Based Approach to Increasing Healthy Eating in Elementary Schools	To evaluate whether the game would retain its efficacy if teachers were relieved of this task; presenting instead all game materials on visual displays in the school cafeteria.	CHL, PRE, ADL $n = 572$	V	The narrative of the FIT Game was that to stop the villains Vegetation Annihilation Team (VAT) from doing evil, the FITs must find and capture the three VAT leaders. In order for the children to help them do this, they should eat more vegetables in the school cafeteria. The FIT Game narrative was presented in daily comic book-formatted episodes on a central display in the school cafeteria.	No	Consumption of school-lunch quality and convenience and consumption	Vegetable consumption increased significantly from 21.3 g during the two baseline phases to 42.5 g during the FIT Game phases; a 99.9% increase.	Incentivizing vegetable consumption in schools is an effective method for promoting the development of long-term healthy eating patterns; then, barriers to their adoption and implementation should be addressed.	Incentives and advertisement
Machado et al. (2020a)	The impact of a multi-pronged intervention on students' perceptions of school-lunch quality and convenience and self-reported fruit and vegetable consumption	To determine the impact of a multifaceted intervention on secondary students' perceptions of school-lunch quality and convenience and FV intake.	PRE, ADL $n = 12,903$ $F = 46\%$ (intervention) $n = 11,156$ $F = 53\%$ (control)	V	The intervention comprised: (1) a cafeteria redesign to update décor, paint, and seating options in the cafeteria; (2) teacher education about school meals (newsletters and short videos) and school meal taste tests; and (3) complete school meals (including FV, per NSLP guidelines) sold through vending machines and mobile carts (students had the option of purchasing meals through the traditional serving line or via a mobile cart or vending machine). Mobile carts and vending machines were located in the cafeteria or in the library or just outside the cafeteria.	Yes—no intervention	Student perceptions of school-lunch quality and convenience and consumption	Among 8th graders, perceptions that school lunch tastes good and is enough to make students feel full increased 0.2 points (on a 5-point scale; $p < .01$) in intervention schools versus control schools. In 10th graders, the intervention group saw decreases in daily consumption of vegetables relative to the control group. Plate waste data show increases in vegetable waste in intervention schools versus control schools.	Only modest changes were observed in perceptions of school meals that were not consistent across grades, suggesting that additional efforts are needed to impact changes in student uptake of school meals.	Availability and cafeteria redesign
Machado et al. (2020b)	Promoting School Lunch Fruit And Vegetable Intake Through Role Modeling: A Pilot Study	To evaluate the acceptability and initial outcomes of an adult role modeling intervention on lunchtime FV consumption among elementary school students participating in the NSLP.	CHL, PRE Baseline n (plates) = 566 Follow-up n (plates) = 231	V	Two male college students (cafeteria role models (CRMs)) implemented the intervention. CRMs interacted with students in the cafeteria two to three times per week for 20 weeks. During each lunch period, CRMs ate lunch with kindergarten through 5th-grade students, verbally promoted FV, and provided social reinforcement of FV consumption. Incentives included: (1) raffle tickets administered by CRMs; and (2) raffle prizes given to students by CRMs.	No	Consumption and plate waste	There was a significant increase in the proportion of students consuming all of their selected vegetable. Approximately 18.6% of students consumed all of their selected vegetable at baseline compared to 27.3% at follow-up. At follow-up, a 0.4% increase was found in the 75% waste category ($p < .01$). From baseline to follow-up, there was a 16.0% increase ($p < .01$) in the proportion of students selecting vegetables. Approximately 60% of plates included vegetables at baseline compared to 76% at follow-up. Total plate waste at the (the) level decreased by 3.0% ($p < .05$).	Role modeling in a school cafeteria setting may be a promising health promotion strategy and provide groundwork for future research in the development of school cafeteria role modeling interventions.	Modeling, prompts, and incentives

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Madden et al. (2013)	A Kitchen-Based Intervention to Improve Nutritional Intake From School Lunches in Children Aged 12–16 Years	To examine the effect of a short, low-budget kitchen-based intervention on energy, nutrient, and fruit and vegetable intakes in children aged 12–16 years.	PRE, ADL $n = 180$ $F = 38.9\%$ (before intervention) $n = 198$ $F = 26.3\%$ (after intervention)	V	The intervention consisted of small, practical changes to the school menu with the purpose of reducing total and saturated fat and increasing fruit and vegetable consumption. During the survey period, a bowl of salad was made available for self-service at no extra cost.	No	Consumption	A significant increase in consumption was observed after the intervention for total vegetable intake and for salad in both boys and girls, although the total amount consumed remained low. The proportion of vegetables contributed by each of the subgroups changed following the intervention with increases observed in salad and relative decreases in vegetables.	Some children will make “healthful” choices if they are affordable, as indicated, for example, by the selection of salad when it was available without cost in the post-intervention phase. However, the total amount of vegetables consumed remained low.	Availability
Marcano-Olivier et al. (2019)	A Low-Cost Behavioural Nudge and Choice Architecture Intervention Targeting School Lunches Increases Children’s Consumption of Fruit: A Cluster Randomized Trial	To investigate the effectiveness of a behavioral nudge intervention encouraging children to consume more 0.4% with their lunchtime meal in the school cafeteria.	CHL, PRE $n = 86$ $F = 46.5\%$ (intervention) $n = 90$ $F = 54.4\%$ (control)	V	Four primary schools were randomly allocated to either the control or the intervention condition and baseline data were collected over 2 days in each school. Changes were made to the choice architecture of the school cafeterias in the intervention schools and maintained over a 3-week period. The intervention included improved positioning and serving of fruit (FV first), accompanied by attractive names and food labeling of both FV on offer, advertisements (brightly colored posters advertising), displaying FV, and cartoon characters of children enjoying these foods were placed around the dinner hall.	Yes—no changes in the cafeteria	Daily consumption at lunchtime	No significant changes in consumption were identified in the intervention condition for vegetables ($F [1, 86] = 0.52, p = .473$) from baseline to follow-up. Vegetable consumption was matched at both baseline and follow-up, with no significant changes recorded in the intervention schools or control schools over time.	The intervention was not effective for vegetable consumption. This has implications for the development of national and international strategies to promote healthy eating in schools.	Placement, modeling, labels, images and names, and advertisement
Marcano-Olivier et al. (2021)	Changes in the Nutritional Content of Children’s Lunches After the Food Dudes Healthy Eating Programme	To examine changes in children’s lunchtime consumption of FV, followed by the Food Dudes programme on calorie consumption, and to a macronutrient and micronutrient level.	CHL, PRE $n = 58$ (intervention) $n = 75$ (control)	V	Children watched an episode of the Food Dudes, while they were presented with one portion of FV. Phase 1: reward for tasting the food items and a prize for eating it. Phase 2: rewards for eating a specified number of FV. Choice architecture changes: increase variety of healthy foods; changing the order of serving; cueing consumption via branding, role models, and encouragement by catering staff. Data were recorded over 4 consecutive days, at baseline and follow-up.	No changes	Consumption	Vegetable consumption increased with a moderate effect in the intervention school (Mdn difference 4 g, $F [1, 57] 8.99, p < .01$) but not in the control school (Mdn difference 0 g, $F (1, 57) 0.37, p = .548$). At follow-up, intervention school consumed higher weight of vegetables versus control school (Mdn intervention 15 g, Mdn control 2.5 g, $U 1251-0, p = .015, r 0.23$).	FD successfully increased vegetable consumption; longer data collection period is recommended.	Incentives, modeling, presentation, and availability

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Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
McCormick et al. (2009)	"Fun Fruit and Veggie Event" Enhances Acceptance of Fruits and Vegetables in School-Aged Children	To determine whether the "Fun Fruit and Veggie Event" program enhanced students' acceptance of FV.	PRE, ADL $n = 1097$	V	All the "Fun Fruit and Veggie Event" events included sampling of raw FV. In addition to FV sampling, other activities included a theme such as a Hawaiian Luau; incentives for children; educational units on the benefits of FV consumption; nutrition information presentations by nurses, dietitians, and the Team Nutrition spokes character, Power Panther; and interactive games, relays, and exercises.	No	Acceptance, consumption, willingness to incorporate more FV into their diet	The event had a positive impact on vegetable acceptance, knowledge, action steps to incorporate vegetables into the diet, and consumption. The K-4 students increased acceptance for three of the six vegetables. The students increased acceptance for 17 of the 31 vegetables, had significant improvement in basic knowledge of vegetables ($p < .001$), and showed willingness to incorporate more vegetables into the diet in 3 of 12 scenarios.	School-based interventions that include vegetable in a fun and exciting manner enhance knowledge and self-reported acceptance of vegetable in children.	Incentives and advertisement
Miller et al. (2015)	Increasing Portion Sizes of Fruits and Vegetables in an Elementary School Lunch Program Can Increase Fruit and Vegetable Consumption	To determine whether increasing the portion sizes of FV in an elementary school cafeteria environment would increase children's consumption of them.	CHL, PRE $n = 643-758$	V, L	Two intervention days: increased the portion size of one vegetable (raw baby carrots) by about 50%. A second vegetable (green beans) was served on control and intervention days at the standard portion size.	Yes—normal portion size	Consumption and number of students eating vegetables	An increase in the portion size of three of the four vegetables by about 50% resulted in an increased consumption by the children who took them. Few children selected any vegetable from the cafeteria line. Only 12%–14% of children selected carrots, and 4%–6% selected green beans. Serving larger portions did not increase or decrease the proportion of students selecting the beans or the carrots.	Children consumed more vegetables in an elementary school cafeteria when the portion sizes of these foods were increased by about 50%. Although this was an effective strategy for increasing vegetable consumption, many children chose not to take any.	Presentation
Mistura et al. (2019)	Examining the Efficacy of a Feasible Nudge Intervention to Increase the Purchase of Vegetables by First Year University Students (17–19 years of age) in British Columbia: A Pilot Study	To examine the impact of a contextually feasible evidence-informed nudge intervention on food purchasing behavior of older adolescents (1st-year students) in a university residence cafeteria in British Columbia, Canada.	ADL $n = 5098$ $F = 40\%$ (baseline 1) $n = 6173$ $F = 41.6\%$ (intervention 1) $n = 5754$ $F = 43\%$ (baseline 2) $n = 7385$ $F = 41.5\%$ (intervention 2)	V	The nudges were placement nudges that involved altering the properties of the vegetables to enhance freshness and appearance. This was implemented by adding an option of a fresh, raw vegetable to the existing cooked vegetable option, in combination with an environmental cue (sensory and cognitive) in the form of a small poster displayed at the eye level, highlighting the addition of the fresh vegetable option with a colorful character and a health message.	No	Number of students purchasing one of the vegetables	Visual inspection showed neither intervention had an effect on the mean proportion of vegetables purchased between phases for the overall sample or for females or males analyzed separately.	More research is needed. Nudges in real-life settings, rather than laboratories, need to have more controls in place.	Placement, presentation, and advertisement

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Perry et al. (2004)	A Randomized School Trial of Environmental Strategies to Encourage Fruit and Vegetable Consumption Among Children	To test whether a cafeteria-based intervention would increase the FV consumption of children.	CHL, $n = 1668$ $F = 49\%$ (baseline) $n = 1168$ (follow-up)	V	The Cafeteria Power Plus intervention program consisted of daily activities (role models, increasing the availability, attractiveness, and encouragement for FV) and special events (kick-offs, samplings, challenge weeks, theater production, posters, and finale meal).	Yes—delayed program	Number of servings consumed	Increasing vegetable appeal was not significantly associated with the outcome measures. There were no significant differences between conditions for vegetables.	The outcomes suggest that multicomponent interventions are more powerful than cafeteria programs alone with this age group.	Availability, prompts, presentation, modeling, advertise-ment, and incentives
Pope and Wolf (2012)	The Influence of Labeling the Vegetable Content of Snack Food on Children's Taste Preferences: A Pilot Study	To investigate whether informing children that they are eating a snack containing a vegetable, by including the its name prominently on the snack's label, influences children's taste preferences.	CHL, PRE, ADL $n = 68$ $F = 43\%$	V, L	Children were asked to taste identical pairs of three baked snacks containing a vegetable and indicate which they prefer. Both samples (labeled and unlabeled) contained the vegetable, but only one sample was labeled with the vegetable's name (e.g., zucchini chocolate chip bread), and a second sample omitted the vegetable's name on the label (e.g., chocolate chip bread).	No	Preference and frequency of consumption	Taste preferences did not differ for the labeled versus the unlabeled sample of zucchini chocolate chip bread, $\chi^2 (2, n = 68) = 3.21, p = .20$ or broccoli gingerbread spice cake, $\chi^2 (2, n = 68) = 2.15, p = .34$. However, students preferred the unlabeled cookies over the V-labeled version, $\chi^2 = (2, n = 68) 9.21, p = .01$. Chickpeas were consumed less frequently (81% had not tried in past year) as compared to zucchini and broccoli.	Informing children of the presence of vegetable hidden within snack food may or may not alter taste preference and may depend on the frequency of prior exposure to the vegetable.	Labels, images, and names
Presti et al. (2015)	Increased Classroom Consumption of Home-Provided Fruits and Vegetables for Normal and Overweight Children: Results of the Food Dudes Program in Italy	To assess whether overweight and normal-weight children who followed the Food Dudes program would differ in the amount of classroom consumption of home-provided FV compared with children who did not follow the program.	CHL, PRE, ADL $n = 672$ $F = 49\%$	V	Intervention schools received the Food Dudes program: 16 days of repeated taste exposure (40 g of fruits and 40 g of vegetables), video modeling, and rewards-based techniques. For each of the 16 days of intervention, two half portions of both fruits (40 g) and vegetables (40 g) were presented in the following rotating order: banana/fennel; cantaloupe/red cabbage; white melon/cherry tomato; pineapple/carrot. On day 1 of the intervention phase, children also received a home pack containing information and tips for parents on healthy eating and a chart for children to record the number of FV portions eaten at home.	Yes—only repeated exposure to vegetables and eaten	Grams of vegetables brought from home	Intervention schools show a significant increase in home-provided vegetable intake ($p < .001$) consumption both in overweight and normal-weight children. The amount of vegetable consumption in the intervention schools was significantly higher at the end of the intervention ($t(60) = 8.02, p < .001$) and maintenance phases ($d(63) = 7.18, p < .001$) versus baseline. Approximately half of children in the intervention schools ate at least one portion of vegetables at the end of the intervention and maintenance phases.	<ul style="list-style-type: none"> The increase in home-provided vegetable intake was similar in overweight and normal-weight children in the FD intervention schools versus the comparison school. The effect of the FD program was higher at the end of the intervention phase versus the end of the maintenance phase. Repeated exposure alone is not enough to increase home-provided vegetable intake. 	Modeling and incentives
Quinn et al. (2018)	Effects of a Behavioral Economics Intervention on Food Choice and Food Consumption in Middle-School and High-School Cafeterias	To evaluate whether a year-long choice architecture intervention implemented by school cafeteria managers changed student selection and consumption of healthy foods.	PRE, ADL $n = 902$ $F = 40.6\%$ (baseline) $n = 1407$ $F = 41.2\%$ (follow-up)	V	Food service staff from six secondary schools in one school district received training and support to implement behavioral economics strategies in their cafeterias to promote student selection of fruits, vegetables, and low-fat white milk. Strategies presented included displaying items in attractive containers, using creative names, using signage, placing items strategically (e.g., at eye-level and/or in multiple places), and having staff prompt students.	Yes—no intervention	Selection and consumption	At baseline, students selecting vegetables including potatoes, were higher for the comparison group. There were no intervention effects for selecting vegetables including potatoes increased significantly in intervention schools from baseline to follow-up. The comparison group increased the proportion of students selecting vegetables.	Results indicate that behavioral economics-based choice architecture can promote student selection of healthy foods, but they raise questions about whether it increases their consumption.	Placement, presentation, prompts, labels, names, and images

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Redden et al. (2015)	Serving First in Isolation Increases Vegetable Intake Among Elementary Schoolchildren	(1) To test if people eat larger quantities of a vegetable when first receiving it in isolation versus alongside other foods. (2) To test whether the predicted effects of food order prove successful as a dietary intervention in the natural setting of a school cafeteria.	CHL, PRE 1st study: $n = 75$ (intervention) $n = 680$ (control) 2nd study: $n = 180$ $F = 38.3\%$	V	Two experiments: (1) Vegetable first alone: Small paper cups for each student that contained two raw mini carrots (the same as those available from the line) were placed on the table so that there would be a cup in front of each student upon arrival. Students could eat these carrots as they waited to enter the line but were not explicitly instructed or encouraged to eat them. (2) Vegetable First day: Small servings of broccoli (two pieces) in 2-oz. paper cups were handed to each student in the hallway to eat while standing in the register line.	(1) Yes—lunch like every other day under “normal” conditions. (2) V from a buffet-type line	Consumption On the day carrots were served first in isolation versus the control day (intervention = 12.7 g vs. control = 2.4 g; $t(1433) = 14.95, p < .0001, d = .83$). The likelihood of choosing carrots from the line did not differ between the two treatment days nor did the mean amount of carrots eaten from the line. The net result was an increase in carrot consumption of over 430% that was almost entirely driven by students eating carrots from the cups before entering the line.	(1) Higher broccoli consumption on the 1st intervention day than either the 1st or last control day. The net result was an increase in broccoli consumption on the intervention days ranging from 150% to 380% that was almost exclusively linked to consumption of the broccoli from the cups.	Serving a food first can increase intake for a less-liked food (carrots and broccoli) versus just well-liked foods, which is essential for promoting the consumption of vegetables. Results also show that effects persist even with repeated exposures spanning nearly 2 months, and with children not actively supervised by a parent or guardian.	Presentation
Stega-Riz et al. (2011)	The Effects of the HEALTHY Study Intervention on Middle School Student Dietary Intakes	To examine the effects of the HEALTHY study on student self-reported dietary intakes (energy, macronutrients, and grams consumed of selected food groups).	PRE, ADL $n = 1964$ $F = 53\%$ (intervention) $n = 1944$ $F = 53\%$ (control)	V, L	Strategies targeting vegetables: offer at least three different fruit and/or vegetable at National School Lunch Program (NSLP) every day and for legumes and the offer of at least two different fruit and/or vegetable at the School Breakfast Program (SBP) every day. Strategies targeting legumes: offer at least three different high-fiber grain-based foods and/or legumes (≥ 2 g fiber/serving) at NSLP every day, offer at least two different high-fiber grain-based foods and/or legumes (≥ 2 g fiber/serving) at SBP every day.	Yes	Consumption There were no significant differences between intervention and control for mean intakes of energy, macronutrients, fiber, grains, vegetables, and legumes consumption.	Subsequent interventions need to go beyond the school environment to change diet behaviors that may affect weight status of children.	Availability	
Song et al. (2016)	Project ReFresh: Testing the Efficacy of a School-Based Classroom and Cafeteria Intervention in Elementary School Children	To assess the effect of a school-based nutrition program using a cafeteria environment intervention and classroom nutrition education on self-reported FV consumption, self-efficacy to select FV, and preference for healthy foods.	PRE $n = 332$ (ReFresh) $n = 142$ (cafeteria) $n = 191$ (control) $F = 51.1\%$	V	The intervention included three conditions: (1) The comprehensive group (ReFresh program group), consisting of nutrition education and behavioral economics-based cafeteria changes (eight schools); (2) The cafeteria group, which only received behavioral economics-based cafeteria changes (two schools); (3) The control group, which received neither (two schools).	Yes—no intervention	Self-reported consumption, self-efficacy to prepare vegetables, and food preference	The comprehensive group increased vegetable consumption for lunch ($p = .007$), number of days eating vegetables ($p < .001$) in the last week, and self-efficacy in preparing vegetables at home ($p = .034$) compared to the control and cafeteria groups. Food preference of vegetables ($p = .003$ for comprehensive group) significantly improved in the cafeteria and/or comprehensive group. Preference for squash/zucchini/pumpkin significantly decreased in the comprehensive intervention group.	Classroom nutrition education combined with cafeteria improvement has the potential to improve diet-related behavior of elementary school children. Data were self-reported by students and food service staff members.	Prompts, placement, incentives, labels, images, and names

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TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Taylor et al. (2013a)	Can a School-Based Intervention Increase Fruit and Vegetable Consumption for Children With Autism?	To evaluate the short and long-term effectiveness of the Food Dudes intervention on lunchtime FV consumption for children with autism spectrum disorder (ASD).	CHL, PRE $n = 12$ $F = 25%$ (children with ASD)	V	A cohort study consisting of children who received the Food Dudes intervention. Food Dudes is built and developed on three pillars of scientific merit: (1) repeated tastings, (2) rewards, and (3) role modeling.	No	Consumption	Mean vegetable consumption decreased between baseline and 3-month follow-up (-3.31 g); however, increased at 1-year follow-up ($+10.57$ g) from baseline. Mean vegetable consumption did not change significantly across the study phases, $\chi^2(3, 12) = 5.40, p > .05$.	There is little evidence that the Food Dudes program produced either short- or long-term changes in children's lunchtime consumption of vegetables for children with ASD.	Modeling, Incentives
Taylor et al. (2013b)	Can a School-Based Intervention Increase Children's Fruit and Vegetable Consumption in the Home Setting?	To establish whether the Food Dudes intervention can influence home vegetable consumption and the long-term effect.	CHL, PRE $n = 16$ $F = 44%$ (intervention) $n = 18$ $F = 56%$ (control)	V	The Food Dudes programme consists of an initial 16-day intervention phase during which children watch a series of episodes of the Food Dudes adventures, encouraging children to eat FV every day. Class teachers also reinforce children by reading letters to them. Children are given rewards for tasting and consuming the target FV. Time-points: baseline (prior to the intervention), 3-month follow-up (post-intervention), and 12-month follow-up.	Yes, no intervention	Consumption at home	Weekdays: No short- or long-term changes in children's vegetable consumption at home during weekdays or at the weekend. Vegetable consumption decreased in both schools between baseline and 3-month follow-up, being greater for the intervention than the control group (-0.32 and -0.14 , respectively). In the intervention schools, vegetable consumption increased at 12-month follow-up but did not reach baseline. Weekend: No program effect on the increases in vegetable consumption between baseline and follow-up.	The Food Dudes programme had no short- or long-term effect on changing children's vegetable consumption in the home environment during weekdays or at the weekend.	Incentives and prompts
Thompson et al. (2017)	The Impact of Multiple Strategies to Encourage Fruit and Vegetable Consumption During School Lunch	To test if multiple school lunch interventions implemented simultaneously increase student consumption of FV during school lunch.	CHL, PRE $n = 373$	V	Implementation of multiple encouragement strategies: labels, menu boards, slicing, placed at register or front of line, black trays/bowls. Schools implemented multiple strategies simultaneously over 12 months. Data were collected on two consecutive days both prior to and after implementation. Two additional strategies were identified; School A changed lunchroom procedure from allowing students to line up for recess when they wanted longer time to eat; School B decreased the size of their utensil table.	No	Consumption	Not significant increase in consumption and number of students selecting vegetables and the number of students consuming an entire serving of vegetables. School A yielded positive results, reducing the number of students with zero vegetables on their trays.	Additional strategies are needed to increase vegetable selection and consumption. Expansion of using labels with all items and cafeteria and names, and redesigning hot vegetables more appealing should be considered.	Presentation, placement, labels, images and names, and cafeteria
Van Kleef et al. (2015)	Encouraging Vegetable Intake as a Snack Among Children: The Influence of Portion and Unit Size	To examine whether providing larger portions of vegetables in larger units would increase their consumption as a snack among elementary-school children during a break at school.	CHL, PRE $n = 255$ $F = 55.7%$	V	Pupils were presented in class with cucumber that varied both in unit size (one piece vs. pre-sliced) and portion size (1/3 vs. 2/3 of a cucumber). Children ate ad libitum during the morning break and filled in a survey.	No	Consumption	Children ate 54% more cucumber when served a large compared with a smaller portion (difference of 49 g; $p < .001$). Larger gage units did not impact consumption (1/3 vs. 2/3 of a cucumber). Children ate convenient to eat than small units ($p = .001$).	Although portion size did influence consumption, serving larger units seemed ineffective in increasing intake in the present study. Children's vegetable intake can be improved by serving larger portions in smaller-sized pieces.	Presentation

(Continues)

TABLE 2 (Continued)

Authors	Title	Aim	Population	Target Food	Intervention	Control	Outcome	Results	Conclusions	Intervention category (type)
Wardle et al. (2003)	Modifying Children's Food Preferences: The Effects of Exposure and Reward on Unfamiliar Vegetable	To evaluate two interventions (one reward-based and one exposure-based) for increasing children's acceptance of an unfamiliar vegetable compared with a no-treatment control.	CHL, $n = 49$ $F = 53\%$	V	Interventions comprised eight daily sessions during which participants in the exposure group were offered a taste of sweet red pepper and were told that they could eat as much as they liked. Participants in the reward group were shown a sheet of cartoon stickers and were told that they could choose one of them on condition that they ate at least one piece of the pepper.	Yes—no treatment	Liking and consumption	The exposure-based intervention increased both liking ($p < .006$) and consumption ($p < .03$) versus the control group. The outcome of the reward intervention did not differ from the exposure or control conditions. The exposure procedure resulted in a slow, steady increase in both liking and consumption. The reward procedure produced a swift increase from the pre-test to treatment session one, but after that no significant increase in consumption over the treatment sessions.	Repeated exposure to the taste of unfamiliar foods is a promising strategy for promoting liking of previously rejected foods in children.	Incentives
Wengreen et al. (2021)	A Randomized Controlled Trial Evaluating the FIT Game's Efficacy in Increasing Fruit and Vegetable Consumption	To address (a) if no-cost virtual incentives can replace tangible, (b) if the virtual incentives can discourage cheating.	CHL, PRE, $n = 881$ $F = 47.2\%$ (intervention) $n = 978$ $F = 46.6\%$ (control)	V	The narrative of the FIT Game was that to stop the villains, VAT, from doing evil, the FITs must find and capture the three VAT leaders. For the children to help them do this, they should eat more V in the school cafeteria. Throughout the intervention phase, a FIT Game episode was displayed on a large screen in the cafeteria. Episodes looped continuously throughout the lunch period. Daily episodes typically ended with a cliff-hanger ending and a request that the children eat a little more vegetable than normal, even if that is just one bite.	Yes—no game	Consumption	At the end of the intervention, children in the FIT Game schools were consuming more vegetables versus baseline ($\Delta\text{MBL-PI} = 10.66 \text{ g}$, $d = 0.41$, $p < .001$). These increases were maintained at a 3-month follow-up. At follow-up, half of the gains measured for vegetable consumption was lost ($\Delta\text{MPI-FU} = -5.25 \text{ g}$, $d = -0.20$, $p < .001$), however, a moderate long-term increase above the baseline was established ($\Delta\text{MBL-FU} = 5.41 \text{ g}$, $d = 0.21$, $p < .001$). A moderate long-term reduction in vegetable consumption was observed for the control schools ($\Delta\text{MPI-FU} = -3.65 \text{ g}$, $d = -0.14$, $p = .007$).	The no-cost virtual incentives of the FIT Game increased vegetable consumption in the short- and long-run, without negatively impacting intrinsic motivation.	Incentives
Wordell et al. (2012)	Changes in a Middle School Food Environment Affect Food Behavior and Food Choices	To determine whether there are associations between an altered school food environment and food choices of early adolescents both in and outside of school.	PRE, ADL, $n = 2292$ $F = 49\%$	V	The school food environment included all foods available to students during the school day. Two of the six schools allowed only bottled water in vending machines, only milk and F on à la carte menus, and offered a seasonal FV bar. Two schools removed juice products and allowed only non-flavored bottled water in vending machines, restricting à la carte items to only milk and fruit removing all other items, and making a seasonal FV bar available to all students.	Yes—no intervention	Frequency of consumption	There were no differences in vegetable consumption reported by children in control and intervention schools. Girls reported more frequent consumption of vegetables than boys outside school.	Restricting unhealthy foods does not increase the consumption of vegetables.	Availability

Note: Population groups considered are the following: Children (CHL) < 9, pre-adolescents (PRE) 9–12, and adolescents (ADL) 13–18. The food groups are vegetables (V), legumes (L), and fruit and vegetables (FV). The gender groups are female (F) and male (M).

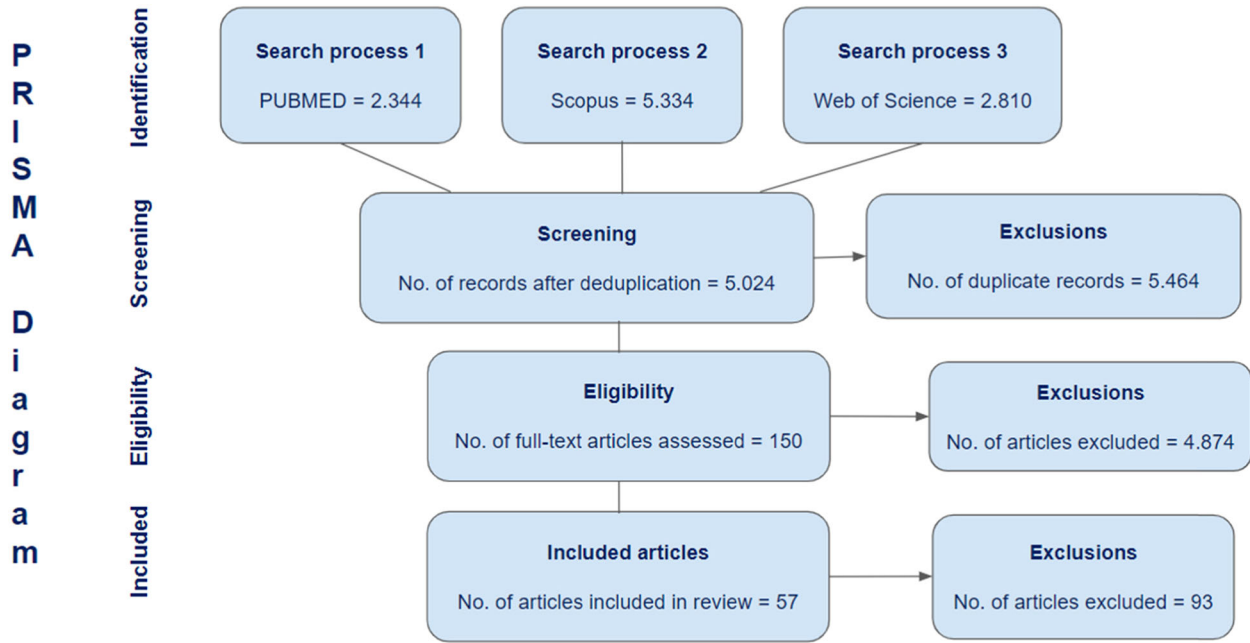


FIGURE 1 PRISMA diagram.

rating legumes in school meals entrée could potentially increase their consumption and acceptability depending on the entrée type and the degree of change in entrée appearance, with highly visible changes resulting in lower consumption compared to when the incorporation of legumes in the dish was not easily detectable by the students (Burgess-Champoux et al., 2018). On top of that, changing the appearance and texture of initially disliked vegetables into appealing snacks positively impacted their consumption both at the first attempt and after repeated exposure (Chung & Fong, 2018; Chung et al., 2020). Positive results also came from the use of a chef-enhanced menu, specifically developed to enhance the sensory appeal of vegetable serving according to the chef's creativity and experience. Chefs were asked to develop new school menus—similar to the standard ones—but with healthier ingredients and higher palatability, with results showing higher consumption of chef-developed vegetable servings in comparison to the standard one (Cohen et al., 2015). Similar results were found when chef-enhanced vegetable dishes were presented in a family-style serving (i.e., using non-disposable plates, glasses, and cutlery; sitting with an adult; table mate serving food to the others) all along the school year (Zellner and Cobuzzi, 2017). Liking and consumption of the target vegetable (cauliflower) were much higher in children participating in the intervention than in those attending the standard program. Similarly, Just et al. (2014) reported an increased vegetable consumption in a chef-created menu in which vegetables were served as a side dish.

On the other hand, mixed findings came from studies using food transformation in combination with other strategies. In particular, Mistura et al. (2019), reported no significant effects in increasing vegetable consumption when food transformation was combined with placement and educational nudges (poster), contrary to findings from Cohen et al. (2015), who reported a positive effect when food transformation was combined with placement and decoration elements.

The addition of herbs and spices to improve flavor without impacting energy load and sugar, saturated fat, or sodium content appears an effective strategy to promote vegetable acceptance. Spice-flavored vegetables were liked and consumed more than their plain version (D'Adamo et al., 2021). It appears that the effectiveness of this strategy depends on the amount of herbs/spices added to provide the optimal level of flavor enhancement as well as on the specific vegetable—herbs/spice pairing (D'Adamo et al., 2021).

3.1.2 | Manipulating valence: Evaluative conditioning and hedonic contrast

Evaluative conditioning refers to the attitude change due to the pairing of a neutrally valenced object, with another stimulus with a positive valence (Jones et al., 2010). A key aspect of this learning mechanism is that the repeated co-occurrence of the neutrally and positive valenced objects induces a durable valence transferred from the positive

to the neutral stimulus and this is associated with its increased acceptance and consumption.

The repeated exposure to combinations of vegetables with other food/ingredients characterized by already preferred flavor appears an actionable strategy to promote long-term vegetable acceptance and consumption. The pairing of vegetables with an already preferred flavor (peanut butter) showed an increase in both the amount and variety of consumed vegetables after repeated exposure, while no difference was observed with the exposure alone (Johnston et al., 2011). Repeated exposure to mixes of neutral and liked or neutral and disliked vegetables showed that liking and consumption of the neutral food, when presented in isolation, was higher in the subject group exposed to the combination of neutral and liked stimuli (Olsen et al., 2012). Interestingly the same study pointed out the lack of a clear effect of repeated exposure on the acceptance of intervention vegetables, rather a lowering of liking and intake was observed and tentatively explained by a “boredom effect” (Köster & Mojet, 2007). According to hedonic contrast theory “how much we like one product is modified by our evaluations of other products evaluated at the same time” (Sherif, Taub, & Hovland, 1958). Several evidence on hedonic contrast effects come from drink and food studies and show that a food is less liked/consumed when presented after/together with one that is more appealing. Thus strategies aimed at promoting the consumption of plant-based dishes (less appealing) might take advantage of avoiding the hedonic contrast effect within a menu.

The modification of the presentation order (from simultaneous to course service) of less (vegetables) and more (fruit) liked food servings indicated an increased intake of the targeted vegetables when the fruit was served after the rest of the meal rather than at the same time, suggesting serving the fruit component at the end of the meal to increase vegetable consumption (Zellner & Cobuzzi, 2016).

3.2 | Nudging interventions

The majority of the identified interventions in this systematic review used nudging as a strategy to promote vegetables and pulses. In fact, 47 interventions were identified, using one or a combination of nudging strategies, details of which are presented in Table 2. Such strategies include:

Availability

- increasing availability and variety of vegetables and pulses (Adams et al., 2005; Bean et al., 2018; Bergamaschi et al., 2016; Birnbaum et al., 2002; Cohen et al., 2014; Machado, Burton et al., 2020; Madden et al., 2013;

Perry et al., 2004; Siega-Riz et al., 2011, Marcano-Olivier et al., 2021),

- decreasing availability of unhealthy foods (Boehm et al., 2020; Wordell et al., 2012);

Placement, environmental changes, and defaults

- changing the placement of vegetables and pulses in the lunchroom (Ensaft et al., 2015; Hubbard et al., 2015; Marcano-Olivier et al., 2019; Mistura et al., 2019; Perry et al., 1998; Quinn et al., 2018; Thompson et al., 2017),
- making environmental changes such as redesigning the cafeteria space to include signs, names, decoration, and menu boards (Cohen et al., 2015; Hamdi et al., 2020; Hubbard et al., 2015; Machado, Burton et al., 2020a; Thompson et al., 2017),
- changing the default (Hubbard et al., 2015);

Serving style, size, and presentation

- changing the size (Adams et al., 2005; Miller et al., 2015; van Kleef et al., 2015),
- improving foods’ presentation (Ensaft et al., 2015; Erjavec et al., 2021; Perry et al., 1998, 2004),
- changing the service style (Adams et al., 2005; Erjavec et al., 2021; Goh et al., 2017; Quinn et al., 2018; Robichaux & Adams, 1985; Thompson et al., 2017),
- changing the serving order (Elsbernd et al., 2016; Redden et al., 2015, Marcano-Olivier et al., 2021);

Packaging and labeling

- changing food packaging (Dial & Musher-Eizenman, 2020; Hanks et al., 2013; Quinn et al., 2018),
- using labeling (Dave et al., 2015; Dial & Musher-Eizenman, 2020; Ensaft et al., 2015; Erjavec et al., 2021; Hamdi et al., 2020; Marcano-Olivier et al., 2019; Pope & Wolf, 2012; Song et al., 2016a; Thompson et al., 2017);

Reinforcement and incentives

- using prompts (Chinchanachokchai et al., 2022; Dave et al., 2015; Erjavec et al., 2021; Machado, Ritchie et al., 2020; Quinn et al., 2018; Song et al., 2016a; Hubbard et al., 2015; Hanks et al., 2013; Hendy et al., 2007; Hoffman et al., 2010; Perry et al., 2004; Taylor, Darby et al., 2013),
- using rewards (Hendy et al., 2007; Horne et al., 2009; McCormick et al., 2009; Perry et al., 2004; Presti et al., 2015; Taylor, Upton et al., 2013; Wardle et al., 2003, Taylor, Darby et al., 2013),
- using incentives (Hoffman et al., 2011; Hudgens et al., 2017; Joyner et al., 2017; Machado, Ritchie et al., 2020;

McCormick et al., 2009; Wengreen et al., 2021, Ansu et al., 2021, Marcano-Olivier et al., 2021),

- using marketing techniques such as characters, banners, and messages,
- using modeling (role and peer modeling) (Hoffman et al., 2010; Horne et al., 2009; Perry et al., 2004; Taylor, Upton et al., 2013; Hubbard et al., 2015; Birnbaum et al., 2002; Machado, Ritchie et al., 2020; Marcano-Olivier et al., 2019, 2021; Presti et al., 2015);

Advertisement

- using marketing techniques such as banners, messages, events and posters (Dave et al., 2015; Ensaff et al., 2015; Erjavec et al., 2021; Hanks et al., 2016; Hoffman et al., 2010; Joyner et al., 2017; Marcano-Olivier et al., 2019; McCormick et al., 2009; Mistura et al., 2019; Perry et al., 2004).

3.2.1 | Presentation

Among the interventions using choice architecture nudging are the ones changing foods' presentation. This systematic review identified 17 studies reporting the use of such a strategy, with all of them focusing on vegetable promotion. When it comes to serving size, five studies reported higher vegetable intake when using larger serving units suggesting serving vegetables as a whole instead of cut in pieces would increase children's consumption (Cohen et al., 2014; Erjavec et al., 2021; Goh et al., 2017; Miller et al., 2015; van Kleef et al., 2015). However, two studies reported that increasing portion size did not nudge more children toward selecting larger foods (Cohen et al., 2014; Miller et al., 2015).

When it comes to changes in the serving style, no effects were reported when decreasing the size of utensil table (Thompson et al., 2017), displaying the vegetables in attractive containers (Quinn et al., 2018), arranging them by color (Mistura et al., 2019; Perry et al., 2004), changing their serving shape (Bergamaschi et al., 2016), and when using salad bars versus pre-portioned vegetable servings (Adams et al., 2005). On the contrary, the use of disposable pots and prefilled trays, in combination with other food choice architecture techniques (e.g., stickers on packages, end-of-shelf labeling, and placing products in a prominent position near the till) nudged secondary school children toward selecting more vegetables (Ensaff et al., 2015). In addition, the use of different packaging styles (healthy, fun, plain, or unpacked) revealed that children are influenced by some aspects of food packaging, with one study reporting positive effects of transparent containers (Hanks et al., 2013) and another reporting that packages providing

more information were generally more appealing (Dial & Musher-Eizenman, 2020).

On the other hand, changing the serving order reported positive results in three studies. In particular, a study using two experiments: (a) serving carrots first in paper cups upon students' arrival in the lunchroom and (b) serving cauliflower first while students waited in the line reported that both experiments had a significant increase in carrots and cauliflower consumption compared to control days (buffet-type lunch) (Redden et al., 2015). Similarly, when students were served raw peppers while waiting in line to receive the rest of their lunch meal, an increased proportion of students taking and eating the vegetable was observed (Elsbernd et al., 2016). Finally, as part of a multicomponent intervention, serving vegetables before other starchy options and making them more attractive was reported to increase vegetable consumption among children and pre-adolescents compared to the control group (Marcano-Olivier et al., 2021).

3.2.2 | Placement

Another typical example of food choice architecture nudging is making changes in the placement of foods, such as placing them at eye level (Quinn et al., 2018), near the till (Thompson et al., 2017), and first in the lunch line (Cohen et al., 2015; Thompson et al., 2017). We identified nine studies (Cohen et al., 2015; Ensaff et al., 2015; Hanks et al., 2013; Hubbard et al., 2015; Marcano-Olivier et al., 2019; Mistura et al., 2019; Quinn et al., 2018; Song et al., 2016a; Thompson et al., 2017) using placement to nudge students toward eating more vegetables, but only four of them reported success in increasing vegetable selection (Cohen et al., 2015; Ensaff et al., 2015; Hanks et al., 2013) or consumption (Cohen et al., 2015; Song et al., 2016a). All studies used a multicomponent approach.

3.2.3 | Incentives

Incentivizing children to eat plant-based foods is a common approach used in school-based interventions, with most studies providing positive effects in promoting vegetables; however, no intervention promoting pulses was identified. Thirteen out of the 16 studies identified reported that incentives such as small prizes (Birnbaum et al., 2002; de Marchi et al., 2020; Hendy et al., 2007; Machado, Ritchie et al., 2020, Marcano-Olivier et al., 2021), raffle tickets (Machado, Ritchie et al., 2020), virtual currencies (Joyner et al., 2017), and stationery (Horne et al., 2009) increased children's liking, acceptance, willingness to try, and intake of vegetables. Incentives were commonly used

together with modeling and education, with most of the interventions reporting positive effects (Birnbaum et al., 2002; Horne et al., 2009; Machado, Ritchie et al., 2020; McCormick et al., 2009; Presti et al., 2015; Song et al., 2016a; Wengreen et al., 2021; Marcano-Olivier et al., 2021), except from one intervention targeting children with autism, in which no significant effect was reported (Taylor, Upton et al., 2013); however, results from the latter could be attributed to the small sample size ($n = 12$) or the special needs of the children. Finally, in a study that used incentives in combination with repeated exposure to sweet peppers, an increase in the peppers' consumption was only recorded in the exposure group and not in the group that was offered stickers if they would choose a piece of pepper (Wardle et al., 2003).

The use of games is another method to nudge children and adolescents toward eating more vegetables and pulses. One intervention was identified using a game-based approach to incentivize students to eat more vegetables (Joyner et al., 2017). The interventions led to an increased consumption of vegetables and pulses suggesting that getting children to carry out activities using real foods could be an effective strategy to increase the acceptance of novel foods. In addition, incentivizing students through a game-based approach could be beneficial in the promotion and establishment of long-term healthy eating patterns.

3.2.4 | Modeling

Ten studies were identified reporting an intervention that included the use of role or peer modeling to promote vegetables. Peer modeling examples include the use of videos with other children or characters of a similar age (Hoffman et al., 2010; Horne et al., 2009; Marcano-Olivier et al., 2019, 2021; Presti et al., 2015; Taylor, Upton et al., 2013) and role modeling examples include celebrities (Hubbard et al., 2015), college students, and school staff (Hoffman et al., 2010; Machado, Ritchie et al., 2020). Eight out of the 10 interventions targeted children and pre-adolescents, except two which also targeted adolescents (Birnbaum et al., 2002; Hubbard et al. 2015).

Modeling (role and peer) generally showed promising results in increasing liking and consumption of vegetables. Two interventions that used role modeling showed a positive effect in increasing vegetable intake with one of them also decreasing vegetable waste among children and pre-adolescents (Machado, Ritchie et al., 2020). Multicomponent interventions using cartoon characters targeting children and pre-adolescents reported different effects, with two resulting in an increased vegetable consumption (Hoffman et al., 2010, Marcano-Olivier et al., 2021) and the others reporting no increase (Marcano-Olivier et al.,

2019; Perry et al., 2004). Meanwhile, the Food Dudes (FD) intervention, which is widely used to promote vegetables to children and pre-adolescents through videos featuring the FD heroes and encouraging children to eat more vegetables, was found to have mixed results. On the one hand, the intervention was not successful in influencing children with autism to consume more vegetables (Taylor, Upton et al., 2013), but on the other, it had a significant effect in three interventions targeting children and pre-adolescents without autism, suggesting that peer modeling might not be the most suitable strategy to increase vegetable intake for children with special needs.

3.2.5 | Labels, images, and names

The use of labels, images, names, and menu wording is another nudging technique identified by this systematic review to promote the consumption of vegetables and pulses; however, results are discouraging as only three interventions targeting pre-adolescents and/or adolescents (Ensaff et al., 2015; Hanks et al., 2013; Song et al., 2016a) out of the nine interventions identified (Ensaff et al., 2015; Erjavec et al., 2021; Hamdi et al., 2020; Marcano-Olivier et al., 2019; Pope & Wolf, 2012; Quinn et al., 2018; Thompson et al., 2017) reported positive effects on students' vegetable selection. Authors suggested that the use of labels is likely more promising for fruit rather than vegetables (Marcano-Olivier et al., 2019) and additional strategies should be used to increase vegetable consumption (Thompson et al., 2017).

Alternative to or in combination with the use of labels, two studies reported the use of images and stickers on vegetables to test whether they could nudge students toward healthy eating. The use of stickers, as part of a multicomponent choice architecture intervention, reported an increase in pre-adolescents and adolescents' likelihood of selecting vegetables, fruits, or salads by three times (Ensaff et al., 2015). Moreover, adding funny elements to food packaging gave children 6–9 years old ($n = 30$) the impression that these foods were tastier (Dial & Musher-Eizenman, 2020).

3.2.6 | Availability

Changes in the availability of foods are a widely used method to promote vegetables in children and adolescents. In particular, 12 interventions were identified using such methods, with only one focusing on legumes (Siegariz et al., 2011). Examples include restricting access to unhealthy foods (vending machines, mobile carts) (Boehm et al., 2020; Wordell et al., 2012), introducing a salad bar (Adams et al., 2005; Bean et al., 2020; Bean et al., 2018), providing additional options for purchasing meals (Machado,

Burton et al., 2020), and increasing the availability and variety of vegetables (Bergamaschi et al., 2016; Birnbaum et al., 2002; Perry et al., 2004) and other healthy snacks (Lytle et al., 2004, Marcano-Olivier et al., 2021).

Restricting access to unhealthy foods provided mixed findings, with one study on students aged 12–19 ($n = 2,229$) reporting no difference in vegetable consumption between intervention and control school (Wordell et al., 2012) and the other showing an increase in adolescents' selection of vegetables ($n = 2,140$), although the intervention only lasted 4 weeks and longer-term results were not available (Boehm et al., 2020). Increasing the availability of vegetables and legumes, through the introduction of salad bars and more purchase points, showed mixed effects on the selection and consumption of the target foods. The addition of two more selling points did not have any effect on 7–10th-grade students' self-reported vegetable consumption (Machado, Burton et al., 2020). Similarly, Bergamaschi et al. (2016) reported a decreased intake with increased variety (age range = 9–11; $n = 132$); however, two studies reported positive results when increasing the availability and variety of vegetables served to first- and third-grade students on the snack cart (Perry et al., 2004, baseline [$n = 1668$], follow-up [$n = 1168$]) and the ones offered to pre-adolescents and adolescents ($n = 1030$) by the National School Lunch Program (NSLP) (Cohen et al., 2014). The latter showed an increase post-implementation of the new nutrition standards and when a salad bowl was made available at no extra cost (Madden et al., 2013; age range = 12–16; before intervention [$n = 180$], after intervention [$n = 198$]), indicating that removing the cost barrier could increase students' healthful choices.

3.2.7 | Cafeteria redesign

Making changes in the lunchroom's environment is a common nudging approach used in schools. However, most interventions identified in this systematic review using cafeteria decorations, updated décor, paint, and seating options were not found to be successful in promoting vegetable selection and consumption (Hamdi et al., 2020; Hubbard et al., 2015; Machado, Burton et al., 2020). Only one intervention incorporating cafeteria decorations in combination with meal modifications (such as increased variety, serving size, and palatability) reported increased vegetable selection (Cohen et al., 2015).

3.2.8 | Prompts

Verbal encouragement has been widely used as a component of nudging interventions promoting vegetables; however, results are inconsistent. Multicomponent inter-

ventions using prompts have reported positive effects in increasing vegetable intake (Hanks et al., 2013; Hendy et al., 2007; Hoffman et al., 2010; Machado, Ritchie et al., 2020; Perry et al., 2004; Song et al., 2016a), with one study reporting these effects regardless of children's weight status (Hendy et al., 2007). In particular, higher levels of encouragement were positively associated with a higher vegetable intake which continued for the short-term (Chinchanchokchai et al., 2022). On the contrary, two multicomponent interventions did not find a significant effect in increasing vegetable selection and self-reported consumption (Dave et al., 2015; Quinn et al., 2018; Taylor, Darby et al., 2013). It should be noted though, that these multicomponent interventions did not report the effect of each of their individual components, and thus, it is not clear whether prompts alone had an effect or not.

3.2.9 | Advertisement

The use of events, posters, and messages promoting healthy eating, in particular vegetables and pulses, has been reported in 10 interventions. Placing posters is a common nudge strategy used in the school environment and more specifically in school lunchrooms, but the results are inconsistent. Only two multicomponent interventions using posters reported an increased vegetable selection (Ensaif et al., 2015) and consumption (Hoffman et al., 2010); however, in the latter, results were not maintained at the end of the second year of the intervention (Hoffman et al., 2010). Similarly, environmental changes including posters and messages did not have an effect on students' vegetable choice and intake (Marcano-Olivier et al., 2019), with authors suggesting a possible dose-response pattern (Birnbaum et al., 2002) and low implementation (Dave et al., 2015). On the other hand, two interventions using events and games had promising results in promoting vegetable intake and acceptance (Joyner et al., 2017; McCormick et al., 2009). Additionally, exposure to both banner and television messages had higher rates of students visiting and selecting vegetables from the salad bar (Hanks et al., 2016).

3.2.10 | Defaults

Interventions that change the default option, for example, the standard menu, are also used as a nudge strategy toward healthy eating. We identified one intervention reporting the use of defaults in which researchers moved peanut butter and jelly sandwiches to the back counter and made them available only by request to promote healthier options including vegetables (Hubbard et al.,

2015). However, the authors did not observe any significant effect in nudging students with intellectual and developmental disabilities toward healthier options, although this could be due to the small sample size ($n = 43$) or to the characteristics of the sample.

4 | DISCUSSION

This systematic review revealed that a wide variety of interventions based on sensory-hedonic strategies and nudging have been used to promote vegetables. However, this is not the case for pulses, as only five studies targeting pulses were identified. In part, this could be because vegetables can be served both raw and cooked, as a starter, a snack, and as a main dish, which makes it easier to manipulate their texture, shape, and serving style/order, whereas in the case of pulses, this is more difficult as they can only be served cooked and mainly as part of a meal. However, considering their nutritional value, the importance of forming healthy dietary habits in childhood, and their environmental impact, more interventions should focus on promoting this rich in protein food group as an alternative to meat.

Among the sensory-hedonic strategies, all those that improved the taste with herbs and spices reported positive results in increasing liking and consumption of the target foods. One contributing factor to this successful outcome was reported to be the use of repeated exposure (D'Adamo et al., 2021; Zellner & Cobuzzi, 2017). Instead, changing vegetables' texture and appearance, or "hiding" them in foods showed inconsistent effects. Two studies were found to be less effective in promoting vegetables (Chung et al., 2020; Mistura et al., 2019); however, for Chung et al. (2020), this could be attributed to the small sample size of the study and the fact that students with autism might need a different approach considering their special needs. On the other hand, when meal sensory appeal was enhanced by professional chefs, the results were promising, especially when they were combined with mere exposure and nudging strategies such as placement (Chung & Fong, 2018; Cohen et al., 2015). These results point out the benefits given by the improvement of sensory aspects and the development of new recipes thanks also to culinary knowledge in food preparation.

Regardless of the fact that the sequence order and evaluative conditioning have been proven to influence liking and consumption of the targeted food in children (Mueller et al., 2004) and adults (Lahne et al., 2017; Yeomans et al., 2020), these strategies are understudied in the school environment, with two interventions exploring the effect of evaluative conditioning (Johnston et al., 2011; Olsen et al., 2012) and only one the effect of hedonic contrast (Zellner & Cobuzzi, 2016) being identified in this systematic

review. Serving vegetables before the fruit (avoiding a hedonic contrast effect) reported an increased consumption of the target vegetable compared to when they are served together (Zellner & Cobuzzi, 2016), suggesting that serving vegetables before the dessert component could be used to promote vegetable eating in children and preadolescents. Unfortunately, at the time of this review, no data were available for adolescents but we might expect a similar outcome since hedonic contrast has been successful in both children and adults. Evaluative conditioning on the other hand suggests that serving neutrally liked vegetables together with liked vegetables might increase the intake of the neutrally liked vegetables (Olsen et al., 2012), which is in agreement with the finding from a study using associative conditioning to promote healthy eating by pairing foods with liked, non-food stimuli (Halbeisen & Walther, 2021). Similarly, studies using flavor-flavor learning in toddlers and children, for example, pairing vegetables with salty (Bouhlal et al., 2014) or sweet flavors (Hausner et al., 2012; Havermans & Jansen, 2007b) was effective in increasing vegetable intake. Halbeisen and Walther suggested that such pairing would be easily implemented in a variety of contexts, such as games and educational programs, ideally suited even for younger children (Halbeisen & Walther, 2021). However, as only three studies using evaluative conditioning in the school environment were identified, the need for more research in this area to better understand the pairing effect in forming students' taste preferences is highlighted.

When it comes to nudging, results indicate that increasing serving size can lead to increased vegetable consumption (Cohen et al., 2014; Goh et al., 2017; Miller et al., 2015; van Kleef et al., 2015) compared to changing the serving style (e.g., shape (Bergamaschi et al., 2016), pre-portioned (Adams et al., 2005), arranged by color (Mistura et al., 2019; Perry et al., 2004), or using labels (Hamdi et al., 2020; Marcano-Olivier et al., 2019; Quinn et al., 2018; Thompson et al., 2017), which did not have significant effects. Similarly, changing the packaging style with transparent containers and adding funny elements to it led to increased consumption (Hanks et al., 2013) and gave children the impression that food was tastier (Dial & Musher-Eizenman, 2020). When talking about consumption, it is also important to consider food waste. Among the studies mentioned above, five reported the results of the intervention on food waste (Adams et al., 2005, Cohen et al., 2014, Hamdi et al., 2020, Miller et al., 2015, Thompson et al., 2017), with only one of them reporting that the implementation of the new food standards did not increase waste of vegetables (Cohen et al., 2014); however, levels of food waste were high both pre- and post-implementation of the standards. On the other hand, increasing the variety (Adams et al., 2005) and portion size (Miller et al., 2015) of the vegetables resulted in higher food waste.

These successful strategies are generally inexpensive and easy to implement and could be used by food providers and school canteens when preparing students' lunch portions to nudge toward healthy eating, but they could also be expanded to food procurement in general, such as in the case of children's hospitals. However, more research is needed to identify strategies that also limit food waste.

Two additional nudging strategies that showed promising results in increasing vegetable liking and intake are the use of incentives and modeling. Results from such strategies, alone and in combination, suggest that using small rewards and videos with characters of similar age to the target group can influence children into consuming more vegetables and pulses. However, the effect of modeling in adolescents is not clear, as the two identified studies targeting this age group reported mixed results. This could be because adolescents might not be as influenced by cartoon characters as younger children are, or they might find these characters too "childish." Therefore, carefully selecting the proper models based on the target group is important. Similarly, no significant effects were reported from the use of incentives and modeling in children with special needs (Taylor, Upton et al., 2013). This shows that there is no "one-for-all" approach and that a better understanding of the specificities of the groups of children considered is necessary when designing school interventions.

Similar results were reported from the use of games, which were positive for children and preadolescents (Joyner et al., 2017); however, it is unclear whether adolescents would respond to the games in the same way, or whether this strategy is only effective in younger children.

Another strategy widely used to nudge students toward healthier options is to increase the availability of vegetables and legumes and/or to decrease the one of unhealthy foods; however, results are not very encouraging, as only 4 out of the 12 interventions reported positive effects. Authors suggested that short-term interventions (Adams et al., 2005; Boehm et al., 2020), not using a control group (Bean et al., 2018), and only using a salad bar to increase availability (Adams et al., 2005) could be among the reasons why no significant changes were observed. One explanation of why variety was not found successful in increasing vegetable consumption although it increased vegetable liking came from Bergamaschi et al. (2016), who proposed that vegetable consumption is more affected by acceptability and familiarity rather than by the variety of the stimuli (Bergamaschi et al., 2016). To overcome these barriers, authors suggested the use of multicomponent interventions instead of cafeteria programs alone (Perry et al., 2004) as well as removing the cost barrier (Madden et al., 2013).

In the case of advertisements and prompts, the dose (Birnbaum et al., 2002; Chinchanchokchai et al., 2022) and degree of implementation (Dave et al., 2015) were reported as an important factor associated with their effectiveness. In particular for posters and messages, positive results came only after combining them with other strategies including educational campaigns and games (Joyner et al., 2017; McCormick et al., 2009), suggesting the incorporation of these elements for increasing vegetable selection and consumption. For prompts on the other hand, results were generally inconsistent, with the majority of them deriving from multicomponent interventions which did not measure the effect of each element separately, making it hard to know whether prompts alone have an effect or not. This, however, is not only the case for prompts but it is a common challenge when implementing multi-component interventions. Although it might be difficult to isolate the effect of each intervention component, such insights would be helpful, as it could save both time and cost in future interventions.

Finally, it was found that cafeteria redesign, including changes in the cafeteria decorations, décor, paint, and seating options, as well as changing the choice default, was not effective in nudging toward eating more vegetables. In particular for the case of defaults, although literature (Giesen et al., 2013) suggests that changing the choice defaults is an effective way to nudge consumers toward healthy eating, this systematic review only identified one such intervention which did not report a significant effect (Hubbard et al., 2015). However, as only one intervention was identified, it is not possible to know the real effect of changing the choice defaults in school settings and future research should try to fill this gap.

An important aspect is how durable are the effects found, or if the insufficient exposure duration in the intervention could have contributed to a lack of its effectiveness. Many sensory-hedonic interventions described in this review pointed out the role of exposure as a key to the success of increasing vegetable liking and intake. This suggests also that their results could be more durable in time because learning aspects intervened and are more difficult to change. Hedonic contrast was reported to occur at the first exposure and we do not have information about its effectiveness in time, while evaluative conditioning, for example, requires exposure to be developed as a learning mechanism but has also a durable effect in time. Mere exposure has also been reported as a good strategy to decrease food neophobia and increase the acceptance and liking of unfamiliar and disliked foods (Chung & Fong, 2018; Cohen et al., 2015; Wardle et al., 2003). In particular, strategies combining repeated exposure with rewards have reported positive effects on the consumption and liking of new and unfamiliar vegetables (Appleton et al., 2018,

Wardle et al., 2003). Thus, interventions using a multi-component approach might benefit from including mere exposure in their design. However, attention should be paid to the number of exposures, as too short exposure might not have significant effects, and high frequency, on the other hand, could lead to boredom (Jönsson et al., 2019). Depending on the vegetables, at least four to five exposures were reported to be needed to increase their liking (Lakkakula et al., 2011) contrary to fruits, for which even only one exposure led to a significantly higher intake (Barends et al., 2013). This highlights the importance that although fruits and vegetables are commonly studied together, in principle they are very different food groups, especially in their sensory properties, and these differences should be taken into consideration when designing interventions aiming at changing children's behaviors toward these foods.

Another important aspect to consider is the long-term effect of exposure to food stimuli. For example, Olsen et al., in their paper, suggest that the liking for a vegetable could decrease during the exposure period due to boredom, but a recovery effect (increased acceptance) might be seen in the longer-term (Olsen et al., 2012). However, this recovery effect can depend on the time elapsed between the last exposure and the follow-up, as well as the strength of the boredom effect (Olsen et al., 2012). Therefore, follow-up studies exploring the longer-term effects of exposure should be designed carefully considering the above-mentioned aspects.

4.1 | Limitations

While our systematic review did not use a publication date limit, we only considered published literature in the English language, and therefore, it might be biased toward grey literature, such as conference papers and lay publications. In addition, only one reviewer performed the first screening (titles and abstracts), which might have led to a selection bias. It is also worth pointing out that results are highly dependent on the sample size and this systematic review identified several studies with a small number of participants. This probably accounts for some inconsistencies in the results and makes drawing general conclusions difficult. Finally, due to the high heterogeneity between study methodologies and the small number of studies per intervention type, it was considered that performing a meta-analysis would be inappropriate.

5 | CONCLUSION

This paper aimed to systematically review all the published literature on interventions based on sensory-hedonic strategies and nudging taking place in the school environment and focusing on increasing children's and adolescents' vegetable and pulses consumption. Overall, both interventions are effective strategies for promoting healthy eating, but consideration should be made when selecting the intervention type based on the target group (e.g., children with special needs, children vs. adolescents). In addition, multicomponent interventions rather than the use of a single approach have been reported to be more successful, with exposure being an important factor in their success.

Results also revealed a general lack of interventions promoting pulses with the vast majority only focusing on vegetables. On top of that, only a few studies targeted adolescents. Considering the importance of childhood and adolescence in forming dietary habits that extend into adulthood together with the nutritional benefits of consuming pulses, future research should be directed more toward promoting pulses and expanding the target group to include adolescents as well. Understanding which interventions work in promoting healthy and sustainable eating at schools would lead to both a healthier population and a safer environment.

AUTHOR CONTRIBUTIONS

Kokkorou Margarita: Conceptualization; investigation; writing—original draft; methodology; writing—review and editing. **Spinelli Sara:** Conceptualization; supervision; writing—review and editing; methodology. **Dinnella Caterina:** Conceptualization; supervision; writing—review and editing; methodology. **Monteleone Erminio:** Conceptualization; supervision; writing—review and editing; methodology.


ACKNOWLEDGMENTS

This work was realized with the collaboration of the European Commission Joint Research Centre under the Collaborative Doctoral Partnership Agreement No 36142.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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How to cite this article: Kokkorou, M., Spinelli, S., Dinnella, C., & Monteleone, E. (2024). Interventions based on sensory-hedonic strategies and on nudging to facilitate vegetable and pulses consumption in the school environment. *Comprehensive Reviews in Food Science and Food Safety*, *23*, e13312. <https://doi.org/10.1111/1541-4337.13312>