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Healthy eating interventions delivered in the family home: a systematic review

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Healthy eating interventions delivered in the family home:

A systematic review

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Introduction

Food preferences and eating behaviours develop early in life (Savage, Fisher, & Birch, 2007). Healthy eating in the first five years is linked to current and future health (Branca, Piwoz, Schultink, & Sullivan, 2015; Ogden, 2012; Rasmussen et al., 2006), and both dietary variety seeking (Nicklaus, Boggio, Chabanet, & Issanchou, 2005) and untreated overweight/obesity (Vivier & Tompkins, 2008) are likely to track from childhood into adulthood. Thus, it is important to address unhealthy eating as early as possible.

Healthy eating refers to the consumption of a wide variety of foods in the correct proportions to achieve and maintain a healthy body weight (National Health Service (NHS), 2014). A balance of fruit, vegetables, complex carbohydrates and protein is considered beneficial (NHS, 2015), while high intake of processed food, sugar and/or salt reflects a substandard diet, and both over- and undereating are considered unhealthy behaviours (World Health Organisation (WHO), 2015). Unhealthy diet in children is considered to be a widespread problem (WHO, 2015). Across the economically developed world, between a quarter and a third of children are typically overweight or obese (NHS, 2017; Rodd & Sharma, 2016; State of Obesity, 2017). Children also consume fewer fruit and vegetable (FV) portions than the recommended daily guidance (Dennison, Rockwell, & Baker, 1998; Kim et al., 2014) and both obese and non-obese children are thought to consume inadequate nutrients (Gillis & Gillis, 2005). Many national governments have therefore introduced campaigns to address children's food choices, many emphasising the need for balance and variety in children's diets (e.g. Change4Life, 2015; Government of Canada, 2018; USDA, 2018).

A key focus for such interventions is what young people eat at home. In their first few, formative, years, and even once they have started school, children eat most of their meals in the home environment (Poti & Popkin, 2011). Inevitably, parents play an important role in

shaping children's food choices, eating behaviours and habits. Evidence indicates that eating behaviour interventions for children should target parents as the principal agents of change (Golan, 2006) (although adolescents may achieve greater dietary change when treated directly; see McLean, Griffin, Toney, & Hardeman, 2003). This systematic review evaluates the evidence relating to interventions delivered at home that seek to support healthy eating in children who are both overweight and of a healthy weight.

There are a number of well-established home environment correlates to healthy eating and willingness to try new foods in children (Blanchette & Brug, 2005; Pearson, Ball, & Crawford, 2012). Children are more likely to consume and enjoy new foods if they are exposed to them repeatedly (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012; Mitchell, Farrow, Haycraft, & Meyer, 2013; Patrick & Nicklas, 2005). This is thought to be due to learned safety of exposed foods (Kalat & Rozin, 1973) or exposure effects leading to positive attitudes to more familiar foods (Zajonc, 1968). Parents' modelling of healthy food consumption also influences children's food choices, both through social learning processes such as imitation and through greater exposure to foods parents are eating (Dickens & Ogden, 2014; Savage, et al., 2007). For children to consume a food, it must be both available (in the home and offered to the child) and accessible (in a format easy to reach and consume) (Patrick & Nicklas, 2005). Exposure, modelling, availability and accessibility of healthy foods are consistently found to be strong predictors of children's healthy eating (Pearson, et al., 2012). In addition, children's and adolescents' nutritional health is associated with the frequency of shared family meals (Dwyer, Oh, Patrick, & Hennessy, 2015), which is thought to be a protective factor against obesity and, possibly, disordered eating (Ackard and Neumark-Sztainer, 2001; Berge, Loth, Hanson, Croll-Lampert, & Neumark-Sztainer, 2012). Shared family meals are more likely to be home-cooked (rather than 'ready-made') and nutritious (Gillman et al., 2000), and provide parents with more opportunity to model healthy

eating. Social learning may partly explain the link between family meals and positive eating habits.

Some parents struggle to implement positive feeding practices, however (Carruth & Skinner, 2000; Shloim, Edelson, Martin, & Hetherington, 2015), even when informed about strategies to encourage healthy eating (Lindsay, Sussner, Greaney, & Peterson, 2011). Parents cite time, budget and children's food preferences as interfering with their ability to follow relevant advice (Fulkerson et al., 2011). Interventions have been developed to support parents' behaviours and strategies around feeding children (both normal weight and overweight/obese) (Campbell & Hesketh, 2007; Knowlden & Sharma, 2012; Ling, Robbins, & Wen, 2016; Van Lippevelde et al., 2012), typically delivered through group or individual meetings held in schools (Evans, Christian, Cleghorn, Greenwood, & Cade, 2012; Mikkelsen, Husby, Skov, & Perez-Cueto, 2014) or community venues (Bleich, Segal, Wu, Wilson, & Wang, 2013). However, parents cite time, location and childcare considerations as barriers to participating in such eating behaviour interventions (Alff et al., 2012; Virudachalam et al., 2016).

To be effective, family eating interventions must be both practical and accessible for parents. Until recently, few interventions met these criteria; the majority were expensive and impractical to deliver on a large scale (Rudolf, 2012). For example, a Cochrane review conducted in 2012 (Wolfenden et al., 2012) identified only two home visit-based interventions that might be effective in increasing fruit and vegetable consumption in pre-school children. However, in recent years, more interventions have been delivered within the family home, which reduces the barriers to participation for parents; advances in technology also permit the development of cheaper, more accessible, health behaviour interventions (WHO, 2017). Many of these draw on Social Cognitive Theory (SCT, Bandura, 1986) which

attempts to change behaviour by addressing social cognitions. In the context of healthy eating, this involves addressing expectancies such as the health consequences of eating specific foods or incentives, for example, how individuals might feel after eating particular foods. For example, the Health Belief Model (Becker, 1974) has been used to predict healthy eating amongst various populations (Deshpande, Basil & Basil, 2009) while the Theory of Planned Behaviour (Ajzen, 1991) has been used to address the intention-behaviour gap (Sheeran & Webb, 2016) through manipulating parents' implementation intentions in relation to their children's sugar intake (Beale & Manstead, 1991).

This current review considers the full literature that has addressed the question *what is effective in changing eating behaviours in the family home?* Given the broad implications of unhealthy eating in children, the review will include obesity prevention studies, obesity reduction studies and healthy eating studies in normal weight populations. It seeks to systematically review all intervention studies that have set out to change children's or families' eating behaviours and that are delivered exclusively to parents, children or families in the home environment and, in doing so, to address two questions:

(1) What intervention studies have been conducted to try to enhance healthy family eating behaviours within the family home? Outcomes considered include both changes in child health (e.g. adiposity, weight) and other positive features of family mealtimes (e.g. family mealtime frequency, positive feeding practices).
(2) What characteristics do successful interventions exhibit in relation to both their theoretical basis and more practical aspects of their design and implementation?

Method

The review protocol was registered with Prospero, the international prospective register of

systematic reviews (https://www.crd.york.ac.uk/prospero/) on 5th July 2016, with a revision on 17th February 2017 (registration number PROSPERO 2016:CRD42016042387).

Search strategy

A search was conducted in three electronic databases (Medline, Web of Science, The Cochrane Library) for articles published from 1980 to the present day on 12th May 2016, and repeated on 22nd January 2018 to update the results. The following search terms were used:

(1) Home*/house*/famil*/child*/toddler/pre-school*/preschool*/adolescen*/parent*

AND

(2) Eat*/feeding practice(s)/meal*

AND

(3) Intervention/prevention/program*/randomised controlled trial/randomized controlled trial/RCT/qualitative/course

Forward and backward citation searching, and additional hand-searching were also conducted. Reports outside academic peer-reviewed publications were not included.

PRISMA guidelines and checklist were complied with throughout (Moher, Liberati, Tetzlaff, Altman, & The, 2009).

Inclusion/exclusion criteria

Step 1: Initial criteria to determine whether articles would be considered were: 1) English language; 2) human participants; 3) peer-reviewed journal publication.

Step 2: For articles that met these initial criteria, one researcher (SS) screened the titles and abstracts for inclusion using the following criteria:

1) relevance (i.e. titles were excluded if the topic was unequivocally irrelevant. Examples of irrelevant topics included smoking cessation, Alzheimer's disease and alcohol abuse);

2) home-delivered intervention (studies involving visits to sites other than the family home for data collection purposes were included if all aspects of the intervention were delivered within the family home; interventions *intended* to be delivered at home but that could be accessed elsewhere (e.g. through a mobile device, or if visit locations were rearranged for convenience) were included);

3) focus on eating (however, studies were excluded if the focus was on condition-specific eating (e.g. autism, cerebral palsy), eating disorders or malnutrition in developing countries);

4) randomised controlled trial/ case-controlled trial/other controlled design/qualitative evaluation of intervention (reviews and meta-analyses were not included but were examined for relevant studies);

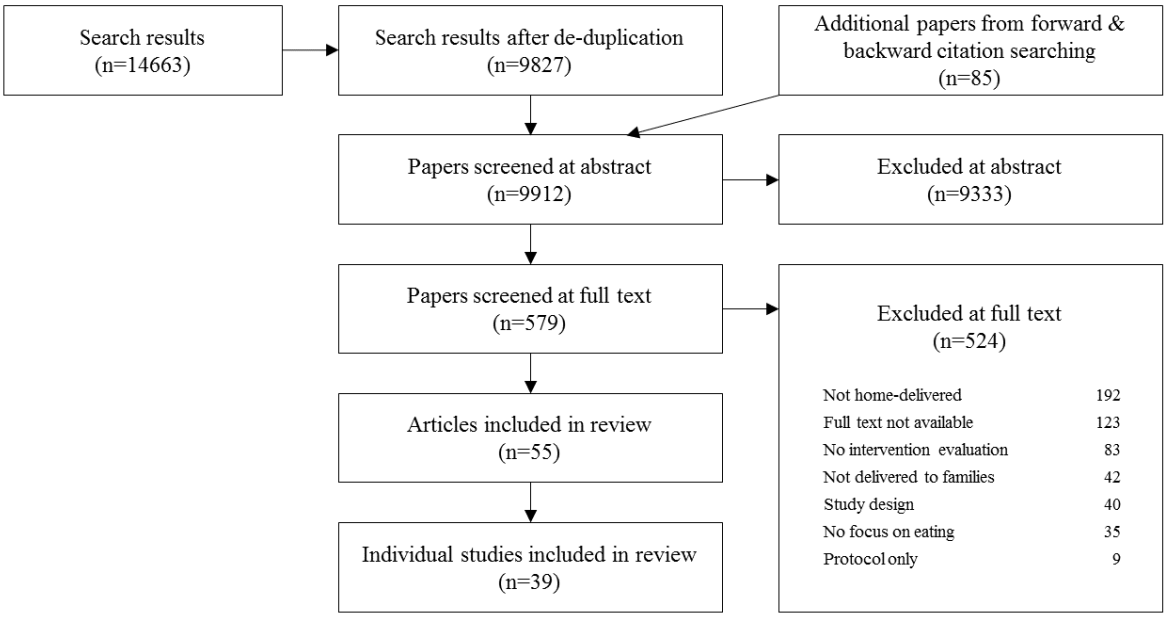
5) families had children aged > 6mo and < 16 yo (participants could be children and/or parents/ carers; interventions were included if they were initiated before the child reached 6 mo but continued beyond this age *and* were focused on eating, rather than breast-feeding);

6) health-related outcome measure (e.g. dietary intake, BMI, parental feeding practices);

7) outcome data are published.

Five research assistants 'second-coded' all articles using the same criteria. All articles included by at least one coder underwent full text screening (step 3), to double check that criteria were met. Any article with unclear inclusion status at step 3 was considered by a third researcher (KH). Where appropriate, study authors were contacted to clarify methodological details. See figure 1 for flow diagram of these steps.

Figure 1: Study selection process



Quality appraisal

The quality appraisal considered criteria laid out by the Centre for Reviews and Dissemination (CRD) (CRD, 2009), as follows: 1) Appropriateness of study design to research objective; 2) Risk of bias; 3) Choice of outcome measure; 4) Statistical issues; 5) Quality of reporting; 6) Quality of the intervention; 7) Generalisability. The CRD recognises that elements of quality appraisal can be subjective and does not always recommend the use of checklists or scales to allocate quality scores (CRD, 2009 p.33-44). Thus, the above criteria were considered when evaluating studies but studies were not given quality ratings. Instead, studies were weighted equally and quality assessment is described in the narrative.

Data synthesis

A narrative summary technique was used to describe findings. Meta-analysis was not used as intervention formats, outcome measures and times of follow-ups varied widely between studies.

Results

The search strategy yielded 9827 unique titles, 9774 of which were excluded. Fifty-five articles were included in the systematic review, representing 39 unique studies (some studies were reported in more than one paper) (Figure 1).

In all but three studies, participants were randomised or cluster-randomised to one or more Intervention Groups (IG) or to a Control or Comparator Group (CG). One of the remaining studies included a non-randomly allocated comparison group; two studies incorporated control through within-subjects designs. Three studies identified as pilot randomised trials.

A summary of the characteristics of included studies is provided in Table 1. Included studies were conducted in the United States (US, n=15), United Kingdom (UK, n=9), Australia (n=4), US/Mexico border (n=2), Germany (n=2), US and Canada (n=1), Brazil, Hong Kong, Italy, the Netherlands, New Zealand and Sweden (n=1 in each case). Where studies did not state the setting, it was assumed that this was the authors' country of residence.

Table 1. Intervention characteristics

Study type (n)	**Formative work/intervention development described or pilot work referenced: n (%)**	**Participant or process evaluation reported (or referenced): n (%)**	**Retention rate range***	**Financial incentives used to engage in study: n (%)**	**Effect sizes reported in conventional format: n (%)**	**Intention to treat analysis employed n (%)**
Home visit (15)	9 (60%)	5 (33%)	55% - 100%	3 (20%)	3 (20%)	6 (43%)
Telephone (3)	2 (66)%	2 (33%)	55% - 86%	1 (33%)	0	2 (66%)
Printed materials (9)	2 (22%)	4 (44%)	38% - 100%	0	4 (44%)	3 (33%)
Video game (4)	4 (100%)	3 (75%)	87% - 97%	1 (25%)	1 (25%)	2 (66%)
mHealth**(7)	6 (86%)	4 (57%)	35% - 91%	3 (43%)	3 (43%)	1 (14%)
Other (1)	1 (100%)	0	100%	0	0	n/a
All studies	**24 (61%)**	**18 (46%)**	**35% - 100%**	**8 (21%)**	**11 (29%)**	**14 (39%)**

*For studies with insufficient information, no retention rate has been reported
**mHealth refers to health interventions delivered through wireless technology (e.g. mobile phones)

The majority of studies targeted families with children of normal weight; one study targeted picky eaters. Just over half reported the theory or evidence base behind the intervention, with Social Cognitive Theory as the most commonly cited theory. A similar number reported evidence of formative work around the development of the intervention, although fewer than half reported any element of participant or process evaluation. Most studies did not report using intention to treat (ITT) analyses (i.e. including all randomised participants in analyses, regardless of completion status). Follow-up periods varied, from no follow up (i.e. immediate post-intervention data collection only) to four years.

Only eight studies reported effect sizes in a conventional format (e.g. Cohen's *d*); a further seven discussed the size of the effects found (e.g. increases in vegetable intake in terms of portions). No study reported a cost-effectiveness analysis, although one collected cost data for future analysis. No study blinded participants to condition; several explained that this was procedurally impossible, given the behavioural nature of the interventions.

The interventions discussed in the following section are divided into those that are person-delivered (face-to-face or telephone) versus information/technology-delivered (printed materials, video games and mHealth) and further categorised by intervention type and setting. Studies are first summarised and evaluated in detail, after which the evidence is synthesised and conclusions drawn.

PERSON-DELIVERED INTERVENTIONS

Home visits

Fifteen of the 39 identified studies involved home visits. Table 1 summarises the characteristics of these studies. Table 2 provides further details of the individual studies. Given that the cost, practicality and resources required by such interventions vary widely

depending on who undertakes the home visits, studies are divided into interventions delivered by healthcare professionals, peer supporters and researchers.

Table 2: Home visit study characteristics

Home visit intervention studies										
Authors	**Year**	**Home visitors**	**Other resources**	**N of visits (intervention length)**	**Length of visits**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Corsini et al.	2013	Market researchers	Booklet with guidance around refusal to taste	1 (followed by 2wk intervention period)	NR	Liking & intake of previously disliked vegetable	Vegetable liking & consumption (5-point scale & weight of leftover vegetable)	Liking increased for exposure & exposure + reward groups ($p=0.002$ & $p<0.001$) but no significant difference between CG & IGs for consumption	No further change in liking at 4wks or 3m (p value not reported for between group differences). Consumption increased in exposure + reward and CG groups ($p=0.013$ & $p<0.001$) but not exposure only. (3m)	Not stated
Cravener et al.	2015	Researchers	Vegetable packages, granola bars, sticker incentives	4 (4 wks)	NR	Vegetable intake	Veg & Granola intake (Pre/post taste food weight change)	IG group increased vegetable intake at wk 2 compared to CG ($p<0.01$) but this effect was not sustained to the end of intervention period (4 weeks). Granola intake decreased in IG relative to CG at wks 2 & 3 but NS difference at Wk4.	No LTFU	Behavioural economics
Crespo et al.	2012	Promotoras	4 phone calls	7 (7 months)	1.5 hours	Healthy eating & weight gain prevention in children	Adiposity (BMI z-score)	No	No (3 years)	SCT (HBM)

Home visit intervention studies										
Authors	**Year**	**Home visitors**	**Other resources**	**N of visits (intervention length)**	**Length of visits**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Haines et al.	2013	'Health educators' (no further description provided)	40 SMS messages, mailed educational materials	4 (6 months)	NR	Family meal frequency	Family meal frequency (FMF question)	No	No LTFU	Not stated
Haire-Joshu et al.	2008	'Parents as teachers' (existing scheme)	Computer tailored nutrition newsletter, sing along storybook	4 (NR)	1 hour	Parents' & children's FV intake	Child & parents' FV intake (Saint Louis University for Kids Food Frequency Questionnaire)	Increase in F intake in parents & normal weight children only (p = 0.04 & 0.05). No increase in V intake.	No LTFU	SCT; Ecological framework; Reciprocal determinism
Harvey-Berino & Rourke	2003	Peer educators	n/a	11 (16 wks)	NR	Childhood obesity reduction	Adiposity (Weight fo height z-score)	No (p=0.06)	No LTFU	Not stated
Horton et al.	2013	Promotoras	3 phone calls, 'telenovela' DVD, family manual	11 (4 months)	1.5 hours	Childhood obesity risk behaviours	Child FV intake & variety (National Cancer Institute Food Attitudes & Behaviour Survey)	No	No LTFU	Not stated
Leung et al.	2015	'Parent ambassadors' (local volunteer parents)	Illustration booklet	20 (NR)	1 - 2 hours	Feeding practices	Feeding practices (Hong Kong Parent Feeding Questionnaire, HKPFQ)	IG scored higher on HKPFQ than CG indicating improved practices, but practices not specified (p<0.001)	No LTFU	Not stated

Home visit intervention studies										
Authors	**Year**	**Home visitors**	**Other resources**	**N of visits (intervention length)**	**Length of visits**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
McGowan et al.	2013	Researchers	n/a	4 (8 wks)	NR	Healthy feeding habits	Automaticity (habit strength related to feeding habits) (Self-Report Habit Index)	IG parents had higher scores for giving the child 5 FV per day ($p<0.01$)	No LTFU	Habit theory
Rodearmel et al.	2006	Researchers	Educational logs	1 (13 wks)	NR	Weight gain reduction in children & parents	Adiposity (BMI for adults, BMI-for-age change for children)	BMI lower in IG than CG in children & adults (difference -1.12 & -0.58, $p=0.03$ & $p<0.001$)	No LTFU	Not stated
Vitolo et al.	2012	Undergraduate students	Leaflet depicting 'healthy meal' image	10 (12 months)	1 hour	Infants' consumption of energy dense food	Consumption of sugar-dense & lipid-dense food (Food frequency questionnaire)	IG infants consumed fewer sugar-dense & lipid-dense foods ($p<0.05$)	Unclear as different measures reported (~3 years)	Not stated
Wardle et al.	2003	Researchers	n/a	1 (followed by 2wk intervention period)	NR	Liking & intake of previously disliked vegetable	Vegetable liking & consumption (3-point scale & weight of leftover vegetable)	Child liking, preference ranking & consumption for target vegetable increased in exposure group & increased by more than the other groups ($p<0.001$ for liking & preference, $p<0.01$ for consumption)	No LTFU	Not stated

Home visit intervention studies										
Authors	**Year**	**Home visitors**	**Other resources**	**N of visits (intervention length)**	**Length of visits**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Watt et al.	2009	Local mothers	n/a	21 (9 months)	1 hour	Infant feeding practices at 12m	Vitamin C intake (24-hr multiple pass recall method)	No	No (4 years)	Social support theoretical model
Wen et al.	2012	Community nurses	n/a	8 (2 years)	1 - 2 hours	Infant feeding practices/family nutrition	Adiposity (BMI)	BMI lower in IG (p=0.04)	No (3 years)	Not stated
Wieland et al.	2013	'Family health promotors' from a community based participatory research partnership	Up to 12 phone calls in the 2nd 6 months of the intervention	12 (6 focus on healthful eating) (6 months)	30 - 90 minutes	Parents' & adolescents dietary quality	Dietary quality (Healthy Eating Index, HEI/24 hr recall)	Adults in IG had higher HEI score than CG at 12m, but adolescents did not	No LTFU	SCT

IPI = Immediately post-intervention
LTFU = Long Term Follow Up
NR = Not reported
SCT = Social Cognitive Theory
HBM = Health Belief Model
Promotoras = Community members trained to deliver health education
*If a PO is not explicitly stated in the study, it is selected according to the aims & objectives of the study. Where the study involves other health behaviours, the primary eating-related outcome & behaviour has been selected.

Home visits by healthcare professionals

The *Healthy Beginnings Trial* (Wen, Baur, Simpson, et al., 2012) describes a longitudinal intervention in which parents were recruited and visited by a nurse in late pregnancy and then at other time-points coinciding with developmental milestones. Key messages included *breast is best, no solids until 6m, variety of FV every day, only water in cup,* and *active family.* No explicit theoretical rationale was provided for this intervention; instead it drew on evidence-based information and guidelines. Intervention reporting for this study is of high quality, with a separate paper reporting the study design and considerable transparency around eligibility, retention and long term follow-up (LTFU). Participants represent a wider socio-economic range than most other studies reviewed. At the end of the intervention, children in the Intervention Group (IG) had a lower BMI than the Control/ Comparison Group (CG) (difference of 0.29 kg/m^2, $p = 0.04$), although both were within the healthy range defined by the authors. IG parents also reported that their children were more likely to eat one or more servings of vegetables a day, were less likely to be given food as a reward and were less likely to eat meals in front of the television. Mothers in the IG were also more likely to eat more than two servings of vegetables a day, suggesting possible mechanisms for the effects of the intervention on children (i.e. modelling & exposure). This study was unique in attempting a cost-effectiveness analysis (Wen, Baur, Rissel, et al., 2012). It also reported one of the longest follow-up periods (3 years post-intervention); however, all significant differences between groups had disappeared by the time children were 5 years old (Wen, Baur, Simpson et al., 2015).

Healthy Habits, Happy Homes (Haines et al., 2013) involved home visits and phone calls delivered by 'health educators', accompanied by educational materials. Motivational Interviewing was employed but no further theoretical detail was provided. The intervention,

aimed at families with 2- to 5-year-olds, focused on routine setting, predominantly through reduction of television viewing and increasing family meal frequency (FMF). Despite apparent success on some measures (reduction of TV time; lower BMI in IG), no between-group differences were seen in FMF. The authors noted that the high baseline FMF in both groups, and/or the imprecise wording ('at least some of the family ate together') may have contributed to a ceiling effect on this measure. Nevertheless, it seems unlikely that FMF acted as a mechanism for BMI reduction in this study.

The *Healthy Immigrant Families* study (Wieland et al., 2017) drew on Social Cognitive Theory (SCT) and recruited families to an intervention involving 12 home visits by family health promotors, six of which focused on healthy eating. Families comprised at least one adult and one adolescent (10 – 18 years). Adults (but not adolescents) in the IG showed an increase in *Healthy Eating Index* scores after 12 months compared to a CG, and after 24 months compared to baseline. Changes were not reflected in other behavioural or physiological measures collected in both groups (BMI, weight, waist circumference, blood pressure).

Home visits by peer educators

The *High 5 for Kids* programme (Haire-Joshu et al., 2008) involved visits focusing on knowledge, modelling of FV intake, non-coercive feeding practices and FV availability. This intervention drew on a 'combination of theoretical models', including SCT, an ecological framework and reciprocal determinism. Educators and families were participants in an existing parenting and development programme in the U.S, '*Parents as Teachers*' (PAT). Thus, the IG received PAT and High 5 for Kids, while control participants received PAT only, providing a more stringent control condition than studies with limited interaction with the CG. Parents in the IG significantly increased their intake of fruit but not vegetables,

although effects were small (parental fruit intake was, on average, 0.16 servings higher in the IG than in CG); had intention to treat analysis been employed, such small effects might not have reached significance. The change in parents' FV intake predicted the change in child FV consumption (an increase of 1 serving for parents led to an increase of 0. 5 servings for children), suggesting modelling or availability as mechanisms supporting the efficacy of such interventions. However, parents did not report increased modelling; rather, they reported increased coercive feeding practices. Importantly, intervention effectiveness varied according to child weight status; FV servings increased for healthy weight but not overweight children. Families of overweight children may need more intensive or longer-lasting interventions to effectively change feeding practices and eating behaviours.

Harvey-Berino and Rourke (2003) also based their peer-educator programme on a pre-existing general parent education program, *Women, Infants and Children (WIC)*, in the US. While the existing program was delivered with the CG, the IG received an adapted program in which all sessions were related to healthy eating. Although there was some focus on the concept of parents acting as mediators to change, there was no expansion of the theoretical underpinnings of the intervention. Forty three mother-child dyads participated in this pilot study; only pre- and post-intervention data were collected. The authors noted trends towards significance in between-group differences on weight to height z-scores and energy intake (with decreases in IG and increases in CG; $p=0.06$ for both). IG mothers reported significantly lower use of restrictive feeding practices than mothers in the CG group. Although this was one of the study's aims, the authors appear unclear about whether this represents a positive change. No other differences were detected on a range of outcome measures (diet, physical activity, self-efficacy, intentions, other elements of child feeding questionnaire) but the authors concluded that the pilot study showed promise and warranted

further research. To our knowledge, a larger evaluation of the intervention has not yet been published.

The *Healthy Start Visit Program* (Leung, Tsang, & Heung, 2015) aimed to improve parents' feeding practices as part of a wider program addressing health and well-being, which specifically targeted disadvantaged parents. 'Parent ambassadors' (local volunteer parents) were given 50 hours of training to deliver the intervention by psychologists and social workers. One intervention session exclusively covered healthy diet and mealtime routines (Leung, Tsang & Heung, 2013). The theoretical framework is not stated in the paper for either the intervention as a whole or the healthy eating section. Participants in the CG attended a series of parent talks. Although no follow-up data are provided, participants in the IG had improved their feeding practices to a greater extent than those in the CG immediately post-intervention. The authors also present an interesting description of their completers and non-completers, showing that non-completers were more likely to be divorced, on lower incomes and receiving social-welfare benefits.

The '*Entre familia: reflejos de salud'* study (Horton et al., 2013) employed *promotoras* (typically Hispanic or Latino community members trained to provide health education) to deliver a healthy eating intervention to families living on the US/Mexico border. Formative work (focus groups and depth interviews with the target population) were referenced but no psychological theory was described as background to intervention design. Weekly fast food intake decreased in the IG, and a 'trend' towards an increase in monthly FV variety was reported but there were no between-group differences on other outcome measures (FV consumption, Sugar-sweetened Beverage intake). A dose-response relationship was present, such that children who had more contact with the *promotora* showed greater FV intake. A process evaluation (Schmied, Parada, Horton, Ibarra, & Ayala, 2015) indicated that number

of visits and visit length predicted *lower* use of strategies to decrease fat intake, while sharing the manual with friends predicted higher use of strategies to increase fibre intake, which the authors attribute to over-reliance on the *promotora* and social support respectively. Greater satisfaction with the DVD (which could not be shared as it was taken away after each session) also predicted use of fibre-increase strategies. Retention rates and fidelity were high (almost 90% of families received the 11 planned visits), and the evaluation indicated high levels of satisfaction with the programme. Limitations of the study include the convenience sampling method (participants were likely to be highly motivated), self-report methodology, the possibility of contamination (IG members may have shared the manual with CG members) and the lack of follow-up data.

In the *Aventuras Para Niños* study (Crespo et al., 2012), mothers were allocated to a 'micro-intervention' (delivered by *promotora* in the family home), a 'macro-intervention' (delivered through school and community), 'micro + macro', or control (data collection only) conditions. This study drew on SCT (specifically, the Health Belief Model). The authors found no significant reduction in BMI z-scores for any of the groups over time. The micro-intervention (the condition meeting inclusion criteria for this review) had an initial effect on parenting styles; mothers in this group showed the largest increase in use of positive reinforcement. However, by the 2-year follow-up, the micro+macro group were reporting more positive reinforcement than other groups. Both these groups demonstrated a decrease in controlling strategies, indicating that home visits may be responsible for this.

Watt et al. (2009) used a 'social support theoretical model' and trained local mothers to deliver a home-visiting intervention covering exclusive breastfeeding, introducing solids, appropriate food and drink and when to cease bottle-feeding. New mothers, recruited through baby clinics, received four weekly followed by nine monthly visits, while CG

participants received standard care from General Practitioners and Health Visitors. No between-group differences were detected in intake of Vitamin C or any other micro or macro nutrients at post-intervention or 6m follow-up. At post-intervention, IG children were less likely to be given goats or soya milk, more likely to have 3 solid meals a day and more likely to consume apples, pears, boiled potatoes and carrots. At 6m FU, they were less likely to be using a feeding bottle, and more likely to consume pears, potatoes and (somewhat surprisingly) chips. There were no differences between groups in terms of mothers' FV intake. Further follow up was conducted at 4 years (Scheiwe, Hardy & Watt, 2010), when the authors found no significant differences on their primary outcome measures. IG children were more likely to be given unsweetened fruit juice and less likely to drink squash and remained less likely to use a feeding beaker or bottle, or to take a bottle to bed after their 4th birthday. The authors concluded that the intervention had 'limited long term impact' and suggest that 'improving knowledge might not be enough to achieve behavioural changes' (p.334).

Home visits by researchers (researcher-led interventions)

Rodearmel et al. (2006) evaluated a dietary and physical activity intervention delivered through home visits by researchers. IG parent-child dyads (and other family members should they wish to take part) were asked to consume two servings of breakfast cereal per day (one for breakfast and another for a snack). No psychological rationale was provided for this, rather a biological explanation; that eating breakfast is consistently associated with successful weight management (although this depends on breakfast content, Spence, 2017), while cereal consumption can aid weight loss. The authors did not specify the cereal type, but did state that the manufacturer *Kelloggs* provided it. The IG was also asked to increase their daily step count by 2000. The study targeted families with children whose percentage BMI for age ≥ 85th centile. Although the IG did not achieve two portions of cereal a day, they consumed a

mean of 1 portion, double that of the CG (who participated only in data collection). There was no pre-/post-intervention change in self-reported energy intake but IG parents and children had lower % BMI and % body fat (but not weight) than CG participants post-intervention. The IG also significantly increased their daily step count, which is the more likely explanation for their health improvements. Furthermore, this line of research should be pursued with caution due to the high sugar content of many types of cereal.

The *Healthy Feeding Habits* intervention was assessed in an RCT with a no-treatment control group (McGowan et al., 2013). Parents of 2- to 6-year-olds worked through an 'intervention booklet' during researcher visits. The intervention focused on 'habit-theory' and habit forming around various feeding domains, plus self-monitoring and goal setting. At the end of the intervention, participants reported higher 'automaticity' (a measure of habit strength) and greater child fruit and vegetable intake (increases of 0.5 and 0.8 servings respectively). No follow-up data were reported. A second paper by the same group (Gardner, Sheals, Wardle, & McGowan, 2014) concluded that the habit-forming intervention was acceptable to participants, as reflected by the high retention rate (84%).

Vitolo, Bortolini, Campagnolo, & Hoffman (2012) evaluated an intervention delivered to new mothers through home visits by undergraduate students. Content focused on the 'Ten Steps to Healthy Eating' (Brazilian Ministry of Health, 2002) but no further theoretical rationale was provided. Six months post-intervention (children were aged 12-16 months), there were no differences between-groups in the number of children who were overweight but IG children were less likely to consume sweets, soft drinks, honey, cookies, chocolate and salty snacks. Similarly, at 3- to 4-years old, the IG had a lower prevalence of 'poor diet' (as measured by the Healthy Eating Index, Kennedy, Ohls, Carlson & Fleming, 1995) than the CG (Vitolo, Rauber, Campagnolo, Feldens, & Hoffman, 2010). BMI was not reported at follow-up so no conclusions can be drawn regarding obesity prevention.

Home visits by researchers (parent-led interventions)

Wardle et al. (2003) trialled a parent-led intervention in which parents of 2- to 6-year-olds were allocated to one of three conditions; exposure, information or control. This study did not provide a psychological theoretical framework, instead drawing from the evidence base around exposure to healthy foods as a predictor of healthy eating. The exposure group was asked to offer children a target vegetable (chosen for 'moderate' disliking by the child) every day for 14 days. The information group was given nutritional information in printed format and the CG was asked only to attend in-home data collection appointments. Using per-protocol analysis (i.e. including only those participants who followed the study protocol in analyses), the hypothesised effects were supported; liking, preference ranking and consumption of the target vegetable all increased in the exposure group. Although the CG also showed increased liking for the target vegetable, only the exposure group demonstrated a significant positive change on all three outcome measures. However, with ITT analysis, the increases in preference ranking and consumption in the exposure group were no longer significant, highlighting the challenge of persuading parents to engage in and persist with exposure strategies. This was also highlighted in post-intervention qualitative work, where several parents complained about the duration of the exposure period.

Another exposure-based intervention (Corsini, Slater, Harrison, Cooke, & Cox, 2013) employed a market research company to support parents in delivering the intervention. Parents who stated that they found it difficult to persuade their 4- to 6-year-olds to eat vegetables were randomly assigned to exposure, exposure + reward or control groups. Both intervention groups exposed children to a target vegetable (disliked at baseline) every day for 14 days. In the exposure + reward group, parents also gave children a sticker after tasting (children could choose a 'yummy', 'okay' or 'yucky' face sticker). Liking of the vegetable

increased equally in the two exposure groups but not in the CG. Surprisingly, consumption of the vegetable increased in all three groups. The authors attribute this finding to demand characteristics, emphasising the importance of an authentic control group. Moreover, only children who achieved 9 or more exposures (79% of the exposure group, 60% of the exposure + reward group) were included in analyses. Fidelity of the intervention was therefore not fully tested. The authors acknowledge that intensive repeated exposure may be burdensome for many parents and that distributed exposure over longer periods might be more feasible.

Cravener et al. (2015) also used home visits by researchers to support a 4-week parent-led intervention based on behavioural economics. Participants were parents of pre-school children who consumed fewer than two vegetable portions per day and were considered at risk for obesity. After a baseline period in which vegetable consumption was measured, the IG were given vegetables in packaging with cartoon characters, stickers to use as incentives for consumption and unbranded granola bars. At snack times, children were offered the vegetables and told that, if they waited 5 minutes, they could alternatively have a granola bar. If children requested the bar but started to eat the vegetables while waiting, the granola bar option was removed on that occasion. However, as parents were allowed to offer snacks and children were allowed to request these as often as they liked, children could presumably request the granola bar immediately after consuming the vegetables. IG parents were also given some instructions around feeding practices (e.g. no pressuring, bribing, non-study rewards or pleading). CG participants were provided with the same vegetables and bars but with plain packaging and no instructions about how to offer snacks. IG children's vegetable intake increased post-intervention by approximately 1 serving per day, compared to no increase in the CG. Both groups' liking for vegetables increased over time, likely due to exposure. Because of the complex nature of this intervention, the unclear purpose of the CG (i.e. to control for feeding practices, branding, incentives or both of these) and confusion

around when children were allowed to consume the granola bar, it is difficult to determine which elements of the intervention might have been effective. The sample size was also very small (N=24). A larger sample and more precise control groups would be required to confirm the benefits of this approach to increasing vegetable intake.

Telephone-based interventions

Three studies involved interventions primarily delivered through telephone calls. Two studies targeted FV intake in normal weight pre-school children, while one study targeted children with obesity. Table 1 summarises the characteristics of the telephone interventions, while Table 3 provides details of individual studies.

Table 3: Telephone intervention study characteristics

Telephone intervention studies										
Authors	**Year**	**Callers**	**Other resources**	**N of calls (intervention length)**	**Call length**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU?**	**Theoretical framework**
Makert et al.	2014	Trained prevention managers	Newsletter	14 (12 months)	20-30 minutes	Child obesity prevention	Child adiposity (BMI-SDS)	More of the IG reduced BMI-SDS by ≥ 0.2 than CG (P=0.03 with PPA only)	No LTFU	Not stated
Tabak et al.	2012	Dieticians	Newsletter	2 (4 months)	34 minutes	Pre-school children's vegetable intake	Child vegetable intake (Block Kids Food Frequency Questionnaire)	No	No LTFU	SCT
Wyse et al.	2012	'Experienced health interviewers' (no further information)	Guidebook, meal planner, cookbooks, water bottle	4 (4wk)	30 minutes	Home food environment associated with children's FV consumption	FV intake (Children's Dietary Questionnaire)	FV scores higher in IG than CG at 2m with ITT (p=0.008)	FV scores higher in IG than CG at 6m with PPA (p=0.021) and at 12m with ITT (p<0.001)	Conceptual model of family-based intervention behaviour change techniques

IPI = Immediately post-intervention

*If a PO is not explicitly stated in the study, it is selected according to the aims & objectives of the study. Where the study involves other health behaviours, the primary eating-related outcome & behaviour have been selected.

PPA = Per protocol analysis

The widely-reported *Healthy Habits* intervention used an RCT design to test the efficacy of a telephone-based intervention to increase preschoolers' FV intake (Wolfenden et al., 2014; Wyse, Campbell, Brennan, & Wolfenden, 2014; Wyse, Wolfenden, & Bisquera, 2015; Wyse et al., 2012; Wyse et al., 2010). Telephone calls were delivered by trained and supervised telephonists using computer-assisted telephone calls (CATI). The intervention drew on Golan & Weizman's conceptual model of family-based interventions (Golan & Weizman, 2001) and used a number of behaviour change techniques (e.g. goal-setting). Interviewers were discouraged from deviating from the script to ensure standardisation. The CG received one booklet on dietary guidelines through the post. The study was followed up at 6, 12 and 18 months (5, 11 and 17 months after completion of intervention, respectively). Both parent and child FV intake increased as a result of the intervention. FV increase was significantly higher for children in the IG than those in the CG one month post-intervention. At 6 months, this difference remained significant in analyses using all available data and per-protocol analyses, and approached significance with sensitivity analysis using baseline observation carried forward (BOCF) ($p=0.069$). Effect sizes are not reported, but the main analysis shows that the IG increased by 2 points at both 1 month and 6 month assessments; each point denoted an additional portion of FV or a newly-tried FV in the past 24 hours, suggesting a meaningful change. However, mean scores for both groups at baseline were > 14, indicating that children were already meeting Australian Dietary Guidelines. Furthermore, parents in the sample were more educated and had a higher household income than a random sample of parents from the region, indicating that the intervention did not reach the families most in need. Nevertheless, subgroup analysis indicated that the intervention was effective for children in the sample who were not reaching the recommended daily allowance at baseline, and that these effects lasted for at least 12m (although the between-group difference was no longer significant at 18m),

suggesting that there would be merit in re-testing the intervention with a disadvantaged sample.

Tabak, Tate, Stevens, Siega-Riz and Ward (2012) evaluated an intervention comprising two motivational telephone calls and four newsletters. Parents of 2- to 5-year-olds were asked to select one of four target areas: picky eating, vegetable availability, modelling and family meal frequency. The authors stated that these areas were specifically chosen because of their relevance to Social Cognitive Theory. No participant chose modelling or family meal frequency, suggesting that they did not see a need for improvement in these areas or consider such improvements to be important. Increased vegetable availability was detected post-intervention in the IG (although group was not a significant predictor of availability, there was a significant group difference in change in availability), along with increased offering of FV as a snack and decreased cooking of separate meals due to the child demanding something different. There were no significant differences between the IG and CG groups' vegetable intake immediately post-intervention; it is feasible that more time may have been needed for changes in parental behaviour to translate into changes in child intake. No evidence of any dose-dependent effects was seen, although the study had a very small sample and was underpowered. The authors acknowledge that their sample was also relatively high in socio-economic status and that parents' reporting of children's diets might have been inaccurate due to the time children spent in childcare. However, the finding of effects within such a small sample indicates that the intervention warrants further investigation.

The *Telephone-Based Adiposity Prevention for Families with Overweight Children (TAFF)* study (Markert et al., 2014) also used CATI and supporting printed material (a newsletter delivered by post or email). This obesity prevention intervention focused on medical aspects of obesity, dietary habits, eating behaviour, physical activity, leisure activity, psychological

support and stress. Its design drew on therapy approaches (specifically family therapy and solution-focused systemic therapy) but the authors did not expand on the theoretical rationale beyond this. Parent-child triads were recruited where young people were aged between 4 and 17 years old and had a BMI-SDS $\geq 90^{th}$ centile. Strengths of this study included its duration and the pragmatic nature of recruitment (through Cresnet, a German association of independent paediatricians, with whom participants were registered). Unfortunately, a significant intervention effect identified with per-protocol analysis disappeared with ITT analysis. The authors also note that most young people ≥ 10 years old (who were interviewed separately from their parents) claimed to have 'very good eating habits' at baseline, which, given the children's adiposity, raises questions around the validity of self-report dietary measures in young people. Also of concern, of 3387 eligible families contacted by paediatricians, only 13% expressed an interest in the study, and 9% consented to take part. Coupled with the high attrition rate within the IG (63%, compared to 22% in the CG), the intervention clearly failed to appeal to families. Predictors of non-participation included believing that the family already practiced a healthy lifestyle, being unwilling to make lifestyle changes, greater subjective physical wellbeing and eating irregular breakfasts (Alff et al., 2012). The authors concluded that 'even a low-threshold intervention program does not reach the families who really need it' (p.1). A further limitation is that data was collected immediately post-intervention with, to our knowledge, no subsequent follow up. Given the small effect of the intervention and the fact that most other studies see a decrease in effects over time, it is unlikely that this telephone intervention would achieve long-term benefits.

INFORMATION/TECHNOLOGY-DELIVERED INTERVENTIONS

Printed materials

Nine studies involved interventions delivered through printed materials alone. Studies were included in this section of the review if printed information was the active intervention under evaluation; studies using printed information as the control condition are reported elsewhere. Three studies included more than one intervention; in each case, only the printed materials condition qualified for inclusion in the review. Table 1 provides a summary of the studies delivered through printed materials, while Table 4 provides details of individual studies.

Table 4: Printed materials intervention study characteristics

Printed information intervention studies								
Authors	**Year**	**Type of information**	**Correspondence N (intervention length when N>1)**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Croker et al.	2012	Personalised 'family information pack'	1	Children's unhealthy eating	None identified as primary. (SR BMI, 4-food frequency questionnaire to calculate over all healthy eating score)	No (data collected 6m PI)	No additional LTFU	Not stated
Estabrooks et al.	2009	Workbook with 'targeted intervention days'	1	Healthy lifestyle behaviours	Child adiposity (BMI z-score)	No change at 6m post-baseline (unclear how long intervention lasts)	Within subjects BMI reduction in workbook condition ($p<0.05$)but no between groups change (12m)	Socio-ecologic theory
Gholami et al.	2014	Leaflet	1	Mothers' self-regulatory skills for providing vegetables to children	Child vegetable intake (Study-specific question)	Vegetable intake higher in IG than CG 2-weeks ($p=0.04$)	No (3m)	Behaviour change theory
Hart et al.	2016	2 booklets, poster, children's book, accompanying website	1	Healthy eating, weight management and body satisfaction in childhood	Child adiposity, parental knowledge, family meal characteristics, parental feeding practices (various Likert scale measures, child BMI-z scores)	Yes, but not for workbook condition	No (6 wks)	Not stated

Printed information intervention studies								
Authors	**Year**	**Type of information**	**Correspondence N (intervention length when N>1)**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Heath et al.	2014	Picture books	1	Child's willingness to look at, taste and consume vegetables	Child's visual preference for target vegetable Child's willingness to taste target vegetable Child's intake of target vegetable (child offered choice of FV in all cases)	Toddlers looked at target vegetable for longer than control ($p<0.001$) No significant difference between willingness to taste target vs control vegetable Toddlers consumed more of target than control vegetable ($p=0.016$)	No LTFU	Not stated
Houston-Price et al.	2009	Picture books	1	Child's willingness to taste	Child's willingness to taste (child offered choice of FV)	No	No LTFU	Not stated
Looney et al.	2014	Monthly newsletter	6 (6 months)	Childhood obesity/overweight	Child adiposity (BMI z-score)	BMI z-score reduced for whole sample ($p<0.036$)	No LTFU	Not stated
Pearson et al.	2010	Separate newsletters for parents and children	2 each (1 month)	FV consumption in adolescents	FV consumption (previously validated youth FFQ)	IG adolescents reported higher fruit ($p<0.01$) and vegetable ($p<0.05$) consumption than CG	IG adolescents reported higher fruit ($p<0.01$) and vegetable ($p<0.05$) consumption than CG (6wks)	Behavioral choice theory; SCT

Printed information intervention studies								
Authors	**Year**	**Type of information**	**Correspondence N (intervention length when N>1)**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Wrieden & Levy	2016	'Smart swaps' information pack	1	Purchasing behaviour of children's snacks	Self-reported swaps	IG reported more swaps to lower-fat dairy products, lower-sugar drinks and lower-sugar cereal ($p<0.001$, $p=0.01$, $p=0.009$)	No LTFU	Not stated

IPI = Immediately post-intervention
*If a PO is not explicitly stated in the study, it is selected according to the aims & objectives of the study. Where the study involves other health behaviours, the primary eating outcome & behaviour have been selected.
FFQ = Food frequency questionnaire
SCT = Social Cognitive Theory

Change for Life is a UK-based national obesity prevention program. One element of the campaign is an information pack for families, which was evaluated with parents of 5- to 11-year-olds (Croker, Lucas, & Wardle, 2012). After completing a baseline questionnaire, parents in the IG were sent standard *Change for Life* materials and a 'How are the Kids?' questionnaire, on completion of which they received a personalised family information pack. The CG received 'standard exposure to healthy lifestyle messages'. Due to extremely low response rates to the second questionnaire (of the 3774 families who signed up, 98 returned the questionnaire, only three of whom were in the CG), the protocol was adjusted; parents who did not complete the questionnaire were sent an un-personalised family information pack. At a 6-month follow-up, responses were obtained from 29% and 46% of the original samples in the IG and CG, respectively. No significant changes from pre- to post-intervention were found on any measure (monitoring, modelling, child FV intake, child sugar intake, PA duration, snacking and regular mealtimes) and parents in the IG placed *less* importance on physical activity than those in the CG. The authors provide a transparent and detailed list of potential explanations for the lack of success, including lack of theoretical basis, lack of clarity over the target audience (children or parents), targeting too many complex behaviours and CG contamination. For example, the authors acknowledge that the lack of focus to the intervention was demonstrated by the failure to refer to 'obesity' in the materials used, despite obesity prevention being the primary aim. Feedback from focus groups also suggested that some parents found the materials 'patronising' or 'unrealistic'.

Wrieden and Levy (2016) evaluated the *Smart Swaps* element of the Change4Life campaign, which focuses on reducing the fat and sugar content of children's snacks through information packs suggesting healthy swaps. As with the Change4Life study described above, the *Smart*

Swaps study did not report any theoretical rationale. Self-reported purchasing behaviour indicated that parents in the IG implemented more 'smart swaps' than those in the CG one and two weeks after receiving the packs, but no longer-term follow-up data were collected. Further limitations were that IG and CG participants lived in different geographical regions, that participants were not randomly allocated to groups, and that many of the CG had heard of the campaign (13% had signed up to it). The low retention rate in the IG (55%) further limits the conclusions that can be drawn about behaviour change within the whole sample.

Estabrooks et al. (2009) ran a study with three conditions, one of which was delivered in the home, satisfying criteria for inclusion in this review. Parent-child dyads were recruited when children were aged 8 to 12 years and $\geq 85^{th}$ percentile in BMI. Parents were provided with Family Connections workbooks, including 'intervention homework assignments'. The intervention was based on Golan and Weizman's model which purports that parents are the agent of children's eating behaviour change (Golan & Weizman, 2001). Results were inconsistent: children showed a within-group decrease in BMI z-scores at 12-month follow up (but not at 6 months) but there were no between-group differences. The study was also underpowered due to the high attrition rates, raising the possibility of a Type I error.

Pearson, Atkin, Biddle, & Gorely (2010) carried out a newsletter-based intervention targeting adolescent children (12-14 years), drawing on 'Behavioural Choice Theory' and Social Cognitive Theory. The adolescents' newsletters targeted normative beliefs, health and nutritional knowledge, aiming to increase FV preferences and 'improve behavioural skills and healthy eating' (p.877). The parents' newsletters targeted nutritional knowledge, parents' FV intake and FV accessibility and availability. Post-intervention, parents and adolescents in the IG reported increased consumption of fruits and vegetables; parents also reported increased availability and accessibility. Results appeared to be robust and consistent with

medium-large effect sizes ($\eta^2 = 0.08 – 0.32$ for the above findings), most likely due to the intervention's basis in theory, and the provision of targeted messaging for parents and children. However, the sample was mostly of relatively high social-economic status, and desirability may have played a role in responses in this study. Follow-up data collected 6-weeks post intervention were consistent with initial findings; whether effects are maintained in the longer-term remains unknown. Nevertheless, the promising results warrant a larger randomised controlled trial, which could also explore whether higher doses are able to maintain effects.

The *Confident Body, Confident Child (CBCC)* programme (Hart, Damiano, & Paxton, 2016) aims to change parenting behaviours and strategies around food. Resources consist of booklets (one on parenting strategies, another for extended family members), a "Do's and Don'ts" poster, an evidence-based children's book with messages about appearance and self-worth, and an associated *CBCC* website. The evaluation involved two intervention groups, both of whom received the *CBCC* materials; one group additionally participated in a parenting workshop. There were two control groups: nutritional information and wait-list. The IG who took part in the workshop demonstrated the greatest behaviour change, suggesting limitations to the benefits of simply receiving information booklets. However, some outcome measures demonstrated improvement in both IGs, with no between-group differences (e.g. knowledge, parenting intention, weight restriction), while others showed equivalent benefits in all groups other than the wait-list CG (e.g. instrumental feeding, emotional feeding, pushing to eat). Thus, the nature and intensity of the intervention appears to matter more for some behavioural outcomes than for others. The study acknowledges the difficulties around self-report measures and the high socio-economic status of participants. To enable parents who lived further away from the study centre to participate, all potential participants were asked whether they could attend the workshop, and responses were taken

into account when allocating participants to groups (i.e. those who could not attend were not allocated to the workshop condition). Steps were taken to ensure even distribution and attrition rates were not noticeably larger in any group (statistical differences not reported). However, by attempting to be inclusive, the authors may have inadvertently assigned more engaged participants, willing to travel to the workshops, to the IG that participated in these. Nevertheless, the *CBCC* intervention was evidence-based and transparently reported; future work could address the necessity of the workshop component to the intervention.

Looney and Raynor (2014) compared outcomes between a group who received printed materials alone versus groups who received newsletters alongside higher intensity interventions (regular growth monitoring with or without counselling). No theoretical rationale was explicitly mentioned. Children all had a BMI z score $\geq 85^{th}$ centile at baseline. All groups showed a decrease in BMI z-score, but effect sizes grew as intervention intensity increased. Sugar-sweetened beverage consumption also decreased over time but no group effects or effect sizes were reported. No changes were seen on other outcome variables (FV intake, moderate-to-vigorous physical activity total energy intake, percentage energy from fat). Because there was no 'inactive' control group, it is impossible to ascertain whether the changes seen were due to participation in the study; this highlights the need for a proper control condition when comparing interventions.

Gholami, Wiedemann, Knoll, & Schwarzer (2015) investigated the efficacy of a 'theory-based' leaflet, targeted at mothers and aiming to increase their daughters' (aged 6 – 11 years) vegetable intake. Little information or theoretical explanation is given about leaflet contents other than that they drew on Michie et al.'s (2011) behaviour change techniques. Although increased vegetable intake was reported in the IG compared to the CG two weeks post-intervention, the difference had disappeared by three months.

Houston-Price, Butler and Shiba (2009) introduced printed information into the family home through the novel use of picture books, with the aim of supporting healthy eating through exposure to pictures of foods. This study aimed to build on the evidence base indicating that exposure to new foods can increase children's willingness to try them but did not cite any specific underpinning theory behind intervention design. Families with toddlers received one of two books through the post containing familiar and unfamiliar fruits and vegetables. 'Willingness to taste' tests were conducted after 14 consecutive days of reading the books. The study was controlled through a within-subjects design; each food served as an exposed or non-exposed food for different children, controlling for any preferences for specific foods. A main effect of familiarity was seen, along with an interaction between familiarity and exposure; children were more likely to try unfamiliar foods that they had been exposed to but less likely to try familiar foods they had been exposed to.

Heath, Houston-Price and Kennedy (2014) built on these findings with a further experiment addressing the effects of picture-book exposure on willingness to taste vegetables, due to the 'particular challenge' that vegetables present for healthy eating interventions. Toddlers were randomised to receive a picture book in the post about a liked, disliked, or unfamiliar vegetable, which parents were asked to read with the child for 5 minutes every day for two weeks. No significant differences in willingness to taste target versus control vegetables were seen in any IG. However, children consumed more of the target vegetable than the corresponding control vegetable when foods were initially unfamiliar. The authors suggest that this may be due to the 'learned safety' of exposed foods, or to the lack of 'pre-existing schemas' for unfamiliar foods. They also discuss the importance of parents' role in reading the book with the child, emphasising the need for a 'positive attitude' and citing an example of a parent who said 'Yuk!' at the end of every page, whose child did not show any positive exposure effects.

Game-based interventions

Video games have also been investigated as vehicles for delivering healthy eating and weight management interventions to adolescents. Two studies used non-active video-games (Non-AVG) as engaging ways to promote dietary change. Two further studies involved active video-games (AVG), which encourage physical activity by requiring active participation for success; these are included in this review as they cite decreased snacking as a secondary aim. Table 1 summarises these studies' characteristics, while Table 5 provides details of individual studies.

Table 5: Video gaming intervention study characteristics

Video game interventions								
Authors	**Year**	**AVG/ Non-AVG**	**Session N**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Baranowski et al.	2011	Non-AVG	9	Diet and PA	Child FV intake (24hr recall)	IPI and FU not reported separately.	FV intake increased in IG relative to CG (p=0.018) (2m)	SCT; SDT; Persuasion theory
Maddison et al.	2013	AVG	NR	Snacking	BMI	BMI decreased in IG group (p=0.02) but no significant difference for self-reported snacking	No LTFU	Behavioural economic theory
Simons et al.	2015	AVG	NR	Snacking	BMI-SDS	CG decreased BMI-SDS by more than IG (p value not reported)	No (10m)	SDT: TPB
Thompson et al.	2015	Non-AVG	10	Child FV intake	Child FV intake (24hr recall)	FV intake increased in 'Action' IG only (p<0.0001)	FV intake increased in 'Action' IG only (p<0.0001) (3m)	SCT: SDT; Elaboration likelihood model Behavioural inoculation Maintenance theories

IPI = Immediately post-intervention
*If a PO is not explicitly stated in the study, it is selected according to the aims & objectives of the study. Where the study involves other health behaviours, the primary eating outcome & behaviour have been selected.
NR = not reported
AVG = Active Video Game
SCT = Social Cognitive Theory
SDT = Self Determination Theory
TPB = Theory of Planned Behaviour

Non-active video games. Baranowski et al. (2011) investigated the efficacy of a video game as an agent for changing eating behaviour in adolescents aged 10 to 12 years. A CG received 'knowledge-enhancing' materials about healthy eating, including nutrition-based computer games. This was designed to act as a control but to 'meet recruitees' expectations of playing health-related video games' (p.3). The intervention was described as drawing on Social Cognitive Theory (SCT), Self-Determination Theory (SDT) (Deci, 2012) and persuasion models. An increase in FV intake was seen in the IG two months after post-intervention; the effect size was small (Cohen's d = 0.18), equating to an increase of 0.67 portions to a total of 2.15 portions per day, considerably lower than recommended guidelines. However, dietary data collection took place through 24hr dietary recall, the validity of which is often questioned (Ioannidis, 2013). There were no between-group differences on other outcome measures (water intake, physical activity or body composition) and no long-term follow-up data were provided. By the authors' own admission, the study was underpowered and would benefit from replication with a larger sample. It is also worth noting that sedentary behaviour increased in the intervention group (albeit not significantly), raising the possibility that any positive health behaviour changes brought about by non-active video games might be negated by increased screentime.

The same research group also evaluated a video game that encouraged the setting of implementation intentions by 9- to 11-year-old children (Thompson et al., 2015). This also drew on SCT and SDT, as well as an elaboration likelihood model (Petty & Brinol, 2012), 'behavioural inoculation' and maintenance theories. Building on a previous school-based trial of the 'Squire's Quest!' video game (Baranowski et al., 2003), 'Squires Quest II' was developed for home delivery, with a parallel parental component; parents received a relevant

newsletter alongside each of the 10 game episodes. Participants were randomly allocated to one of four groups: Action (goal setting and action intentions, i.e. planning how to achieve goals), Coping (goal setting and coping intentions, i.e. identifying barriers to goals and describing coping strategies), Both Action and Coping, or None. Compared to baseline, the Coping and Action groups showed increased FV intake following the 3-month-long intervention. At the final follow-up, 3 months later, only the Action group maintained the increase; this equated to 0.68 servings per day, almost a 50% increase from baseline. Nevertheless, FV intake for all groups remained well below recommended daily guidelines. The authors noted their surprise in finding that participants in the 'Both' group showed no change in FV intake, and suggested that the cognitive load involved in setting two different types of implementation intention might be too demanding at this age. Again, the study relied on children's self-reported FV intake, which was not compared to parents' reports. Interestingly, a process evaluation showed that, although child participation was consistently high (91% completed all 10 episodes, with no between-group differences), parental involvement varied widely; around a third reported that they had read three or fewer of the 10 newsletters. This is an important finding, given the widely-held assumption that parents are the agent of change in relation to children's eating (Golan, 2006). While an intervention aimed at the child may invoke behaviour change in children's asking behaviour, preferences or willingness to consume FV, parents must facilitate availability and accessibility for these effects to lead to dietary changes. Conclusions about the impact of parents' engagement on the study's outcomes cannot be drawn in this case as the article does not report on many of the secondary outcome measures of interest cited in the original protocol (e.g. accessibility, availability, family barriers to FV, etc.) (Thompson et al., 2012).

Active Video Gaming. Two studies investigated Active Video Gaming (AVG) as a means of weight management. Maddison, Jull, Marsh, Dieito and Mhurchu (2013) recruited

adolescents with overweight or obesity. Participants in the IG reported lower snack consumption but the difference from the CG was not significant. IG participants also reported lower sedentary screentime; these reports were supported by larger decreases in BMI and BMI z-scores among this group (IG BMI difference = -0.24 kg/m^2, IG BMI z-score difference = -0.06).

In a second, similar study (Simons et al., 2015) (also drawing on SDT and the Theory of Planned Behaviour), IG participants reported lower snack consumption than those in the CG; again, the difference was not significant. IG participants also reported lower sedentary screentime and reduced non-active video gaming. Conversely, this study found that CG participants had a greater reduction in BMI-SDS than IG participants (difference = 0.13, NS); the authors attribute the discrepancy to social desirability bias in self-report responses. A process evaluation provided valuable insight into the reasons for participant engagement; the authors found that 25% of the IG did not engage with the active games at all, and noted that enjoyment of the games decreased over time while agreement with the statement 'I'd rather play non-active video games' increased. This suggests that AVG is unlikely, in its current form, to be a broadly-effective weight management tool. However, half of the process evaluation respondents stated their intention to continue using AVG beyond study completion, suggesting that enjoyment was high for some. Despite the mixed findings, the authors suggest that AVG might prove effective among adolescents at risk or already obese (as in Maddison et al.'s, 2013, study) or among less 'excessive' gamers (participants spent > 13 hours per week playing games at baseline), or with a higher 'treatment dose' (i.e. more time on AVG). Given the 'popularity of video gaming among youth', the authors conclude that further research is needed to bring AVGs in line with non-AVGs in terms of fun, attractiveness and sustainability. On the basis of current evidence, however, reduction in snacking is unlikely to underpin the efficacy of AVGs.

mHealth

Mobile health, often referred to as ‘mHealth’ is defined as ‘medical health practice supported by mobile devices’ (e.g. mobile phones, tablets and other wireless technology) (WHO, 2017). Mobile devices are increasingly common in both the developing and developed world, providing an opportunity to deliver convenient and innovative health behaviour change interventions to a wide audience. Seven studies of this kind were identified for the review. Table 1 summarises these studies’ characteristics, while Table 6 provides details of individual studies.

Table 6: mHealth intervention study characteristics

mHealth interventions							
Authors	**Year**	**mHealth type (intervention length)**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Byrd-Bredbenner et al.	2018	Website (12 months)	Healthy home environment	Household food availability Food-related lifestyle practices (measure not named, various questions related to FMF, FV availability etc.)	No	No LTFU	SCT; Social ecological model
Carfora et al.	2016	SMS text message (x 14) (2 weeks)	Adolescent FV intake	Adolescent FV intake (Author-scripted q on FV portions)	Increase FV intake in both Igs as compared to CG ($p=0.001$ for the affective group and $p=0.01$ for the instrumental group as compared to CG).	No LTFU	TPB
Cullen et al.	2013	Website (8 wks)	Adolescent eating behaviour	FV intake (Youth Risk Behavior Survey)	More IG participants reported consuming 3 or more FV portions than CG ($p<0.01$), but not 5 or more	No LTFU	SCT
Cullen et al.	2017	Website (8 wks)	Home food environment & dietary behaviour	Availability of FV and high/low fat foods (author-scripted questionnaire) Child FV intake (Youth Risk Behaviour Survey)	No	No (4m)	Not stated
Knowlden et al.	2015	Website (4 wks)	Childhood obesity prevention	Child FV intake (scale not named but e.g. questions provided)	IG increased FV consumption relative to CG ($p=0.036$)	IG increased FV consumption ($p<0.001$) (12m)	SCT
Nystrom et al.	2015	App (6 months)	Childhood obesity prevention	Body fat (Fat Mass Index, FMI)	No	No LTFU	SCT

mHealth interventions							
Authors	**Year**	**mHealth type (intervention length)**	**Target of intervention**	**Primary outcome (measure)***	**Statistically significant difference shown on primary outcome immediate IPI?**	**Statistically significant difference shown at LTFU? (LTFU period)**	**Theoretical framework**
Sun et al.	2017	Tablet computer-based (8 wks)	Childhood obesity prevention	Child BMI	No	No (6m)	Information Behaviour Model

IPI = Immediately post-intervention
*If a PO is not explicitly stated in the study, it is selected according to the aims & objectives of the study. Where the study involves other health behaviours, the primary eating outcome & behaviour have been selected.
NR = not reported

SCT = Social Cognitive Theory
TPB = Theory of Planned Behaviour

MINISTOP (Nyström et al., 2017) is a smartphone application (app) delivered to parents and designed to prevent obesity in pre-schoolers drawing on Social Cognitive Theory (SCT). The app delivers information, tips and strategies on 12 topics (e.g. healthy foods, breakfast, physical activity), with prompts if parents fail to access the app regularly. It provides weekly graphical feedback based on information provided by parents and, if required, support from a dietician and/or psychologist. Alongside traditional parent-report measures, the study used novel methods of data collection (such as the Tool for Energy Balance in Children, (TECH), Delisle et al., 2015), which estimates dietary intake from photographs of meals taken by parents. Body fatness (Fat Mass Index, FMI) was measured, rather than BMI; the authors suggest that BMI is a poor indicator of body fat. The intervention had no effect on FMI alone, but IG participants increased their 'composite component score' (a summation of FMI, FV intake, sweet intake, sugar-sweetened beverage intake, sedentary time and moderate to vigorous physical activity). Although FMI was the primary outcome measure, the composite score was arguably the more important outcome, given that the study was an obesity *prevention* intervention that recruited children of normal weight (mean weight for age z-score was 0 +/- 1.16 at baseline). Interestingly, the study actively accommodated separated parents, allowing both to participate. The study maintained high levels of engagement (with no report of incentives for retention) and produced promising results. Future work should consider whether FMI is the appropriate primary outcome measure for similar interventions and why this showed no change.

Teen Choice: Food & Fitness is a website designed to promote healthy eating and physical activity in adolescents, also using SCT as a theoretical framework (Cullen, Thompson, Boushey, Konzelman & Chen., 2013). Twelve- to 17-year-olds were randomly allocated to receive details of the intervention website, containing materials about nutrition and physical activity, goal setting, a healthy eating calculator, 12 model video stories, recipes and a blog,

or to receive details of a similar control website. The IG reported an increase in daily vegetable consumption of more than 3 portions, but there was no between-group difference in the numbers achieving at least 5 daily portions of FV. Both groups reduced their television viewing and increased their physical activity to at least 60 minutes per day. This study addressed the problem of social desirability in self-report measures by collecting an independent index of social desirability and entering this as a covariate in analyses. Nevertheless, questions remain over the reliability of young people's self-reports. This study also had a self-selecting sample and a control condition in which several elements were identical to the intervention, making it difficult to ascertain which of the study's findings might generalize to a wider sample.

Also grounded in SCT is *EMPOWER* (Knowlden, Sharma, Cottrell, Wilson, & Johnson, 2015) a web-based intervention which aims to support mothers' self-development across several constructs: environment, emotional coping, expectations, self-control and self-efficacy. The intervention was expected to lead to positive outcomes for children including increased physical activity and FV consumption and decreased sugar-free beverage consumption and screentime. The study had an active-control group who participated in 5 knowledge-based (rather than theory-based) 'educational sessions'. Immediately post-intervention and at a 4-week follow up, both groups showed significant improvements in physical activity, sugar-free beverage intake and screentime (with no between-group differences) but only the IG showed an improvement in FV intake. At a 1-year follow-up (Knowlden & Sharma, 2016), this effect remained in the IG, equating to an increase of 1.8 cups of FV per day; all other significant effects had disappeared. The targeted maternal SCT constructs accounted for 33% and 13% of the change in FV consumption in the IG at the two follow-up time points, respectively. The authors provide a detailed theoretical rationale for the *EMPOWER* intervention and achieved a considerable increase in FV consumption, with a

methodology that is practicable to roll out to a wider group. However, results should be treated with caution as F and V are not treated separately and may, therefore, be driven solely by increases in fruit consumption. It is also unfortunate that, despite the several published papers about the intervention, little detail is provided regarding its content, inhibiting the development of similar interventions.

The *HomeStyles* (Byrd-Bredbenner et al., 2018) program is a web-based intervention designed to help parents 'make quick, easy, no-cost changes to their home environment…to support child growth and avoid childhood obesity' (p.140). The intervention content extracts from SCT, while 'adult learning theory' and 'motivational interviewing' are employed as learning techniques for participants, Spanish- and English-speaking parents of 2- to 6-year-olds were invited to select among modules that focussed on nutrition, physical activity, sleep and advocacy, which were delivered over 12 months. CG participants engaged with a website with an identical format but with content focussing on safety in the home. No changes in dietary intake were observed in either group immediately post-intervention. Long-term follow-up outcomes are still to be reported. Data collection occurred online and, as is often the case with web-based studies, retention rates were low (35% post-intervention), despite the authors' notable efforts to reduce attrition.

Carfora, Caso, and Conner (2016) conducted a randomised controlled trial to assess the efficacy of text messages sent to adolescents at increasing FV intake and drew on the Theory of Planned Behaviour in their design. Messages were either 'instrumental' (e.g. 'a diet rich in fruits and vegetables promote [sic] emotional well-being being associated with a lower prevalence of anxiety and depression') or 'affective' (e.g. 'a diet rich in vegetable and fruit reduces by 30-40% the probability of contracting cancer'). CG participants received no messages. The messages provoked a larger increase in FV consumption in both IGs (>1

portion per day) compared to the CG, with larger effects for affective messages. No long-term follow-up data is provided. Again, little detail is provided regarding the text message contents, which appear to be long and potentially disengaging for teenagers, and no formative or evaluative work is reported regarding feasibility or acceptability. The authors also point out that messages were not exclusively instrumental or affective and that affective messages tended to focus on the short-term outcomes of FV consumption, suggesting alternative psychological explanations for the behaviour change seen in that group. Nevertheless, the relatively large effect sizes suggest that a more carefully designed RCT with longer-term outcome measures might be fruitful.

Family Eats (Cullen, Thompson & Chen, 2017) is a web-based program targeting the home food environment and dietary behaviour of parents and children aged 8 to 12 years. It comprises 8 weekly online 'sessions' including graphics that tell the story of a family trying to develop healthier eating habits, tip sheets and recipes. Formative work in intervention development took place but no theoretical framework is explicitly described. The CG had access to the same website without the graphics. There were no between-group differences in FV consumption either post-intervention or 4 months later. Some positive changes were reported by the IG group alone (e.g. increased juice availability), but many were demonstrated in both groups (e.g. increased fruit availability). Strengths of the study include the recruitment of a more disadvantaged participant group than is typical and the positive feedback and evaluation provided by participants, reflected in a relatively high retention rate (68%). Given the high degree of overlap between the IG and CG intervention materials, further research would be necessary to better unpick the more effective elements of the intervention.

Sun et al. (2017) evaluated a tablet-based intervention that aimed to prevent obesity in American-Chinese mothers with children aged 3 to 5 years old. Its theoretical framework was described as being based on the 'Information-Motivation Behaviour Model' (Fisher, Fisher & Harman, 2003). The intervention consisted of animated short videos, including two in 'talk-show' format', and children's songs, re-worded to fit the intervention. The CG received weekly mailings of printed health information. It is unclear whether the primary targets of this study were mothers, children, or both; results showed that more IG mothers had reduced BMI six months post-intervention but no group difference for child BMI.

Other equipment

One study (Galhardo et al., 2012) did not fit neatly into other categories but remained within the scope of our review. This evaluated the use of a Mandometer in the home for children and adolescents with obesity (BMI SDS $\geq 95^{th}$ centile, 9 – 18 years old). The Mandometer is a machine that is sometimes used to treat eating disorders; it provides the user with feedback about their eating rate, based on plate weight, and can be used to achieve an 'ideal eating speed'. It was hypothesised that, by slowing eating rates and inducing postprandial suppression of ghrelin, the IG would show increased weight loss. As predicted, the IG showed significant decreases in BMI-SDS, percent body fat, meal portion size, glucose and fasting ghrelin, while the CG did not. The study had a very small sample (N=27) but nevertheless showed promising results in a clinical population. Cost-effectiveness was not addressed and may prove an obstacle to wider implementation. However, smartphone apps have been designed that provide a similar service; further research could explore their effectiveness in this population.

Synthesis of Literature and Conclusions for Future Research and Application

This review set out to describe and evaluate the evidence relating to home-based family eating interventions and to establish the elements of such interventions that might lead to successful behaviour change. The following section synthesises the key findings of the literature reviewed, first drawing out the characteristics of successful and unsuccessful interventions in terms of both their design and implementation and their basis in theory or evidence, and second highlighting the methodological limitations of the studies reviewed and making recommendations for how these should be addressed in future research.

Characteristics of successful and unsuccessful interventions

Most of the studies that reported follow-up data collected six months or more after intervention delivery did not find significant long-term behaviour change; effect sizes, where reported, were small. One notable exception is the *EMPOWER* study (Knowlden & Sharma, 2016), a theory driven, web-based intervention which showed an increase in consumption of FV of almost two cups per day, 12 months post-intervention. This study reflects a broad trend for interventions based on theory to result more often in significant behaviour change, as we discuss in the next section.

Basis in theory and evidence

In total, six studies (Pearson et al., 2010, Baranowski et al., 2011, Wyse et al., 2012, Corsini et al., 2013, Knowlden et al., 2015, Thompson et al., 2015) showed some behaviour change in an IG compared to a CG beyond immediate post-intervention data collection (see tables 2 – 6). All but one provided theoretical rationale, with the majority focussing on Social Cognitive Theory (SCT) and/or similar principles (in the case of Wyse et al., the authors did not cite SCT but did refer to a socio-ecological framework). This collection of studies appears to be set apart from the many others in the review referring to SCT in that authors

went into noticeably more theoretical detail and attempted to integrate the principles of SCT with other theories (e.g. Self-Determination Theory, Behavioural Choice Theory, maintenance theories and Golan et al.'s 2001 Familial Model). The remaining study with longer term success (Corsini et al., 2013) took a more experimental approach and was rooted in the evidence base surrounding exposure.

There is an important distinction between no change at follow-up and no evidence of change at follow-up due to lack of data. Given the high number of studies which did not conduct any follow up beyond the end of the intervention, we also examined the characteristics of interventions with significant results immediately post-intervention where the study did not collect LTFU data. Of the studies that reported no LTFU, 12 reported significant between-groups differences on their primary eating-related outcome measure immediately post-intervention (Wardle et al., 2003, Rodearmal et al., 2006, Haire-Joshu et al., 2008, Cullen et al., 2013, McGowan et al., 2013, Wieland et al., 2013, Makert et al., 2014, Heath et al., 2014, Cravener et al., 2015, Leung et al., 2015, Carfora et al., 2016, Wrieden & Levy., 2016) . Half of these studies reported a theoretical rationale. These interventions warrant further investigation to establish whether longer-term behaviour change can be achieved.

Careful analysis showed no systematic similarities shared by the short-term successful interventions. Studies drawing on exposure as a mechanism to encourage FV consumption appeared to show promise collectively. However, all but one lacked long-term follow-up of the observed behaviour changes, and some reported that parents found repeated exposure to be burdensome. Future research might seek to identify more natural implementations of exposure-based interventions in the family home; novel methods of exposure (such as picture books, Houston-Price, Owen, Kennedy & Hill, 2019) might be easier for parents.

Methodological factors

The six studies that did demonstrate longer-term behaviour change represented a range of delivery methods (the collection comprised one of each of home visit, telephone, printed information and mHealth, and two video-game studies), suggesting that all of these methods could feasibly lead to behaviour change. However, when examining the wider collection of studies described above (i.e. short-term behaviour change but no long-term follow-up), interventions that were person-delivered (i.e. involved human contact either face-to-face or over the telephone) were noticeably more likely to result in behaviour change than those which were information-delivered. Within the person-delivered category, however, studies in which a 'peer educator' delivered the intervention resulted in less success than those delivered by a researcher or health professional.

Information/technology-delivered interventions were less successful. Those that involved printed material and mHealth interventions were least likely to result in behaviour change. Both suffered from high attrition rates; the absence of the encouragement of a researcher or health professional may have reduced participants' motivation or willingness to continue. The information-based content of these types of intervention might also be off-putting or unengaging. Alternatively, most parents may already have reasonable knowledge of what constitutes healthy foods for children (Hart, Damiano, Cornell, & Paxton, 2015), and therefore benefit little from receiving further similar information. Parents may be less aware of the influence of their own feeding practices on children's behaviour, however. For example, in the motivational interviewing study (Tabak et al., 2012), no parents chose intervention elements that tackled their own behaviour at mealtimes (i.e. modelling and family meal frequency). Parents might not see the need to change their own feeding practices or might perceive this to be more difficult than tackling their child's eating. Future research should therefore consider parents' understanding of their role in shaping children's eating behaviours.

It is noteworthy that the number of mHealth interventions (and published protocols) included in the review doubled when the search was re-run in early 2018; this research area is evidently expanding rapidly despite the failures of early studies. Although current evidence indicates that the more intense interventions delivered through home-visits and telephone may be necessary to invoke meaningful behaviour change, the success of the *EMPOWER* study suggests mHealth may have the power to change behaviour with extensive formative work. More informed development could lead to improved outcomes for this type of intervention.

The majority of studies aimed to change parental behaviour, although those interventions targeting adolescent eating behaviour were more likely to involve active participation from the child. This is in line with evidence that suggests parents are the agent of change for younger but not teenage children (Golan, 2006, McLean et al., 2003). Several studies were based on the concept that parents' behaviour change might mediate the relationship between interventions and children's behaviour change (e.g. Wyse et al., 2014). This is a sensible assumption; if parents are responsible for making healthy food available and accessible, their engagement in a healthy eating intervention alongside the child is likely to be beneficial. It is interesting to note that one of the few printed materials studies to induce higher FV consumption in the IG was unique in targeting children and adults separately (Pearson et al., 2010), while an unsuccessful printed information study highlighted the confusion about which family members their intervention was targeting (Croker et al., 2012). It is surprising, then, that most interventions focus on the child or parent alone, or adopt a 'one size fits all' approach. Consideration should be given to the target participants within family interventions.

Weaknesses of the literature reviewed

The variation in the length of follow-up periods across the studies in this review renders it impossible to compare the interventions' long-term efficacy. Many studies did not identify their primary outcome measures *a priori*, instead leading their results sections with significant findings, regardless of whether these related to the aims and objectives set out in the title and introduction. Some studies included numerous outcome measures, making the chance of Type 1 errors higher.

There was also little consistency in the selected outcome measures, even though studies often aimed for the same outcomes. For example, BMI, BMI-SDS, BMI z scores and Fat Mass Index were all used as indices of weight loss/gain in different studies. This inconsistency makes comparison between findings difficult, and meta-analysis impossible. Another difficulty specific to the interpretation of BMI outcome data is that several 'obesity prevention' studies interpreted a lower BMI in the IG than in the CG as a success, even for those within the healthy range. Arguably, it would be more meaningful to examine those in each group whose BMI is outside the healthy range, for example, by investigating whether overweight individuals' BMI reduced as a result of intervention, or whether the proportion of participants with a healthy BMI score increased post-intervention. Outcome measures should also reflect the target of the intervention; for example, obesity prevention studies involving healthy weight individuals might examine the proportion of participants who enter an unhealthy BMI category, while obesity reduction studies might be more concerned with absolute weight loss.

FV intake was similarly measured using a variety of scales. Only a handful of studies considered fruit intake and vegetable intake separately. As several studies suggest that fruit intake may be easier to increase, the two food types should be measured separately;

otherwise, apparently successful interventions reporting increased FV intake might solely reflect changes in fruit intake.

Most behavioural measures were collected using self-report instruments, not all of which had been validated. Although self-report is widely used for collecting dietary data, its reliability is questioned, particularly when obtained from children or adolescents (Walker, Ardouin & Burrows, 2017). Guidelines exist to improve the reliability of such measures (e.g. comparing parents' and children's reports; biochemical validation; see Subar et al. 2015); no study included in this review reported following these guidelines. Some findings collected from children seem implausible (Markert et al., 2014), indicating the possibility of a more wide-spread problem with self-report measures in this population.

People from more advantaged backgrounds and higher socio-economic status are more likely to display healthier eating habits (Pampel, Krueger & Denney, 2010). Healthy eating interventions typically aim to reduce such health inequalities, by recruiting participants from more disadvantaged backgrounds. While most studies in this review attempted to recruit participants from disadvantaged or at-risk groups, many authors were open about the difficulties they encountered in doing so. Most studies relied on self-selecting samples; those providing information on non-completers noted that those on lower incomes were more likely to withdraw (e.g. Leung et al. 2015). The challenge to recruit 'those who really need it' to interventions merits attention.

Analyses

A notable inconsistency related to authors' use of Intention to Treat (ITT) analyses versus Per Protocol Analyses (PPA) or 'all available data'. Although ITT is considered 'gold-standard' in health research (see Armijo-Olivo, Warren & Magee, 2009), the majority of studies did not employ this method. Printed materials and mHealth interventions were most likely to follow

PPA, perhaps reflecting the much lower retention rates in these studies. This may be a sensible approach, however, depending on the intervention's cost. If an intervention is cheap to roll out to a wide audience, engages only a small subgroup of participants but leads to significant behaviour change within the participating group, there is a strong rationale to pursue the intervention. If, on the other hand, an intervention is costly and engages only a small number of people with a small effect size, the case for supporting it is less convincing. Future assessments of interventions in relation to their cost and effect size, as well as their retention rates, could therefore be fruitful.

Financial cost of interventions

Few studies discussed the cost of their intervention or its further development. Only one study attempted a cost-effectiveness analysis, which has yet to be published (Wen et al., 2012). Setting development costs aside, home visits and other person-delivered interventions are likely to be very expensive to deliver on a large scale (Rudolf, 2012), unless they can be incorporated into a pre-existing home visit programme. Technology-delivered interventions vary in their costs. While web-based interventions reach large audiences quickly, conveniently and inexpensively, smartphone/ tablet applications are very expensive to maintain (Bartle, Wallace & Curtis, 2015). If difficulties around engagement can be overcome, carefully-designed web-based interventions may therefore play an important role in the future of family eating interventions.

Conclusions

Changing healthy eating behaviour within the family home is challenging. Successful interventions tend to have a robust theory-driven evidence-base, are based on carefully-designed formative work and deliver engaging content. Furthermore, they have clear objectives with a well-defined target population. Future studies should address the difficulties

around recruiting participants from disadvantaged backgrounds, demonstrate a better understanding of cost implications, and take a more consistent approach to measurement and analysis to allow intervention effects to be compared.

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