

Review Article

Relationship between the home environment and fruit and vegetable consumption in children aged 6–12 years: a systematic review

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Submitted 6 October 2015: Final revision received 15 September 2016: Accepted 26 September 2016: First published online 21 November 2016

Abstract

Objective: As numerous factors in the home environment have been related to children's fruit and vegetable (F&V) consumption as a component of a healthy diet, the purpose of the present systematic review was to examine these factors specifically for children aged 6–12 years.

Design: Relevant observational studies published in English between January 2007 and December 2015 were obtained through electronic database searches. Studies were included if the researchers reported on a potentially modifiable measure of the home physical, political and sociocultural environment related to child F&V consumption.

Results: Of the thirty-three articles reviewed, overall methodological quality was poor with twenty studies rated as weak, mainly due to cross-sectional design (majority of studies), selection bias, convenience sampling and voluntary participation. Half of the studies had strong–moderate ratings for using valid and/or reliable tools while for the other half, psychometric properties were either not reported or weak. The most consistent evidence for children's combined F&V consumption was found for availability and accessibility of F&V, parental role modelling of F&V and maternal intake of F&V.

Conclusions: A vast array of home environment components and their influence on children's consumption of fruits and/or vegetables have been studied in recent years. Specific components of the home environment may have more influence than others, but more compelling evidence is needed to draw strong conclusions. Recommendations are made for future studies to be based upon conceptual/theoretical models to provide consistency in defining the home environment and investigation of potential moderators, such as personal or contextual factors.

Keywords
Home environment
Food availability
Role modelling

A diet high in fruits and vegetables (F&V) is essential for good health and to prevent chronic disease. However, a high proportion of children from Western countries do not meet recommendations for F&V intake^(1–4). F&V consumption is a key behaviour to target during childhood because dietary behaviours track from childhood into adolescence and adulthood^(5–7) and food habits in children are still flexible to change⁽⁸⁾. Interventions targeting F&V intake have had limited impact^(9–11). One possible explanation is that some key influencing factors are not addressed in these interventions⁽¹²⁾.

Using the social ecological theory, children's home environment is a key setting in supporting or inhibiting

healthy eating, as it represents the immediate environment in which the child lives, grows and plays⁽⁵⁾. Parents determine the home environment. Systematic reviews summarising the literature have concluded that components of the home environment, such as availability and accessibility of F&V, parental role modelling and parental intake of F&V, are related to children's F&V consumption^(13–16). Factors influencing children's dietary behaviours vary according to age. In early childhood it is acknowledged that children are most dependent on their parents and dietary intake is largely influenced by their home environment⁽⁷⁾. However, it is unclear how the home environment influences F&V consumption in children aged 6–12 years, especially as

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they enter primary school, gain more independence and competing influences like the media, peers and the school environment come into play. An increasing number of studies have been published on this topic in recent years^(13–17); however, many of these have included a wide age range (4–18 years old), have not differentiated between children and adolescents and have examined only F&V in combination. Combined analyses of F&V may mask the fact that eating fruits may have different correlates compared with eating vegetables.

Therefore, the current review aimed to explore the components of the home environment that have been studied in relation to children's F&V consumption, and to examine and add to the existing literature updated to 2015 regarding this relationship, focusing specifically on primary-school children aged 6–12 years.

Methods

The present review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

systematic procedures⁽¹⁸⁾. The aim was to locate studies which focused on the association between the broad home environment and F&V intake in children aged 6–12 years. The searches were conducted in the following databases: Medline, PubMed, CINAHL, Scopus, Web of Science and the Cochrane Library. The search terms were broad and included truncations and synonyms for 'diet', 'fruit', 'vegetable', 'food habits' and 'eating behavior', which were combined with the Boolean operator 'OR' and 'home environment', OR 'parent', 'family'. These two search strategies were then combined with the Boolean operator 'AND'. Both keywords and Medical Subject Headings (MeSH) were used. The searches were limited to English language, child (6–12 years) and publication date of January 2007 to December 2015 where these functions were available in the databases. January 2007 was selected to capture studies after the systematic reviews in this area. The full search strategy is available from the authors on request. Only observational studies were included as the aim was to examine associations and in a non-controlled setting. As depicted in Fig. 1, studies were screened and selected according to the inclusion and exclusion criteria

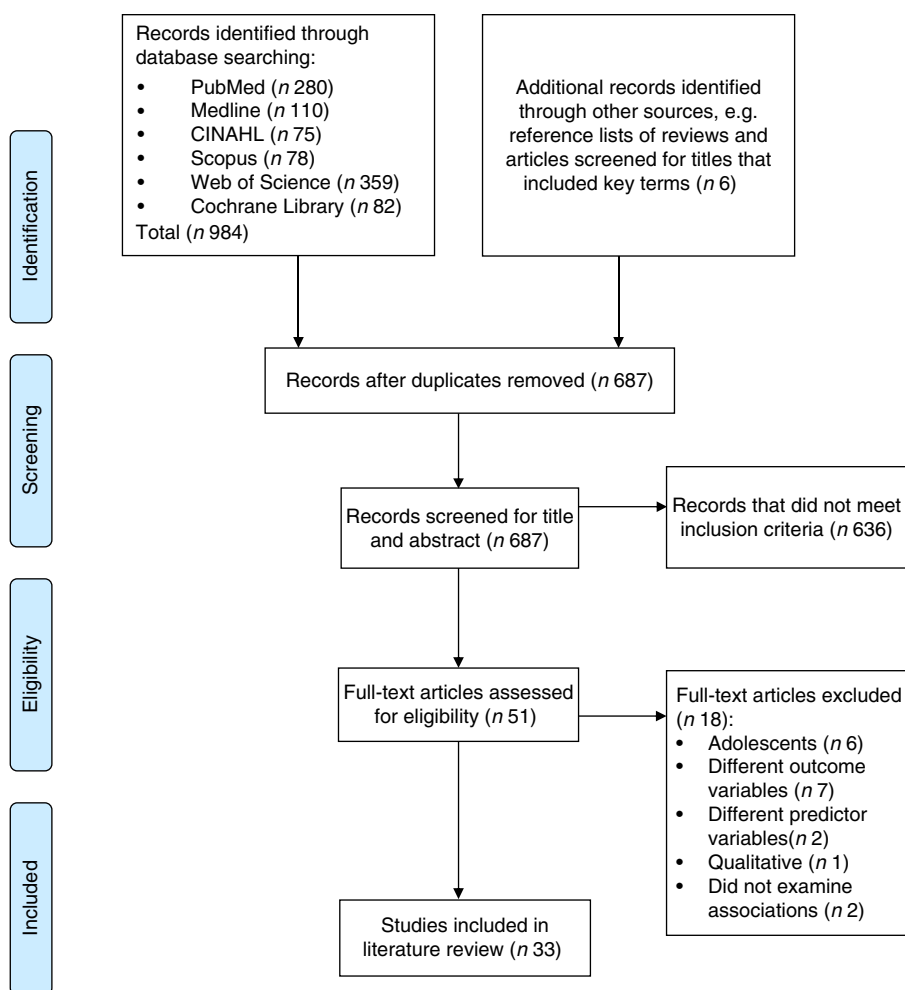


Fig. 1 (colour online) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram showing selection of studies for the present review

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Healthy children • Age within the range 6–12 years, as most studies included a wider age range • Investigating modifiable home physical, political and sociocultural environment as predictor variables • Reported fruits and/or vegetables consumption as outcome variables • Published from 2007 to 2015 • Full-article publications in English, peer-reviewed journals and based on research in human subjects • Observational studies 	<ul style="list-style-type: none"> • Papers only describing prevalence, thus without analytical approach • Studies on adults, homeless youth, pregnant women, acutely ill or institutionalised individuals, eating disorders or other medical conditions • Papers with methodological aims, such as validation papers • Studies investigating the home economic environment or demographics as predictors as they cannot be easily influenced through interventions and are non-modifiable • Qualitative studies, abstracts, case reports, expert opinions, dissertations and unpublished data • Experimental/intervention studies

(Table 1). Due to the wide range of possible home environment components obtained from the studies in the review, conceptually similar components were combined under a general category (Table 2). Search and selection of studies were completed independently by two authors using the stated criteria and uncertainties regarding the inclusion or exclusion of studies were discussed with other authors until a consensus was reached.

Data extraction and quality appraisal

Data extracted from studies were: study design, participant characteristics, sample size, recruitment method, measures of predictor and outcome variables, and psychometric properties of measures. Reliability and validity of the tools used for predictor and outcome measures of ≥ 0.70 was considered acceptable. These are shown in Table 2. All identified components of the home environment were extracted and, using the Analysis Grid for Elements Linked to Obesity (ANGELO) framework⁽⁵⁾, classified into three categories, namely home physical, political and socio-cultural environment. The home economic environment (e.g. socio-economic status) and demographic factors were excluded as the review was interested only in modifiable components of the home environment.

The Quality Assessment Tool for Quantitative Studies (QATQS) developed by the Effective Public Health Practice Project⁽¹⁹⁾, which is suitable and has been validated for use in observational or experimental studies, was used to assess the methodological quality of the studies across five domains (selection bias, study design, confounders,

blinding, data collection methods, and withdrawals and dropouts)⁽²⁰⁾. All identified studies were assessed by a two reviewers and given an overall rating of weak, moderate or strong. The QATQS served to provide insight to limitations within studies and was taken into consideration in combination with findings from the studies.

Summarising associations

Significant ($P < 0.05$) and non-significant associations between the home environment and children's F&V consumption are summarised in Table 3. Findings from analyses which separated boys and girls, and fruits and vegetables, and baseline and follow-up results from longitudinal studies were summarised separately as individual relationships⁽²¹⁾, as they are likely to have different correlates⁽¹⁴⁾. Only multivariate results were included, as significant associations from univariate analyses were generally more abundant and would likely inflate overall findings.

The total number of relationships analysed for each home environment component was determined and the percentage of significant relationships used to determine consistency, which was defined as: no association (0–33%), indeterminate/inconsistent (34–59%) and positive/negative association (60–100%; see Table 3). These methods were based on those that have been used previously^(22,23).

Results

General characteristics of studies reviewed

Within the thirty-three studies in the present review, 205 independent relationships were identified (Table 3). Studies are categorised according to their general characteristics in Table 2. All but two studies were cross-sectional, with follow-up periods between 9 and 36 months in the two longitudinal studies^(24,25). Most studies were conducted in the USA^(26–34) and European countries^(24,35–44). Sample size ranged from fifty⁽⁴⁵⁾ to 13 305⁽³⁷⁾, and six studies had fewer than 100 subjects^(30,34,45–48). Measures of the home environment and F&V consumption varied. Twenty-four studies used scales from existing tools to measure home environment components, while the rest developed new questionnaires^(24,25,28,32,37,39,49,50,56). From the thirty-three studies, fifteen measured F&V in combination, nineteen measured fruit consumption and seventeen measured vegetable consumption, and definitions differed (Table 2). Five studies reported results for boys and girls separately^(25,31,37,45,50). Five studies used only child-reported data, seventeen used only parent reports and eleven used a combination (Table 2). Twenty-three studies adjusted for potential confounders, while in the other ten studies^(26,29–32,41,45,47,51,56), confounding was not reported. Covariates were varied and most commonly included child's age, gender, ethnicity, socio-economic status and BMI. Twenty-three studies used regression^(24,25,27,31–41,43,44,46,49–52,56,77) and eleven used

Table 2 Summary of studies identified in the present review

Study	Participants	Recruitment	Response rate	Predictor variables and measures	Outcome and measures	Study quality ⁽¹⁹⁾
Cross-sectional studies						
Amuta <i>et al.</i> (2015) ⁽⁶³⁾ USA	Grades K5/6 and parents Mean (range) age: NA <i>n</i> 298	Student Wellness Assessment and Advocacy Project Predominantly Hispanic/Latino and African American/Black respondents from low-income families in rural areas	Parents: 41.2%	Parent report Physical: F&V availability at home Political: dinnertime rules; dinner preparation rules; dinner consumption rules Sociocultural: eating with child Tool: Texas Food and Nutrition Questionnaire	Parent report Child's F&V intake at evening meals (freq/week) Tool: Texas Food and Nutrition Questionnaire	Weak
Attorp <i>et al.</i> (2014) ⁽²⁶⁾ Canada	10–12 years and parents Mean (range) age: 11.3 (10.3–12.5) years <i>n</i> 597	Baseline data: SFVNP Volunteers	Schools: 22–30% Students: 51% Parents: 49%	Parent report Sociocultural: family dining behaviours; parents' perception of child's eating habits; parental concerns about healthy eating and PA Tool: REAL KIDS parent survey, Harvard Food Frequency Youth Adolescent Questionnaire	Child report F&V intake previous weekday (incl. potatoes, French fries, juice) Tool: web-based 24 h dietary food recall (validated)	Weak
Brown <i>et al.</i> (2008) ⁽³⁵⁾ England	4–7 years and parents Mean (sd) age: 6 (0.8) years <i>n</i> 518	Eighteen primary schools	Parents: 28%	Parent report Sociocultural: overt control ($\alpha=0.68$ – 0.76); covert control ($\alpha=0.77$ – 0.80); pressure to eat ($\alpha=0.79$) Tool: CFQ	Parent report Mean fruit and vegetable (portions/d) Tool: FFQ (validity and reliability NR)	Weak
Christian <i>et al.</i> (2013) ⁽³⁶⁾ England	4–8 years Mean (95% CI) age: 8.3 (8.2, 8.3) years <i>n</i> 2383	Fifty-two primary schools from two RCT Cluster randomisation at school level	Schools: 92% Parents: 59%	Parent report Physical: availability of F&V at home Political: allowing child to eat as much F&V as they like Sociocultural: eating together at family table; cutting up F&V for child; eating F&V with child; parental role modelling; buying F&V because child asks for it; asking child to eat F&V Tool: Modified version of CADET (home food diary; reliability and validity unknown)	Parent report Total fruit and vegetable intake (g) Tool: modified version of CADET (24 h food tick list)	Moderate
Couch <i>et al.</i> (2014) ⁽²⁷⁾ USA	6–11 years and parents Mean (sd) age: 9.1 (1.5) years <i>n</i> 699 (child–parent pairs)	NIK cohort study Four neighbourhood types Predominantly non-Hispanic White, 26.6% of children OW/OB, 41.9% of parents OW/OB	Parents: 14%	Parent report Physical: home availability of low-energy, nutrient-dense ($\alpha=0.52$) & high-energy, nutrient-poor foods ($\alpha=0.76$) Political: family food rules ($\alpha=0.60$); restrictive feeding strategies ($\alpha=0.78$) Sociocultural: parental encouragement/modelling ($\alpha=0.77$); pressure to eat ($\alpha=0.76$); permissive feeding practices ($\alpha=0.55$); frequency of eating out; perception of food costs ($\alpha=0.64$) Tool: AWPCS, CFQ, PCQ, FEAHQ, YAFFQ	Child report Average F&V intake (freq/d; incl. 100% FJ, VJ, excl. fried F&V) Tool: three 24 h recalls (two weekdays, one weekend day)	Moderate

Table 2 Continued

Study	Participants	Recruitment	Response rate	Predictor variables and measures	Outcome and measures	Study quality ⁽¹⁹⁾
De Bourdeaudhuij <i>et al.</i> (2008) ⁽³⁷⁾ Europe	11 years Mean (SD) age: 11.4 (0.5) years <i>n</i> 13 305 (children)	Pro Children project Twenty randomly selected schools (sampling unit)	Children: 90.4 % Parents: 76.1 %	Child report Physical: availability of F&V at home Political: family rules: demands and allowances Sociocultural: role modelling (by mother or father); active parental encouragement; parental facilitation (cutting up F&V); bringing F&V to school Tool: PCQ ($\alpha = 0.59-0.89$; good to very good test-retest reliability, most ICC >0.60; moderate-good predictive validity, Spearman $r = 0.05-0.38$)	Child report Usual F&V intake Tool: FFQ (good test-retest reliability, Spearman $r = 0.45-0.77$; adequate validity, Spearman $r = 0.38-0.53$)	Moderate
de Jong <i>et al.</i> (2015) ⁽⁵⁶⁾ Netherlands	4-13 years and parents Mean (range) age: 8.1 (5.8-10.4) years <i>n</i> 3859	CheckKid Study	Schools: 80 % Parents: 65 %	Parent report Physical: F&V availability at home Political: dinnertime rules; dinner consumption rules Sociocultural: eating at table; cooking dinner together; doing groceries together Dichotomised Tool: questionnaire (validity and reliability NR)	Child report Frequency of eating vegetables at dinner (freq/week) Dichotomized into consuming vegetables 7 d/week and <7 d/week Tool: FFQ (validity and reliability NR)	Weak
Ding <i>et al.</i> (2012) ⁽²⁸⁾ USA	5-11 years and parents Mean (SD) age: 8.3 (1.9) years <i>n</i> 116 (child-parent pairs)	Randomly selected by phone, mail Diverse neighbourhoods and low-income students with diverse backgrounds	Parents: 47 %	Parent report Physical: availability of F&V at home (test-retest ICC = 0.70; internal consistency $\alpha = 0.67$) Tool: questionnaire developed for study (items adapted from FFE; validity unknown)	Parent report No. of servings of F&V child ate in a typical day Questionnaire (ICC = 0.78, $\alpha = 0.58$, reliable and valid)	Moderate
Draxten <i>et al.</i> (2014) ⁽²⁹⁾ USA	8-12 years and parents Mean (SD) age: 10.4 (1.4) years <i>n</i> 160 (child-parent dyads)	HOME Plus study (RCT) Through events, flyers and recreation centres	NR	Child and parent report Sociocultural: parental role modelling of F&V: at snacks; at dinner; salad consumption; filling ½ plate with F&V Tool: Parent and child questionnaire (validated, parent $\alpha = 0.66$, child $\alpha = 0.84$)	Child report No. of servings of F&V consumed for: total day; at snacks; at dinner; meeting F&V guidelines (excl. fried veg, incl. 100% FJ or VJ) Tool: three 24 h dietary recalls (two weekdays, one weekend day; valid)	Weak
Gross <i>et al.</i> (2010) ⁽³⁰⁾ USA	Fourth- and fifth-graders and parents Mean (SD) age: 9.6 (0.6) years <i>n</i> 93 (parent-child pairs)	Baseline: nine classrooms from one public school	Students: 63 %	Parent report Physical: home availability of F&V Sociocultural: home engagement; parental role modelling; parental support; parent's F&V intake; F&V served at home Student report Sociocultural: perceived parental support for eating F&V Tool: Modified shelf inventory from TEENS Study, HBQ (reliability and validity NR)	Student report Average daily F&V consumption (excluding fruit juice) Tool: CATCH FFQ (valid and reliable)	Weak

Table 2 Continued

Study	Participants	Recruitment	Response rate	Predictor variables and measures	Outcome and measures	Study quality ⁽¹⁹⁾
Hall <i>et al.</i> (2011) ⁽⁴⁵⁾ Australia	5–12 years and overweight fathers Mean (sd) age: 8.5 (3.0) years <i>n</i> 50 (father–child dyads)	Baseline: Healthy Dads, Healthy Kids RCT Local community through media, newsletters and ads Predominantly White, OW	NR	Father report Sociocultural: father's dietary intake (g/d, servings/d) Tool: DQES v2 (FFQ; validated)	Mother report Child's F&V intake Tool: ACAES (FFQ; validated in children) Note: two different FFQ for father and mother Parent report Average F&V intake (excl. potatoes and fruit juice; servings/d) Tool: two 24 h recalls	Weak
Hendrie <i>et al.</i> (2012) ⁽⁵¹⁾ Australia	5–10 years and parents <i>n</i> 157 (families)	Ten schools randomly selected from each of four SEIFA quartiles	Families: 5%	Parent report Sociocultural: parent's knowledge (validated; moderate internal reliability, Kuder–Richardson = 0.59); parent's diet quality; parenting style ($\alpha = 0.74–0.86$); child feeding practices (Cronbach's $\alpha = 0.65–0.88$) Composite measure: family food environment: usual food availability, perception of adequacy of child's diet, parental modelling of eating behaviour, food related behaviour, views of meal preparation, meal preparation practices, TV interruption, general involvement in food Tool: GNKQ, GPPQ, CFQ, FFE, FIS	Parent report F&V intake (cups/d per 1000 kcal) Tool: BKFS (valid)	Weak
Jackson <i>et al.</i> (2015) ⁽⁴⁸⁾ USA	Grades K5–6 and parents Mean (range) age: 8.4 (6.4–10.4) years <i>n</i> 95	GROW Healthy Kids and Communities Six rural communities	Parents: 12%	Parent report Political: food as reward; restriction of EDNP foods Sociocultural: eating family meals together Tool: Family Nutrition and Physical Activity screening tool (valid and reliable; internal consistency $\alpha = 0.72$)	Parent or caregiver report Child's F&V intake the previous day (excl. potatoes, juice; g/d) Three 1 d diaries (two weekdays, one weekend day) Data collected when child was 7 years old	Weak
Jones <i>et al.</i> (2010) ⁽³⁸⁾ UK	7 years (<i>n</i> 7285) and mothers (<i>n</i> 6086)	Pregnant women from ALSPAC (cohort study) More mothers from higher income groups	Mothers: 42%	Parent or caregiver report Sociocultural: mother's F&V intake (completed when child 47 months old) Political: rules on food provision at home (asked when child 65 months old) Tool: FFQ	Parent report; F&V intake (cups/d per 1000 kcal, excl. potatoes and juice) Dichotomized into meeting guidelines or not Tool: single, multi-pass, 24 h recall	Weak
Kunin-Batson <i>et al.</i> (2015) ⁽⁷⁷⁾ USA	5–10 years and parents Mean (range) age: 6.6 (4.9–8.3) years <i>n</i> 421	Healthy Homes/Healthy Kids Study	NA	Parent report Physical: availability of F&V Tool: FFQ	Parent report F&V intake (cups/d per 1000 kcal, excl. potatoes and juice) Dichotomized into meeting guidelines or not Tool: single, multi-pass, 24 h recall	Weak
Li <i>et al.</i> (2014) ⁽⁴⁹⁾ China	8–10 years and parents <i>n</i> 497 (child–parent dyads)	Four socio-economically distinct primary schools in two urban cities, three classes/school randomly selected	Parents: 91.7%	Parent report Sociocultural: family eating habits Tool: questionnaire developed for study (elements from previously validated tool, translated to Chinese; validity and reliability NR)	Parent report F&V intake the previous week (d/week) Tool: HBSC (FFQ; validated in school-aged children)	Moderate

Table 2 Continued

Study	Participants	Recruitment	Response rate	Predictor variables and measures	Outcome and measures	Study quality ⁽¹⁹⁾
Marshall <i>et al.</i> (2011) ⁽⁴⁶⁾ Australia	4–13 years and caregivers Mean (sd) age: 7.6 (2.9) years n 93 (parent–child dyads)	Participants from RCT selected based on dairy intake criteria for study	NR	Parent report Sociocultural: mealtime opportunities for learning, tracking and talking about food; shaping, guidance and rewards; shaping, parental responsibility for child feeding; shaping, concern about poor intake Tool: NKQ, CFQ, FFE, FPQ (valid and reliable tools)	Parent report (<10 years) Child report (>10 years) Fruit and vegetables intake (incl. 100% FJ, potatoes; g/d) Tool: three 24 h diet recalls	Weak
Mushi-Brunt <i>et al.</i> (2007) ⁽³¹⁾ USA	6–12 years Mean (sd) age: 8.6 (1.7) years n 555 (parent–child dyads)	PARADE study Children with academic, behavioural problems, minority status. Predominantly African American, low-income, OW	NR	Parent report Sociocultural: grocery spending perceptions and behaviours Tool: PARADE parent questionnaire	Parent report Child's F&V intake (excl. potatoes and FJ; freq/week) Tool: FFQ (internal consistency $\alpha=0.75$)	Weak
Pearson <i>et al.</i> (2009) ⁽⁵⁰⁾ Australia	10–12 years and parents Mean (sd) age: 11.2 (0.6) years n 775 (parent–child pairs)	Health, Eating and Play Study Seventeen state/Catholic primary schools randomly selected from SES-distinct areas	Children: 46%	Parent report Sociocultural: parental modelling of healthy eating behaviours; parental support for healthy eating behaviours (transport and financial) Tool: questionnaire developed for study (reliability and validity NR)	Parent report Child's F&V intake (times/d) Tool: Australian NNS (tested in parents; ICC = 0.44–0.96)	Weak
Perez-Lizaur <i>et al.</i> (2008) ⁽³²⁾ Mexico	7–9 years Mean (range) age: 8.8 (7–10) years n 327 (parent–child pairs)	Two socio-economically deprived state schools Low-income, urban population, >50% of boys and girls OW/OB	NR	Child report Physical: accessibility Sociocultural: person in charge of cooking at home Tool: questionnaire developed for study (validated, Cronbach's $\alpha=0.84$, adapted for sample population)	Child report Child's F&V intake (excl. potatoes, FJ; no. of times/d) Tool: 2 d 24 h recall (including weekend day; validated, Cronbach's $\alpha=0.84$)	Weak
Raynor <i>et al.</i> (2011) ⁽³³⁾ USA	4–9 years Mean (sd) age: 7.2 (1.6) years OW or OB children and parents n 135 (parent–child pairs)	Through media and referrals Two 6-month family-based childhood weight-control trials Randomised after baseline Ax Predominantly White, OW/OB	NR	Parent report Sociocultural: hedonic ratings of foods; parent's dietary intake Tool: questionnaire (validated; reliability and validity NR)	Child report Child's F&V intake (excl. juice, fried potatoes; servings/d) Tool: 3 d food records (two weekdays, one weekend day)	Weak
Reinaerts <i>et al.</i> (2007) ⁽³⁹⁾ Netherlands	4–12 years and parents Mean (sd) age: 8 (2.5) years n 1739 (parent–child pairs)	Convenience sampling Parents of children from forty-nine primary schools participating in longitudinal study	Parents: 69%	Parent report Physical: availability of F&V at home ($\alpha=0.54$ – 0.68); accessibility of F&V Sociocultural: parental F&V consumption (validated); parental role modelling ($\alpha < 0.48$) Tool: questionnaire developed (limited info on validity, reliability of items/scales used; PCA to determine factors for each construct)	Parent report Child's average daily F&V intake (g/d) Tool: PCQ (FFQ; validated in children)	Weak
Robinson <i>et al.</i> (2014) ⁽⁴⁷⁾ Australia	8–12 years and parents Mean (sd) age: 10.6 (1.09) years n 66 (families)	Family Diet Quality Study (validation study) Self-selected High education and SES background	NR	Parent report Sociocultural: parental F&V intake Tool: ACAES (FFQ; validated in adults, reliable)	Child report Child's F&V intake (d/week) Tool: ACAES (FFQ; validated in children, reliable)	Weak

Table 2 Continued

Study	Participants	Recruitment	Response rate	Predictor variables and measures	Outcome and measures	Study quality ⁽¹⁹⁾
Robinson-O'Brien <i>et al.</i> (2009) ⁽³⁴⁾ USA	9–11 years and parents Mean (SD) age: 10.1 (1.1) years <i>n</i> 73 (parent–child pairs)	RSA programme Convenience sampling: four urban schools Ethnically diverse, primarily low-income, African American, qualify for free or reduced-price school lunch	Students: 68 %	Parent and child report Physical: home availability of F&V (child: Cronbach's α = 0.6; parent: 0.61); home accessibility of F&V (child: Cronbach's α = 0.72; parent: 0.78) Sociocultural: parental encouragement to eat F&V (Cronbach's α = 0.83); family meal frequency Tool: RSA child and parent survey (adapted from existing instruments)	Parent and child report No. of servings of fruits and vegetables/d Tool: RSA child and parent survey	Weak
Rodenburg <i>et al.</i> (2013) ⁽⁴⁰⁾ Netherlands	8–11 years and parents Mean (SD) age: 8.2 (0.5) years <i>n</i> 1480 (parent–child dyads)	Baseline and 2nd assessment (1 year) from parent–child dyads in Dutch INPACT study	Caregivers: 62.4 % Follow-up: 80 %	Caregiver report; five clusters of parenting practices Physical: high visibility and accessibility of screens and unhealthy food; low availability of unhealthy food Sociocultural: diet- and activity-related positive modelling; positive modelling on sports and fruit Political: diet- and activity-related rules Tool: HES (validated; Cronbach's α = 0.48–0.72)	Caregiver report Child's fruit intake (excl. juice; d/week) Tool: FFQ (validated; correlation coefficient = 0.62 with DLW)	Moderate
van Ansem <i>et al.</i> (2013) ⁽⁴¹⁾ Netherlands	8–12 years and primary caregivers Mean age: 10.2 years <i>n</i> 1501 (parent–child pairs)	3rd wave (2 years from baseline) of INPACT study	Schools: 34 % Caregivers: 81.4 %	Caregiver report Physical: home availability of F&V Tool: HES (validated)	Caregiver report % of children not meeting F&V guidelines Tool: FFQ (validated)	Moderate
Van Strien <i>et al.</i> (2009) ⁽⁴²⁾ Netherlands	7–12 years Mean (SD) age: 9.5 (1.5) years <i>n</i> 943 (children)	Six primary schools	NR	Child report Political: maternal control of food intake Tool: modified CFQ (KCFQ; validity and reliability unknown)	Child report Freq of fruit consumption (/week) Tool: FFQ (validated)	Weak
Wind <i>et al.</i> (2010) ⁽⁴³⁾ Europe	11 years Mean (SD) age: 11.4 (0.48) years <i>n</i> 12200	Pro Children Study; at least twenty schools sampled from each country	Schools: 70–97 % Children: 90.4 %	Child report Physical: perceived availability of fruit at home Tool: PCQ (test–retest reliability, ICC = 0.58–0.74; tested in parents)	Child report Fruit intake (d/week) Tool: FFQ (good test–retest reliability, Spearman r = 0.47–0.77; adequate validity, Spearman r = 0.43–0.51)	Moderate
Wolnicka <i>et al.</i> (2015) ⁽⁷⁸⁾ Poland	9 years and parents Mean (range) age: NR <i>n</i> 1255	Fruits in Schools programme Randomly selected primary schools and parents	Children: 78.7 %	Parent report Physical: accessibility to F&V Sociocultural: parental F&V intake; parental encouragement Tool: PCQ (validated)	Parent and child report F&V intake (freq/week, excl. potatoes and juice) Tool: PCQ (validated)	Moderate
Zarnowiecki <i>et al.</i> (2014) ⁽⁵²⁾ Australia	9–13 years Mean (SD) age: 11.3 (0.9) years <i>n</i> 395 (children)	Primary schools randomly selected from each SEP tertile	Schools: 32.1 % Parents: 48.8 % Higher response rate in higher-SEP school	Social ecological framework Child and parent report Composite measure: supportive home environment scale: child-reported parental encouragement; home food availability; accessibility; parent modelling; parent-reported home food availability; parent upbringing in relation to food	Child report Usual F&V intake (servings/d) Tool: CNQ (FFQ; validated)	Moderate

Table 2 Continued

Study	Participants	Recruitment	Response rate	Predictor variables and measures	Outcome and measures	Study quality ⁽¹⁹⁾
De Bourdeaudhuij <i>et al.</i> (2009) ⁽⁴⁴⁾ Europe	11 years <i>n</i> 4555 (children)	Pro Children Study; at least twenty schools sampled from each country	Parents: 67.8–83.4 %	Tool: CNQ (validated in young children; some scores developed for study using CFA, Cronbach's $\alpha = 0.52$ – 0.90) Combination of both child and parent report for different variables Parent report Sociocultural: parenting style: authoritative; authoritarian; indulgent; neglectful Tool: Steinberg instrument ($\alpha = 0.75$ – 0.76)	Child report; Usual F&V intake (portions/d) Tool: FFQ (good test–retest reliability, Spearman $r = 0.45$ – 0.77 ; adequate validity, Spearman $r = 0.38$ – 0.53)	Moderate
Longitudinal studies Tak <i>et al.</i> (2008) ⁽²⁴⁾ Netherlands	9–11 years Schoolgruitem Project: <i>n</i> 344 (children) Mean (sd) age: 10.0 (0.6) years Pro Children Study: <i>n</i> 258 (children) Mean (sd) age: 10.7 (0.5) years	Pro Children Study: Baseline, follow-up (9 & 21 months) data Randomly assigned Schoolgruitem Project: Thirty-one intervention schools randomly selected by phone Baseline, follow-up (1 year and 2 year) data	Pro Children Study: Schools: 32 % Children: 90 % Follow-up: 70 % Schoolgruitem Project: Children: 100 % 1st follow-up: 88 % 2nd follow-up: 72 %	Child report Physical: availability at home Sociocultural: parental modelling; active encouragement; facilitation Political: family rules (demand/allow) Tool: PCQ (internal consistency and predictive validity measured; good–very good test–retest reliability, ICC >0.60 for most items; Cronbach's α moderate–high, 0.52–0.89, except for one scale where $\alpha = 0.42$ – 0.49 ; Spearman $r = 0.16$ – 0.38)	Child report Pro Children Study: Usual daily intake freq of F&V Tool: PCQ (FFQ; valid and reliable) Schoolgruitem Project: Average daily fruit intake, average daily veg intake Tool: PCQ, Dutch EPIC FFQ (valid and reliable)	Moderate
Vereecken <i>et al.</i> (2010) ⁽²⁵⁾ Belgium	10 years and parents <i>n</i> 609 (parent–child pairs)	1st (T1) and 4th (T4) measurements of LEAS (2002–2005) 100 elementary schools randomly selected	Schools: 59 % Students/parents: T1, 44 %; T4, 51 %	Parent report Physical: availability of unhealthy food Sociocultural: parental F&V consumption; use of pressure; encouragement through material reward; encouragement through negotiation; catering on child's demand; permissiveness; avoiding negative modelling; verbal praise Tool: questionnaire (Cronbach's $\alpha = 0.64$ – 0.94 ; validity unknown)	Child report Freq of fruit and vegetables consumption (d/week) Tool: FFQ (reliability and validity unknown)	Moderate

NA, not available; OW, overweight; OB, obese; SFVNP, School F&V Nutrition Programme; RCT, randomised controlled trial; NIK, Neighbourhood Impact on Kids; SEIFA, Socio-Economic Indexes for Areas; GROW, Generating Rural Options for Weight; ALSPAC, Avon Longitudinal Study of Parents and Children; PARADE, Partners of All Ages Reading About Diet and Exercise; SES, socio-economic status; Ax, assessment; RSA, Ready Set Action; INPACT, ICO Nutrition and Physical Activity Child Cohort; SEP, socio-economic position; LEAS, Longitudinal Eating and Activity Study; NR, not reported; F&V, fruit and vegetable; PA, physical activity; REAL KIDS, Raising Healthy Eating and Active Living in Kids; CFQ, Child Feeding Questionnaire; CADET, Child and Diet Evaluation Tool; AWPCS, Active Where Parent–Child Survey; PCQ, Pro Children Questionnaire; FEAHQ, Family Eating and Activity Habits Questionnaire; YAFFQ, Youth and Adolescent FFQ; ICC, intra-class correlation; FFE, Family Food Environment; TEENS, Teens Eating for Energy and Nutrition; HBQ, Health Behaviour Questionnaire; DQES, Dietary Questionnaire for Epidemiological Studies; TV, television; GNKQ, General Nutrition Knowledge Questionnaire; GPPQ, General Parenting Practices Questionnaire; FIS, Food Involvement Scale; EDNP, energy-dense nutrient-poor; NKQ, Nutrition Knowledge Questionnaire; FPQ, Feeding Practices Questionnaire; PCA, principal component analysis; HES, Home Environment Survey; KCFQ, Kids' Child Feeding Questionnaire; CNQ, Child Nutrition Questionnaire; freq, frequency; CFA, confirmatory factor analysis; freq, frequency; incl., including; FJ, fruit juice; VJ, vegetable juice; excl., excluding; veg, vegetables; CATCH, Child and Adolescent Trial for Cardiovascular Health; ACAES, Australian Child and Adolescent Eating Survey; BKFS, Block Kids Food Screener; HBSC, Health Behaviour in School-age Children; NNS, National Nutrition Survey; DLW, doubly labelled water; EPIC, European Prospective Investigation into Cancer and Nutrition.

Table 3 Summary of associations between home environment components and consumption of fruits and vegetables in children aged 6–12 years

Predictor variables	Related			Total*	Summary (%)		
	(+)	(-)	Unrelated (0)		(+)	(-)	(0)
Composite measure							
Family/home food environment	F&V: ⁽⁵¹⁾			1	100		
	F: ⁽⁵³⁾ B&G			2	100		
	V: ⁽⁵³⁾ B&G			2	100		
Physical							
Availability							
Fruits and/or vegetables	F&V: ^(28, 34, 36)		F&V: ^(30, 77)	5	60		40
	F: ⁽²⁴⁾ I, ^(39, 41, 43, 52)		F: ⁽²⁴⁾ II, ⁽³⁷⁾ B&G&T	9	56		44
	V: ⁽²⁴⁾ II, ⁽³⁷⁾ B&G&T, ^(41, 52)		V: ⁽²⁴⁾ I, ⁽³⁹⁾	8	75		25
Unhealthy food	F&V: ⁽²⁵⁾ I&II		F: ⁽⁴⁰⁾	2	100		
				1			100
Accessibility							
Fruits and/or vegetables	F&V: ^(30, 32, 34)			3	100		
	F: ^(39, 78)			2	100		
	V: ^(39, 78)			2	100		
Low-calorie, nutrient-dense food			F&V: ⁽²⁷⁾	1			100
Unhealthy food		F&V: ⁽²⁷⁾		1		100	
Screens and unhealthy food		F: ⁽⁴⁰⁾		1		100	
Sociocultural							
Parental role modelling							
Fruits and/or vegetables intake	F&V: ^(27, 29, 30, 36)		F&V: ⁽²⁵⁾ I&II, ⁽²⁹⁾	7	57		43
	F: ⁽³⁷⁾ B&G&T, ⁽⁷⁸⁾		F: ⁽²⁴⁾ II, ⁽³⁹⁾	6	67		33
	V: ⁽²⁴⁾ I, ⁽³⁷⁾ B&G&T, ^(77, 78)		V: ⁽²⁴⁾ II, ⁽³⁹⁾	7	71		29
Diet and PA	F: ⁽⁴⁰⁾			1	100		
Sports and fruit intake	F: ⁽⁴⁰⁾			1	100		
PA/exercise	F&V: ⁽⁵⁰⁾ G		F&V: ⁽⁵⁰⁾ G	2	50		50
Parental intake							
Maternal							
	F&V: ⁽²⁵⁾ I&II			2	100		
	F: ^(38, 47)			2	100		
	V: ^(38, 47)			2	100		
Paternal							
	F: ⁽⁴⁵⁾ B&G&T, ⁽⁴⁷⁾		V: ⁽⁴⁵⁾ B&G, ⁽⁴⁷⁾	3			100
Maternal or paternal	F: ^(33, 39)			2	100		
	V: ^(33, 39)			2	100		
Parental facilitation/support							
	F&V: ^(30, 36)		F&V: ^(30, 36, 46, 50) B&G	7	29		71
	F: ⁽³⁷⁾ B&T		F: ⁽²⁴⁾ I&II, ⁽³⁷⁾ G&T	10	40		60
	V: ⁽²⁴⁾ I&II, ⁽³⁷⁾ B&G&T, ⁽³⁷⁾ G&T, ⁽⁵⁶⁾		V: ⁽³⁷⁾ B	10	80		20
Parental encouragement							
	F&V: ^(27, 30, 34)		F&V: ⁽²⁵⁾ I&II, ⁽³⁶⁾	6	50		50
	F: ⁽²⁴⁾ I		F: ⁽²⁴⁾ II, ⁽³⁷⁾ B&G&T	5	20		80
	V: ⁽²⁴⁾ I, ⁽³⁷⁾ B&G&T		V: ⁽²⁴⁾ II	5	82		18
Parenting practices							
Permissiveness							
Catering on demand			F&V: ⁽²⁵⁾ I&II, ⁽²⁷⁾	3			100
Negotiation	F&V: ⁽²⁵⁾ II		F&V: ⁽²⁵⁾ I&II, ⁽³⁶⁾	3			100
Pressure to eat		F&V: ⁽²⁷⁾	F&V: ⁽²⁵⁾ I	2	50		50
			F&V: ⁽²⁵⁾ I&II, ^(27, 36)	5		20	80
			F: ⁽⁴²⁾	1			100
Food as reward							
			F&V: ⁽²⁵⁾ I&II, ⁽⁴⁶⁾	3			100
			F: ⁽⁴⁸⁾	1			100
			V: ⁽⁴⁸⁾	1			100
Parenting style (all dimensions)							
Family eating behaviours	F&V: ^(49, 50) B&G	F&V: ⁽²⁴⁾	F&V: ⁽⁴⁴⁾	7	43	14	43
	V: ⁽⁵⁶⁾		F&V: ^(26, 27)	1	100		
Family meal frequency	F&V: ^(34, 36)		F&V: ⁽⁴⁶⁾	3	67		33
	F: ⁽⁴⁸⁾		F: ⁽⁵²⁾	2	50		50
	V: ^(52, 56)		V: ⁽⁴⁸⁾	3	67		33
Parental perceptions							
Healthiness of child's diet							
Food cost	F&V: ⁽²⁶⁾	F&V: ⁽²⁷⁾	F&V: ⁽²⁷⁾	1	100	50	
		F: ⁽²⁷⁾		2		50	50
			V: ⁽³¹⁾	1		100	
Parental concerns							
Child's dietary intake							
Physically active	F&V: ⁽²⁶⁾		F&V: ⁽³⁶⁾	2	50		50
Parental liking	V: ⁽³³⁾		F&V: ⁽²⁶⁾	1	100		100
Person in charge of cooking meals							
Mothers	F&V: ⁽³³⁾		F: ⁽³³⁾	1	100		100

Table 3 Continued

Predictor variables	Related		Unrelated (0)	Total*	Summary (%)		
	(+)	(-)			(+)	(-)	(0)
Fathers			F&V: ⁽³²⁾	1			100
Political							
Rules							
Demand	F: ⁽³⁷⁾ <i>B&T</i> , ⁽²⁴⁾ <i>I</i> ; V: ⁽²⁴⁾ <i>I&II</i> , ⁽³⁷⁾ <i>B&G&T</i>		F: ⁽²⁴⁾ <i>II</i> , ⁽³⁷⁾ <i>G</i> V: ⁽⁵²⁾	6	50		50
Allowance			F&V: ⁽³⁶⁾ F: ⁽²⁴⁾ <i>I&II</i> , ⁽³⁷⁾ <i>B&G&T</i> V: ⁽²⁴⁾ <i>I</i> , ⁽³⁷⁾ <i>B</i>	1			100
Diet	V: ⁽²⁴⁾ <i>II</i> , ⁽³⁷⁾ <i>G&T</i> F: ⁽³⁸⁾ V: ⁽³⁸⁾		5 1 1	5	60		100 40
Diet and activity	F: ⁽⁴⁰⁾		F&V: ⁽²⁷⁾	1			100
Restrictions	F: ⁽⁴²⁾		F&V: ⁽²⁷⁾ F: ⁽⁴⁸⁾ V: ⁽⁴⁸⁾	1 2 1	100 50		50 100
Parental control							
Overt/covert	F&V: ⁽³⁵⁾			2	100		

(+), positive; (-), negative; (0), nil; PA, physical activity; F, fruit; V, vegetable; F&V, fruit and vegetable; B, boys only; G, girls only; B&T, boys and total sample; G&T, girls and total sample; B&G&T, boys and girls and total sample; I, baseline results from longitudinal studies, II, follow-up results from longitudinal studies. If boys and girls/fruits and vegetables are analysed separately, they are summarised as individual relationships.

Superscripted numbers in parentheses refer to citation numbers. References for longitudinal studies are in italics.

*Total number of relationships for each home environment component.

correlation analysis^(28–31,40,42,43,45,47,48,78). Only one study used structural equation modelling⁽⁵¹⁾.

Measures of effect size varied between studies and were not reported in two studies^(34,46). Only two studies^(30,52) reported conducting a power calculation, and all but one study provided confidence intervals for results⁽³⁷⁾. The home sociocultural environment was most commonly investigated, while the home political environment was less studied. Studies differed in the definition, number and combination of home environment components studied.

Quality assessment

Overall, methodological quality was poor, with twenty out of thirty-three studies rated as weak. This was mainly due to the cross-sectional design in a majority of studies and selection bias as evidenced by the homogeneous sample with limited representativeness (Table 2), recruitment through convenience sampling^(30,34,39) and voluntary participation^(26,29,45,46,47,51). About half of the studies had strong–moderate ratings for using valid and/or reliable tools, while, for the other half, psychometric properties were either not reported or weak. Most studies either did not report, or had a low, response or follow-up rate (Table 2). It was not possible to assess publication bias as hypotheses were not reported in many studies.

Similar to a previous review⁽¹⁶⁾, only home environment components with three or more significant relationships with combined F&V (described as F&V in the following sections), fruit or vegetable consumption will be reported and discussed, as findings for components that were investigated sparsely, all listed in Table 3, are limited and inconclusive.

Home physical environment and children's fruit and/or vegetable consumption

Six home physical environment components were identified (Table 3). Availability and accessibility of F&V were most commonly studied and were positively associated with children's F&V consumption more consistently than other components. All five studies examining home accessibility^(30,32,34,39,78) reported a positive association, although the strength of the relationship was unclear due to lack of reporting in two studies^(30,34). With respect to home availability, no association with F&V consumption was found when it was measured through direct observation using a shelf inventory⁽³⁰⁾, compared with parent reports of perceived home availability in the three positive relationships found^(28,34,36), with Robinson-O'Brien *et al.* also including child reports, although the effect size was not reported in their study⁽³⁴⁾. One study reported home availability as the strongest correlate ($r=0.342$, $P=0.001$)⁽²⁸⁾. These studies were conducted predominantly in Americans from low-income backgrounds^(30,32,34), except for one in London⁽³⁶⁾, thus limiting the representativeness of findings.

The consistently positive association was evident only for home availability in relation to frequency of vegetable consumption (OR=1.27; 98% CI 1.12, 1.44)⁽³⁷⁾ and at follow-up (OR=2.14; 95% CI 1.17, 3.91, $P<0.05$)⁽²⁴⁾, and was found to be most strongly related to frequency of vegetable consumption ($\beta=0.652$, $P<0.001$)⁽⁵³⁾ and meeting guidelines for vegetable consumption (OR=2.62; 95% CI 1.61, 4.26, $P<0.001$)⁽⁴¹⁾. Despite the more consistent association found for vegetable consumption (six of eight relationships) than fruit consumption (five of nine

relationships), associations tended to be stronger for fruit consumption in van Ansem *et al.*'s study (OR = 4.08; 98% CI 1.75, 9.48)⁽⁴¹⁾ and at baseline (OR = 2.97; 95% CI 1.65, 5.46, $P < 0.05$)⁽²⁴⁾ than for vegetable consumption. Collectively, all studies had the strength of adjusting for common confounders except for the only study where no significant association with F&V consumption was found, in which confounding was not reported⁽³⁰⁾.

Home sociocultural environment and children's fruit and/or vegetable consumption

Twenty-four home sociocultural environment components were identified (Table 3), but most were investigated sparsely. Parental modelling was positively associated with children's F&V consumption in four of seven relationships^(27,29,30,36). No association was found longitudinally⁽²⁵⁾. All studies measured parent-reported parental role modelling, and Draxten *et al.* also included child reports⁽²⁹⁾. It should be noted that there were methodological limitations in these studies, as detailed in Table 2.

Parental modelling was also related to higher intakes of fruits (four of six relationships)^(24,37,39,78) and vegetables (five of seven relationships)^(24,37,39,78), although the positive associations obtained only slightly outnumbered those with none. All three studies which analysed fruits and vegetables separately were predominantly in the Netherlands^(24,37,39). Operationalisation of parental modelling was inconsistent; in six studies reporting a significant positive association^(24,30,36,37,39,78), parental intake was used to define modelling, while in another study with no association⁽²⁵⁾ it was defined as avoiding negative modelling. In the only study where it was the strongest correlate of children's F&V consumption (OR = 0.68; 95% CI 0.34, 1.02, $P < 0.001$), parental modelling was measured on the same scale as parental encouragement and thus the association may have been blurred⁽²⁷⁾.

Parental intake was defined as a component distinct from parental modelling, as the former solely refers to the amount or frequency of fruits and/or vegetables consumed by the parent. Parental role modelling may refer to the parents being a role model through their intake, but may also encompass other aspects like their feeding attitude, eating styles and mealtime behaviours^(54,55). In the present review, parental intake was positively associated with children's F&V consumption, especially in mothers⁽²⁵⁾, although no studies examined this relationship in fathers. When F&V consumption was analysed separately, maternal intake appeared to be a stronger correlate than fathers' intake, whereas weak positive associations were found when mothers and fathers were not differentiated^(33,39). Paternal intake was positively associated with fruit but not vegetable consumption^(45,47). However, these studies consisted of a homogeneous sample of predominantly overweight Australian fathers^(45,47), and parents reporting dietary intake in the identified studies were mostly mothers.

Indeterminate associations with children's F&V consumption were observed for parental encouragement, with half of the six relationships from five studies^(25,27,30,34,36) showing no association^(25,36) including those at follow-up⁽²⁵⁾. This was similar for fruit consumption (three of four relationships)^(24,37). Associations were more consistently positive for vegetable consumption (five of six relationships)^(24,37), although no association was found at follow-up as well⁽²⁴⁾.

Similarly, inconsistent findings for parental facilitation/support as a correlate of children's F&V consumption were found, mainly due to the varied components in this category, each of which was investigated infrequently (see Table 2). Nevertheless, strong, positive associations in relation to children's fruit consumption were reported for cutting up fruit (OR = 1.34; 98% CI 1.20, 1.51) and bringing fruit to school (OR = 2.75, 98% CI 2.43, 3.12), regardless of gender⁽³⁷⁾, but no association was found longitudinally⁽²⁴⁾. Similarly, cutting up vegetables (OR = 1.16; 98% CI 1.03, 1.31) and bringing vegetables to school (OR = 1.99; 98% CI 1.68, 2.36) were strongly and positively associated only with girls' and combined boys' and girls' vegetable consumption⁽³⁷⁾. Longitudinally, the positive association was weakened from baseline (OR = 2.57; 95% CI 1.32, 4.98, $P < 0.05$) to follow-up (OR = 2.12; 95% CI 1.12, 4.01, $P < 0.05$)⁽²⁴⁾. Weaker associations were found for cooking together most days of the week (OR = 0.64; 95% CI 0.41, 0.99, $P < 0.05$) and doing groceries together 2–4 d/week (OR = 0.94; 95% CI 0.81, 1.09, $P < 0.05$)⁽⁵⁶⁾. However, despite the same specific combination of home environment components measured, the same Pro Children Questionnaire used and large sample size, these findings for parental encouragement and facilitation/support are limited in generalisability as they were mostly obtained from studies by De Bourdeauhuiji *et al.*⁽³⁷⁾ and Tak *et al.*⁽²⁴⁾, where study populations were part of the same projects in Europe.

Home political environment and children's fruit and/or vegetable consumption

Findings for most of the home political environment components examined in relation to children's F&V consumption were sparse and thus inconclusive (Table 3). However, having demand rules was positively related to fruit consumption in three of six relationships^(24,37), including those at baseline⁽²⁴⁾. Associations were of similar strength in analyses for gender groups, although not significant for girls⁽³⁷⁾. Compared with fruit consumption, demand rules had stronger and more consistent associations (83% of relationships) with children's vegetable consumption, persisting from baseline (OR = 3.10; 95% CI 1.66, 5.79, $P < 0.05$) to follow-up (OR = 3.06; 95% CI 1.64, 5.68, $P < 0.05$), and this association was the strongest and most consistent compared with other components investigated⁽²⁴⁾. However, these results were also obtained from the two European studies by De Bourdeauhuiji *et al.*⁽³⁷⁾

and Tak *et al.*⁽²⁴⁾, and thus should be interpreted in view of the limitations mentioned previously.

No association was found between F&V and allowance rules^(24,37), but there were positive associations with vegetable consumption in girls, combined boys and girls, and at follow-up in three of five relationships^(24,37).

Composite measure of the home environment

Only two studies, both conducted in Adelaide, Australia, examining the association between the overall home environment and children's F&V consumption were identified in the current review^(51,52). Findings were inconclusive despite all associations with fruits and/or vegetables being significantly positive in both studies, likely due to differences in the combination of components measured.

It is evident that studies in the present review were highly heterogeneous in methodological design and quality, limiting the ability to compare results. In line with previous reviews^(13,14,15,16,22,23), results presented have focused mainly on the consistency of associations and not the magnitude of associations across studies, as the heterogeneity in effect estimates and lack of reporting in some studies also limited the direct comparison of effect sizes.

Discussion

The present review aimed to add to the existing literature and expand the understanding on the influence of the home environment on F&V consumption in children aged 6–12 years. This could inform the development of more effective interventions to encourage F&V consumption. A vast array of home environment components studied were differentially associated with children's fruit and/or vegetable consumption, suggesting that specific components of the home environment may have more influence than others. However, studies should be interpreted in light of the heterogeneity in study methodology, design and effect estimates.

The results of the present review showed that the most consistent evidence for children's combined F&V consumption was found for availability and accessibility of F&V, parental role modelling of F&V and maternal intake of F&V. These components, together with parental facilitation/support and demand rules, showed consistently positive associations when fruits and vegetables were analysed separately; although in some studies, availability, maternal intake and parental facilitation were more strongly and positively associated with fruit consumption, while demand and allowance rules were stronger correlates of vegetable consumption. These findings support previous work that correlates of fruits and vegetables differ^(14,15), and support the social ecological theory⁽⁵⁾ indicating that primary-school children aged 6–12 years

are still dependent on their parents and that the home environment is a major influential setting to target.

The present review supports previous findings of the positive influence of home availability and accessibility of F&V on children's F&V consumption^(13–16). This elucidates the importance of both components, as children may not consume F&V that are hard to access even if they are available, especially if unhealthy foods are also available⁽⁵⁷⁾. Most studies in the review reporting positive associations with F&V consumption included parent reports. Currently, there is no gold standard for measuring home food availability; little is known about the accuracy of perceived reports compared with direct observations⁽⁵⁸⁾. Moreover, agreement between parents' and children's perceptions of home availability and accessibility of F&V is low^(59–61). Parents may be more prone to social desirability bias⁽⁵⁸⁾ and report greater availability of F&V than their children⁽⁶¹⁾, and child-reported availability was more likely to correlate with F&V consumption and improve internal consistency of scales^(62,63). This could explain the inconsistencies in results between studies. If parents perceive availability and accessibility to be good, such a perception could prevent increasing children's F&V intake. Thus, both parents and children provide invaluable information and different perspectives should be taken into consideration^(47,61,64).

Apart from being nutritional gatekeepers controlling home availability and accessibility of F&V⁽⁶⁵⁾, parents also act as powerful socialisation agents, influencing children's food intake by being role models and through the rules they impose⁽⁶⁶⁾. Past evidence for parental rules was indeterminate and seldom differentiated between demand and allowance rules^(14,66). The present review provides new insight to the current literature, showing that demand and allowance rules are positively and more strongly related to vegetable than to fruit consumption. The persistent and stronger associations for maternal compared with paternal intake also attest to the fact that mothers have more influence than fathers on children's intake and may be better role models. This finding is especially important as maternal employment continues to increase globally, changing the influence of family routines and opportunities for role modelling at mealtimes^(67,68). With most children not meeting recommendations for F&V^(1–4), these findings are promising because strategies like encouragement, cutting F&V up, bringing them to school and enforcing demand rules may promote consumption, especially for vegetables. Interventions should not just encourage children's consumption but also aim to improve parents' consumption. The indeterminate or absent associations found for all parenting practices (such as parental role modelling), consistent with previous reviews^(14–16), indicates that such practices are unlikely to be useful in children age 6–12 years who have increasing autonomy compared with early childhood⁽⁶⁹⁾. Parents employing these strategies should be informed that these

alone will not be adequate for increasing children's F&V consumption.

Nevertheless, it may be inaccurate to view each component of the home environment independently as they may interact to influence F&V consumption differently. To the authors' knowledge, the current review is the first time that the relationship between the overall home environment and children's F&V consumption is summarised, although only two studies were identified^(51,52). However, using an overall measure of the home environment assumes equal contribution of all components and does not enable the identification of the strongest correlate of F&V consumption.

Overall, the evidence presented in the current review is encouraging, but limitations should also be considered before stronger conclusions can be made. Causation and direction of associations cannot be determined due to the cross-sectional design of most studies. It is possible that the reverse is operative as well, such that children's F&V consumption prompts parental encouragement, practices like cutting up F&V or rules demanding consumption, as supported by Ventura and Birch's model postulating a bidirectional relationship⁽⁶⁹⁾. Evidence supporting this is limited. One longitudinal study showed that changes in F&V intake frequency did not predict changes in home environmental components and concluded that the home environment is likely to have a larger impact on F&V consumption⁽²⁴⁾. More research is needed to further explore this relationship.

Cross-sectional data are also limited by confounding. Recent studies have suggested that unhealthy and healthy lifestyle behaviours tend to cluster⁽⁷⁰⁾ and associations have been shown to be moderated by personal factors, such that children with more positive self-efficacy, liking or preference for F&V may be more influenced by the home environment^(24,71). Therefore, these are potential confounders to consider in disentangling the effects of lifestyle factors on F&V consumption.

Psychometric strength of measures used differed across studies. In six of twelve studies using valid measures^(24,28,37,40,43,50), correlation statistics were used to test for validity rather than the more robust test of agreement⁽⁷²⁾. Parent reports are often used to measure F&V consumption based on the assumption that children cannot estimate portion sizes well⁽⁷³⁾, but children above 8 years of age are able to accurately self-report intake⁽⁶⁴⁾. It remains unclear whose report is more accurate and valid^(59,64). More studies investigating their validity are required. Furthermore, the present review used overall fruits and/or vegetables consumption as the main outcome without distinguishing between meeting guidelines, frequency or amount of consumption (Table 2). These were often dichotomised from continuous measures^(29-32,37,41,50), increasing the likelihood of loss of power and precision of effect sizes⁽⁷⁴⁾. While meeting guidelines may be related to enhanced intake, they may have different correlates;

children can eat more frequently in limited amounts and may not be meeting recommendations. Also, some included potatoes, or fruit and/or vegetable juice, and most studies used a 24 h recall (Table 2), which may not be representative of usual intake⁽⁶⁴⁾. Collectively, these may lead to inconsistencies in measured intake, especially in countries where potatoes and/or juice make up a large proportion of children's F&V intake^(2,75,76), and may explain the inconsistent associations obtained.

Lastly, a considerable number of significant findings, especially those from separate analyses for fruits and vegetables and gender groups, were from the two European studies^(24,37). While effect has been shown to be modified in different groups, they may be limited in generalisability. The multiple strategies employed in the two longitudinal studies also makes it hard to attribute which home environment component brought about change in consumption. Thus, conclusions with regard to home environment predictors of change in children's F&V consumption are likely to be weak.

Strengths and limitations

The current review is strengthened by its systematic approach and compliance with reporting guidelines. Despite consisting mainly of cross-sectional studies, the findings are useful for hypothesis generation. Similar to past reviews⁽¹⁴⁻¹⁶⁾, the present review focused on the consistency of association and not the strength of association. However, as most studies had a large sample size, statistical significance may have been more easily achieved than in smaller studies. Conceptually similar components were combined under a general category but results of studies with stronger methodological quality could be masked by those that were weaker. This was accounted for by considering quality assessment ratings of the studies in our review. Nevertheless, weaker ratings may not necessarily reflect a low-quality study but a lack of reported detail in the papers. Finally, search terms used to retrieve studies from existing databases may not have been sensitive enough and more studies could have been obtained with a more specific search strategy.

Implications for practice/future research

Future studies should be based upon conceptual or theoretical models^(17,65) to enhance understanding of mechanisms involved and provide consistency in defining the home environment. New components such as availability and accessibility of unhealthy foods, clusters of diet and activity-related parenting practices and the overall home environment were identified in the present review, none of which were previously examined. Together with those investigated sparsely, they should be replicated to generate more compelling evidence. Analyses for fruits and vegetables and gender groups should be

separated where possible. Investigation of potential moderators, such as personal or contextual factors, is also needed to ensure sufficient confounder control in future studies. Stronger longitudinal or intervention studies analysing causation are also warranted. These should be accompanied by improvements in methodological design, through the use of reliable and valid tools specific to the study population, and theoretically driven statistical approaches. These will ensure that interventions to increase F&V consumption among children are evidence based and supported by strong methodological design.

Conclusion

In accordance with social ecological theories, the current review demonstrates the various influences of the home environment on children's fruit and/or vegetable consumption, adding new insight and further support of previous work^(13–16). Nevertheless, the relationship between the home environment and children's F&V consumption is complex and still not well understood. Evidence is consistent only for a limited number of home environment components. Too few studies have been conducted on many of the home environment components to draw strong conclusions.

Nevertheless, parents of primary-school-aged children are important role models who determine the home availability and accessibility of F&V, facilitate easy consumption and enforce rules demanding children to eat F&V. Future interventions promoting F&V consumption in children aged 6–12 years should target both parents and these components of the home environment.

Acknowledgements

Financial support: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. *Conflict of interest:* None. *Authorship:* J.X.O. and A.M. conducted initial searches. J.X.O. tabled results and drafted the manuscript. A.M. and S.U. provided academic supervision and support in all aspects of the study. A.M., S.U. and E.L. reviewed search results and all authors reached consensus on inclusion criteria. E.L. and J.M. contributed to drafting, critical revision and final approval of the version to be published. All authors reviewed the final manuscript. *Ethics of human subject participation:* Not applicable.

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