

## Home-based interventions targeting vegetable intake and liking among preschoolers: A systematic review

Marcella Caputi<sup>◦,\*^</sup>, Daniela Bulgarelli<sup>\*,^</sup>, Giuseppina Cerrato<sup>◦◦</sup>, Paola Molina<sup>\*\*</sup>

<sup>◦</sup> Department of Life Sciences, University of Trieste,  
Via Weiss 21, 34128 Trieste, Italy  
e-mail: marcella.caputi@units.it;

<sup>\*</sup> University of Turin, Department of Psychology,  
Via Verdi 10, 10124 Turin, Italy  
e-mail: daniela.bulgarelli@unito.it;

<sup>◦◦</sup> University of Turin, Department of Chemistry,  
Via Giuria 7, 10125 Turin, Italy  
e-mail: giuseppina.cerrato@unito.it;

<sup>\*\*</sup> University of Turin,

Interuniversity Department of Regional and Urban Studies and Planning,  
Via Morgari 36, 10125 Turin, Italy  
e-mail: paola.molina@unito.it.

<sup>^</sup> These authors have contributed equally to this work and share first authorship

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### Abstract

Consumption of vegetables is low among preschoolers and does not meet WHO recommendations. We conducted a systematic review of home-based interventions aimed at increasing vegetable consumption and liking among preschoolers. The main aim was to synthesize existing studies and to identify relevant features of successful interventions, especially looking at those with long-lasting effects. A comprehensive search strategy was performed using Psychinfo, PsychArticles, Psynindex, Medline and ERIC databases. Articles published until February 2020, regarding evaluation of vegetable intake and/or liking following an intervention, were included. Fourteen articles were selected, encompassing seven intervention strategies: familiarization with vegetable, tasting of the vegetable, intake of the vegetable, reward, information to parents

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about healthy eating, how-to-do tips to parents to improve healthy eating, intervention tailored to the characteristics of the family. Successful interventions on vegetable intake did not present systematic similarities in terms of type of intervention, but were characterized by an intense intervention (high frequency/length ratio). Successful interventions on vegetable liking mainly included a small reward. Interestingly, the few studies including a long-term follow-up found persistent positive effects. Despite interesting and promising outcomes, the present review highlighted a number of methodological issues that limited the generalisability of findings. Such limitations are discussed, together with outlets for future directions concerning this research topic.

**Keywords:** vegetable consumption, vegetable liking, preschool children, PRISMA method, healthy eating intervention, home-based intervention

## **Introduction**

Consumption of vegetables is associated with less probability of developing future chronic diseases (FAO & WHO, 2019). Nonetheless, vegetable intake still does not reach adequate levels in developed countries (Jaffee et al., 2018; WHO, 2019; Wolfenden et al., 2012). Looking at the developmental trajectories of children's eating behaviours, we know that food preferences emerge early and tend to persist for a long time (Touyz et al., 2018). Hence, interventions promoting vegetable intake should be carried out at an early age and possibly involve parents, who are the main caregivers and influencers of their children's behaviour. Indeed, parents can encourage their children in several ways: eating healthy themselves, making vegetables constantly available at home, structuring mealtime routines, and insisting on offering vegetables at mealtimes or as a snack (Touyz et al., 2018). Overall, parent-targeted interventions provided mixed results, but, according to Touyz and colleagues' review, the most effective strategy seems to be regular exposure to a vegetable tasting at home (daily or weekly) (Touyz et al., 2018). There has been a growing interest in this topic, as testified by a living systematic review authored by Hodder and colleagues (2020). Until 2012, only five randomised controlled trials of vegetable interventions conducted among preschoolers (in whatever context) were available, and those trials failed to report effective strategies (Wolfenden et al., 2012). At present, 80 studies are available,

which show that multicomponent interventions, which are those combining parent nutrition education with pre-school nutrition policy changes, are promising (Hodder et al., 2020).

A further reason for promoting early-age interventions is that, between 2 and 5 years of age, two types of eating behaviours are more likely to emerge among children and contribute to vegetable acceptance or rejection, being one of the main topics in the field of early healthy eating (Dovey et al., 2008). A peak emerges in food fussiness that means eating selectively, being picky and refusing both familiar and unfamiliar foods (Addessi et al., 2005; Cooke & Wardle, 2005). Another undesired child's reaction is food neophobia that means avoidance of new foods until they prove 'safe' as they are not followed by negative gastrointestinal consequences (Cooke et al., 2007; Dovey et al., 2008; Houston-Price, Butler et al., 2009). Both food fussiness and food neophobia are partly responsible of preschoolers' low consumption of vegetables, which are introduced *ex novo* in the first years of life and often have a bitter taste that makes them not appreciated until an older age (Cooke & Wardle, 2005; Houston-Price, Butler et al., 2009b).

When vegetable intake during pre-school age is low, several strategies might prove successful in increasing it, as reported above. Another recent meta-analysis, including interventions conducted both at home and in childcare settings, detected nine dominant intervention strategies, with those implementing repeated taste exposure showing better-pooled effects. Indeed, intake was greater when vegetables were offered in their plain form at least eight times. Interestingly, unfamiliar/disliked vegetables were eaten more than familiar/liked ones following intervention (Nekitsing et al., 2018). Similar results were obtained by Holley and colleagues in a systematic review including studies aimed at increasing vegetable consumption in 2-5 year-olds (Holley et al., 2017). They found repeated exposure to be the best method, adding that it could be enhanced with the inclusion of non-food rewards to favor tasting. Notably, also peer models appeared particularly effective in many included studies.

The primary aim of the present systematic review was to synthesise the relevant literature relating to home-based interventions conducted in order to increase preschoolers' consumption or liking of vegetables. A similar aim was addressed by previously published reviews (Hendrie et al., 2017; Holley et al., 2017; Nekitsing et al., 2018; Touyz et al., 2018). Nonetheless, Touyz and colleagues included studies aimed at increasing preschoolers' consumption of both fruit and vegetable. As argued by Holley and colleagues (2017), even if nutrition guidelines usually indicate a daily number of fruit-vegetable portions, fruits are high in

naturally occurring sugars (thus worrisome for overweight and type 2 diabetes) and are liked by children more than vegetables. Therefore, including both fruits and vegetables might be problematic as these foods do not have the same beneficial effects on health and the presence of fruit in a study might dilute intervention effects. Moreover, both Touyz and colleagues and Hendrie and colleagues focused on a broad age range, including studies conducted with children between 2 and 12 years of age (Hendrie et al., 2017; Touyz et al., 2018). Such a wide age range makes it difficult to suggest practical strategies to parents and professionals, as eating behaviours and preferences change a lot after pre-school years and specific trajectories might become stable and barely alterable (Snuggs et al., 2019). Finally, Nekitsing and colleagues and Holley and colleagues, albeit both reviewing studies conducted among preschoolers and targeting vegetable intake, included also researches conducted outside the domestic environment (Holley et al., 2017; Nekitsing et al., 2018).

Thus, our contribution is original in that it reviews studies conducted exclusively within the home context, intended to increase preschoolers' intake and liking of vegetables only. A secondary aim of the present review was to examine features of interventions that obtained significant results both at post-test and at follow-up(s), in order to provide useful guidance for parents interested in long-lasting effects.

## **Method**

### ***Eligibility criteria***

To be eligible for inclusion, the papers had to meet the following criteria: typically developing children as the final target of the intervention; participants' average age falling between 18 and 48 months; intervention run at home; vegetable intake and/or liking as the intervention outcome; studies published in English in peer-reviewed journals. The articles were excluded if participants had medical conditions (i.e., obesity, disabilities, etc.), interventions were addressed to only low-income children, interventions were meant against malnutrition; also, dissertations, reviews or meta-analyses, correlational studies and trial registrations were not included.

### ***Information sources and search strategy***

On February the 29th, 2020, an online literature search was run on Psychinfo, PsychArticles, Psyn dex, Medline and ERIC, using the following keywords to be searched in the paper abstracts: intervention OR trial OR training OR treatment AND vegetable OR healthy food

AND consumption OR intake OR liking AND toddler OR children NOT review OR meta-analysis [only in the title]. A filter was added to specifically focus on studies involving children between 1 and 5 years.

**Data management and selection process**

Each study was identified through a unique code. The databases returned 1,090 papers. The selection processes include two phases. The screening phase was run on the paper title and abstracts: two independent reviewers (DB and MC) read the first 50 abstracts and calculated the agreement regarding the inclusion of the studies (Cohen’s K = .86). Then, the reviewers evaluated 495 abstracts each. A second agreement between the inclusion of studies by the two reviewers was run on the last 50 abstracts (Cohen’s K = .86). The screening phase allowed to include 161 papers. The eligibility phase was run by the two reviewers on the whole set of papers previously selected. One reviewer read 80 papers, the other 81. One-hundred forty-seven papers met the exclusion criteria; two papers were duplicates. Therefore, the eligibility phase allowed to include 14 papers, as shown in the PRISMA flow diagram (Figure 1).

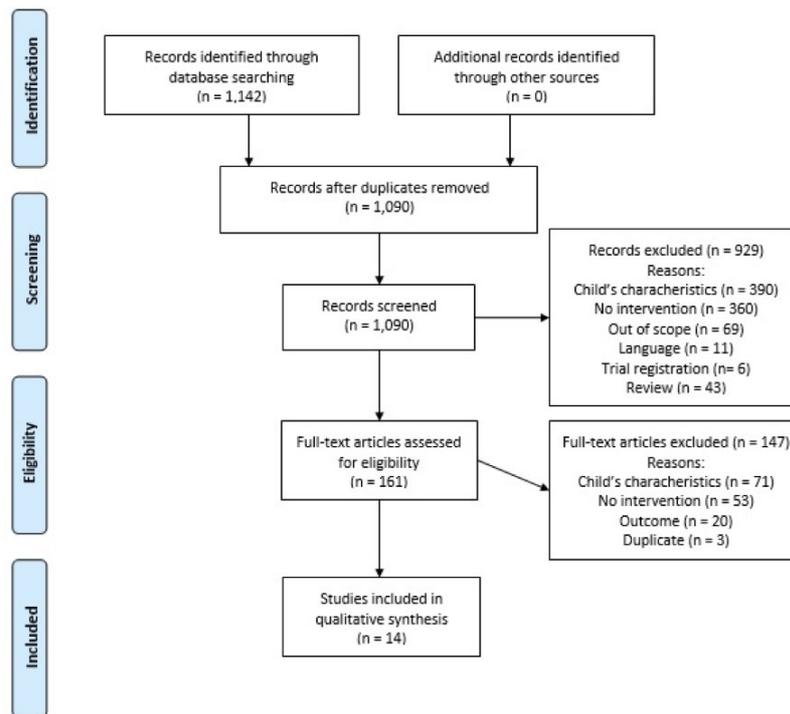


Fig. 1 - PRISMA Flow Diagram of the Identification Process for Papers Included in This Systematic Review

### ***Data collection process***

Both reviewers (DB and MC) filled a piloting form developed ad hoc for this review, to extract relevant data from the selected papers. They discussed and solved the disagreements.

### ***Data items***

The following variables were collected (Table 1): year of the publication; the country where the study was run; participants' average age, age-range and gender; numerosity of experimental group and control group(s) (if existing); type of vegetable (specific vegetable, all vegetables); length and frequency of the intervention (i.e., number of sessions during the intervention); intervention description; target person of the intervention (i.e., child; parents; intervention administered by parents supported by a trainer).

### ***Outcomes***

The following data were analysed (Table 2): duration (i.e., high = 8 weeks or more, medium = between 4 and 7 weeks, low = between 1 and 3 weeks); ratio frequency/duration (i.e., high, medium, low); type of intervention (i.e., 1. familiarization with vegetable; 2. tasting of the vegetable; 3. intake of the vegetable; 4. reward to the child; 5. information to parents about healthy eating; 6. how-to-do tips to parents to improve healthy eating; 7. intervention tailored to the characteristics of the family); type of outcome (i.e., intake, liking, or preference; each outcome was further identified as perception by child or parent about the eaten quantity of vegetable, or objective measure like food weight or number of portion or physiological marker like skin carotenoid levels); significant effect on intake at post-test and follow-up (yes on all vegetable/targeted vegetable; no); significant effect on liking at post-test and follow-up (yes on all vegetable/targeted vegetable; no). Where both fruit and vegetables were targeted, only findings concerning vegetables were considered and discussed in the present review.

A meta-analysis was not feasible due to paucity of articles addressing the specific topic of the present review and to significant heterogeneity in measuring outcomes.

Tab. 1 - Summary of Extracted Data from Articles Included in The Systematic Review of Interventions to Increase 18-48 Month-Old's Intake and Liking of Vegetables

Reference	Participants: sample size (N); Age M ± SD (range); % girls*	Country	Type of veg	Length; frequency; follow-up	Description of intervention as reported in the original paper	Target person of the intervention
1-Bakirci-Taylor <i>et al.</i> , 2019	30; intervention group: 3.77 ± .80 years, control group: 3.64 ± 1.39 years (3–8 years); 50%	USA	23 vegetables (and fruits) high in provitamin A	5 weeks; 3 days in week 1 and week 5; follow-up: no	Jump2Health is a parent-focused intervention with 3 technologies (mobile Jump2Health website, 12 text messages, and Facebook page). They addressed 7 evidence-based healthy habits (more whole grains, more fruits and vegetables, less sweet drinks, less screen time, more physical activity, more family meals, and more sleep). Cooking videos and recipes, strategies to address picky eating, and food budgeting and meal planning were included. Parents in the control group only received 12 text messages about physical activity and did not receive access to the website or social media. Parents took electronic food photos using their mobile devices to assess the effect of the intervention on vegetable accessibility.	Child; intervention administered by parents supported by a trainer

2-Cravener <i>et al.</i> , 2015	24; intervention group: 3.80 ± .87 years, control group: 4.00 ± .75 years (3–5 years); 50%	USA	Celery, broccoli, carrots, red peppers, cauliflower, and sweet snap peas	2 weeks; parents: 5 meetings; children: at least three veg snacks and/or meals every day; follow-up: no	It consists of pairing positive stimuli (e.g., cartoon packaging and sticker incentives) with vegetable intake, and presenting vegetables as the optimal default at snacks and meals. The control group received generic packages of vegetables presented as a free choice, but the intervention group received vegetables packaged in containers with favorite cartoon characters and stickers inside, presented by parents as the default choice. Child-targeted nutrition education lessons were delivered in the home for both groups on a weekly basis. In both the control and treatment groups, parents were given specific instructions on when and how to present snacks to children.	Child; intervention administered by parents supported by a trainer
3-De Wild <i>et al.</i> , 2017	103; 35.5 ± 6.8 months (2–4 years); 48%	The Netherlands	Spinach, green beans	6 weeks; once a week; follow-up: no	During the intervention, children were served the vegetable at their main meal at home. They were divided into four parallel groups who ate plain spinach, creamed spinach, spinach ravioli, and green beans.	Child; parents gave the food prepared by the experimenter
4-Fildes <i>et al.</i> , 2014	442; intervention group: 3.9 ± .3 years, control group: 3.8 ± .3 years (3–4 years); 50%	United Kingdom	Cabbage; carrot; celery; cucumber; red pepper; sugar snap peas; other	2 weeks; every day; follow-up: no	Intervention families were sent information on the exposure protocol (called the tasting game) in a sealed envelope. Parents were asked to select a target vegetable themselves that children did not like. Parents offered the children a single very small piece of their target vegetable every day outside mealtimes, allowing the child to choose a sticker as a reward if they tried it.	Child; intervention administered by parents supported by a trainer

5-Haines <i>et al.</i> , 2018	42; intervention group 4HV: 2.70 ± 1.1 years, intervention group 2HV: 3.39 ± 1.1, control group: 3.06 ± 1.2 years (18–60 months); 52.8%	Canada	Different type of vegetables	The home visits were scheduled approximately 4–6 weeks apart; follow-up: no	The intervention involved three groups: (1) four home visits (HV) with a health educator, emails, and mailed incentives; (2) two HV, emails, and mailed incentives; or (3) general health advice through emails. HVs were conducted by health educators who asked families if they wanted to set any behaviour change goals. The health educators used motivational interviewing techniques to work with families to identify specific steps required to implement the desired change. Families were also asked if they wanted to have the health educators email to check on progress.	Child; intervention administered by parents supported by a trainer
6-Heath <i>et al.</i> , 2014 (Study 2)	60; 22.3 months (20.9–24.0 months); 42%	UK	16 vegetables	2 weeks; every day; follow-up: no	The child was randomly allocated to one of three initial status conditions (liked, disliked, or unfamiliar vegetable). Parents were sent a picture book about their child's target vegetable and were asked to read this with their child for approximately 5 min a day. The taste test took place at the University.	Child; intervention administered by parents supported by a trainer

7-Holley <i>et al.</i> , 2015	111; intervention group 1: 38.24 ± 8.82 months, intervention group 2: 39.38 ± 9.01 months, intervention group 3: 40.20 ± 6.58 months, intervention group 4: 38.09 ± 8.16 months, control group: 34.17 ± 6.17 months (25–55 months); 60%	UK	Baby corn, cherry tomato, celery, cucumber, red pepper, sugar snap peas	2 weeks; every day; follow-up: no	The four intervention conditions were: repeated exposure (1); modelling and repeated exposure (2); rewards and repeated exposure (3); or modelling, rewards and repeated exposure (4). Each child was assigned a single target disliked vegetable. Children in all of the intervention conditions were exposed by a parent to daily offerings of a disliked vegetable.	Child; intervention administered by parents supported by a trainer
8-McGowan <i>et al.</i> , 2013	126; intervention group: 3.4 ± 1.2 years, control group: 3.0 ± 0.9 years (2–6 years); 50%	UK	All vegetables	8 weeks; 4 visits to the family home in the period; follow-up: no	Each visit lasted > 1 h and involved the researcher working through an intervention booklet with the parent. The child was not directly involved. The booklet introduced the concept of habit formation along with tips for habit formation. There were sections for each target feeding domain (serving fruit/vegetables, healthy snacks, and healthy drinks). Parents discussed with the researcher why it is important to have healthy feeding habits for children. Tips were provided on how best to aid habit formation and practical advice specific to each feeding habit. Parents then formulated a specific, healthy feeding goal in that area. At each subsequent visit, parents were encouraged to continue with the previous habit(s) while introducing a new one. In sessions 2, 3, and 4, there was a brief discussion of progress with the current feeding habit(s) before moving on to the next habit.	Parents

9-Mirotta <i>et al.</i> , 2018	35; 3.19 ± 0.17 years (1.5–5 years); 55.6%	Canada	Different type of vegetables	The home visits were scheduled approximately 4–6 weeks apart	Same as Haines <i>et al.</i> , 2018	Child; intervention administered by parents supported by a trainer
10-Owen <i>et al.</i> , 2018	127; intervention group vegetable: 21.61 ± 1.60 months, intervention group fruit: 21.82 ± 1.59 months, control group: 21.27 ± 1.44 months (18–24 months); 52%	UK	24 vegetables	4 weeks; every day; follow- up: after 3 months	Upon recruitment, parents were asked to specify one fruit and one vegetable that they wanted their child to eat but that their child refused to eat. Parents of children in the ‘fruit book’ and ‘vegetable book’ groups were sent a picture book about their child’s target fruit or vegetable, respectively, and were asked to look at the book with their child for 5 min every day for 14 consecutive days. Following the visual familiarization phase, parents were asked to offer their child a taste of both target foods every day for 15 consecutive days.	Child; intervention administered by parents supported by a trainer
11-Reale <i>et al.</i> , 2014	46; intervention group reduction: 35.8 ± 9.9 months, intervention group replacement: 37.5 ± 8.9 months, (22–56 months); 48%	UK	Carrot, cucumber, cherry tomato	1 week; every day; follow- up: after 4-6 weeks	In the ‘acclimation week’ children received a standardised selection of high energy-dense (HED) snacks, and in the ‘intervention week’ participants were randomly assigned to snack replacement (swapping HED snacks for fruits and vegetables) or snack reduction (reducing the size of HED snacks by 50%).	Child; intervention administered by parents supported by a trainer

12-Remington <i>et al.</i> , 2012	173; intervention group tangible reward: 3.96 ± .5 years, intervention group social reward: 3.99 ± .5 years, control group: 3.90 ± .5 years, (3–4 years); 48%	UK	Carrot, celery, cucumber, red pepper, sugar snap peas and, white cabbage	12 days; every day; follow-up: after 3 months	In the intervention groups, parents offered their children 12 daily tastes of the vegetable, giving either praise or a sticker for tasting. No specific advice was given to the control group.	Child; intervention administered by parents supported by a trainer
13-Tabak <i>et al.</i> , 2012	43; intervention group: 3.9 ± .7 years, control group: 3.3 ± 0.9 years (2–5 years); 63%	USA	All vegetables	4 months; once a month; follow-up: no	Intervention group: four tailored newsletters and two motivational phone calls; control group: four children's books. The first call addressed vegetable and food issues; the dietitian helped parents select one primary target area for improvement during the intervention from four possible options (vegetable availability; picky eating; modeling; family meals). Content on each of the four topics was included in all newsletters; the order and quantity of the content were adjusted based on the parent-identified intervention goal. A second phone call occurred in the third month; parents were encouraged to describe successes, use problem-solving to overcome barriers, and receive support and encouragement. The final two newsletters were sent following the second call. Control group families received four non-health/nutrition-related children's books, one per month.	Child; intervention administered by parents supported by a trainer

14- Taverno Ross <i>et al.</i> , 2018	49; 3.9 ± 1.3 years, (2–5 years); 40.8%	USA	All vegetables (no potato)	10 weeks; once a week; follow-up: no	Trained promotoras (community health workers) delivered 10, 90-min weekly interactive and tailored sessions. The intervention focused on improving dietary intake, decreasing sedentary behavior, and increasing physical activity using the 5, 2, 1, 0 message (5 or more servings of fruits and vegetables, 2 h or less of recreational screen time, 1 h or more of physical activity, and 0 sugary drinks and more water). The sessions included education (i.e., session content related to the topic), practice (i.e., hands-on activities and role play), and action (i.e., goal setting and problem-solving). Behavior modification constructs and strategies (e.g., goal setting, problem-solving, social support), along with building of self-efficacy through healthy recipe preparation and physical activity breaks, were included.	Child and parents instructed by the trainer; intervention administered by parents supported by a trainer
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\*Data are reported divided by intervention or control group only if specified in the original paper.

Tab. 2 - Summary of Frequency, Intervention, Outcome and Effectiveness of the Studies Included in This Review

Reference	Duration	Ratio frequency/length	Type of intervention	Type of outcome	Significant effect on intake at post-test	Significant effect on intake at follow-up	Significant effect on liking at post-test	Significant effect on liking at follow-up
1-Bakırcı-Taylor <i>et al.</i> , 2019	Medium	Medium	5. Information about healthy eating to parents; 6. How-to-do tips to parents to improve healthy eating	- Measure of physiological marker (blood carotenoid level) - Perception of intake (parent)	Yes, all vegetables	N/A	N/A	N/A
2-Cravener <i>et al.</i> , 2015	Low	High	3. Intake of the vegetable; 4. Reward to the child; 5. Information about healthy eating to parents	- Measure of intake (food weight) - Perception of liking (child)	No, all vegetables	N/A	No, all vegetables	N/A
3-de Wild <i>et al.</i> , 2017	Medium	Medium	2. Tasting of the vegetable; 3. Intake of the vegetable	- Measure of preference - Measure of intake (food weight) - Perception of intake (parent)	Yes, target and non-target vegetable	N/A	N/A	N/A

4-Fildes <i>et al.</i> , 2014	Low	High	2. Tasting of the vegetable; 4. Reward to the child	- Measure of intake (food portion) - Perception of liking (parent)	Yes, target disliked vegetable	N/A	Yes, target (disliked) vegetable	N/A
5-Haines <i>et al.</i> , 2018	Medium	Low	5. Information about healthy eating to parents; 6. How-to-do tips to parents to improve healthy eating; 7. Intervention tailored to family	- Perception of intake (parent)	No, all vegetables	N/A	N/A	N/A
6-Heath <i>et al.</i> , 2014	Low	High	1. Familiarization with vegetable	- Measure of intake (food portion)	Yes, unfamiliar vegetable	N/A	N/A	N/A
7-Holley <i>et al.</i> , 2015	Low	High	1. Familiarization with vegetable; 2. Tasting of the vegetable; 4. Reward to the child	- Measure of intake (food weight) - Perception of liking (child)	Yes, target disliked vegetable	N/A	Yes, target (disliked) vegetable	N/A
							N/A	N/A

8-McGowan <i>et al.</i> , 2013	High	Low	5. Information about healthy eating to parents; 6. How-to-do tips to parents to improve healthy eating; 7. Intervention tailored to family	- Measure of intake (food portion)	Yes, all vegetables	N/A			
9-Mirotta <i>et al.</i> , 2018	Medium	Low	5. Information about healthy eating to parents; 6. How-to-do tips to parents to improve healthy eating; 7. Intervention tailored to family	- Measure of intake (food portion and weight)	No, all vegetables	N/A	N/A	N/A	N/A
10-Owen <i>et al.</i> , 2018	Medium	High	1. Familiarization with vegetable (through ebooks); 2. Tasting of the vegetable	- Measure of intake (food portion) - Perception of liking (parent)	Yes, target disliked vegetable	Yes, target vegetable	Yes, target vegetable	Yes, target vegetable	Yes, target vegetable
11-Reale <i>et al.</i> , 2014	Low	High	3. Intake of the vegetable	- Perception of intake (parent)	Yes, all vegetables	No, all vegetables	N/A	N/A	N/A

12-Remington <i>et al.</i> , 2012	Low	High	2. Tasting of the vegetable; 4. Reward to the child	- Measure of intake (food weight) - Perception of liking (child)	Yes, target vegetables	Yes, target vegetable	Yes, target vegetable	Yes, target vegetable
13-Tabak <i>et al.</i> , 2012	High	Low	5. Information about healthy eating to parents; 6. How-to-do tips to parents to improve healthy eating; 7. Intervention tailored to family	- Perception of intake (parent)	No, all vegetables (no potatoes)	N/A	N/A	N/A
14-Taverno Ross <i>et al.</i> , 2018	Medium	Medium	5. Information about healthy eating to parents; 6. How-to-do tips to parents to improve healthy eating; 7. Intervention tailored to family	- Measure of intake (food portions and weight)	Yes, all vegetables (no potatoes)	N/A	N/A	N/A

## Results

Overall, the 14 selected papers described researches conducted in different countries: half were conducted in the UK (4, 6, 7, 8, 10, 11, 12), four in the USA (1, 2, 3, 14), two in Canada (5, 9), and one in the Netherlands (3). A total of 1,411 children participated in the interventions (age: M: 38.70 months, SD = 8.15, range: 21.21-48 months). In 12 studies, the child was the target person of the intervention, that was administered by the parents, instructed by experimenters or nutritionists or educators. In one paper (8), the target person was only the parent, while in another (14), both child and parents interacted with the experimenter. Moreover, in one paper (10) the exposure did not involve real food but pictures of food.

### *Effects of home-based interventions on vegetable intake*

All the selected papers reported the results of the intervention in terms of vegetable intake, which appeared to significantly increase at post-test in 10 out of the 14 studies (1, 3, 4, 6, 7, 8, 10, 11, 12, 14; see Table 2). In half of the 10 successful papers, a significant increase was reported for all vegetables (1, 3, 8, 11, 14), while the other researches were interested in a specific target vegetable (usually an unfamiliar or a disliked one, that could then vary among participants). Specific types of intervention were not systematically linked to significant effects at post-test, although three out of four studies using reward as a strategy were effective (4, 7, 12). It is worth noticing that one of the 10 successful researches did not have a control group, which limits the robustness of results.

Only three out of the 14 selected papers planned a follow-up timepoint. Two reported a significant effect of the intervention in increasing vegetable intake at follow-up (10, 12) and one did not (11), losing significance at follow-up (i.e., the positive effect was not maintained long-term). This unsuccessful study (11) had a low duration, a high ratio frequency/length (i.e., children were exposed to the intervention every day) and the type of intervention consisted in the consumption of the vegetable.

The type of outcome changed across the studies: direct measure of intake was the most common outcome (1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 14), while in three researches a perception of intake was provided by parents who usually filled a questionnaire to estimate their children's consumption of vegetables (5, 11, 13); two of these papers reported no significant effect at post-test.

The duration and frequency of sessions were also highly variable, spanning from a length of 1 to 10 weeks and from a daily frequency to one session per month. The ratio frequency/length showed that high or medium intense interventions were more likely to be effective. Four studies had a low ratio (5, 8, 9, 13): the only effective one seemed to be counterbalanced by a high duration.

### ***Effects of home-based interventions on vegetable liking***

Only five (2, 4, 7, 10, 12) out of 14 studies analysed the effects on children's vegetable liking, in terms of parent's (4, 10) or child's (2, 7, 12) perception. Children's perception was measured through a five-point facial hedonic scale (2) and the three-point Birch faces scale (7, 12). Parents' perception was measured through a nine-point scale anchored with 'dislikes a lot' and 'likes a lot' (4) or several standardized questionnaires (10). Overall, all the studies but one (2) reported an effect of the intervention at post-test, and all the studies but the same one (2) used a target vegetable. When a follow-up was included (10, 12), the positive effect persisted. When the child's liking was evaluated, the intervention encompassed the exposure to a target vegetable, mainly a disliked one, sometimes accompanied by a small reward (4, 7, 12). The exposure/familiarization alone was not sufficient in modifying the child's expression of liking. Only the study conducted by Owen and colleagues (10) differed from the others, since no reward was offered, and the intervention was not exposure to real vegetables, but picture-books about vegetables, as reported above. The effect on the child's liking, evaluated by the parent, was significant and persisted at the follow-up as in the real exposure to vegetable. In this case, joint book-reading with a parent might have had a reward effect on children. The intensity of all the successful interventions was high, because all the researches utilized a daily exposure and a reward.

Notably, results by Cravener and colleagues (2) are discordant from the other studies: actually, the authors did not find differences in liking vegetables compared to granola-bar snacks after the intervention. Probably, this difference also depended on the type of measures used: the rating concerned a mean of six different vegetables, not a target disliked vegetable, as in the other studies.

## **Discussion**

The present systematic review analysed home-based interventions conducted among preschoolers to increase their consumption of vegetables. A total of 14 studies was identified, addressing vegetable

intake and liking in children aged between 18 and 48 months. Overall, the study design of the selected researches allowed to establish the effectiveness of interventions. The target population was clear, at least one control condition/group was present (except for Taverno Ross and colleagues' pilot study, that was nonetheless valuable as conducted on-site with the involvement of community health workers who tailored the intervention to suit every family), procedures were well-defined and controlled by the researcher.

First of all, we checked whether a specific type of intervention proved to be effective in increasing vegetable intake. The following list of strategies was adopted: familiarization with vegetable, tasting of the vegetable, intake of the vegetable, reward, information to parents about healthy eating, how-to-do tips to parents to improve healthy eating, intervention tailored to the characteristics of the family. On one hand, successful interventions did not present any systematic similarities in terms of type of intervention. In our view, such a result reflects the complexity of preschoolers' attitude towards vegetables, that can be influenced by different factors, such as child's temperament (i.e., food fussiness, neophobia), parental feeding practices, cross-cultural differences. Therefore, different strategies might obtain favourable effects in different contexts. On the other hand, successful interventions showed similarities in terms of intensity, operationalized as frequency/length ratio: high or medium intense interventions were more likely to be effective. The positive effects of the only study characterized by low intensity were probably due to the compensation provided by its length (eight weeks). This result testifies that a significant effort is needed in changing children's habits regarding vegetables. Indeed, the last eight years witnessed a steep rise of researches concerning this issue (Hodder et al., 2020), which still represents a challenge. Overall, ten studies were successful in improving vegetable intake, that was mainly measured employing objective methods (for example weighing leftovers of offered vegetables, detecting carotenoid concentration in the skin, counting the number of pieces of vegetables eaten). Such a result supports the robustness of the intervention effects, based on unbiased procedures.

Concerning the effects on liking, four out of five interventions were successful, targeted a disliked vegetable and included a small tangible reward. Therefore, liking scores did not change when the child was only exposed to the vegetable without incentives. Familiarization interventions using the joint reading of picture-books were successful just like those providing experiences with real food. This finding is interesting as it allows caregivers to use an alternative strategy, which

could be especially useful with neophobic or fussy children, who are less willing to taste some foods and may benefit from an indirect approach (Caputi et al., 2021; Dovey et al., 2008; Nekitsing, Hetherington et al., 2018). Half of the studies gathered liking scores asking the parents' perception, whereas the other half directly asked the children's opinion. Obtaining the child's direct voice about their vegetable preference should be encouraged, as it is an important and reliable source of information. Unfortunately, no study reported both parents' and children's perception of liking, making it impossible to compare their perspectives and estimate their agreement.

Notably, when both intake and liking of vegetables were investigated and the intervention proved to be successful (four out of five studies), the positive effects concerned both outcomes. Collecting children's measure of liking is crucial as the final scope of such kind of interventions should be improving children's appreciation and not just the intake of vegetables. Indeed, expressing appreciation toward food is associated with more enjoyable and less stressful mealtimes, which are desirable for every family (Harada et al., 2019).

A secondary aim of the present review was to examine features of interventions that obtained significant results both at post-test and at follow-up(s), in order to provide useful guidance for parents interested in long-lasting effects. Only a small amount of studies planned a follow-up phase within the design of the research. Overall, when the positive effect was detected at post-test, it persisted at follow-up. Notably, the study in which the significance was lost at follow-up was a pilot study, with fewer subjects and with a short-term follow-up, whereas the two studies reporting a persistent positive effect had a large sample and conducted a long-term follow-up (three months later). Albeit promising, such findings need further replication. We acknowledge that planning a follow-up requires a big amount of resources; however, literature in this field lacks data about long-term persistence of effects.

The topic of the reward merits further consideration. Four of the selected studies used such strategy in order to increase children's intake and liking and three of them were successful. Rewards could be verbal or tangible, with the latter being more effective according to Remington and colleagues (2012). It is worth noting that attention should be paid when using rewards, as they might have a positive effect when aiming at increasing intake, but might show a detrimental effect on liking, especially when the target food is already liked. Moreover, non-food rewards, both tangible or non-tangible, appeared to be preferable to encourage children to taste new vegetables and to familiarize with them (for a discussion, see Cooke et al., 2011 and Wardle et al., 2003).

Another interesting topic, that was beyond the present review's scopes and might be addressed by future researches, refers to the differences in the feeding context. Indeed, the reviewed studies asked parents to offer vegetables to their children under three different conditions: during main meals, as a snack, or as a game outside mealtimes; in some researches, details concerning this information were missing. According to us, this represents a crucial aspect to understand if there is a winning strategy for vegetable familiarization.

In conclusion, the generalisability of the results of this review is limited by some methodological issues. The selected studies typically involve a relatively low number of participants, not always tracked in the long-term through follow-ups. Moreover, the geographical distribution of the studies is mainly representative of Northern American and Northern European cultures. In fact, in our view, it should be taken into account that strategies adopted in a specific culture might not be effective in a different context, due to peculiarities in food availability, feeding habits, cultural approach to food and mealtimes, parental beliefs in terms of food education, priorities in policymakers' agenda regarding health promotion.

### **Conflict of Interest**

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

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