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A systematic review of practices to promote vegetable acceptance in the first three years of life

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Background

Consumption of vegetables has a protective effect in adults against obesity, type 2 diabetes, cardiovascular disease and some types of cancer (Carter, Gray, Troughton, Khunti, & Davies, 2010; Marmot, Atinmo, Byers, Chen, Hirohata, Jackson, James, Kolonel, Kumanyika, & Leitzmann, 2007; Riboli & Norat, 2003; WHO, 2005). In a critical review of the literature on the role of vegetable and fruit intake in preventing chronic disease in adults, Boeing *et al.* (2012) found convincing evidence that increasing vegetable and fruit intakes reduced the risk of hypertension, coronary heart disease, and stroke (Boeing, Bechthold, Bub, Ellinger, Haller, Kroke, Leschik-Bonnet, Müller, Oberritter, & Schulze, 2012). A systematic review and meta-analysis of the effect of increased vegetable and fruit consumption on body weight and energy intake (Mytton, Nnoaham, Eyles, Scarborough, & Mhurchu, 2014), concluded that the mean increase in body weight was less in consumers with "high vegetable and fruit" intakes than those with "low vegetable and fruit" intakes, and that promoting increased fruit and vegetable consumption may have a role in weight maintenance or loss. Since overweight is the most important risk factor for type 2 diabetes, an increased consumption of vegetables and fruit might also indirectly reduce the risk of type 2 diabetes.

The relationship between vegetable intake in children and a reduced risk of chronic diseases later in life is less clear. Some studies indicate that markers of chronic diseases are already present in childhood. For example, levels of blood pressure and serum lipid and lipoproteins are intermediate markers of disease that track from childhood into adulthood (Li, Chen, Srinivasan, & Berenson, 2005; Lynch & Smith, 2005; Webber, Srinivasan, Wattigney, & Berenson, 1991). However, whether a healthy diet in childhood influences these markers of chronic disease is not known. If a healthy diet during childhood protects against overweight then this may reduce the risk of diabetes (Brisbois, Farmer, & McCargar, 2012) and coronary heart disease (Baker, Olsen, & Sørensen, 2007) in adulthood.

Early flavour experience may have an enduring influence on flavour preferences and food habits including vegetable intake. Several studies have shown that early learned food habits track into later eating patterns including vegetable consumption (Nicklaus & Remy, 2013). Thus, a healthy diet with a sufficient amount of vegetables in childhood may be helpful to prevent chronic diseases in adulthood in various ways, either directly through healthy eating patterns or as a function of the effect on body weight.

Despite the known health benefits, most children do not meet recommendations concerning vegetable and fruit intake (Ocke, Van Rossum, Fransen, Buurma, De Boer, Brants, & al., 2008; Van Rossum, Buurma-Rethans, Vennemann, Beukers, Brants, De Boer, & Ocké, 2016). In the Netherlands, for example, the percentage of children aged between 4 to 6 years old that consume at least the recommended amount of vegetables is less than 1%; while 25% consume the recommended amount of fruit. Children aged 2 to 3 years do slightly better, but still only 17 to 21% of them reach the recommended level of vegetable intake (Ocke, et al., 2008). Vegetable consumption is also low in other European countries and in the USA (Huybrechts, Matthys, Vereecken, Maes, Temme, Van Oyen, De Backer, & De Henauw, 2008; Leclercq, Arcella, Piccinelli, Sette, & Le Donne, 2009; Lorson, Melgar-Quinonez, & Taylor, 2009; Yngve, Wolf, Poortvliet, Elmadfa, Brug, Ehrenblad, Franchini, Haraldsdóttir, Krølner, & Maes, 2005). All these studies show that young children's vegetable intake is much lower than their fruit intake. In addition, the study of Barends et al (2013 and 2014), showed that from the start of complementary feeding, infants show greater acceptance of fruit than vegetables. At 12 and 23 months of age daily fruit intake was double that of daily vegetable intake. This underlines the greater importance of finding strategies to promote vegetable intake, and therefore this review focusses on vegetables only.

The age range selected for this review was from 4 months until three years in order to include the complementary feeding period. The first years of life are important for the development of healthy eating habits (Cashdan, 1994), as this is a period in which new foods are relatively easily accepted and first food preferences are formed. A recent review on sensitive periods for early food learning (Harris & Mason, 2017) concluded that the period between 4 - 6 months of life is a sensitive period for the introduction of taste, the period between 6 – 12 months for the introduction of texture, and the period before 20 months (i.e. before neophobia begins) for the introduction of a large variety of tastes, textures and foods. Food neophobia usually starts at around 20 months, peaks at about 5 years and then declines (Pliner & Salvy, 2006; Rozin, 1976). Introducing a large variety of tastes, textures and foods before the onset of neophobia may encourage greater acceptance in early life (Hendrie, Lease, Bowen, Baird, & Cox, 2017).

The question of when to introduce vegetables is related to the question when to start with complementary foods, which for most international organizations is at 6 months or between 4 and 6 months. The World Health Organisation (WHO) recommends that mothers exclusively breastfeed until the age of six months, and then introduce complementary feeding

(Organization, 2003), with the proviso that some infants may need complementary foods earlier, but not before 4 months of age (Michaelsen, 2000). The European Food and Safety Authority (EFSA) panel suggests that it is safe to introduce complementary foods including gluten containing foods between 4 - 6 months (EFSA Panel on Dietetic Products & Allergies, 2009). The position paper by the European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) on nutrition (Fewtrell, Bronsky, Campoy, Domellöf, Embleton, Mis, Hojsak, Hulst, Indrio, & Lapillonne, 2017) recommends that complementary foods (solids and liquids other than breast milk or infant formula) should not be introduced before 4 months but not be delayed beyond 6 months. The recommendations of EFSA and ESPGHAN are mainly based on benefits for the prevention of celiac disease and allergies, but correspond with a sensitive period for the introduction of vegetable flavours between 4-6 months (Harris & Mason, 2017).

Children are born with a preference for sweet and dislike for bitter tastes; (Mennella, 2014; Schwartz, Issanchou, & Nicklaus, 2009) as vegetables tend to be less sweet and more bitter than other foods, liking of most vegetables has to be acquired through learning. In the seminal paper by Birch and Anzman-Frasca (2011) on opportunities for parents and caregivers to increase the likelihood of healthy weight-status outcomes of children, three main learning paradigms were identified: familiarization, associative learning, and observational learning. From the introduction of complementary feeding, children also start to develop an understanding of categories of foods via observational learning and categorization (Mura Paroche, Caton, Vereijken, Weenen, & Houston-Price, 2017). The literature on how children learn about food from the start of complementary feeding until the age of three years, including the four mechanisms mentioned, has been reviewed by Mura Paroche et al. (2017). Many studies on vegetable liking in young children have tested one or more of these strategies, and their relevance for parental practices to promoting infants' acceptance of vegetables will be discussed in more detail in this review.

A review focussing on methods to increase vegetable intake in children of 2-12 years old showed that only 12 out of 22 studies were found to be effective short-term, and 6/10 long-term (>6 months) (Hendrie, et al., 2017). The review focused on behaviour change strategies, not on parental practices, but is relevant for our review as it shows that vegetable intake interventions should take place at an early age. Another review which focused on methods for increasing vegetable consumption in children of 2-5 years old (Holley, Farrow, & Haycraft, 2017) is closer in age range to our review. The authors found that repeated exposure is a highly effective method for increasing children's vegetable consumption and

that this approach may benefit from being paired with modelling by peers or parents, as well as non-food rewards. A published report (Chambers, 2016) and consensus paper (Chambers, Hetherington, Cooke, Coulthard, Fewtrell, Emmett, Lowdon, Blissett, Lanigan, & Baseley, 2016) both focused on recent evidence using a "vegetables first approach" to complementary feeding. They concluded that repeated exposure to vegetables, offering a wide variety of vegetables and introducing vegetables as first foods during complementary feeding can increase vegetable acceptance in early life and in later childhood. They recommended that a further systematic review is needed in this area,

This systematic review complements and extends existing reviews on promoting vegetable consumption and food learning in children. It complements existing reviews of the strategies used in children aged 2 years and older (Evans, Christian, Cleghorn, Greenwood, & Cade, 2012; Hendrie, et al., 2017; Holley, et al., 2017), and then extends beyond previous reviews by including the period from the start of complementary feeding until 36 months of age. The overall aim of this review was to interrogate evidence on how to introduce and promote consumption of vegetables in early life. The specific objective of the review was to identify which feeding practices achieved the best outcomes for vegetable acceptance.

Methods

Literature search

A literature search was carried out using the databases Scopus and PubMed. The final database search took place on the 28th of March 2018. The search was done in two steps. In the preliminary search, the list of search terms consisting of vegetables and/or fruit, different exposures to food, age of the children and an initial list of excluded terms was used. From the first 2000 titles, the frequency of each term in the abstracts was calculated. The most frequently used terms relevant to the question were retained and irrelevant research topics were then added to the exclusion list. For example, the words: pesticides, metal, and salmonella showed up frequently in the abstracts and they did not relate to the current research question.

In the second step, the final search string with the search terms and the complete exclusion list was applied in Scopus and Pubmed (see supplemental material online link). In the search in Scopus we excluded papers that were classified by Scopus in subject areas not relevant to our search (pharmacology, toxicology, pharmaceutics, immunology, microbiology, environmental

science, dentistry, earth and planetary science, physics, astronomy, veterinary, chemical engineering, mathematics). This second step resulted in the retrieval of 4669 citations.

Table 1 about here

Selection process

The selection process was done systematically based on the PRISMA statement (Liberati, Altman, Tetzlaff, Mulrow, Gøtzsche, Ioannidis, Clarke, Devereaux, Kleijnen, & Moher, 2009) (Figure1). From this total of 4669 papers, we included and excluded papers according to the criteria described in Table 1. Because most research on health benefits is on fruit and vegetables together, the initial search string was focused on identifying studies of vegetables and/or fruit. In the selection process following the initial search only papers on vegetable acceptance were included.

Articles investigating typical healthy children of either gender, starting complementary feeding regardless of age, and feeding up to 36 months old were included. Studies including children of an age outside this age range, for example, 12 to 48 months, were only included if separate results were given for the children under 36 months, or if the mean age was under 36 months. Results of follow-up assessments were included for ages older than 3 years if the intervention had taken place before 36 months. Similarly, in retrospective studies, effects of strategies applied before the age of 36 months had to be described. Articles with a clinical or disease focus and articles that were not written in English were excluded.

The inclusion and exclusion criteria were applied in three different runs. In the first run only the titles were manually screened and papers that clearly did not comply with the original search criteria were excluded (Figure 1). The abstracts of the papers that were not excluded during the first run were taken into account in a second run. In this run the abstracts were scanned specifically for age of participants and whether vegetable intake was actually assessed. From the remaining articles the abstracts or, when the abstract was not informative enough, the whole articles were reviewed more thoroughly according to the criteria in Table 1.

Inter-rater reliability for the inclusion process was calculated with Cohen's Kappa from a set of 50 randomly selected papers from the 2nd run that were assessed by two authors. The Cohen's Kappa reliability score of the coding scheme was 0.92. The two authors

discussed any disagreement and came to a consensus on the interpretation of the inclusion and exclusion rules. The remaining papers were assessed by one of the authors according to the adapted inclusion and exclusion criteria.

Figure 1 about here

General characteristics of the studies

We reviewed 25 experimental and 21 observational studies and made an inventory and categorized all articles by different strategies and practices (see table 2). All data relating to vegetable intake and other measures of vegetable acceptance were extracted from the articles and summarized in tables 3-6. Some of the included studies were not designed to specifically assess vegetable intake, but vegetable intake was a secondary outcome.

Table 2 about here

Results

To facilitate logical reporting of the results, the articles were clustered according to method or strategy to introduce and promote vegetables in the first three years of life. Most of the papers on interventions described intervention studies of two to four week duration, with no follow up. In the majority of intervention studies, vegetable intake was weighed and the children's liking of a vegetable as rated by their mother was assessed, while in the observational studies food frequency and food preference questionnaires were mostly used. Feeding strategies included repeated consumption, repeated visual exposure, conditioning (flavour-flavour and flavour-nutrient learning), exposure to variety, starting complementary feeding with vegetables, introducing vegetables using a stepwise approach and modelling. Moderators included milk feeding, age of starting complementary feeding and baby led weaning. Intervention studies are summarized in tables 3 and 5, observational studies in tables 4 and 6.

Tables 3-6

Repeated exposure

Repeated exposure was the subject of the largest number of papers (N=21). In this strategy the infant is offered the same vegetable on more than one occasion and up to 10 or more times. It

is hypothesized that by doing this, the infants acquire familiarity to the taste and therefore increase the intake of the vegetable (Birch & Doub, 2014; Mura Paroche, et al., 2017).

All *intervention studies* (Tables 3 & 5) on repeated exposure showed that this strategy increased vegetable intake during and directly after the exposure period (Ahern, Caton, Blundell, & Hetherington, 2014; Barends, de Vries, Mojet, & de Graaf, 2013; Barends, de Vries, Mojet, & de Graaf, 2014; Birch, Gunder, Grimm-Thomas, & Laing, 1998; Bouhlal, Issanchou, Chabanet, & Nicklaus, 2014; Caton, Ahern, Remy, Nicklaus, Blundell, & Hetherington, 2012; Caton, Blundell, Ahern, Nekitsing, Olsen, Møller, Hausner, Remy, Nicklaus, Chabanet, Issanchou, & Hetherington, 2014; Coulthard, Harris, & Fogel, 2014; De Wild, De Graaf, & Jager, 2014; de Wild, de Graaf, & Jager, 2017; De Wild, de Graaf, & Jager, 2013; Forestell & Mennella, 2007; Gerrish & Mennella, 2001; Hausner, Olsen, & Møller, 2012; Maier-Nöth, Schaal, Leathwood, & Issanchou, 2016; Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007; Mennella, Nicklaus, Jagolino, & Yourshaw, 2008; Remy, Issanchou, Chabanet, & Nicklaus, 2013; Sullivan & Birch, 1994; Zeinstra, Vrijhof, & Kremer, 2018). Most studies found increases between 25 and 40 grams (Barends, et al., 2013; Birch, et al., 1998; Forestell & Mennella, 2007; Gerrish & Mennella, 2001; Sullivan & Birch, 1994). Four studies on repeated exposure to vegetables after the start of complementary feeding with older infants (between 7 months and three years of age) found an even greater increase in intake (Bouhlal, et al., 2014; Caton, et al., 2012; Caton, et al., 2014; de Wild, et al., 2017; De Wild, et al., 2013; Hausner, et al., 2012; Maier, et al., 2007), while one study about repeated exposure and preparation method in children of 25±10 months found an increase of only 16 grams or less (Zeinstra, et al., 2018). Interestingly, there was an inverse correlation between age and intake in these studies, suggesting that repeated exposure is more effective in younger babies (Caton, et al., 2014). This was also observed in the study by Ahern, et al. (2014), who found that infants > 24 months of age showed a smaller magnitude in the increase of vegetable intake after repeated exposure than infants between 15 and 24 months of age. This suggests that the effect of repeated exposure increases to a certain age (about 24 months) and then may level off or even decrease; it also indicates the importance of early introduction of vegetables.

Repeated exposure to vegetables in infants consisted of exposures to the same vegetable for 8 to 10 consecutive days. Some indication of how many exposures are needed can be obtained from three studies: Caton, et al. (2014) showed that a significant increase of an initially disliked vegetable can already be observed by the third exposure; Hausner, et al. (2012) found that by the 5^{th} exposure intake had significantly increased, and Maier, et al.

(2007) found that by the 8th exposure 71% of the participating infants ate as much of the initially disliked vegetable as of the initially liked vegetable . Interestingly, they also found that in some children ten repeated exposures were not sufficient to achieve the same acceptance as the control vegetable. This suggests both individual differences according to the child and differences in acceptance trajectory by vegetable.

In the studies on repeated exposure the most studied vegetables were green beans, carrots, peas and artichoke. In the studies that took place after solid food introduction, other vegetables were tested: spinach and endive soup, turnip and salsify. In most studies intake of carrots increased less than intake of other vegetables or did not increase at all. A likely explanation is that carrots are generally well liked and intake of carrots was already relatively high before the intervention began. This is probably explained by the relative sweet taste of carrots compared to the more bitter taste of most green vegetables and children's inborn preferences for sweet taste and aversion to bitter taste (Steiner, 1977).

Further evidence for the effect of repeated exposure on vegetable acceptance comes from six *observational studies* that investigated the frequency of consumption, liking and intake of vegetables via questionnaires (Ahern, Caton, Bouhlal, Hausner, Olsen, Nicklaus, Møller, & Hetherington, 2013; Coulthard, Harris, & Emmett, 2010; Gregory, Paxton, & Brozovic, 2011; Grimm, Kim, Yaroch, & Scanlon, 2014; Howard, Mallan, Byrne, Magarey, & Daniels, 2012; Kong, Gillman, Rifas-Shiman, & Wen, 2016). Five studies found a positive association between frequency of vegetable intake at or before the age of one year and later (age 2-7 years) vegetable intake or liking (Ahern, et al., 2014; Ahern, et al., 2013; Coulthard, et al., 2010; Gregory, et al., 2011; Grimm, et al., 2014; Kong, et al., 2016). Coulthard, et al. (2010) reported a correlation between the frequency of consumption of home cooked vegetables during complementary feeding, and the frequency of vegetable intake at the age of 7 years, but no such effect was found for manufactured, pre-cooked vegetables offered during complementary feeding. The study of Gregory, et al. (2011) followed children for 2 years, and found that frequency of vegetable consumption at 1 year predicted vegetable intake at age 2 years. Grimm, et al. (2014) found an association between infrequent vegetable intake (less than once a day) during late infancy (mean age 10.5 months) and infrequency of vegetable intake at age of 6 years. In the study of Ahern, et al. (2013) a significant positive relationship between a child's liking for a vegetable and the frequency with which it had been offered to them was found in the Danish and UK samples, but not in the French sample. The study of Kong, et al. (2016) investigated the relationship between liking, intake and maternal intake of

vegetables at 2 years of age and vegetable intake in mid childhood (mean age 7.7 years). They found that early vegetable consumption frequency (assessed by food frequency questionnaire) had the most significant influence on later vegetable consumption.

An observational study by Howard, et al. (2012) investigated the relationship between the number of repeated exposures to a new food and liking of fruits and vegetables in 23 month old children, but no significant association was found. However, the authors suggest that this result may reflect the question asked; mothers were asked how often they had *offered* a new food before deciding whether their child liked the food, rather than how often the child had *tasted* the food. Moreover the question did not distinguish between categories of food such as vegetables. Therefore, this paper might not have measured actual frequency of exposure to vegetables as it is not clear which foods were repeatedly offered to and tasted by the children.

Visual exposure

Repeated exposure to vegetables can be achieved by feeding the same vegetable multiple days in a row, but also every two to five days, with other vegetables between these. In studies testing *visual exposure* (N=4) children became familiar with a vegetable using visual representation within a picture book, and in most cases did not taste the food during the repeated exposures.

Four *experimental studies* assessed the effect of visual exposure on the acceptance of vegetables (Dazeley & Houston-Price, 2015; de Droog, van Nee, Govers, & Buijzen, 2017; Heath, Houston-Price, & Kennedy, 2014; Houston-Price, Butler, & Shiba, 2009). The study by Houston-Price, et al. (2009) showed that a storybook about specific unfamiliar and familiar vegetables increased the observed acceptance of unfamiliar vegetables, but decreased acceptance of familiar vegetables in children aged 21 to 24 months.

The follow-up study of Heath, et al. (2014) examined if initial familiarity and liking for a food influenced the effect of picture book exposure. They found that significantly more children tasted the initially liked vegetable first. Whether the children had seen the vegetables in a picture book did not affect their willingness to try. However, tasting a target vegetable required significantly less encouragement than tasting the control vegetable. Furthermore, when children tasted the food, they consumed more of the target than of the control vegetable, but only when they had been initially unfamiliar with that vegetable. The study by de Droog, et al. (2017) investigated whether the effect of vegetable promoting picture books on toddlers'

vegetable consumption differed according to the reading style and the use of a hand puppet during reading. Interactive reading increased vegetable intake, the use of a hand puppet did not. In a study by Dazeley and Houston-Price (2015), infants were exposed to real vegetables, via food-related activities that included seeing, smelling or touching the vegetables, but tasting was discouraged. Children touched and tasted more of the exposed unfamiliar vegetables than of the non-exposed vegetables.

Conditioning: Flavour-flavour learning and flavour-nutrient learning

Experimental studies on conditioning (*flavour-flavour* and *flavour-nutrient* learning) were characterized by a comparison with repeated exposure alone. In flavour-flavour learning, children are also offered a vegetable repeatedly but with a pleasant or at least familiar, usually sweet, flavour added. The hypothesized effect of flavour-flavour learning is that after repeated exposure to a vegetable associated with a pleasant or familiar flavour, the infant associates the taste of the vegetable with that pleasant taste and consequently will increase intake of the plain version of the vegetable (Havermans & Jansen, 2007). Flavour-nutrient learning is a form of learning in which the vegetable is paired or mixed with a food or ingredient (such as oil) that is energy dense rather than a distinctive, familiar and liked flavour. Flavour nutrient learning is based on the expected associations between the sensory properties of the ingested food or drink and positive consequences of nutrient ingestion, which lead to acquired liking for the flavour (Havermans & Jansen, 2007). Pairing a flavour with energy could also induce flavour-nutrient satiety learning, which could possibly induce an adjustment of intake (Yeomans, 2012). The explanation is that vegetables may be disliked by children, since they are generally low in energy density, and children tend to prefer foods which are high in energy and/or taste sweet (Gibson & Wardle, 2003).This would suggest that flavour-nutrient learning could increase the intake of the vegetable.

All studies that used vegetables to test flavour-flavour learning (FFL) or flavour-nutrient learning (FNL) found similar results: the effects of FFL (Bouhlal, et al., 2014; Caton, et al., 2012; De Wild, et al., 2014; Hausner, et al., 2012; Remy, et al., 2013) and FNL(Ahern, et al., 2014; Caton, et al., 2012; De Wild, et al., 2013; Hausner, et al., 2012; Remy, et al., 2013) were not more effective than repeated exposure in infants, toddlers and pre-school children (Ahern, et al., 2014; Caton, et al., 2012; De Wild, et al., 2014; De Wild, et al., 2013; Hausner, et al., 2012; Remy, et al., 2013). Types of vegetables that were used in the conditioning phase included: celeriac, swede and turnip puree (Ahern, et al., 2014), turnip and beet-root crisps (De Wild, et al., 2013), salsify (Bouhlal, et al., 2014) endive and spinach soup

(De Wild, et al., 2014) and artichoke (Caton, et al., 2012; Hausner, et al., 2012; Remy, et al., 2013). In several studies (Ahern, et al., 2014; Bouhlal, et al., 2014; Caton, et al., 2012) the effect of FFL on the acceptance of the target vegetable was even less than with repeated exposure. However in the study by Hausner, et al. (2012) children assigned to the FFL condition (added flavour was sugar), consumed significantly more of the sweet puree than the plain puree in the conditioning phase. This strategy may therefore have value for foods that are initially rejected, for fussier eaters or for older pre-school children (Remy, et al., 2013), but this has not been tested. In the study by intake Bouhlal, et al. (2014) salt and nutmeg were used in the FFL condition, and in this case intake of the three groups (repeated exposure, FFL with added salt and FFL with added nutmeg) during the conditioning phase was not different, indicating that mere exposure can promote.

Three studies compared the FFL and FNL strategies with repeated exposure using the same products in three countries (Caton, et al., 2012; Hausner, et al., 2012; Remy, et al., 2013). This made it possible to combine the data of all children from the three countries (N = 332; age 4–38 months) (Caton, et al., 2014). Four distinct patterns of eating behaviour during the exposure period emerged: most children (40%) were ‘‘learners’’ who increased intake over time; 21% consumed more than 75% of what was offered each time and were labelled ‘‘plate-clearers’’; 16% were considered ‘‘non-eaters’’ eating less than 10g by the 5th exposure and the remainder were classified as ‘‘others’’ (23%) since their pattern was highly variable. Age was a significant predictor of eating behaviour, with older pre-school children more likely to be non-eaters. Plate-clearers had higher enjoyment of food and lower satiety responsiveness than non-eaters. Non-eaters scored highest on food fussiness. Children in the FNL condition showed the smallest increase in intake over time, compared to those in the repeated exposure or FFL condition. This suggests that adding oil to provide additional energy may have suppressed intake as a function of conditioned satiety.

Variety

Exposure to a variety of vegetables included mainly the application of daily variety in giving infants vegetables, but one study focused on variety within a meal Some studies on repeated exposure and exposure to a variety of vegetables also investigated the effect of *starting complementary feeding with vegetables only* (Barends, et al., 2013; Barends, et al., 2014; Fildes, Lopes, Moreira, Moschonis, Oliveira, Mavrogianni, Manios, Beeken, Wardle, & Cooke, 2015). In experimental research on exposure to a *variety* of vegetables, variety was always combined with at least three repeated exposures to the same vegetable.

Study paradigms exploring the effects of variety mainly focused on the acceptance of new foods but some also assessed the acceptance of vegetables that were part of the repeated exposure to variety. This second category is a special case of repeated exposure and the outcomes of these studies are therefore summarized under "Repeated exposure". Here the effects of variety on the acceptance of a new vegetable are considered. Two paradigms are used for this: 1. the acceptance of a new food is measured before and after the variety intervention and the increase in acceptance is the parameter to be assessed; 2. the acceptance of the new food is only measured after the exposure to a variety of vegetables, and the significance of the effect is determined by comparing the absolute quantity consumed by the variety group with a control group.

Five *intervention studies* on exposure to a variety of different vegetables were effective in increasing vegetable intake of a new vegetable (Barends, et al., 2013; Coulthard, et al., 2014; Gerrish & Mennella, 2001; Maier, Chabanet, Schaal, Leathwood, & Issanchou, 2008; Mennella, et al., 2008). This effect was age dependent, as one study showed that exposure to variety only influenced intake of a new vegetable in infants given solids at six months of age and not in infants given solids earlier than six months (Coulthard, et al., 2014).

Two studies showed that the effect of vegetable variety is also dependent on the degree of variety (Maier, et al., 2008; Mennella, et al., 2008) The study of Maier, et al. (2008) showed that daily variety is more effective than varying every three days in a nine day intervention. In a follow-up study at the age of 6 years, children who had experienced high vegetable variety at the start of complementary feeding ate more of the new vegetables offered and liked them more (Maier-Nöth, et al., 2016). A more detailed study of the effect of variety was done by Mennella, et al. (2008), who compared high variety (daily + within meal variety), medium variety (two vegetables given on alternating days) and no variety (repeated exposure) in infants. All three strategies increased the intake of green beans, but the increase in green bean intake was higher in the high variety group than in the other two groups.

The effect of exposure to vegetables on fruit acceptance and vice versa, was studied in several studies. Mennella, et al. (2008) found no effect of exposure to a variety of fruits on intake of green vegetables. A similar result was found in the study of Barends, et al. (2013) in which exposure to vegetables did not influence initial fruit intake, and exposure to fruits did not affect vegetable intake.

Observational studies show mixed results about the effects of exposure to variety on vegetable acceptance, as two longitudinal studies (Lange, Visalli, Jacob, Chabanet, Schlich, & Nicklaus, 2013; Mallan, Fildes, Magarey, & Daniels, 2016) showed a positive association and

one cross-sectional study (Ahern, et al., 2013) a negative association with vegetable acceptance. One of the longitudinal observation studies showed that new vegetable acceptance at the age of 15 months was significantly correlated with the number of different types of foods offered during complementary feeding (Lange, et al., 2013). This included all types of foods, thus when a high variety of foods had been offered, particularly a large number of different types of vegetables, vegetable acceptance was higher. Acceptance of each food was measured one week per month by the mothers at home from the beginning of complementary feeding until the child was one year, and was scored on a 4-point Likert scale. Intake was not measured. The other longitudinal study found that the number of vegetables tried at the age of 14 months was associated with a higher preference of vegetables at the age of 3.7 years (Mallan, et al., 2016). The data were collected via questionnaires. The cross-sectional study of Ahern, et al. (2013) found unexpected contradicting results, namely an inverse correlation between liking and number of vegetables introduced for children between 6 to 12 month. The authors commented that children offered a wider variety of vegetables may have been offered a higher proportion of disliked vegetables lowering the average liking, which would explain the inverse association between variety exposure and liking.

Starting complementary feeding with vegetables

The *intervention study* of Barends, et al. (2013) addressed the question of whether vegetables should be introduced before fruit, or *vice versa*. To let children get familiar with spoon feeding they were first given rice porridge for five days. The actual intervention consisted of giving children either a daily variety of pure vegetable purees (group 1) or a daily variety of pure fruit purees (group 2). On the first day of the intervention, fruit intake was about twice as high as vegetable intake. Infants who started complementary feeding with vegetable purees almost doubled their intake of the vegetable puree between day 1 and 18. Infants that started with fruit purees also increased fruit puree intake, but their vegetable intake did not increase. This study showed that initial acceptance is considerably lower for vegetables than for fruits, and that starting complementary feeding with vegetables is feasible and considerably increased infants' vegetable intake. In a follow-up study at age 12 months, daily vegetable intake in infants who had been introduced exclusively to vegetables for the first 2 weeks of complementary feeding was still 38% higher than in those who had been introduced to fruit first (Barends, et al., 2014). These differences were no longer apparent at 23 months. This

study complements earlier results from Mennella, et al. (2008) who found that repeated exposure to fruits (pear or variety of fruits not including pear) increased pear intake but not vegetable intake, and that repeated exposure to green beans or a variety of vegetables increased acceptance of green beans.

Another intervention conducted in the UK, Portugal and Greece studied the effects of starting with a daily variety of vegetables versus standard practice in the country in which the study took place (Fildes, et al., 2015). After the intervention period of 15 days, the intake of a new vegetable by the UK children in the intervention group was almost twice as much as the intake of the new vegetable in the control group. No such effect was observed in Portugal and Greece, possibly because early introduction of vegetables is already common in these countries, especially in Portugal, where it is recommended to start complementary feeding with vegetable-based purees and/or soups. These studies (Barends, et al., 2013; Barends, et al., 2014; Fildes, et al., 2015; Mennella, et al., 2008) suggest there is an advantage of introducing vegetables early during complementary feeding for the later acceptance of vegetables, which is in agreement with two earlier review papers on this topic (Chambers, 2016; Chambers, et al., 2016).

Introducing vegetables step-by-step

A variant of starting complementary feeding with vegetables was studied by Hetherington, Schwartz, Madrelle, Croden, Nekitsing, Vereijken, and Weenen (2015): in a two-arm RCT at the onset of complementary feeding, children in arm one were first given milk mixed with vegetable puree, then rice porridge mixed with vegetable puree and finally pure vegetable puree (stepwise introduction group) by day 25. In arm two, children transitioned directly from milk feeding to baby rice which had not been flavoured with vegetable purees (control group) and then finally pure vegetable puree on day 25. When given vegetable purees for the first time, the stepwise introduction group showed higher intake, pace of eating and liking of vegetables. At subsequent follow ups when infants were 12 months and 24 months old, group differences were no longer significant, in part due to increased general exposure to vegetables across groups. The results suggest that a gradual stepwise introduction approach is feasible at the time of complementary feeding and that this enhances acceptance of vegetables, at least in the short term.

Milk feeding method as a determinant of vegetable intake

Studies on the *influence of milk feeding method* compared breastfeeding with formula feeding on later vegetable intake. These studies are based on the hypothesis that the greater variety of flavours in breast milk influence taste preferences positively.

None of the *experimental studies* had breastfeeding vs formula feeding as a primary effect, but five studies assessed the effect of breastfeeding as a cofactor. Three studies assessed whether breastfeeding was associated with the outcome of a repeated vegetable exposure intervention (Maier-Nöth, et al., 2016; Maier, et al., 2008; Sullivan & Birch, 1994) and found a positive association and three further studies assessed whether there was an association of breastfeeding with vegetable acceptance before a vegetable intervention took place (Caton, et al., 2014; Forestell & Mennella, 2007; Remy, et al., 2013) and found no association.

A possible explanation for the association of breastfeeding with the outcome of the vegetable interventions is that children are more familiar with taste variety via breast milk, hence develop a liking for new flavours more quickly. The lack of an association of breastfeeding with vegetable acceptance at the start of the intervention is unexpected. This inconsistency may be attributed to differences in methodology (e.g. in reporting breastfeeding practices), or to the possibility that breastfeeding mothers may not consume a vegetable rich diet themselves and so infants are not exposed to more vegetable flavours. It is clear, that further research is needed to examine this important relationship.

Breastfeeding Duration

Seven *observational studies* investigated the association between the duration of (exclusive) breastfeeding and later vegetable intake. All of them found significant positive associations between breastfeeding duration (De Lauzon-Guillain, Jones, Oliveira, Moschonis, Betoko, Lopes, Moreira, Manios, Papadopoulos, & Emmett, 2014; Okubo, Miyake, Sasaki, Tanaka, & Hirota, 2015; Soldateli, Vigo, & Giugliani, 2016; Yuan, Rigal, Monnery-Patris, Chabanet, Forhan, Charles, de Lauzon-Guillain, Annesi-Maesano, Bernard, Botton, Dargent-Molina, Ducimetière, de Agostini, Foliguet, Fritel, Germa, Goua, Hankard, Heude, Kaminski, Larroque, Lelong, Lepeule, Magnin, Marchand, Nabet, Pierre, Slama, Saurel-Cubizolles, Schweitzer, & Thiebaugeorges, 2016) exclusive breastfeeding duration (Möller, De Hoog, Van Eijsden, Gemke, & Vrijkotte, 2013; Perrine, Galuska, Thompson, & Scanlon, 2014), or breastfeeding or not (Grieger, Scott, & Cobiac, 2011), and vegetable intake frequency at ages between 16 months and 5 years or a healthy eating pattern at 2.5 years that included vegetables (Grieger, et al., 2011).

Two observational studies that evaluated the associations of liking or acceptance of vegetables with breastfeeding found mixed results. New vegetable (and fruit) acceptance at 4-8 months was not associated with exclusive breastfeeding duration (Lange, et al., 2013), liking of vegetables at 23 months was also not associated with breastfeeding duration, but liking of vegetables at 3.7 years was found to be associated with breastfeeding duration (Mallan, et al., 2016). Two studies (Armstrong, Abraham, Squair, Brogan, & Merewood, 2014; Burnier, Dubois, & Girard, 2011) assessed associations between breastfeeding and giving vegetables to children, both with positive associations.

Two possible explanations for the effect of breastfeeding on vegetable consumption and acceptance have been suggested: (1) the flavour of breast milk varies with the maternal diet and hence exposes the child to flavour variation and the flavour of specific vegetables, this way preparing the child to new flavours / foods in general and more specifically to the flavours of specific vegetables (Mennella & Beauchamp, 1991); (2) mothers who breast feed longer may be more health conscious and therefore eat and feed more vegetables. There is some evidence for both of these explanations. An intervention study by Mennella, Jagnow, and Beauchamp (2001) found that giving carrots to breastfeeding mothers improved their infants' acceptance of carrots which is in line with ~~s~~the first explanation. An indication for the second explanation comes from an observational study showing that exclusive breastfeeding (Armstrong, et al., 2014) or breastfeeding (Burnier, et al., 2011) for 3 months or longer was associated with parents giving more vegetables to their child.

Age of introduction to complementary foods and vegetables

Studies that investigated the association between age of introduction to solid foods and vegetable intake were all large scale longitudinal *observational studies*. Seven studies investigated the influence of the age of introduction to vegetables on later intake. Lange, et al. (2013) found that the earlier vegetables were introduced, the higher was the acceptance of new vegetables as rated by the mother. The study of de De Lauzon-Guillain, et al. (2014) found only a weak positive correlation between age of introduction to vegetables and later vegetable intake. Five other studies did not find a relationship between age of introduction to vegetables and later vegetable intake (Burnier, et al., 2011; Grimm, et al., 2014; Möller, et al., 2013; Okubo, et al., 2015; Yuan, et al., 2016).

Another study found that when children were introduced to lumpy solid foods after the age of 9 months compared to between 6-9 months, they ate a lower variety of vegetables at 7

years of age and a smaller proportion of these children consumed vegetables (Coulthard, Harris, & Emmett, 2009).

Taken together, these results suggest that early introduction of vegetables may have a small positive effect on acceptance of a new vegetable, but that this effect is not strong enough to be detectable at 4 years of age. Longer term effects were observed for the timely introduction to lumpy foods in the first year on vegetable acceptance at 7 years.

Modelling

In studies where mothers set an example of eating vegetables themselves, it is assumed that infants model this behaviour through observational learning. Also, it is likely that these mothers will offer vegetables to their infants more than mothers who eat few vegetables. Three *observational studies* investigated modelling or had results relevant for modelling, all of which showed positive associations of modelling or parental vegetable intake with children's vegetable acceptance and/or intake. The study by Gregory, et al. (2011) found that maternal modelling of healthy eating in the presence of their child at one year predicted higher frequency of vegetable consumption at 2 years. The study by Edelson, Mokdad, and Martin (2016) showed that prompting and especially parental modelling, can be effective in increasing acceptance of a novel vegetable and vegetable intake in general. The study of Yuan, et al. (2016) showed that children's fruit and vegetable intake at 3 years of age was positively associated with maternal fruit and vegetable intake, long breastfeeding and later introduction of various foods. Restriction did not significantly predict child frequency of consumption of fruits, vegetables or sweets over time.

Baby-lead weaning

One study analysed the effect of baby-led weaning in comparison with spoon feeding (Townsend & Pitchford, 2012). The results showed no effect of baby-led weaning on vegetable intake. Exposure to vegetables was higher in the spoon-fed group and associated with liking for vegetables. The characteristics of the children in the baby-led weaning group were significantly different from those in the spoon-fed group. To control for this, the results of the baby-led weaning group were compared with a matched sub-sample of the initial group. This led to a relatively small sample size and could have compromised power and representativeness of the sample.

598 ***Discussion***

599

600 This review investigated different practices for vegetable introduction during the first three
601 years of life on short or long-term vegetable intake. A systematic search was used to find all
602 relevant papers on this subject. To make sure that relevant papers were not overlooked, we
603 applied a search string that resulted in a large number of papers and then narrowed it down by
604 manually scanning the titles and abstracts. Although we carefully selected the papers using
605 the inclusion and exclusion criteria, we cannot rule out that we missed some papers in our
606 review (Savoie, Helmer, Green, & Kazanjian, 2003). The inclusion process was first applied
607 to 50 papers by two authors and we found a high inter-rater reliability for the inclusion
608 process, which showed that our manual inclusion approach was reliable and consistent with
609 the protocol.

610 Forty-seven papers were reviewed that addressed the question how to best introduce
611 and promote vegetables during the first 3 years of life. One third of the papers involved
612 repeated exposure, which was most often studied in the interventions. About half of the
613 papers described intervention studies, the other half reported observational studies. We found
614 papers describing interventions with very different strategies: repeated consumption, repeated
615 exposure to variety, visual exposure, flavour- flavour and flavour-nutrient learning and
616 various ways of introducing vegetables early and / or stepwise. We also found papers which
617 reported on results from large scale, observational studies using self-report on the frequency
618 of exposure, variety, age of introduction of solid foods, type of milk feeding, baby-led
619 weaning, modelling of healthy eating and prompting. Studies were not necessarily designed to
620 improve or measure the increase of vegetable intake, nonetheless they all had vegetable
621 consumption, feeding or liking as one of the outcome measures.

622 The most effective strategy to promote vegetable consumption appeared to be
623 repeated exposure to vegetables. Also exposure to a variety of vegetables was effective at
624 increasing intake. Flavour-flavour and flavour-nutrient learning did not produce any
625 additional benefit over repeated exposure in encouraging intake, although preschool children
626 showed an initial preference for sweetened vegetable puree or high energy soups but this did
627 not affect final outcomes.

628 The effectiveness of a repeated exposure paradigm for children in the 0-3 year age
629 group has first been shown by Birch et al. (1998), who showed that repeated exposure to fruits
630 or vegetables increased acceptance of the target food as well of similar foods, but not of
631 different foods. In our review we focused on interventions of vegetables only and found that

all 18 intervention studies on repeated exposure to a particular vegetable showed that this strategy positively affected intake of this vegetable. Seven of the repeated exposure intervention studies had follow-ups that varied between one week and six months. Most of these studies found that the effect was stable or that vegetable intake in the intervention group increased more than in the control group. The results of this review for children 0-3 years are in line with a recent meta-analysis in children 2-5 years, which concluded that interventions implementing repeated taste exposure had better pooled effects than those which did not (Birch, et al., 1998).

The importance of repeated exposure was also supported by the findings of the observational studies investigating frequency of vegetable exposure. Five out of six studies found a positive association between frequency of vegetable intake at or before the age of one year and later (age 2-7 years) vegetable intake or liking (Ahern, et al., 2014; Ahern, et al., 2013; Coulthard, et al., 2010; Gregory, et al., 2011; Grimm, et al., 2014; Kong, et al., 2016). A particularly interesting variant of the repeated exposure paradigm is when repeated exposure is combined with daily variety. This combination was shown to result not only in improved acceptance of the target vegetable(s) (Caton, et al., 2012; Gerrish & Mennella, 2001), but also in improved acceptance of a new vegetable (Gerrish & Mennella, 2001; Maier, et al., 2008; Mennella, et al., 2008). When looking at the impact of variety, a higher variation in vegetables was found to be more effective in promoting acceptance than lower variety (Maier-Nöth, et al., 2016; Maier, et al., 2008). Variety of fruits did increase the intake of a new fruit, but did not increase the intake of a new vegetable (Barends, et al., 2013). This suggests that especially for improving vegetable intake it is important that an infant is given a variety of vegetables, and that vegetables should be repeatedly offered. All studies on repeated exposure have used single vegetables as the stimulus that is repeated and for which acceptance is tested. Based on the current evidence the recommendation therefore should be that single vegetables are used when familiarizing children to vegetables. It would be interesting to study whether repeated exposure to a mixture of vegetables leads to the expected increase of the acceptance of that specific mixture and to what extent acceptance may generalize to other vegetables.

Flavour-flavour and flavour-nutrient learning increased intake of the plain vegetable in all studies, but not more than a repeated exposure paradigm, in some studies even less (De Wild, et al., 2014; Forestell & Mennella, 2007; Remy, et al., 2013). Flavour-flavour learning may have some value for foods that are initially rejected, for fussier eaters or for older pre-school children (Remy, et al., 2013), but this has not been tested specifically in fussy eaters.

Repeated experience of vegetables was effective, however two studies on visual exposure indicated that just showing children pictures of vegetables in a picture book could increase their willingness to try unfamiliar vegetables (Heath, et al., 2014; Houston-Price, et al., 2009). These results are different from the results of an earlier study on visual exposure to fruits in children of 2-5 years old by Birch et al. (1987), from which it was concluded that visual exposure increases visual acceptance but not acceptance when tasting (Birch, McPhee, Shoba, Pirok, & Steinberg, 1987). The reason for the differences between the studies on visual exposure to vegetables versus the study on visual exposure to fruits is not immediately apparent, but may be due to the target food (vegetables vs fruits), familiarity (visual exposure was effective in increasing an unfamiliar vegetable but not a disliked or liked vegetable, whereas in the fruit study no such distinction was made) and/or different age group (20-27 months in the vegetable studies, 23-69 months in the fruit study).

One study found that interactive reading increased vegetable acceptance and one study showed that letting children participate in looking, listening, feeling and smelling activities increased their willingness to taste unusual fruits and vegetables. The results of the latter study are complementary to a study in pre-school children showing that sensory play with fruits and vegetables increased the number of fruits and vegetables that were tasted by the participating children after the intervention (Coulthard & Sealy, 2017) and with a recent study on texture that showed that tactile play can improve acceptance of foods in 3-10y children (Nederkoorn, Theiβen, Tummers, & Roefs, 2018). These may be interesting interventions for further investigation.

Another way of exposing children to the flavour of vegetables is during pregnancy and breastfeeding. There is evidence that the mothers' diet can influence their infants' taste preferences through exposure via their amniotic fluid during pregnancy and via breast milk during breastfeeding (Mennella, Daniels, & Reiter, 2017; Mennella, et al., 2001; Ventura, 2017). Also the higher variation of taste in maternal milk compared to formula-milk is believed to increase acceptance of novel foods (Mennella & Beauchamp, 1991). This was supported by a recent randomized clinical trial of lactating mothers and infants that showed that a relatively brief experience (1 month) with carrot flavours in mothers' milk resulted in a faster rate of eating a carrot-flavoured cereal (Mennella, et al., 2017). Timing was found to affect the results as exposure 0.5 months after birth had a stronger effect than exposure later, and one month exposure had a stronger effect than 3 month exposure or no exposure (Mennella, et al., 2017). All of the observational studies reviewed here are supportive of a relationship between breastfeeding and vegetable acceptance. In a recent paper (de Wild,

Jager, Olsen, Costarelli, Boer, & Zeinstra, 2018) and summary (Issanchou, 2017) of the HabEat project which included analyses of cohorts in three European countries, it was concluded that never or short duration of breastfeeding but not timing of complementary feeding were associated with a lower vegetable intake in early childhood. The authors commented that the quite similar results obtained for the cohorts in three countries suggest that the benefits of breastfeeding on the development of healthy eating habits would not be country-specific. Overall, breastfeeding may promote higher vegetable intake, in part, through more varied flavor exposure than other modes of milk feeding. In this context the suggestion from Forestell and Mennella (2007) that breastfeeding may confer an advantage of the initial acceptance of a food only if mothers eat that food regularly is relevant. More research is needed to understand better the precise mechanisms underlying this important relationship.

Baby-led weaning has recently been proposed as an alternative to more traditional weaning. Traditional weaning is based on gradual step-wise introduction of texture via spoon feeding of purees and thereafter progressing textures; in baby led weaning solid foods are introduced directly after milk feeding (Townsend & Pitchford, 2012). Studies on baby-led weaning have not specifically focussed on improving vegetable acceptance, therefore were not identified from our search, nevertheless at least one study had assessed the effect on vegetable acceptance (Townsend & Pitchford, 2012). The results showed no effect of baby-led weaning on vegetable intake for a sample of 20 to 78 months of age. Exposure to vegetables was higher in the spoon-fed group and associated with liking for vegetables.

A large number of studies investigated *how* to introduce vegetables to infants. Few studies investigated *when* vegetables should be introduced (Burnier, et al., 2011; Coulthard, et al., 2009), one focused on the introduction of all solid/lumpy foods (Coulthard, et al., 2009), and one focussed on starting complementary feeding with vegetables versus fruits (Barends, et al., 2013) and one observational study on the acceptance of complementary foods had timing of vegetable introduction as a parameter for the acceptance of new vegetables (Lange, et al., 2013). The results of these studies suggest the importance of introducing vegetables early. Furthermore, it seems to be more important to focus on familiarizing infants with vegetables than with fruit, since vegetable intakes are in general lower than fruit intakes and these differences were found to be present already at the start of complementary feeding (Barends, et al., 2013; Mennella, et al., 2008). This suggests that acceptance is a more important factor for the consumption of vegetables than for fruits.

The age of introducing vegetables may interact with the effect of exclusive breastfeeding, because when mothers exclusively breast feed longer, this may delay the

introduction of solid foods including vegetables, with possible negative effects on vegetable and texture acceptance. This is another topic that is worth investigating further. During the first years of life in particular, parents have a substantial influence on children's eating habits. It is therefore important to provide parents with information and tools on how to best introduce vegetables to their children to achieve good acceptance. However, simply providing information may not be enough and it must be combined with approaches that motivate parents to implement recommended strategies. When it comes to their own eating habits, most adults know the importance of eating vegetables, however, only 3 to 14% eat a sufficient amount of vegetables (Van Rossum, Fransen, Verkaik-Kloosterman, Buurma-Rethans, & Ocké, 2011). Nevertheless, most mothers are motivated when it comes to healthy nutrition for their children (Caton, Ahern, & Hetherington, 2011). The review on strategies to increase vegetable intake in home and community settings by Hendrie, et al. (2017) could inspire more nuanced recommendations.

This review complements an earlier review of methods to improve vegetable acceptance in 2-5 year old children (Holley, et al., 2017) about the importance of repeated exposure and the limited effectiveness of food adaptations (FFL and FNL) . Methods that succeed for 2-5 year old children have not yet been shown to work for children of 0-3 years include the use of non-food rewards and peer modelling. The recommendation to start complementary feeding with vegetables is shared with two position papers (Chambers, 2016; Chambers, et al., 2016). The main conclusions from our review are generally congruent with the reviews on how children learn about foods (Birch & Anzman-Frasca, 2011; Mura Paroche, et al., 2017): familiarization (repeated exposure, visual exposure, breast feeding) is particularly effective, as well as observational learning (modelling) whereas to date studies of associative learning (FFL & FNL) show no additional advantage over repeated exposure. Parental practices that also contribute to early vegetable acceptance and that have not been covered by earlier reviews include the effects of stepwise introduction and the timely introduction of texture.

A strength of the present review is its focus on vegetables, parental practices occurring, and the period from the start of complementary feeding till the age of three years, hence findings are relevant for public health initiatives in this period to promote vegetable acceptance. Many research papers on this topic have been published in the last five years (25/46), therefore the present review is timely considering the growing attention given to the role of vegetables in improving the diet of children and potential prevention of obesity. While the main focus was on the complementary feeding period, studies relevant to the question up

to 36 months and on the effects of milk feeding on vegetable acceptance were also included. A weakness of this review is that despite applying a rigorous and systematic search strategy, some relevant papers, may have been missed. Another weakness of this review is the diversity of methods and outcome parameters in the experimental papers and lack of randomised controlled trials, especially for some topics e.g. breastfeeding, and the limited number of longer term follow-up studies. This may limit the generalisability of the research findings.

In conclusion, based on the evidence of the papers reviewed, introducing vegetables at the beginning of complementary feeding by repeated exposure to a daily variety of different vegetables is a successful strategy for improving vegetable acceptance. Other practices that may be used to improve vegetable acceptance include the use of visual exposure to unfamiliar vegetables, stepwise introduction, modelling, breast feeding and the timely introduction of texture. This information could be included in advice to parents during milk feeding and in the complementary feeding advice given to parents by health care professionals as well as included on child nutrition websites.

Author contributions statement

All authors contributed to the design of the study. C.B. conducted the search and inclusion process of the articles. J.H.M.d.V, and J.W. contributed to the inclusion process of the articles. C.B. wrote the manuscript and had primary responsibility for final content. All authors reviewed and revised the manuscript, and approved the final manuscript as submitted.

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Conflict of interest

Janet Warren was and Hugo Weenen is an employee of Danone Nutricia Research.

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Inclusion criteria	Exclusion criteria
Study population:	
Healthy children from 0 to 3 years old, or a group with a mean age < 3y	Children treated in a clinical setting of having a disease
Children between 0 and 3 years old during at least a part of the intervention in longitudinal studies	Animal studies
Pre-schoolers, toddlers, infants, and baby's without further age specification	
Outcome variables:	
Vegetable intake, acceptance or liking	
Short-term or long-term vegetable intake	
Food refusal, picky eating etc.	
Method or strategy:	
Introducing vegetables to children	Family food programs focused on vegetable intake of the child
Feeding vegetables to children	
Taking into account age for introduction of vegetables	
Taste learning strategies including repeated exposure, variety, responsive feeding, visual exposure, modelling in relation to vegetable feeding	
Breast- versus formula feeding	
Type of papers	
International peer reviewed	Including case studies with < 5 subjects
Observational or intervention studies	Position papers not clearly based on literature
Clinical trials	Describing development of a questionnaire
Meta-analyses	Not complying with the original search criteria
Randomised controlled trials	In languages other than English
Practice guidelines (for discussion)	Conference abstracts
Reviews and position papers based on proper scientific literature (to check for additional references)	

Table 1: Inclusion and exclusion criteria for the papers found with the research

Table 2. General characteristics of the studies included in the review

	Number of Intervention studies (N=25)	Number of observational studies (N=21)
Total number of studies *per country of origin*		
Australia	-	4
Brazil	-	1
Canada	-	1
Denmark	1	-
France	2	2
France & Germany	2	-
France, Denmark & UK	1	1
France, Portugal & Greece	-	1
Germany	1	-
Japan	-	1
Netherlands	6	2
United Kingdom	7	4
United States of America	5	4
Number of participants (range)		
20 -50	10	-
50-100	6	2
100-500	9	7
>500	-	12
Focus study or intervention strategy*		
Repeated exposure	21	-
Frequency vegetable intake	-	6
Repeated visual exposure	3	-
Sensory engagement	1	-
Variety	6	3
Flavour-flavour learning	8	-
Flavour nutrient learning	5	-
Food preparation method	1	-
Age of introduction to vegetables	-	7
Vegetables first	3	-
Stepwise introduction	1	-
Effects of milk feeding method	4	7
Maternal modelling	-	3
Prompting	-	1
Baby-led weaning	-	1
Encouragement at daycare	-	1
Length of Follow up		
No follow up	17	6
<1 year	5	3
1 – 2 years	2	2
3 – 4 years	0	3
5 – 10 years	1	7

	Number of Intervention studies	Number of observational studies
Vegetable intake/ liking assessment*		
Food pre- and post-weighed	23	-
Infant liking assessed by caregiver	11	5
Infant liking assessed by experimenter	5	-
Willingness to taste	4	-
Other measures of acceptance	4	-
Facial expressions	2	-
Dietary range/ food frequency/intake questionnaire	-	13
Food preferences questionnaire	-	2
24-h recall	-	3
Food diary	1	2
Preference	2	-
Questionnaire on giving vegetables	-	2

* Studies can fall in multiple categories

Table 3 Papers about interventions to increase vegetable acceptance

Repeated exposure	Flavour-flavour learning	Flavour – nutrient learning	Variety	Starting with vegetables / Stepwise introduction	Visual exposure / sensory engagement
Sullivan 1994 (l)	Caton 2012	Caton 2012	Gerrish 2001	Barends 2013	Houston-Price 2009
Birch 1998	Hausner 2012	Hausner 2012	Maier 2008	Barends 2014 (l)	Heath 2014
Gerrish 2001	Remy 2013 (l)	De Wild 2013 (l)	Mennella 2008	Fildes 2015	Dazely 2015
Forestell 2007	Ahern 2014 (l)	Remy 2013 (l)	Barends 2013	Hetherington 2015 (l)	De Droog 2017
Maier 2007 (l)	De Wild 2014 (l)		Coulthard 2014		
Maier 2008	Bouhlal 2014		Fildes 2015		
Mennella 2008					
Caton 2012					
Hausner 2012					
Barends 2013					
De Wild 2013 (l)					
Remy 2013 (l)					
Barends 2014 (l)					
Ahern 2014 (l)					
Caton 2014					
Coulthard 2014					
De Wild 2014 (l)					
Bouhlal 2014					
Maier-Noth 2016 (l)					
De Wild 2017					
Zeinstra 2017					

l = longitudinal

Table 4 Papers about observational studies to increase vegetable acceptance

Frequency of exposure	Variety	Effect of milk feeding method / duration	Effect of age of introduction of solid foods / vegetables	Maternal feeding practices / modeling
Coulthard 2010 (l)	Ahern 2013	Burnier 2011 (l)	Coulthard 2009 (l)	Gregory 2011 (l)
Gregory 2011 (l)	Lange 2013 (l)	Grieger 2011 (r)	Coulthard 2010 (l)	Townsend 2012 (r)
Howard 2012 (l)	Mallan 2016 (l)	Howard 2012 (l)	Burnier 2011 (l)	Yuan 2016 (l)
Ahern 2013	Lange 2012 (l)	Lange 2012 (l)	Lange 2013 (l)	Edelson 2016
Grimm 2014 (l)	Moller 2013 (l)	Moller 2013		
Kong 2016 (l)	De Lauzon-Guillain 2014 (l)	Perrine 2014 (l)		
	Grimm 2014 (l)	Armstrong 2014		
	Okubo 2015 (l)	De Lauzon-Guillain 2014 (l)		
	Yuan 2016 (l)	Okubo 2015 (l)		
		Yuan 2016 (l)		
		Soldateli 2016 (l)		

r = retrospective; l = longitudinal

Table 5. Summaries of the included randomized controlled trials, with results on vegetable (V) and fruit (F) consumption and/or liking

Authors (year) (ref #)	Sample	Data collection	Focus paper	Design of study	Reported findings on vegetable and fruit intake, acceptance or liking
Ahern, Caton, Blundel & Hetherington (2014)	N = 29 (recruited 42) Age 15-56m, Country: UK	Intake in grams	RE* and FFL*	*Within Subject design* Each child received 6 to 8 exposures to a root vegetable puree with added apple puree (FFL) alternating with 6 to 8 exposures to another with nothing added (RE). A third puree acted as a control. *Measurement:* Change in intake was assessed by pre- and post-intervention intake measures of the three purees with nothing added. Follow-up measures took place 1 month (n = 28) and 6 months (n = 10) post-intervention.	Intake increased from pre- to post-intervention for all purees (~36 g, $p < 0.001$), with no effect of condition. Magnitude of change was smaller in the control condition. This means FFL was not better than repeated exposure. Post-intervention intake correlated between all conditions. Intake remained significantly higher than baseline 1 month ($p < 0.001$) and 6 months ($p < 0.001$) post-intervention for all conditions. Children under 24m ate consistently more across the intervention than the older children (≥24 m) with no differences found in response to condition.
Barends, de Vries, Mojet et al. (2013 & 2014);	Paper 1 N = 101 mean age 5.4m (range 4-6m) Country: the Netherlands Paper 2: *Follow-up 1:* N = 84 (of which 71 recorded a food diary) mean age: 12m (SD=1.4m) *Follow-up 2:* N=81 (of which 69 recorded a food diary) Mean age = 23m (SD=1m)	Paper 1 Intake in grams, mothers rated liking. Paper 2: daily intake was recorded in a 3-day food diary.	RE	*Paper 1:* *Intervention* 4 groups: 18 days exposure to variation of vegetables with 9x RE to: (1) green beans, (2) artichoke. Or variation of fruits with RE to (3) apple, (4) plum. *Measurements*: Day 1 and 2 measurements of intake and liking (assessed by mothers) in the lab of exposed and other vegetable in vegetable groups. Exposed fruit and other fruit in fruit groups. Day 19 1st fruit in vegetable group and 1st vegetable in fruit group. Paper 2 *Follow-up measurements*: When the infants were 12 and 23m of age their intake of the same fruit and vegetables was measured in the lab at 2 consecutive days. In addition their vegetable intake was recorded with a food diary on 3 random days in a week.	Mean vegetable intake in the vegetable group increased significantly from 24 ± 28 g (mean ± SD) on days 1 and 2 to 45 ± 44 g on days 17 and 18. 1st intake of green beans in the fruit groups at day 19, was 24 ± 29 g and as low as the green beans intake in the vegetable groups at the 1st exposure on day 1 or 2. 1st apple intake in the fruit groups on day 1 or 2 of 47 ± 48 g did on average not differ from the first apple intake of 45 ± 49 g in the vegetable groups on day 19. Mean intake of green beans increased significantly both in groups 1 ($p=0.016$) and 2 ($p<0.001$). Intake of artichoke only increased significantly in group 1 ($p=0.042$) but not in group 2 ($p=0.603$). Liking correlated positively with intake. The paper in 2014 reports follow-up measurements 12 & 23 months after the intervention: reported daily intake of vegetables was higher in the group that had started with vegetables than in the group that had started with fruits at 12m but not at 23m.
Birch, Gunder, Grimm-Thomas et al. (1998)	N = 39 Mean age: 24 weeks	Intake in grams	RE	*Intervention*: 4 groups: 2 were RE to peas puree. Two groups were RE to banana puree. RE to target food once a day for 10 days.	RE increased mean intake of the target food from 35 to 72 g ($p < 0.01$). Same food increased from 59 to 65 g (ns). Similar food increased from 60 to 77 g ($p <$

	(range: 16–31) Country: USA			*Measurement:* Pre- and post-exposure intake of target, same (different brand), similar (fruit-fruit, vegetable – vegetable) and different food (vegetable – fruit).	0.01). No effect on a different food.
Bouhlal, Issanchou, Chabanet & Nicklaus (2014)	N = 151, Mean age: 27m (SD = 0.6m). Country: France	Intake in grams, liking (rated by caretaker on Likert scale)	RE, FFL with salt and spice	*Between subject design* The effect of RE and of FFL on toddlers' acceptance of a non-familiar vegetable was investigated. Toddlers attending six nurseries were assigned to 3 groups. Groups were exposed 8 times to a basic salsify puree (RE group), a salty salsify puree (FFL-salt group) or a spiced salsify puree (FFL-Nutmeg group; n = 50). Acceptance (intake and liking assessed by caregiver) of the target vegetable (basic salsify puree) and of a control vegetable (carrot puree) was evaluated at pre-exposure, at each exposure of the learning period, at post-exposure, and at 1, 3 and 6 months after exposure.	In all groups, intake of the target vegetable increased from pre- to post-exposure. This increase was significantly higher in the RE group (64 ± 11 g) than in the FFL-Salt group (23 ± 11 g) and marginally higher than in the FFL-Nutmeg group (36 ± 11 g). No difference between groups was observed on the increase in liking of the target vegetable from pre- to post-exposure. The increase of the target vegetable intake was still observed after 6 months for all groups.
Caton, Ahern, & Hethering-ton (2012)	N = 72 Mean age: 23.6m (SEM: 0.9, range: 9-38m) Country: UK	Intake in grams	RE, FFL and FNL*	*Intervention:* 3 conditions (RE, FFL and FNL). 10 exposures to a novel vegetable. RE: plain artichoke puree. FFL: sweet (sucrose) added. FNL: added energy using oil *Measurement:* Pre- a[(1)]nd post-intervention intake measures of plain artichoke and carrot puree (control vegetable). Durability assessed 2 weeks post RE. Intake of Artichoke puree once a week for 3 weeks. Last week also carrot.	During 10 exposures intake of both vegetables increased (P=0.001); artichoke sign. more than carrot (P=0.001) and to the same extent in all three conditions. This effect was persistent up to 5 weeks post-intervention. 5 Exposures sufficient to increase intake (p=0.001). No sign. condition effect immediately after intervention. Elevated intake in RE condition at post-test (p=0.02). Significant vegetable by condition effect between RE and FFL. Artichoke intake post-test higher in RE group than in FFL group (p=0.024), not between RE and FNL and FFL and FNL.
Caton, Blundell, Ahern et al. (2014)	N = 332 Mean age: 19m (±9.9m) Countries: Denmark, France, UK	Questionnaire on breastfeeding, child eating behavior questionnaire, intake in grams	Influence of timing, breastfeeding duration, age and traits on effectiveness of RE, FFL and FNL	In order to understand the factors which predict different responses to repeated exposure, data from the same experiment conducted in three groups of children from three countries (n = 332) aged 4–38m were combined and modelled. During the intervention period each child was given between 5 and 10 exposures to a novel	Breastfeeding duration and age of introduction to solid foods was not associated with intake or eating pattern (1. learners; 2. plate cleaners; 3. non-eaters; 4. others) and did not interact with group (RE, FFL or FNL). Age was a significant predictor of eating pattern, with older pre-school children more likely to be non-eaters.

				vegetable (artichoke puree) in one of three versions (basic, sweet or added energy). Intake of basic artichoke puree was measured both before and after the exposure period	
Coulthard, Harris & Fogel (2014)	N = 60, Mean age: 5.18m (± 0.84m), Country: UK	Intake in grams, enjoyment of food (5 points scale), age in months	RE, variety, age of introduction to solid foods	*Randomized controlled trial* The effectiveness of variety versus single taste exposure was measured in (1) infants introduced to solids prior to the age of 5.5m, and (2) those introduced after 5.5m. Infants' acceptance of a novel vegetable (pea puree) was measured after a 9 day exposure period in the infants a week after they were first introduced to solid foods. During the exposure period half of each age group was given carrot every day, and the other half was given a variety pack of zucchini, parsnip and sweet potato. A baseline measurement of the infants' acceptance of a vegetable (carrot) was taken prior to the exposure period.	There were no significant differences in demographic factors between groups, except for maternal and child age. There was no difference between the groups in consumption of the baseline vegetable (carrot). There were no main effects of exposure group or age group on consumption of pea after the exposure period. There was an interaction between the age of introduction and exposure group on consumption of the new vegetable (pea) $F(1, 59) = 4.72$, $p < 0.05$. In particular, infants weaned at 6m in the single taste group ate significantly less pea puree than those in the variety group ($p < 0.05$).
Dazely & Houston-Price (2015)	N = 92, Age range: 12-36m, Country: UK	Two-alternative choice procedure: 4 plates with each 1 food from set A and 1 from set B	Non taste sensory engagement	Exploration of the effectiveness of a non-taste sensory activity program in a nursery school setting. Children were allocated either to (1) an intervention group, who took part in looking, listening, feeling and smelling activities with unusual fruits and vegetables every day for 4 weeks, or (2) to a non-intervention control group. The experimental group was divided in 2 groups that were exposed to different food sets: Set A: sweet potato, green pepper, rhubarb and dried fugs; or B: butternut squash, broad beans, dried prunes and pomegranates.	The results demonstrate that hands-on activities with unfamiliar fruits and vegetables can enhance children's willingness to taste. Children in the experimental group touched ($Z = 2.87$, $p = .004$) and tasted ($Z = 0.24$, $p = 0.025$) more of the exposed, than non-exposed vegetables). This effect was not found for fruits. The exposed foods were also systematically touched and tasted before the non-exposed foods. Again this effect was stronger with vegetables than fruits.
De Wild, de Graaf & de Jager (2013)	N = 28 Mean age: 36 m (SD = 7.3m, range: 21 – 46m) Country: the Netherlands	Intake in grams, paired preference test.	RE and FNL	*Intervention:* 2 groups were fed soups for 7 weeks 2x a week at nursery. (1)High- energy (HE) spinach soup and low-energy (LE) endive soup. (2)HE endive soup and LE spinach soup *Measurement:* Preference and ad libitum intake (with a maximum of 200 g) of both vegetable products (LE), measured before, shortly after	After completion of intervention, 28 children met criteria for FNL, and were included in further data analysis. Significant increase (58 g) in intake for both vegetable soups (stable over time), irrespective of the energy content, immediately after the intervention (+58 g), but also after 2 and 6 months.

				the intervention period, and 2 and 6 months following conditioning to assess longer-term effects.	This indicates a robust effect of mere exposure on intake, but no effect of FNL. Preference results showed a significant shift in liking for the vegetable soup consistently paired with high energy, supporting FNL
De Wild, de Graaf & de Jager (2014)	N Baseline = 39, N 2-month follow-up = 37, N 6-month follow-up = 36, Mean age = 33m (±8.4m), Country: the Netherlands	Intake in grams	RE and FFL	*Within subject design, semi cross-over* The relative effectiveness of RE and FFL in increasing vegetable intake and acceptance in preschoolers was investigated. During an intervention period of 7 weeks, toddlers consumed red beet and parsnip crisps at day-care centers. (1)Half of the group received red beet crisps with a dip of tomato ketchup (Conditioned [C]) and parsnip with a neutral white sauce (Unconditioned,[UC]), whereas (2) for the other half the order was reversed (red beet [UC], parsnip [C]). Preference and ad libitum consumption of vegetable crisps were measured once before and three times after the intervention over the course of a 6-month follow-up period to assess longer-term effects.	Intake increased significantly after the intervention for both vegetables (on average with 8 g), and this effect was persistent even 6 months afterwards. The increase was irrespective of crisps being offered with C or UC dip sauce.
De Wild, de Graaf & de Jager (2017)	N=103 Mean age: 35.5m(SD: 6.8m) Country: the Netherlands	Intake, preference, food-neophobia	RE; Food preparation method	*Randomized controlled trial* Intervention: The study compared three preparation practices for a target vegetable ((1)plain spinach, (2) creamed spinach and (3) spinach ravioli) on their effectiveness in increasing preschool-aged children's preference for and intake of the target vegetable in comparison to a control vegetable ((4)green beans).During the intervention, children were served the vegetable at their main meal six times during 6 weeks at home. *Measurement:* Preference and libitum intake of cooked spinach were assessed during a test meal at the day-care center pre- and post-intervention.	All four groups significantly increased their spinach intake from pre- (53 g) to post-intervention (91 g) by an average of 70%. For preference, no significant shift toward the target vegetable was found from pre- to post-intervention. The effect on intake depended on the child's neophobia status and pre-intervention spinach consumption, with children with neophobia being less responsive to the intervention and with children who ate more spinach before the intervention being more responsive to the intervention.
Droog, van Nee, Govers & Buijzen (2017)	N=163 Mean age: 2.6y (SD: 0.5)	Narrative involvement checklist, intake	Visual exposure / picture book	*Intervention*: The study investigated whether the effect of vegetable promoting picture books on toddlers' vegetable consumption differed	Analysis showed a main effect for reading style, $F(1,150) = 4.15$, $p < 0.05$, $h2 = 0.03$, with toddlers who were read to interactively eating a significantly

	Country: the Netherlands	(# pieces)		according to the reading style and the use of a hand puppet during reading. In a 2 (reading style: interactive vs. passive) x 2 (puppet use: with vs. without puppet) between-subjects design, toddlers were randomly assigned to one of the four reading conditions. The story was about a rabbit that loves to eat carrots. *Measurement:* After reading day 4, an eating task was conducted in which children could eat freely from four different snacks, including carrots.	higher proportion of carrots than those who were read to passively. The main effect for puppet use, $F(1,150) = 0.44$, $p > 0.50$, and the interaction effect, $F(1,150) = 0.04$, $p > 0.80$, were not significant. The explanation for this effect was that interactive reading stimulated toddlers to imitate poses of the book characters, even more when interactive reading was supported by the use of a hand puppet.
Forestell and Mennella (2007)	N = 45 Mean age 5.8m (SEM: 0.2m, range: 4-8m. Country: USA	Intake, mothers rated liking, facial expressions.	RE; variety	*Intervention:* 2 groups: *(*1) RE to green beans, (2) RE to green beans and after 1 hour peaches. 8 consecutive days. *Measurement*: Acceptance of both foods (consumption and liking based on facial expression) was assessed before and after the home-exposure period.	Initially infants ate more energy from peaches than from green beans. RE to green beans, with or without peaches, increased consumption of green beans (from 56.8 to 93.6 g; $p < 0.05$). Only infants who experienced green beans with peaches displayed fewer facial expressions of distaste during feeding. Breastfed children showed greater liking of peaches but no difference in acceptance of green beans.
Gerrish and Mennella (2001)	N = 48 Mean age 4.6m (SD: 0.2m) Country: USA	Intake in grams,. mothers rated liking.	RE; variety	*Intervention:* Acceptance evaluated of a novel V (pureed carrot) and meat (pureed chicken) after a 9-days RE at home in 3 groups of infants. (1) was fed only carrots, the target V; (2) was fed only potatoes, a V that differed in flavour from carrots; (3) was fed a variety of vegetables that did not include carrots. *Measurement:* Intake and liking (assessed by mother) of carrot puree pre- and post RE in the lab. Intake of meat last day in the lab	Infants' carrots intake increased significantly when exposed to either carrots (50 ± 6 g to 90 ± 11 g) or a variety of V (62 ± 12 to 108 ±11; $P < 0.05$), but not those exposed to potatoes. RE to a variety of V also facilitated the acceptance of the novel food, pureed chicken, and daily experience with fruit enhanced the infants' initial acceptance of carrots.
Hausner, Olsen, & Møller (2012)	N = 106 Mean age: 28m (range 22-38m) At nurseries. Country: Denmark	Intake in grams	RE, FFL and FNL	*Intervention:* Nurseries were randomly assigned to one of three learning strategies. 3 groups: Children were exposed 10 times to unmodified puree (RE), a sweetened puree (FF) or an energy dense with added fat (FN). *Measurement:* Intake. Pre-testing with an unmodified artichoke puree. Post-test with unmodified puree, 3 and 6 months	Intake of puree increased in the RE and FF condition, and was unchanged in the FN condition. RE changed children's intake by the 5th exposure, FF learning by the 10th. RE led to the largest increase in intake of unmodified puree at post-test and at 6 months follow-up. Children following FF learning consumed more of the sweet puree than of unmodified puree. About 30–40% of the children were resistant to acceptance

				after last exposure to monitor long-term effects of learning.	changes.
Heath, Houston-Price & Kennedy (2014)	*Experiment 1:* N = 119, Mean age: 21.9 m (range: 19.8 – 26.5m) *Experiment 2:* N = 60, mean Age: 22.3m (range: 20.9 – 24.0m), Country: UK	Vegetable liking and familiarity questionnaire, willingness to taste	Visual exposure / picture book	Experiment 2: Children were randomly assigned to 1 of 3 conditions: (1) disliked vegetable, (2) liked vegetable, (3) unfamiliar vegetable. For each participant 2 vegetables that matched their condition were selected. Parents were asked to read a special made picture book with their child about the exposed vegetables every day for 2 weeks. After these 2 weeks a taste test was done in 2 steps. First the children were offered a plate with a liked and a disliked vegetable. Second, they were offered a plate with the exposed and the unexposed vegetable from the condition they were assigned to. *Measurement:* Liking by parent, willingness to taste	The vegetable that was reported to be liked, was tasted more often, was tasted first and needed less encouragement to taste than the disliked vegetable. Whether vegetables were tasted or the order in which they were tasted, was not influenced by condition or whether the children were exposed to it with a picture book. However, control vegetables needed more encouragement to taste than exposed vegetables (Z = -3.14, p = 0.001) Only the children in the unfamiliar initial status condition consumed significantly more of the target vegetable (Z = -2.5, p = 0.011).
Hetherington, Schwartz, Madrelle et al. (2015)	N = 36, mean age: 4.8m (± 0.6m, Country: UK	Intake in grams, rated liking	Early exposure / Stepwise introduction	The study tested a step-by-step exposure to vegetables in milk then rice during CF, on intake and liking of vegetables. Just before CF, enrolled mothers were randomised to an intervention (IG) or control group (CG). IG infants received 12 daily exposures to vegetable puree added to milk (days 1–12), then 12 × 2 daily exposures to vegetable puree added to rice at home (days 13–24). Plain milk and rice were given to CG. Then both received 11 daily exposures to vegetable puree. Intake was weighed and liking rated (by mother and experimenter) on days 25–26 and 33–35 after the start of CF in the laboratory, supplemented by the same data recorded at home. Vegetables were rotated daily (carrots, green beans, spinach, broccoli).	Intake, liking and pace of eating were greater for IG than CG infants. Intake and liking of carrots were greater than green beans. However, at 6m then 18m follow up, vegetable (carrot > green beans) but not group differences were observed. Mothers reported appreciation of the structure and guidance of this systematic approach.
Houston-Price, Butler, & Shiba (2009)	N = 20 infants Mean age: 23.2m(range 21-24m)	Tasting test, number and order of foods tasted were	Visual exposure	*Intervention:* 2 groups. In each group parents read a different picture book with their child every day for two weeks. About 2 familiar and 2 unfamiliar fruits, and 2 familiar and 2	Children tasted more familiar than unfamiliar foods (p = 0.046). Overall no exposure effect. However, exposure served to decrease children's willingness to

	Country: UK	counted.		unfamiliar vegetables. *Measurement:* In a 'taste test' following the exposure period they were offered all eight foods shown in the two books: the four vegetables followed by the four fruits. Number of foods the children tasted and the order in which they did were video recorded.	taste familiar vegetables, it increased their willingness to taste unfamiliar vegetables. Order of tasting only sign. effect in fruits. Exposure fruits were tasted before non-exposed fruits. Children displayed neophobic behaviour towards foods to which they had not been exposed, but not towards exposed foods.
Maier, Chabanet, Schaal et al. (2007)	N = 49 Mean age: 6.9m (SD: 0.9m). Country: Germany	Intake in grams, mothers rated liking.	RE	*Intervention study:* From a larger study infants who disliked at least one vegetable were selected. Mothers were asked to offer a disliked vegetable on alternate days for 16 days, and to offer a well-liked one (carrot puree) on the other days. *Measurement:* Intake and liking (by mother) were measured at each meal.	Intake of disliked vegetable increased from 39 ± 29 g at first exposure to 174 ± 54 g at the 8th exposure. Similar to that of the liked vegetable (186 ± 68 g). Nine months later, 63% of the infants were still eating and liking the initially disliked vegetable. Similar results were found for mother-reported liking ratings.
Maier, Chabanet, Schaal et al. (2008)	N = 147 Mean age: 5.2m (SEM: 0.1, range 4-7 m). Country: Germany and France	Intake in grams, mothers rated liking.	RE and variety during weaning	*Intervention:* 3 groups received their first vegetable (carrot puree) in the lab and, 9 days at home, either (1) carrots every day; (2) 3 vegetables changed every 3 days; or (3) 3 vegetables changed daily. On the 12th and 23rd days they received new vegetable purees, zucchini-tomato then peas. *Measurement:* Acceptance of new foods was measured by intake and by liking ratings of mothers and observer.	Intake on day 1 was the same in breast and formula fed and in 3 conditions. Breastfeeding ($p < 0.001$) and variety ($p < 0.001$) increased new food acceptance. Frequency of change was more effective than number of vegetables fed. The combination of breastfeeding and high variety produced greatest new food intake. Intake scores were supported by liking scores.
Maier-Noth, Schaal, Leathwood & Issanchou (2016)	Baseline: N = 72; mean age: 5 months Follow-up 1: N = 45; age 15m Follow-up 2: N = 39; age 3y; Follow-up 3: N = 31; age = 6y Countries: Germany & France	- Baseline: intake in grams +liking rating - Follow ups: questionnaires - 6 yrs.: taste test, rated liking	Breastfeeding /RE / variety	This study presents data of the follow-up of 2 intervention studies on increasing vegetable acceptance. (1) The first, consisted of offering infants a high variety of vegetables at weaning(2) The second cinsisted of offering an initially disliked vegetable at 8 subsequent meals. Follow-up data were obtained at 15m, 3y and 6y through questionnaires (15m, 3y) and experimental (6y) approaches. Measurements: intake, liking (by mother), willingness to taste	At 15m, participants who had been breast-fed were reported as eating and liking more vegetables than those who had been formula-fed. The initially disliked vegetable that became accepted after repeated exposure was still liked and eaten by 79% of the children. At 3 years, the initially disliked vegetable was still liked and eaten by 73% of the children. At 6 years, observations in an experimental setting showed that children who had been breast-fed and children who had experienced high vegetable variety at the start of weaning ate more of new vegetables and liked them more. They were also more willing to taste vegetables than formula-fed children or the no or low variety groups. The initially

					disliked vegetable was still liked by 57% of children.
Mennella, Nicklaus, Jagolino et al. (2008)	N = 74 Mean age: 6.6m (SEM: 0.3m, range: 4-9m) Country: USA	Intake in grams, mothers rated liking.	RE and variety during weaning	Study 1: *Intervention:* 2 groups. During meal at 8X home exposure. (1) RE to only pears (2) exposure to a daily variety of 3 fruits not including pear. *Measurement:* Infants' intake, liking (assessed by mothers), length and rate of feeding of pears on days 1 and 11 and green beans on days 2 and 12. Study 2: *Intervention:* 3 groups, 8 exposures at home. (1) only green beans. (2) Between-Meal variety: green and orange vegetables alternated daily. (3)Within meal Variety: two vegetables each day (one green, one orange). Pair of vegetables varied from day-to-day but one of the pair was offered the day before. *Measurement:* Infants' intake, liking (assessed by mothers), length and rate of feeding of green beans on days 1 and 11 and of alternating spoonfuls of carrots and spinach on days 2 and 12 in lab.	Study 1: In both groups pear intake increased, but not green beans intake. Study 2: Increased intake of green beans in group (1) from 15 to 24 kcal ($p < 0.08$); group (2) from 20 to 26 kcal ($p < 0.08$); group (3) from 12 to 27 kcal ($p < 0.05$). Increase in carrot-spinach intake: only in group (3): 9 to 16 kcal ($p < 0.05$)
Remy, Issanchou, Chabanet at al. (2013)	N = 95 Age: 4-8m. Country: France	Intake in grams, mothers rated liking.	RE, FFL and FNL	*Intervention:* 3 groups (random): 1. RE: 10 x basic artichoke puree; 2. FFL: 10x sweet artichoke puree; 3. FNL: 10x energy dense artichoke puree *Measurement:* intake and liking (by parent)	Pre-exposure: No association of breastfeeding duration with intake. No effect of number of vegetables eaten before starting the study on liking. Post exposure: Liking (assessed by parents) increased only in RE group (+39%; $p = 0.005$) Amount of vegetables eaten before starting the study, influenced artichoke intake at pre-exposure (+8 ± 2 g/vegetable previously eaten; $p = 0.0001$). Post exposure: Both intake of RE (+63%, $p = 0.0001$) and FFL (+39%, $p = 0.007$) groups increased, FNL group did not. Intake of RE and FFL did not differ. Learning was stable up to 3 months post exposure.
Sullivan and Birch (1994)	N = 36 Mean age: 22w (range: 17-27w) Country: USA	Intake in grams, mothers rated liking (ML).	RE; FFL by adding salt	*Intervention:*(home) 4 groups: 10 x RE once a day on consecutive days to salted peas, unsalted peas, salted green beans or unsalted green beans	After RE intake significantly increased, regardless of which vegetable was consumed and whether or not the vegetable contained added salt ($P < .001$). Increase was 28 to 63 g for salted vegetables and 36

				Measurements: Intake & liking (by mother & other adult) of salted and unsalted food on 2 separate days: (1) before the 10-days RE, (2) immediately after RE; and (3) one week after RE. Intake control food before and after RE	to 58 g for unsalted vegetables. One week after RE intake of V did not change significantly. Breastfed infants showed larger increases in vegetable consumption (39 to 72 g) than formula fed infants (25 to 46 g, *P* <0.01). Rated liking (assessed by adults) showed same effect as intake.
Zeinstra, Vrijhof & Kremer (2017)	N=250 Mean age: 25m (SD: 10m) Country: the Netherlands	Willingness to taste, intake in grams	RE; preparation method	The study investigated the effect of RE to three a priori unfamiliar vegetables, each prepared in two ways, on children's vegetable acceptance in a childcare setting. The intervention group (N = 125) participated in a 5-month exposure period, where they were exposed repeatedly (~12x) to the vegetables: pumpkin blanched and as a cracker spread; courgette blanched and as soup; white radish raw and as a cracker spread. The control group (N =- 125) maintained their normal routine. *Measurement*: Acceptance and willingness to taste. Children participated in a pre-test and a post-test, where they were offered pumpkin, courgette, and white radish.	At pre-test, children ate about 20 g of pumpkin and courgette, whereas white radish intake was approximately 10 g. There was a significant positive effect of the intervention for pumpkin (+15 g; p < 0.001) and white radish (+16 g; p = 0.01). Results for willingness to taste were in the same direction. There was no RE effect for courgette (p = 0.54).

* RE = Repeated Exposure; FFL = Flavour – Flavour learning; FNL = Flavour – Nutrient learning

1. Coulthard H, Harris G & Fogel A (2014) Exposure to vegetable variety in infants weaned at different ages. *Appetite* **78**, 1-6.

Table 6. Summaries of the included observational studies, with results on vegetable (V) and fruit (F) consumption and/ or liking

Authors (year) (ref #)	Sample	Data collection	Focus paper	Design of study	Reported findings on vegetable and fruit intake, acceptance or liking
Ahern, Caton, Bouhlal et al. (2013)	N = 234 Mean age: 21m (0.6) Countries: UK, Denmark, France	Questionnaire on early feeding practices and liking	Frequency of exposure / preparation method	*Survey:* Mothers completed a survey assessing parental and infant familiarity, frequency of offering and liking for 56 vegetables as well as preparation techniques for these vegetables.	Children aged 6-12m were offered vegetables more frequently and had a higher reported liking for these vegetables than children 25-36m. UK children's liking was related to frequency of maternal intake and frequency of offering.
Armstrong, Abraham, Squair et al. (2014)	N = 12,290 Age (range 8-10m) Country: UK	Questionnaire at age 4-6w, 4-6m and 8-10m	Breastfeeding and age of introduction to vegetables	*Survey:* Secondary data analysis was performed on the UK Infant Feeding Survey 2005.	Exclusive breastfeeding for 3m, compared to mixed or formula feeding, was positively associated with giving vegetables (AOR = 1.46; 95% CI, 1.25-1.72) at the age of 8m to 10m.
Burnier, Dubois, & Girard (2011)	N = 1,549 Age all: 4y. Data collection started at the age of 5m. Country: Canada	Interviews and questionnaires about infants feeding at the age of 5m. 24-h dietary recall of food consumption at the age of 4y.	Breastfeeding and age of introduction to vegetables	*Longitudinal*: Collection of information on children's food consumption patterns and behaviours of the infants from the age of 5m and once a year thereafter. At the age of 4y a 24-hr dietary recall. *Analysis*: Relation between exclusive breastfeeding duration and vegetable intake	Age of introduction to vegetables was not related to vegetable consumption at the age of 4y. Infants that were breastfed longer than 3m and infants with a mother that had a university degree had a higher chance to get more than 2 servings of vegetables a day ($p < 0.05$)
Coulthard, Harris, and Emmett (2009)	N = 7821 Age all: 7y olds who participated in ALSPAC study at the age of 6m and 15m. Country: UK	Questionnaire about introduction of vegetables (at age of 15m). Dietary range questionnaire (at age 7y)	Effect of age of introduction of solid foods on vegetable and fruit intake	*Longitudinal:* Groups: Children were divided into three groups based on the age at which they were first introduced to 'lumpy' solids: (1) <6m 12.1%. (2) 6-9m, 69.8% (3) ≥10m, 18.1% *Measurement:* Self-report questionnaires completed by the mother about her child at 6m, 15m, and 7y postpartum about foods eaten and feeding difficulties.	Fewer children in group (3) ate vegetables ($p = 0.001$) than children in group (2) (about 7% less children). They also ate fewer portions and fewer types of vegetables. In addition they were reported as having significantly more feeding problems at seven years More children in group 1 ate green vegetables and tomatoes ($p = 0.001$).
Coulthard, Harris, & Emmett (2010)	N = 7821 Age all: 7y Data collection started at 6m of age Country: UK	Questionnaire about introduction of vegetables (at age 6m). Dietary range questionnaire (at age 7y)	Longitudinal effects of frequency, type, and age of introduction of fruit and vegetable intake during weaning	*Longitudinal:* Mothers completed self-reported questionnaires about the introduction of vegetables during weaning at 6 months and FFQ at 7y postpartum. Relation between frequency of consumption of types of fruit and vegetables at or before the age of 6m and fruit and vegetable consumption at the age of 7y were calculated.	Frequency of consumption of home-cooked vegetables (and not ready prepared) at 6m correlated ($\beta = 0.14$; $P < 0.001$) with frequency of vegetable consumption at 7y. Age of introduction moderates frequency effect, but does not affect intake at 7y directly.

De Lauzon-Guillain, Jones, Oliveira et al. (2014)	UK N = 7269, France N = 1302, Portugal N = 800, Greece N = 556 Birth cohorts to 13y	Infant feeding questionnaire. FFQ at 2y or 4y	Breastfeeding and age of introduction to vegetables	*Longitudinal:* Associations between breastfeeding and timing of complementary feeding, and fruit and/or vegetable intake in 2-4-y-old children were tested by using logistic regressions, separately in each cohort, after adjustment for infant's age and sex and maternal age, educational level, smoking during pregnancy, and maternal fruit and vegetable intake.	Longer breastfeeding duration was consistently related to higher fruit and vegetable intake in young children. The associations with age of introduction to fruit and vegetable intake were weaker and less consistent across the cohorts. Mothers' fruit and vegetable intake (available in 3 of the cohorts) did not substantially attenuate the relation with breastfeeding duration.
Edelson, Mokdad & Martin (2016)	N = 60 Age range 1-3y. Country: USA	Video recording of two meals - Feeding style questionnaire 24-h dietary recalls	Parental feeding style/ Prompting	*Behavior observation:* Families recorded all toddler meals over one day, plus a meal in which parents introduced a novel fruit/vegetable to the child. Videos were coded for parent and child behaviors. Parents completed a feeding style questionnaire and three 24-h dietary recalls about their children's intake.	There was a trend for using another food as a reward to work less well than a neutral prompt for encouraging children to try a novel fruit or vegetable. More frequent prompts to eat fruits and vegetables during typical meals were associated with higher overall intake of these food groups. More prompts for children to try a novel vegetable was associated with higher overall vegetable intake, this pattern was not seen for fruits, suggesting that vegetable variety may be more strongly associated with intake. Children who ate the most vegetables had parents who used more "reasoning" prompts, which may have become an internalized motivation to eat these foods, but this needs to be tested explicitly using longer-term longitudinal studies
Gregory, Paxton & Brozovic (2011)	78 mothers completed questionnaires when infants were 1y and 60 of them also when they were 2y of age. Country: Australia	Questionnaire maternal feeding practices. Child FFQ	Longitudinal effects of maternal feeding practices on vegetable and fruit intake. Frequency of vegetable consumption	*Longitudinal*: A self-report questionnaire was used for mothers to record demographic and anthropometric information, as well as measures of maternal feeding practices, child food consumption, and food availability. Prospective relationships between maternal feeding practices and young children's frequency of consumption of fruits, vegetables and sweets were calculated.	Frequency of vegetable consumption at 1y of age predicted vegetable intake at 2y of age. Maternal use of pressure to eat at 1y predicted lower child frequency of fruit consumption at 2y and approached significance for lower vegetable consumption. Maternal modelling of healthy eating at 1y predicted higher child frequency of vegetable consumption at 2y. Restriction did not significantly predict child frequency of consumption of fruits, vegetables or sweets over time.
Grieger, Scott & Cobiac (2011)	N = 1071 Mean age: 2.5y (range 2-3). N=1216 Mean age: 6y (range 4-8y)	24- hr dietary recall	Influence breastfeeding on later food intake	*Cross-sectional:* Sample divided in breastfed and non-breastfed. *Measurement*: Food and nutrient intake data were collected on two occasions using a 24-h dietary recall. A computer-	A positive association was found between breast-feeding and the healthy, meat and vegetable food pattern (r = 0.267) (β = 0.23; p=0.03). No data on vegetable intake alone.

	Country: Australia			assisted personal interview (CAPI) was conducted in the child's home including questions about milk and breastfeeding history.	
Grimm, Kim, Jaroch et al. (2014)	N = 1078 Age 6y (data collection from birth). Country: USA	Dietary screener FFQ	Frequency and age of introduction to vegetables	*Longitudinal:* Analysis on fruit and vegetable intake during late infancy, age of fruit and vegetable introduction, and frequency of fruit and vegetable intake at 6y from the Infant Feeding Practices Study II and the Year 6 Follow-Up (Y6FU) Study. Analysis of 6-y-old children consuming fruits and vegetables less than once per day and associations with infant fruit and vegetable intake using logistic regression modeling, controlling for multiple covariates (n = 1078)	Based on maternal report, 19.0% of children consumed vegetables less than once daily. In adjusted analyses, children who consumed fruits and vegetables less than once daily during late infancy had increased odds of eating fruits and vegetables less than once daily at age 6y (fruit, adjusted odds ratio: 2.48; vegetables, adjusted odds ratio: 2.40). Age of introduction of fruits and vegetables was not associated with intake at age 6y.
Howard, Mallan, Byrne et al. (2012)	N = 245. Mean age 24m (± 1m). Country: Australia	Questionnaire of early feeding taken at 13m of age. Food preferences questionnaire at 23m. Question about novel food exposure	Number of novel food exposure	*Longitudinal:* Sample drawn from control group of NOURISH RCT study. Breastfeeding duration measured with characteristics questionnaire at 4, 13 and 23m of age. Child food preferences were collected at 23m of age with food preferences questionnaire. Number of repeated food exposures was assessed in a questionnaire item. The effects of repeated exposure to new foods and child food neophobia on toddlers' liking of vegetables, fruits and non-core foods and the proportion never tried were examined via hierarchical regression models.	Breastfeeding duration and number of repeated exposures to new food were not significantly associated with vegetable or other food liking at 23m of age.
Kong et al. (2016)	N=905. Age 2 and 7.7y. Country: USA	Liking & consumption rating	Frequency of exposure	*Longitudinal:* This study examined the extent to which early liking, early consumption, and maternal consumption of fruits and vegetables (F&V) are associated with F&V consumption in mid-childhood Data from 901 mother-child dyads from Project Viva, a prospective pre-birth cohort study were analysed. Mothers reported their child's early liking and consumption of F&V at age 2y and later consumption at mid-childhood (median age 7.7y). They also reported their own consumption of F&V at 6m postpartum. Frequency of consumption was measured on a scale of: "Never", "Less than once per week", "Once per week",	At 2 years, 53% of the mothers strongly agreed that their child liked fruit and 25% strongly agreed that their child liked vegetables. Children's early consumption played the most predominant role. For every 1 time/d increment in children's early consumption of F&V, mid-childhood consumption was higher by 0.25 (95% confidence interval [CI]: 0.19, 0.30) times/d for fruits and 0.21 (95% CI: 0.16, 0.26) times/d for vegetables, adjusted for confounders plus the other 2 exposures. In conclusion, children's early F&V consumption has the most significant influence on children's later consumption.

				" 2-4 times per week", "Nearly daily or daily", and "2 or more times per day". Results were adjusted for sociodemographic, pregnancy, and child confounders.	
Lange, Visalli, Jacob et al. (2013)	N = 203 Followed from 0m to 15m of age. Country: France	Weekly food diaries Acceptance score	Breastfeeding duration Age of food introduction and food variety	*Longitudinal:* Infants' milk diets were recorded in food diaries one week per month during 1st year of life. Mothers recorded each food offered to the infant from the beginning of weaning to the age of 15m. The acceptance of these foods was scored by the mother on a 4 point scale from very negative (e.g. spitting out food) to very positive (e.g. infant ate spoon immediately with relaxed face or smile).	Fruits and vegetables were the least well-accepted categories at the beginning of weaning. The earlier vegetables were introduced, the higher the acceptance of new vegetables was (p=0.04). New food acceptance was significantly correlated with the number of different foods offered in the first two months of weaning, particularly for fruits (p = 0.01) and vegetables (p < 0.0001). Exclusive breastfeeding duration did not influence new vegetable and fruit acceptance.
Mallan, Fildes, Magarey et al. (2016)	N = 340 Mean Age baseline: 4.3m (± 1), Follow-up at 14m and 3.7y. Country: Australia	Liking (6-point scale) and intake questionnaire (# of foods tried)	Variety	*Longitudinal:* This study reports secondary analyses of longitudinal data of the NOURISH randomized controlled trial. The study examined whether exposure to a greater number of fruits, vegetables, and noncore foods at age 14m was related to children's preference for and intake of these foods at age 3.7y. Exposure was quantified as the number of food items tried by a child from specified lists at age 14m. At age 3.7y, food preferences and intake patterns were assessed.	Having tried a greater number of vegetables at age 14m was associated with liking a greater number of vegetables (β = 0.15; P = 0.001) and a higher fruit and vegetable intake score (β = 0.12, P = 0.054) (F&V were not measures separately) at age 3.7y. Having tried a greater number of fruits at age 14m was associated with liking of fruits, but not of vegetables. Adjusting for fussiness at age 14m, having tried more vegetables at age 14m was associated with lower fussiness at age 3.7y. Breastfeeding duration is positively associated with vegetable preferences (not intake), but not with fruit or noncore food preferences and intake.
Möller, de Hoog, van Eijsden et al. (2013)	N = 2253 Age: ~5y Country: the Netherlands	Children's Eating Behaviour Questionnaire / FFQ	Exclusive breastfeeding / breastfeeding duration / age at introduction to solid foods	*Longitudinal:* Associations of exclusive breastfeeding duration and age at introduction of solid foods with children's eating behaviour and fruit and vegetable intake at age 5y, were investigated. Data were derived from the Amsterdam Born Children and their Development study, a prospective birth cohort. During infancy, data on infant nutrition were collected. At age 5y child eating behaviour was assessed and fruit and vegetable intake was calculated from a validated child FFQ.	Children who were exclusively breast-fed for >6m had a higher vegetable intake at 5y than children who were not exclusively breast fed or breast fed for 1-1.9m. No such association with fruit intake was found. Introducing solid foods before the age of 4m was associated with a higher fruit intake compared with introduction at 6m. No such association with vegetable intake was found.

Okubo, Miyake, Sasaki et al. (2016)	N = 763 Country: Japan	Estimated daily intake / child: early life feeding practices questionnaires / FFQ	Breastfeeding duration / age at introduction to solid foods	*Longitudinal - prospective:* The association of breast-feeding duration and age at introduction of solid foods with later intake of fruit and vegetables among Japanese toddlers was examined. Information on breast-feeding duration, age at introduction of solid foods and children's intake frequency of fruit and vegetables were collected with a self-administered questionnaire at 16–24m postpartum. Logistic regression analysis was used to calculate odds ratios of low intake (<1 time/d) of fruit or vegetables for each infant feeding practice.	Neither breast-feeding duration nor age at introduction of solid foods was associated with fruit intake at 16–24m of age. Breast-feeding duration, but not age at introduction of solid foods, was associated with later intake of vegetables. When breast-feeding duration was categorized into two groups with the cut-off at 6m, children who were breast-fed for ≥6m had a significantly decreased risk of low intake of vegetables (OR=0·53; 95 % CI 0·34, 0·84) than those breast-fed for <6m. Higher maternal education and fruit and vegetable intake during pregnancy were directly associated with a reduced risk of low vegetable intake by children at 16-24m of age.
Perrine, Galuska, Thompson et al. (2014)	N = 1355 Age = 6y Country: USA	Monthly questionnaires on Food frequency and breastfeeding during 1st year of life / Dietary history screener at 6 year follow-up (Y6FU)	Breastfeeding duration / age at introduction to solid foods	*Longitudinal:* Data from the Infant Feeding Practices Study II and Y6FU were linked. Approximately monthly questionnaires throughout infancy were used to calculate any and exclusive breastfeeding duration (n = 1355). Median daily frequency of intake of vegetables and other foods at 6y were calculated from a dietary screener and frequency of consumption of each food or beverage group was examined by any and exclusive breastfeeding duration. Separate multivariable logistic regression models were used to calculate odds of consuming more than the median daily frequency of intake of food or beverage items, adjusting for confounders.	Median frequencies of consumption of water, fruits and vegetables was higher among children with longer breastfeeding durations ($P < 0.05$), while intake of 100% juice and sugar-sweetened beverages was lower. Intake of milk, sweets, and savoury snacks at 6y was not associated with any or exclusive breastfeeding duration in unadjusted analyses. Frequency of consumption of water, fruits, and vegetables was positively associated, and intake of sugar-sweetened beverages was inversely associated with any and exclusive breastfeeding duration in adjusted models.
Soldateli, Vigo & Justo Giugliani (2016)	N = 323 Age: 4-7y. Brazil	Interview on breastfeeding every 2 months during 1st year. FFQ at age 4 to 7y	Breastfeeding duration	*Longitudinal:* This study investigated the association between pattern and duration of breastfeeding and consumption of fruits and vegetables in children aged between 4 and 7y. A secondary analysis was conducted, using data from a former randomized clinical trial with 323 adolescent mothers, their children, and maternal grandmothers, when they cohabited. Information on infant feeding was collected monthly during the first 6m of life, every two months until the child was 1y old over and when children were	Approximately 60% and 45% of children consumed fruits and vegetables, respectively, five or more times a week. Consumption of vegetables among 4-7-y-old children was higher in children who were breastfed for 12m or longer (OR 2.7; 95%CI 1.49–4.93); exclusive breastfeeding duration did not have a significant association with consumption of vegetables (OR 1.5; 95%CI 0.70–3.04). There was no association between weekly consumption of fruits and duration of breastfeeding (OR 1.3; 95%CI 0.71–2.30) or exclusive breastfeeding

				between 4 and 7y old. The associations between duration of breastfeeding and exclusive breastfeeding and consumption of fruits and vegetables were tested by a logistic regression model.	(OR 0.7; 95%CI 0.34–1.44).
Townsend & Pitchford (2012)	155 children aged 20-78m Country: UK	Food preference questionnaire	Weaning style Exposure	*Case control observations via questionnaire* *Design:* 2 groups based on information from questionnaire: (1) baby-led weaning (2) spoon-fed weaning. *Measurement:* Questionnaires on child's preference for 151 foods and exposure (frequency of consumption). Food preference and exposure data were analysed using a case controlled matched sample to account for the effect of age on food preference. Weaning style was investigated with the whole sample	In the BLW group liking of carbohydrates was higher, there were no significant differences in liking for the other food groups Exposure to vegetables, fruit, carbohydrates, protein, meals and sweets was higher in the spoon-fed group, compared to the baby led group. Exposure to vegetables was significantly associated with liking vegetables ($r_s = 0.47$, $p<0.0001$). No such associations were found for carbohydrates, sweet foods, fruits, and meals.
Yuan, Rigal, Monnery-Patris (2016)	N = 1142 Age all: 5y Data collection started at birth Country: France	Infant feeding questionnaire at 4,6 and 12m. Parental feeding practices at 2y. FFQ at 3y Food liking test at 5y	Breastfeeding and age of introduction to vegetables. Parental feeding practices	*Longitudinal:* 5y- old children completed a liking test for "fruit and vegetables", "meat, fish and eggs", "desserts and cheese". Data related to maternal food intake before pregnancy, infant feeding during the first year of life, maternal feeding practices at 2y, child's food intake at 3y, and child's food neophobia from 1 to 4y were collected prospectively from the mother. The associations between these factors and child's liking for each category of foods were analyzed	Children's fruit and vegetable intake at 3y was positively associated with maternal fruit and vegetable intake, long breast feeding and later introduction of various foods. Children's food and vegetable liking at 5y was associated with their intake of fruit and vegetable at 3y.

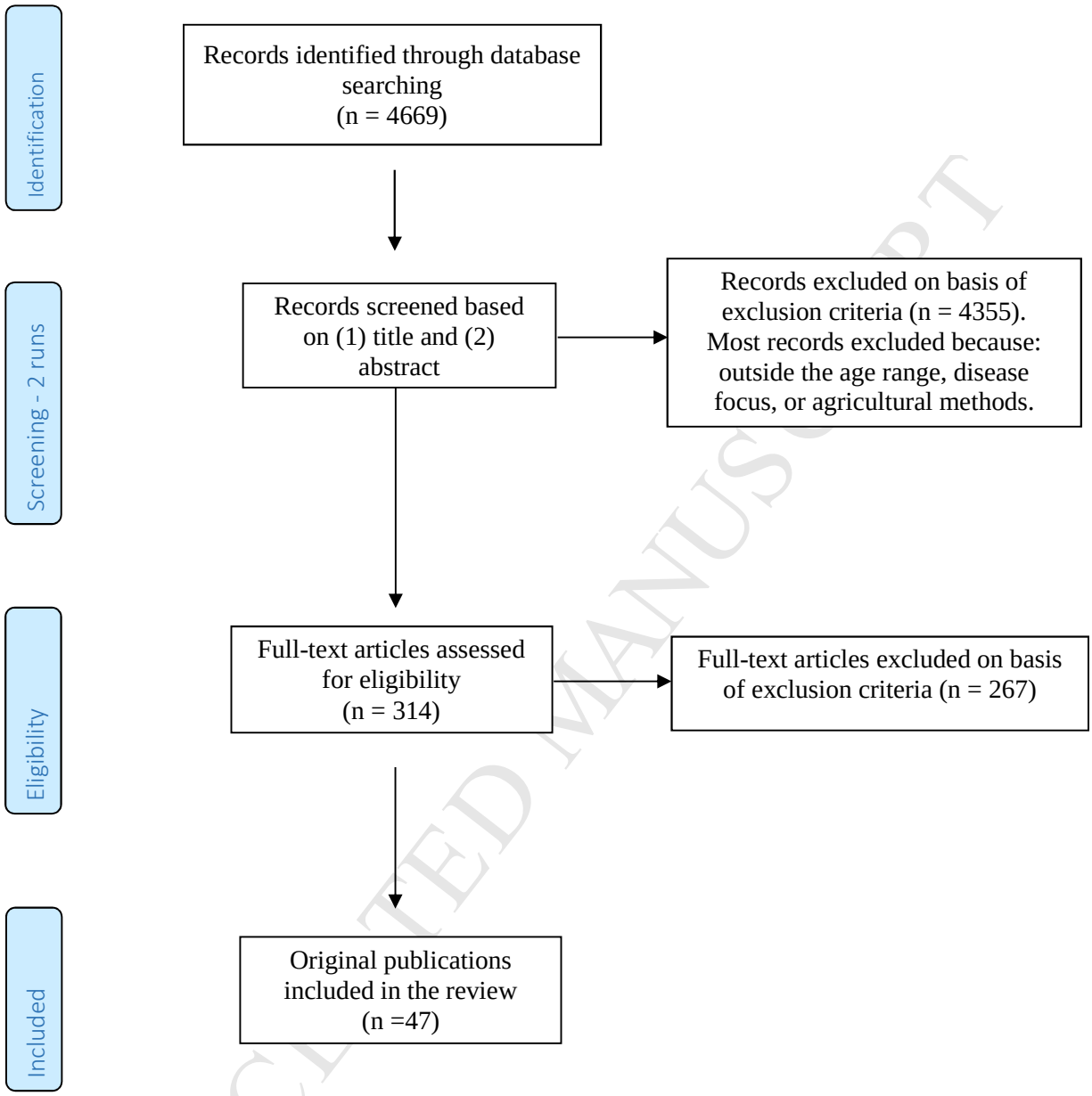

Figure 1. Flow Diagram for literature search