Abstract

Purpose: To evaluate the evidence base of the Food Dudes healthy eating programme, specifically the short and long term effectiveness of the intervention for: a) consumption of fruit and vegetables both at school and at home and b) displacement of unhealthy snack consumption.

Design/methodology/approach: Articles were identified using Academic Search Complete, PsycARTICLES, Medline and PubMed databases keywords for the period January 1995 to August 2013. Articles were included if they reported an empirical evaluation of the Food Dudes programme aimed at children aged between 4-11 years. Articles were included regardless of geographical location and publication type (i.e. published and 'grey' literature).

Findings: Six articles were included for review. Findings indicated that the programme was moderately effective in the short-term; however the long-term effectiveness of the programme is unknown.The ability of the programme to generalise to the home setting and to displace unhealthy snack foods also requires further investigation.

Originality/value: This is the first independent review of the Food Dudes programme. In light of the extensive roll out of the Food Dudes programme, an appraisal of the evidence surrounding the programme is timely. The review highlights that sustaining fruit and vegetable intake cannot be achieved through behaviour-based interventions alone and the long term maintenance of fruit and vegetable consumption requires more than the implementation of an intervention found to be effective in a controlled research environment.

Introduction

There is strong evidence to suggest that eating a diet rich in fruit and vegetables has many health benefits and significantly reduces the risk of chronic diseases such as cardiovascular disease, stroke and some forms of adult cancer (Boeing et al., 2012; O'Flaherty et al., 2012).The UK government recommendations suggest that adults and children over five years of age should eat at least five 80g portions of fruit and vegetables per day (Department of Health, 2000). However, the average consumption of fruit and vegetables in the UK and other western countries is much lower than this and most adults and children fail to meet recommended levels of intake (Department of Health, 2000).

Increasing the consumption of fruit and vegetables in the school aged population is therefore clearly needed. Given the evidence suggesting that children's fruit and vegetable intake levels continue into adolescence (Kelder et al., 1994; Lytle et al., 2000; Lien et al., 2003) and food preferences established in childhood and adolescence are likely to persist into adulthood (Mikkilä et al., 2004), interventions targeted at changing childhood behaviours may be key to changing healthy eating behaviours in the long term. An understanding of the factors that influence health behaviours is also important when designing behaviour change interventions and substantial evidence indicates that basing interventions on psychological theories of behaviour change will improve their effectiveness (Baban and Craciun, 2007). A number of psychologically based interventions to promote children's fruit and vegetable consumption have been developed (Gratton et al., 2007; Reinaerts et al., 2007). One such intervention that has been suggested to be effective is the Food Dudes programme, a behaviour change intervention developed following extensive research into the psychological components influencing children's food choice (Horne et al., 1995). This programme, targeted at primary school children, primarily aims to increase consumption of fruit and vegetables at school; however studies have additionally evaluated changes in children's unhealthy snack consumption and liking of fruit and vegetables. The programme has also been found to generalise across contexts, i.e. school to home (Lowe and Horne, 2009).The programme consists of an initial 16 day intervention phase and a maintenance phase (see Lowe et al., 2004 for details of programme procedures) and is based upon repeated tasting, role modelling and rewards, psychological principles reliably shown to impact upon food consumption (Horne et al.,1995).

Taste exposure is widely accepted as an important determinant of children's food preferences (Cooke, 2007). Increased exposure through repeated tasting of fruit and vegetables has been linked to increases in liking and consumption (Brug et al., 2008; Lakkakula et al., 2011; Wardle et al., 2003). Modelling, based upon social learning theory (Bandura, 1977), also referred to as 'exposure by proxy' (Wardle et al., 2003) has also been linked to increased fruit and vegetable intake. Research has suggested that children are more likely to imitate behaviours if the model is rewarded, is of the same age or slightly older than the child and in cases where multiple models are used (Brody and Stoneman, 1981; Fehrenbach et al., 1979; Flanders, 1968). Consequently, the Food Dudes programme provides opportunities to observe others consuming fruit and vegetables (Savage et al., 2007) in addition to early, positive repeated exposure. The use of rewards to increase children's fruit

and vegetable consumption is more controversial. Whilst it has been argued that providing an individual with extrinsic rewards could impact upon their intrinsic motivation for eating healthy foods and reduce long term consumption (Newman and Taylor, 1992), more recent evidence suggests that external rewards may in fact be useful in promoting healthy eating in children (Cook et al., 2011) especially if combined with non-tangible rewards such as praise (Grubliauskiene et al., 2012).

Development of the Food Dudes programme

The Food Dudes programme has evolved over a number of years following extensive research and development (Lowe and Horne, 2009). Early empirical work investigated the effectiveness of a video based peer modelling and rewards intervention on consumption of foods previously refused by the child (Horne et al., 1995). The studies were conducted in the home environment and involved observing the eating behaviour of four children during family meal times. Whist large increases in fruit and vegetable consumption were evident, these studies were conducted with small numbers of children and further research was required to assess the impact of the intervention with larger groups of children in the school setting (Horne et al., 1998). A standalone programme targeted at primary school children aged 4-11 was subsequently developed and trialled in a number of schools in regions of England and Wales (Horne et al., 2004; Lowe et al., 2004) and a modified version of the programme piloted in Ireland (Horne et al., 2009) prompting national rollout in the country (Lowe and Horne, 2009). The programme has also been trialled in Italy (Presti et al., 2009) and the USA (Wengreen et al., 2013). In light of the roll out of the Food Dudes programme, an appraisal of the evidence surrounding the programme seems timely. Whilst the authors acknowledge that the Food Dudes programme is an on-going programme of research and development, interventions must be based on evidence of effectiveness. However, decision making is often driven by the concerns of organised interest groups rather than adopting an evidence-based approach (Brownson et al., 2011). The strength of research evidence is an important consideration when allocating resources and financial investment (Belsey, 2009) and it is essential that funding is directed into interventions that are based not only upon psychological components that best predict health behaviours, but more importantly those that are supported by robust evidence. The purpose of this review was therefore to evaluate the evidence base of the Food Dudes programme. In particular, to evaluate the rigour of the evidence concerning short and long term effectiveness of the intervention for: a) consumption of fruit and vegetables both at school and at home and b) displacement of unhealthy snack consumption.

Methods

Search strategy

Articles were identified using Academic Search Complete, PsycARTICLES, Medline and PubMed databases. The following terms were searched as keywords anywhere within the article: Food Dudes, child, fruit and vegetables, intervention, programme, repeated tasting, modelling and rewards. The search was conducted for the period January 1995 to August 2013. Relevant articles were hand searched for additional references to Food Dudes studies and internet searches using Boolean logic performed to ensure maximum capture. The final list of articles was checked against the Bangor Food and Activity Research Unit (BFARU) publications list available on the Food Dudes website to ensure that no article was omitted from the review.

Inclusion and exclusion criteria

Articles were included if they reported an empirical evaluation of the Food Dudes programme aimed at children aged between 4-11 years. Articles were included regardless of geographical location and publication type (i.e. published and 'grey' literature). Theoretical papers reporting only the rationale behind the intervention and no evaluation data were excluded. Articles that reported a summary of studies already included in the review or only available as abstracts were also excluded.

Quality assessment of studies

Methodological rigour was assessed using the Effective Public Health Practice Project Quality Assessment Tool for Quantitative studies, a standardised quality assessment tool used in previous systematic reviews concerning children's dietary behaviours (Knai et al., 2006; Van Cauwenberghe et al., 2010) and found to have good content and construct validity (Jackson and Waters, 2005). The tool comprises six criteria: selection bias (i.e. the extent to which individuals were representative of the target population), study design, control of confounding variables, blinding, data collection method (including the reliability and validity of tools), and withdrawals and dropouts. As blinding is not possible for health promotion programmes, papers were not rated on this criterion (Wang and Stuart, 2013). Each criterion was rated as strong, moderate or weak and global ratings calculated for each paper. Studies with no weak ratings and at least four criteria rated as strong were given a global rating of 'strong', studies with one weak rating and less than four strong ratings were given a global rating of 'moderate' and studies with three or more weak ratings given a global rating of 'weak'.

Information was also obtained regarding data analysis but this did not impact upon the final study ratings. Studies were independently assessed by two researchers. Disagreements between researchers were resolved through discussion and a consensus reached.

Data extraction

The following information was recorded for each study:

1. Participant demographics: age range of children participating in the study, country of implementation and sample size;
2. Details of methods: study design, setting (school, home), measure(s) used, and length of follow-up;
3. Description of intervention procedure(s);
4. Outcomes of the study: impact on fruit and vegetable consumption at snack time, lunch time and at home (primary outcome) and displacement of snack consumption (secondary outcome).

Results

The search strategy identified a total of 13 relevant publications of which six met the inclusion criteria for review. Of these, five were academic peer reviewed articles and one a technical report. All articles, except one (Wengreen et al., USA, 6-11, experimental) were published by Bangor Food and Activity Research Unit. Papers excluded from the review and reasons for exclusion are shown in Table 1.

>>INSERT TABLE 1<<

Summary of included studies

Target group and setting

Details of the studies included in the review are shown in Table 2 and description of intervention procedures in Table 3. Studies were conducted in the school setting (n=4), and school and home (n=4). Three studies included a control group (BFARU UK, 4-11, experimental; Horne, UK, 5-11, non-RCT and Horne, Ireland, 4-11, CCT) thus allowing any changes in fruit and vegetable consumption to be attributed to the Food Dudes programme. Changes in fruit and vegetable consumption in studies which did not include a control group could not be attributed to a programme effect. The majority of studies were conducted in the UK (n=7), one in Ireland (Horne et al., Ireland, 4-11, CCT) and one in the USA (Wengreen et al., USA, 6-11, cohort).

Measures of fruit and vegetable intake

Snack-time consumption was measured using weighed measures (Horne et al.,UK, 5-11, non-RCT) and visual estimation validated against weighed measures (Lowe et al., UK, 4-11, cohort). Children's statements of their snack intentions, choices and consumption were recorded in one study (Horne et al., UK, 5-6, experimental). Lunchtime measures included visual estimation (Horne, UK, 5-11, non-RCT, Horne, Ireland, 4-11, CCT and Lowe, UK, 4-11, cohort), weighed measures (Horne, Ireland, 4-11, CCT)) and digital photography (Wengreen et al., USA, 6-11, cohort). An additional study also used weighed measures but only for lunchtime salad and in one school only (Lowe et al., UK, 4-11, cohort). Studies evaluating the impact of the intervention in the home environment used 24-h food diaries (BFARU, UK, 4-11, experimental) and 24-h recall measures (Horne et al., UK, 5-11, non-RCT; Lowe et al., UK, 4-11, cohort).

Length of follow-up

Only one study did not include a follow-up period (Lowe et al., UK, 4-11, cohort); length of follow-up ranged from 2 months (Horne et al., UK, 5-7, experimental) to 12 months (Horne et al., Ireland, 4-11, CCT).

Outcome measures

All studies measured fruit and vegetable consumption, either at school, home or both school and home. Other outcome measures included: skin carotenoid levels (Wengreen et al., USA, 6-11, cohort), changes in children's liking of fruit and vegetables (Lowe et al., UK, 4-11, cohort), changes in parental provision of fruit and vegetables (Horne et al., Ireland, 4-11, CCT) and displacement of snack foods (BFARU, UK, 4-11, experimental; Horne et al., UK, 5-6, experimental).

>>INSERT TABLE 2 AND TABLE 3<<

Changes on fruit and vegetable consumption at school

Snack time consumption

Four studies (BFARU, 2010; Horne et al., 1998; 2004; Lowe et al., 2004) evaluated changes in snack time consumption of fruit and vegetable, however only one study included a control group (Horne et al., 2004). Fruit consumption was significantly higher during the intervention phase compared to baseline (+0.12 and +0.23 portions, equating to 9.6g and 9.2g) in two studies (Horne et al., 2004; Lowe et al., 2004) but not between baseline and follow-up (BFARU, UK, 4-11, experimental; Horne et al., UK, 5-11, non-RCT). Whilst fruit consumption was higher at follow-up compared to baseline (+0.02 and +0.01 portions), these increases were small (see Table 4). Horne et al., (UK, 5-6, experimental) reported a 27% increase in target fruit consumption between baseline and intervention which was sustained at four and six month follow-up (62% and 59% respectively). Consumption of fruit not targeted by the intervention also increased from 12% at first baseline to 38% at second baseline (measured following the intervention) and 33% at six month follow-up. Similarly, vegetable consumption increased from 8% at baseline to 39% during the intervention and maintained at four month (34%) six month follow-up (32%). Consumption of non-target vegetables increased from 9% at first baseline to 23% following the intervention and 24% at six month follow-up. Another study (Lowe et al., UK, 4-11, cohort) reported a significant increase in vegetable consumption during the

intervention phase (+0.23 portions) and between baseline and follow-up (BFARU, UK, 4-11, experimental).

A significant difference in consumption of unhealthy snack foods was found between baseline and 4 month follow-up (-0.12 of a portion) in one study (BFARU, UK, 4-11, experimental). In addition, Horne et al., (UK, 5-6 experimental) demonstrated a decrease in consumption of both sweet (77% at baseline to 64% at follow-up) and savoury snacks (81% at baseline to 48% at follow-up).

Lunchtime consumption

Five studies evaluated the effectiveness of the intervention on lunch time consumption (BFARU, UK, 4-11, experimental; Horne et al., UK, 5-11, non-RCT; Horne et al., Ireland, 4-11, CCT; Lowe et al., UK, 4-11, cohort; Wengreen et al., USA, 6-11, cohort). Significant increases in parental provision of fruit and vegetables were also found in one study (Horne et al., Ireland, 4-11, CCT).

As shown in Table 5, children in the intervention schools consumed more fruit and vegetables than those in the control schools at baseline and follow-up (BFARU, UK, 4-11, experimental; Horne et al., UK, 5-11, non-RCT; Horne et al., Ireland, 4-11, CCT). Significant increases in fruit consumption were evident during the intervention phase in four studies (Horne et al., UK, 5-11, non-RCT; Horne et al., Ireland, 4-11, CCT; Lowe et al., UK, 4-11, cohort; Wengreen et al., USA, 6-11, cohort) ranging from +0.14 to +0.71 portions and at follow-up in one study (Horne et al., UK, 5-11, non-RCT). Increases in consumption of vegetables were also observed in three studies, between baseline and intervention (Horne et al., UK, 5-11, non-RCT; Horne et al., Ireland, 4-11, CCT; Lowe et al., UK, 4-11, cohort) and at follow-up (BFARU, UK, 4-11, experimental and Horne et al., UK, 5-11, non-RCT). Increases in the consumption of home provided fruit, vegetables and juices were also found at 12 month follow-up compared to baseline (Horne et al., Ireland, 4-11, CCT). Evidence of increased consumption of pigmented fruit and vegetables (those that are red, orange or yellow in colour) was also evident in one study (Wengreen et al., USA, 6-11, cohort). Skin carotenoid levels increased significantly between baseline and intervention, $p=0.001$ and baseline and follow-up ($p<0.001$).

>>INSERT TABLE 4 and TABLE 5<<

Changes in fruit and vegetable consumption at home

Four studies evaluated changes in fruit and vegetable consumption in the home environment (BFARU, UK, 4-11, experimental; Horne et al., UK, 5-6, experimental; Horne et al., UK, 5-11, non-RCT; Lowe et al., UK, 4-11, cohort). Horne et al., (UK, 5-6, experimental) reported an increase in fruit consumption from 18% at baseline to 77% at 8 month follow-up and increases in consumption of vegetables form 35% at baseline to 98% at follow-up. Mean differences in fruit and vegetable intake between baseline and intervention were higher for the intervention compared to the control group (Horne et al., UK, 5-11, non-RCT). Significant differences were observed for fruit and vegetable consumption during weekdays (Horne et al., UK, 5-11, non-RCT; Lowe et al., UK, 4-11, cohort). However, no significant differences were found in consumption of fruit or vegetables at the weekend. BFARU (UK, 4-11, experimental) also found significant increases in fruit and vegetable consumption between baseline and follow-up (+0.22 and +0.40 portions respectively) but not in the displacement of unhealthy snacks (-0.08 portions, ns).

Displacement of snacks

One study (BFARU, UK, 4-11, experimental) examined the impact of the programme on the displacement of unhealthy snacks; however data were only available for the intervention schools. No information was available for the matched control group. Increased consumption of fruit and vegetables at lunchtime (1.44 portions) was associated with a 0.23 portion decrease of unhealthy snacks from baseline to follow-up. Conversely, decreases in fruit and vegetable consumption (1.35 portions) were associated with an increase in lunchtime consumption of unhealthy snacks (0.33 portions) from baseline to follow-up. All changes in eating behaviour were significant ($p<0.05$).

Methodological quality of studies

None of the studies included in the review fulfilled all of the quality assessment criteria and all studies (except Horne et al., Ireland, 4-11, CCT and Wengreen et al., USA, 6-11, cohort)) received weak global ratings (see Table 6). Methodological design varied between studies; one study employed a strong design (Horne et al.,Ireland, 4-11, cohort) and two used moderate designs (BFARU, UK, 4-11, experimental; Horne et al., UK, 5-11, non-RCT). Randomisation was described in one study (Horne et al.,Ireland, 4-11, CCT) although description of how this was achieved was inadequate. Schools were randomly allocated to the intervention or control group however the method of allocation was not

reported. Studies that included a control group only allocated one school to this condition resulting in more schools in the intervention than control group (Horne et al., UK, 5-11, non-RCT) and only one study reported baseline comparisons between the intervention and control groups (Horne et al., Ireland, 4-11, CCT)). Withdrawals and drop-outs were only reported fully in one study (BFARU, UK, 4-11, experimental)). Studies that measured fruit and vegetable consumption using visual estimation reported good agreement between raters, however observations were only validated against weighed measures in one study (Lowe et al., UK, 4-11, cohort)) and at snack time only. One study (BFARU, UK, 4-11, experimental)) acknowledged the limitations of the methods used commenting that the 24-hr food diary measure is likely to underestimate behaviour change over time and as such is a relatively insensitive measure of dietary intake. None of the studies included in the review reported the use of power analysis to calculate sample size or reported measures of effect size. One study (Horne et al., UK, 5-6, experimental)) reported percentage consumption of fruit and vegetables however did not provide any information regarding portion size provided to children making it difficult to estimate the magnitude of changes in eating behaviour.

>>INSERT TABLE 6<<

Discussion

The purpose of this review was to evaluate the evidence base of the Food Dudes programme. In particular, to evaluate the rigour of the evidence concerning short and long term effectiveness of the intervention. Whilst the evidence reviewed suggests that the Food Dudes programme is effective in producing short term increases in children's fruit and vegetable consumption, particularly in the school setting (Horne et al., 2004; Horne et al., 2009; Lowe et al., 2004; Wengreen et al., 2013) several limitations with regard to methodological quality were identified which should be taken into account when interpreting study findings.

A critical issue surrounding the effectiveness of the Food Dudes programme is the absence of long term (12 months post intervention) follow-up. In the majority of studies, measures of fruit and vegetable intake were taken towards the end of the intervention phase resulting in large statistically significant findings. This is perhaps not surprising given the fact that intervention procedures are still in place with children receiving rewards for consuming fruit and vegetables. Whilst all studies except one (Lowe et al., 2004) included a follow-up period post intervention, these were typically short term (4 months) Whilst there was some evidence that fruit and vegetable consumption was maintained at six and eight month follow-up (Horne et al., 1998), these studies were conducted on a small scale (26 children, aged 5-6 years) and relied upon measures of snack-time consumption only. With the exception of one study (Horne et al., 2009) which measured home provided lunches; none of the reviewed studies established the long term impact of the programme. Whilst it has been suggested that the intervention has produced substantial increases in parental provision of lunchbox fruit and vegetables in addition to increases in consumption at school and at home up to 2.5 years following the intervention (Lowe & Horne, 2009), these data are not publically available. Therefore, there is currently no evidence that the programme can bring about sustainable changes in children's consumption of fruit and vegetables and the factors which influence the maintenance or extinction of behaviours over time. For example, characteristics of the home environment have been shown to explain the largest variance in children's fruit and vegetable consumption (Gross et al., 2011) therefore parental involvement in the programme (see Horne et al., 2009) is likely to be a contributing factor to its effectiveness. Parental involvement in the programme, as reported in the Horne et al., (2009) study would likely enhance its effectiveness in the home setting. Whilst the intervention

primarily focuses on consumption of fruit and vegetables at school, increasing fruit and vegetable consumption in the home environment is also recognised (Lowe and Horne, 2009).

The extent to which the Food Dudes programme could displace unhealthy food consumption also warrants further investigation. Whilst the programme is effective in increasing fruit and vegetable consumption, it is equally important that calorific foods high in fat and sugar are displaced from the diet. As Tak et al. (2010) note, interventions that can change consumption of unhealthy foods to healthier foods (such as fruit and vegetables) may contribute to the treatment of childhood obesity by reducing calorific intake. Indeed, there is no evidence to suggest that targeting fruit and vegetable consumption alone reduces adiposity (Ledoux et al., 2011). One study (BFARU, 2010) evaluated the impact of the programme on unhealthy food consumption and indicated positive results however further work is required to validate these findings using more sensitive measures of dietary intake. Indeed, the DIET 24 measure used in this study has been shown to have limited sensitivity to behaviour change compared to weighed measures (Pears et al., 2012). Dietary intake should be assessed using valid measures. Whilst all studies reported inter-rater reliability checks, observations were not always validated. Visual estimations were reported to be validated against weighed measures in one study (Lowe et al., 2004) and at snack time only thus the validity of the observational measures used is questionable. Inter-rater measures were taken in the Horne et al., (2004) study however it was not reported whether or not these were validated against weighed measures. A recent review (van Cauwenberghe et al., 2010) also reported the validity of data collection methods used in the Horne et al., (2004) and Lowe et al., (2004) studies as weak. Measures that are shown to be reliable are not necessarily valid and whilst all studies using visual estimation measures demonstrated high inter rater agreement, this does not imply that measures are robust.

Finally, the majority of methodological limitations were due to lack of information reported. Judgements of methodological quality were based on information presented rather than inferences about what the authors intended. For example, little information was provided about how children were randomised to the intervention or control condition and information on attrition rates. Whilst the initial sample size was relatively large in the majority of studies it is not clear how many children were lost at follow-up. For example, in the Horne et al., (2009) study, 228 and 207 children were allocated to the intervention and control groups respectively however the same data presented elsewhere

(Food Dudes, 2009) indicates a much smaller final sample size (n=49 and n=53). These differences may impact upon the power of the study to detect a significant effect and subsequently the reliability of the study findings. Analysis of baseline comparisons between the intervention and control groups was also absent in all studies except one (Horne et al., 2009). Studies that included a comparison group only assigned one school to this condition and did not account for cluster allocation which may lead to statistically significant findings that are not justified by the design of the study (Thomas et al., 2003). Effect sizes of statistical differences in consumption were also not reported in any of the studies included in the review. To establish the effectiveness in a practical sense, research should emphasise the magnitude of effect as opposed to merely reporting statistical significance (Cohen, 1990). Furthermore, effect sizes should be stable across studies to ensure reliability of findings (Thompson, 2008). The reporting of effect sizes is crucial and failure to report effect sizes may be detrimental; not only to a single study but to the accumulation of knowledge in the long run (Sun et al., 2010). Differences in editorial policies of academic journals, or preferences of journal reviewers, inevitably determine the reporting of effect sizes in experimental studies and may explain the absence of these measures in the Food Dudes literature.

Conclusions

In conclusion, the evidence reviewed suggests that the Food Dudes programme is somewhat effective in producing increases in children's fruit and vegetable consumption in the short term however methodological limitations have to be taken into account when interpreting study findings. On the basis of the evidence reviewed, the Food Dudes approach may work to justify a trial with objective measures of dietary intake and longer follow up periods. Evidence for the long term effectiveness of the programme is limited and further development work is required to ensure both the short and long term effectiveness of interventions promoting fruit and vegetable consumption in children such as the Food Dudes programme. Whilst the principles of repeated tasting, role modelling and rewards may increase consumption in the short term, the extent to which these produce sustainable changes in behaviour is unclear. As Thomson and Ravia (2011) suggest, sustaining fruit and vegetable intake cannot be achieved through behaviour-based interventions alone and the long term maintenance of fruit and vegetable consumption requires more than the implementation of an intervention found to be effective in a controlled research environment (Altman, 2009; Moore et al., 2013). The Food Dudes Forever phase currently under development is one approach that may enhance fruit and vegetable

consumption established during the initial phase of the programme (Lowe, 2013). In addition, the Choice Architecture for School Catering scheme also under development, designed to encourage children to make healthy choices and create a positive food environment, may also promote the maintenance of behaviour change (Lowe, 2013).Consideration of the issues discussed here would provide valuable evidence to key stakeholders involved in further roll out of the intervention.

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Table 1. Papers excluded from review and reasons for exclusion

Study	Reason for exclusion
Horne et al., (1995)	Target group not primary school children
Horne et al., (2011)	Target group not primary school children
Lowe et al., (2001)	Descriptive paper, no evaluation data, abstract
Lowe, et al., (2007)	Reports a summary of already included studies
Presti et al., (2009)	Abstract only
Tapper et al., (2002)	Abstract only
Tapper, Horne & Lowe (2003)	Reports a summary of already included studies

Table 2. Description of Food Dudes evaluation studies

Study	Country	Design	Sample size	Age	Setting	Measures	Control group*	Follow-up	Outcome(s) measured
BFARU (2010)	UK	Experimental	405	4-11	School and home	24-h food diary (Diet-24)	x	4 months	FV consumption Displacement of snack consumption
			65	4-11	School	24-h food diary (Diet-24)	✓	4 months	FV consumption
Horne et al (1998)	UK	Experimental	Study 1: 26 (1 class)	5-6	School	Record of children's snack time food intentions, choices and consumption	x	4 and 6 months	Fruit, vegetables and snack consumption
			Study 2: 28 (1 class)	5-6	School and home	*School:* As above *Home:* Records of FV consumption	x	4, 6 and 8 months	FV consumption
Horne et al (2004)	UK	Non-RCT	364 (Intervention) 385 (Control)	5-11	School and home	Weighing of fruit pre and post consumption (snack time), Visual estimation (lunchtime), parental 24-h food recall diary (home)	✓	4 months	FV consumption
Horne et al (2009)	Ireland	CCT	228 (Intervention) 207 (Control)	4-11	School	Visual estimation (home provided) Fruit and vegetables weighed pre and post consumption and percentage consumed calculated (school provided)	✓	12 months	FV consumption Parental provision of FV
Lowe et al (2004)	UK	Cohort	402	4-11	School and home	Visual estimation, visual estimation and weighed validation tests (snack time only) Children's liking for	X	None	FV consumption Liking of FV

						fruit and vegetables measured using a 5 point likert scale (1 =highly disliked to 5 =highly liked).Parental 24-h food recall (home)			
Wengreen et al (2013)	USA	Cohort	253	6-11	School	Digital photography Skin carotenoids	X	3 months	FV consumption

* x = no control group, ✓ = control group

Table 3. Description of intervention procedures

Study	Intervention procedure
BFARU (2010)	1 day baseline, 2 day baseline, followed by a 16 day intervention phase and a maintenance phase. During the intervention phase, children watched a series of DVD episodes of the Food Dudes adventures. The Food Dudes are four super-heroes who gain special powers by eating their favourite fruit and vegetables that help them maintain the life force in their quest to defeat General Junk and the Junk Punks. The Dudes encourage children to 'keep the life force strong' by eating fruit and vegetable every day. Class teachers also read letters to the children from the Food Dudes to reinforce the DVD messages.
Horne et al (1998)	*Study 1:*12 day baseline phase followed by two six day intervention phases. A second baseline phase was implemented followed by 4 and 6 month follow-up phases. During the intervention phases (one of which targeted fruit and the other vegetables), 12 of the 24 foods were presented and children watched a video featuring the Food Dudes and were rewarded with prizes for consuming the target foods. Children also participated in a classroom game in which stickers, badges and tokens could be won. Daily letters were also sent to the children from the Food Dudes to encourage and remind children of what they should do to achieve the rewards. During the second baseline phase, all foods were presented in the absence of videos and rewards to test for generalisation effects. *Study 2:* Similar to study 1 except: intervention phase lasted for 16 days, and an intervention procedure was introduced in the home environment. In the home study, 5 children were given 'cues' in the form of a short Food Dudes video, a form to record consumption and letters from the Food Dudes to remind them to eat their fruit and vegetables at home and at school. Rewards were given for home fruit consumption and vegetable consumption.
Horne et al (2004)	12 day baseline phase followed by a 16 day intervention phase and maintenance phase. During the intervention phase, children watched a series of DVD episodes of the Food Dudes adventures and/or were read letters from the Food Dudes. At snack time, children received a sticker for tasting their fruit and a sticker and reward for eating at least half of their fruit. At lunchtime, during the first 4 days of the intervention, children were given rewards for eating half or more of their fruit and/or vegetables. Children were given a home pack at the start of the intervention phase and rewards given to children at the end of the intervention who recorded their fruit and vegetable consumption on their chart. During the maintenance phase, consumption of snack time fruit and lunchtime fruit and vegetables was monitored by school staff and recorded on a classroom wallchart. Children received a reward once the chart is completed. The second home pack was distributed at the start of the maintenance phase.
Horne et al (2009)	5 day baseline (lunchbox measures), 8 day baseline phase (school provided measures) followed by a 16 day intervention phase, 12 month follow-up. Children watched a series of DVD episodes of the Food Dudes adventures and/or were read letters from the Food Dudes. During the first 4 days of the intervention, children received a reward for tasting both their fruit and vegetables and eating a whole portion of fruit and vegetables on the remaining 12 days. Children were given a home pack at the start of the intervention phase and rewards given to children at the end of the intervention who recorded their fruit and vegetable consumption on their chart. During the first month of the maintenance phase, children received stickers for bringing in fruit and vegetables from home. For the remainder of this phase, children received a sticker each day for the classroom wallchart if they consumed a portion of fruit and vegetables and a reward when they had accumulated sufficient stickers over a given period.
Lowe et al	8-12 day baseline phase followed by a 16 day intervention phase.

(2004)	Children watched a series of DVD episodes of the Food Dudes adventures and/or were read letters from the Food Dudes. During the intervention phase, children received a sticker for consuming some of their fruit or vegetables and a Food Dudes reward (e.g. pen, pencil case etc) for consuming a whole portion. A home pack was distributed to children in one of the intervention schools during the first week of baseline and the last week of the intervention phase.
Wengreen et al (2013)	Naturalistic baseline phase (4 days), default-provision baseline (4 days), followed by 16 day intervention phase and 3 month follow-up. Children watched a series of DVD episodes of the Food Dudes adventures and/or were read letters from the Food Dudes. During the first 4 days of the intervention phase, children received rewards (pencils, pedometers etc) for tasting and swallowing a bite of the fruit and vegetable. On days 5-15 children received rewards for consuming larger portions. During the maintenance phase, consumption of fruit and vegetables was monitored by school staff and recorded on a classroom wallchart.

Table 4. Impact of the Food Dudes intervention, in portions, on snack time consumption of fruit and vegetables and unhealthy snacks (grams in parentheses)

		Intervention						Control				
Study	Food	Portion size	Baseline (Bl)	Intervention (I)	Follow-up (FU)	I - Bl	FU - Bl	Baseline (BL1)	Baseline 2 (BL2)	Follow-up (FU)	BL2 – BL1	FU – BL1
BFARU (2010)	Fruit	Cupped hand	0.95	-	0.97	-	+0.02	-	-	-	-	-
	Vegetables		0.03	-	0.11	-	+0.08*	-	-	-	-	-
	Unhealthy snacks	Unknown	0.13	-	0.01	-	-0.12*	-	-	-	-	-
Horne et al (2004)	Fruit***	80g	0.75 (60g)	0.87* (69.6g)	0.76 (60.8g)	+0.12* (9.6g)	+0.01 (0.8g)	0.65 (52g)	0.61 (48.8g)	0.64 (51.2g)	-0.04 (-3.2g)	-0.01 (-0.8g)
Lowe et al (2004)	Fruit	40g	0.48 (19.2g)	0.71* (28.4g)	- -	+0.23* (9.2g)	- -	- -	- -	- -	- -	- -
	Vegetables	40g	0.38 (15.2g)	0.68* (27.2g)		+0.30* (12g)						

*Significant at $p<0.05$ (Non-parametric tests), **Significant at $p<0.001$, *** 5-7 year old children

Table 5. Impact of the Food Dudes intervention, in portions, on lunch time consumption of fruit and vegetables (grams in parentheses)

		Intervention						Control				
Study	Food	Portion size	Baseline (Bl)	Intervention (I)	Follow-up (FU)	I - Bl	FU - Bl	Baseline (BL1)	Baseline 2 (BL2)	Follow-up (FU)	BL2 – BL1	FU – BL1
BFARU (2010)	Fruit	Cupped hand	0.18	-	0.31	-	+0.13	0.42	-	0.16*	-	-0.26*
	Vegetables		0.65	-	1.00*	-	+0.35*	0.35	-	0.26	-	-0.09
Horne et al (2004)	Fruit	80g	0.34 (27.2g)	0.78** (62.4g)	0.60 (48g)	+0.44** (35.2g)	+0.26** (20.8g)	0.16 (12.8g)	0.15 (12g)	0.09 (7.2g)	-0.01 (-0.8g)	-0.07 (-5.6g)
	Vegetables	60g	0.43 (25.8g)	0.65** (39g)	0.58 (34.8g)	+0.22** (13.2g)	+0.15** (9g)	0.26 (15.6g)	0.13** (7.8g)	0.17 (10.2g)	-0.13** (-7.8g)	-0.13** (-7.8g)
Horne et al (2009)	School provided Fruit	80g	0.45 (36g)	0.59*** 47.2g)	-	+0.14*** (11.2g)	-	0.36 (28.8g)	0.31*** (24.8g)	-	-0.05*** (-4g)	-
	Vegetables	60g	0.12 7.2g)	0.30*** (18g)	-	+0.18*** (10.8g)	-	0.12 (7.2g)	0.08*** (4.8g)	-	-0.04*** (-2.4g)	-
	Home provided Fruit, Vegetables & juice	80g	0.51 (40.8g)	-	0.89*** (71.2g)	-	+0.38*** (30.4g)	0.53 (42.4g)	-	0.59 (47.2g)	-	-0.06 (-4.8g)
Lowe et al (2004)	Fruit	80g	-	-	-	+0.71*** (56.8g)	-	-	-	-	-	-
	Vegetables	60g	-	-	-	+0.45*** (27g)	-	-	-	-	-	-
Wengreen et al (2013)	Fruit	50/60g[1]	0.46	0.65	0.43	+0.19***	-0.03	-	-	-	-	-
	Vegetables	50/60g	0.22	0.40	0.36	+0.18***	+0.14	-	-	-	-	-

*Significant at $p<0.05$, **Significant at $p<0.002$, ***significant at $p<0.001$,

[1] 50g = 6-7 year olds and 60g = 8-11 year olds.

Table 6. Methodological quality ratings of included studies.

Study	Selection bias	Study design	Confounders	Data collection method(s)	Withdrawals and drop-outs	Analysis	Global rating
BFARU (2010)	Weak	Moderate	Weak	Weak	Strong	– No power calculations – Effect sizes not calculated	Weak
Horne et al (1998)	Weak	Weak	NA	Weak	NA	– Information regarding portion size not provided– difficult to ascertain impact on consumption – Descriptive analysis only, no inferential statistics reported	Weak
Horne et al (2004)	Weak	Moderate	Strong	Visual estimation: strong Weighed measure: weak Parental 24h recall: weak	Visual estimation: weak Weighed measure: weak Parental 24h recall: moderate	– No power calculations – No cluster analysis – Effect sizes not calculated	Weak
Horne et al (2009)	Weak	Strong	Strong	Weighed measure: strong Visual estimation: strong	Weighed measure:weak Visual estimation: weak	– No power calculations – Effect sizes not calculated	Moderate
Lowe et al (2004)	Weak	Weak	NA	Visual estimation: strong Parental 24h recall: weak	Visual estimation: weak Parental 24h recall: moderate	– No power calculations – Effect sizes not calculated	Weak
Wengreen et al (2013)	Weak	Weak	NA	Strong	Strong	– No power calculations	Moderate