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Delivering in-school interventions to improve dietary behaviours amongst 11- to 16-year-olds: A systematic review.

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Abbreviations

EPHPP – *Effective Public Health Practice Project tool*

RCT – *Randomised Controlled Trial*

SSB - *Sugar-sweetened beverage*

FFQ - *Food Frequency Questionnaire*

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Abstract

Childhood obesity is a global health concern, which has both short- and long-term health consequences for the individual and is a potential burden on healthcare services and the wider economy. The school environment is a setting where changes can be applied to dietary behaviours, as schools have direct and intensive contact with children. This systematic review evaluated school-based interventions designed to improve dietary behaviours among adolescents (11- to 16-year-olds). The aims were to review: types of interventions delivered; dietary behaviours targeted; interventions' effectiveness in improving dietary behaviour and associated intervention components. Twenty-nine school-based interventional studies with this population were identified for review. The data was synthesized by identifying and comparing individual studies' results, intervention components and characteristics. Interventions appeared more effective when they: involved peers; used educational media to deliver health messages; increased availability of healthy foods in school; and incorporated computer-based individualised feedback with normative information on eating behaviours. A limitation of the review was the lack of description in certain reviewed studies, and the non-feasibility of conducting a meta-analysis owing to studies heterogeneity. Future interventions with this population could consider including the aforementioned components, gender-specific feedback, and both short- and long-term follow-ups as change may not be apparent immediately and to determine if changes are sustained.

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Introduction

Childhood obesity is a global public health concern, which affects all socioeconomic groups irrespective of a child's age, sex or ethnicity (1). Rates of childhood obesity have doubled over the past 30 years (2). Blake and Patel (2015) (3) suggest that obesity rates in England of children below 11 years of age appear to be stabilising; however, there is still an indication of rising obesity trends in children aged 11 years and above. Childhood obesity is linked with adulthood obesity, which has health (increased rates of morbidity) and economic (increased healthcare costs) consequences for the individual and for society as a whole (4). Childhood obesity has also been suggested to be the least socially-acceptable condition of childhood (5); children that are overweight can face discrimination and social marginalization, which can result in bullying by other children (6). Interventions that help to prevent and decrease unhealthy dietary behaviours are essential to avoid the long-term effects of these behaviours (7). Dietary behaviour is defined as the pattern of consumption of food by an individual (8).

Davison and Birch (2001) (9) suggest that to challenge the increasing prevalence of childhood obesity the immediate physical environment needs to change. Some authors (10) argue that a school's environment can play a part in the development and maintenance of obesity by promoting high energy food intake and sedentary behaviour (10,11) which may be conducive to weight gain (12). The school environment has been suggested as a platform where positive changes to behaviours can be implemented as interventions can be easily delivered and evaluated; given that schools have continuous, direct and intensive contact with children where a supportive healthy environment can be created (13–15) (Calvert, Dempsey & Povey – unpublished). Modifying the school environment could yield a long-lasting effect on childhood eating behaviours and obesity (12) by shaping the environment to allow children to make healthier choices (11).

Interventions to help prevent obesity need to have a key focus on dietary behaviour change (16). The volume of unhealthy food consumed by children cannot be solely offset by physical activity; for example, an average high-calorie meal would take up two hours of vigorous physical activity to counteract it (17). The improvement of children's dietary behaviours has been proposed by the World Health Organization (18) as a priority in every school because of the potential positive effects on general

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well-being. A healthy diet will not only help prevent obesity but can improve cognitive function that can lead to better concentration in class, which can in turn improve academic grades (19). Evidence suggests that maintaining a balanced diet supports a child's normal development and energy levels and reduces the risk of non-communicable diseases (2). Therefore, dietary behaviour change will be the focus of interventions evaluated in this present review. In addition, the review will focus on early adolescence (11 to 16 years) as this is a key time for the formation of dietary habits where adolescents are becoming increasingly independent and have more control over their own diets compared to younger children (20) given that in later adolescence (age 16 and above), behaviours are more resistant to change (7).

Previous systematic reviews that aimed to evaluated interventions designed to improve dietary behaviours have focused on using education with a younger age range within a school (21) or on older adolescents to young adults in a mixture of settings to improve nutrition (22), or targeted both dietary and physical activity behaviour change within schools (23), altered school environment policy (e.g. reduced the availability of certain unhealthy food) only (24,25) or were not in a school setting (26,27). None of these reviews has focused on improving dietary behaviours using school-based interventions solely with 11 to 16-year-olds. The primary aim of this current review is therefore to evaluate the effectiveness of school-based interventions in improving dietary behaviour for 11- to 16-year-olds. The secondary aim is to identify intervention characteristics and moderators that may contribute to the effectiveness of such school-based dietary behaviour change interventions.

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Methods

Identification of studies

The first author (SC) conducted the initial literature searches in February 2016, with a top-up search performed in May 2018 (the top-up search used the same search terms and databases as the initial search).

PICO search

The authors collaborated to develop the PICO (population, intervention, comparator, and outcome) framework which was as follows: (P) students 11-16 years old; (I) healthy eating intervention; (C) school-based intervention; (O) change in dietary behaviours. To maximize the yield of results we conducted a PICO search of key words, which were: *child, intervention, school* and *healthy eating*. A broad search strategy was employed to maximize the results of the search to help avoid excluding potential relevant studies.

Literature search

We conducted a systematic literature search for research published in English, with no date restrictions. Electronic searches were conducted using the following databases: CINAHL, ERIC, MEDLINE, PsycInfo, SPORTDiscus, ScienceDirect, and Opengrey. Additional literature searches using the reference lists of identified articles were also conducted. Restrictions were applied when searching databases, which were participant age (to include 8-18 years old) and quantitative-only studies.

Inclusion and exclusion criteria

Studies were selected for inclusion in the review if they met the following criteria: (1) the sample included children aged between 11-16 years old; (2) the dietary behaviour intervention included a component delivered in a school setting (e.g. at lunchtime, during class time, or at before/after school clubs); (3) at least one outcome measure of dietary behaviour was reported (can also include non-dietary behaviour measure e.g. amount of physical activity or anthropometric assessment); and (4) there was at least one pre- and post-intervention comparison of dietary behaviour. Articles describing observational methodology or qualitative studies, process evaluations or scale development were ineligible for this review.

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Selection process

All search results retrieved were exported into reference management software for eligibility screening. SC initially screened all titles and abstracts independently and removed duplicates from the database. The abstracts of studies were then screened for their eligibility for the review based on the inclusion and exclusion criteria. Ineligible studies were removed from the database and the reason for exclusion was noted (e.g., had no measure of dietary behaviour, did not include a school-based intervention). A second author (RD) independently screened a sample (10%) of the initial abstracts using the inclusion and exclusion criteria to ensure consistency. There were no discrepancies in ratings between the two authors. Finally, the full texts of the remaining studies were read by SC initially, and a random proportion (10%) were additionally reviewed by RD. Some further studies at the full text reading stage were discussed as a group (all 3 authors) to make a final decision on inclusion or exclusion. A high level of agreement was observed for inclusion of studies (>90%). Disagreements between the reviewers were resolved by discussion until consensus was reached.

Data extraction and analysis

An extraction sheet was used to extract relevant data including: title of the study; author name(s); year of publication; journal name; target behaviour; context and sample; design of the study; behavioural measure; theoretical base; and results. A random sample (10%) of the studies' extraction data were checked for accuracy by an independent researcher. A meta-analysis of the results from the reviewed interventions was not conducted owing to the diversity of outcome measures featured in the screened studies.

Analysis of intervention components

To identify common intervention components that were documented as contributing to successful interventions, we synthesised the data to compare intervention components between studies. Stage one

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of the analysis was to identify specific intervention components within each study as described by the author(s) (See Table 2). Stage two was to identify studies that improved dietary behaviours (29 studies) and cross-match any common intervention components. Once common components were identified, the contextual information of these individual components within studies was compared to investigate whether there were any common features of the individual components.

Quality assessment

The Effective Public Health Practice Project tool (EPHPP) (27) was used to rate the quality of the studies included within the review. In the EPHPP, quality of studies is assessed based on: selection bias (whether the sample was reflective of the target population); study design (whether the study was described as randomized and if so to what extent); confounding variables (whether the authors identified any confounding variables and if so were they controlled); blinding (whether participants and/or researchers delivering the intervention are blind to the aims of the studies); data collection methods (whether reliable and valid measures were used, and withdrawal and dropout rates were reported). Each component received a global rating of weak, moderate or strong, with scores across components calculated to provide an overall quality assessment of the study as weak, moderate or strong. Studies rated 'strong' overall were required to have no 'weak' rated components on the EPHPP, with 'moderate' studies having only one 'weak' rating, and 'weak' studies having two or more 'weak' ratings. One author (SC) assessed the quality of all studies and another author (RD) assessed the quality of 10% of the final studies (28). The authors agreed in their quality assessment of the reviews and there were no conflicts between authors of the final ratings (100% agreement).

Risk of bias

All studies were assessed individually for their risk of bias using six domains based on the Cochrane Risk of Bias tool (28) (selection bias, study design, confounding variables, blinding, data collection methods, withdrawal and dropout rates) (see Table 3) (29). Seven studies were judged to be a low Risk

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of bias (13, 29–34). An additional seven studies were judged to be at high risk of bias (36–42) primarily because the individual study designs were identified as not being random control trials (RCTs). Most of the studies (13,30–32,34,35,37–56) were judged to have at least one domain of unclear risk of bias, this was mainly owing to the selective reporting of features of these studies. The main feature that was not reported was the blinding of participants and/or researchers to study group allocation.

Results

A total of 1991 articles were initially identified, 1961 from electronic databases and 30 using reference lists, with seven duplicated articles removed. Of the 1984 titles, 24 studies met the inclusion and exclusion criteria after a title, abstract and full article review (see Figure 1 for the review flowchart and Table 1 for details of the reviewed studies) and the top-up search identified 77 extra studies by title; 5 studies were added to the final review, resulting in a total of 29 studies.

---- Figure 1 about here ----

General characteristics of the studies

The number of participants per study ranged from 88 to 32,482, and included adolescents aged 11-16 years old from a number of different countries. The majority of studies were conducted in the United States of America (n = 10) followed by Australia (n = 3), Canada (n = 2), England (n = 2), Norway (n = 2), Denmark (n = 2), Greece (n = 1), China (n = 1), Taiwan (n = 1), Israel (n = 1), Belgium (n = 1), Spain (n = 1), Tunisia (n = 1) and the Netherlands (n = 1). Of the 29 reviewed studies, 19 were randomized controlled trials (RCTs), 7 were of quasi-experimental design and 3 were cross-sectional. Intervention durations ranged from 2 weeks to 3 school years (see Table 1).

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Target behaviours and measurements

The target behaviours in the reviewed studies included: increasing fruit and/or vegetable consumption (n = 19) (30,31,33–38,40,43,44,46,47,49,50,53,56–58); improving snacking behaviours (n = 8) (this included both decreasing the intake of energy-dense nutrient-poor snacks, (13,33,47,50)) and increasing healthy snacks like fruits and vegetables, (34,38,45,52); decreasing sugar-sweetened beverage (SSB) intake (n = 8) (13,31,33,37,39,46,47,50); encouragement to eat meals on a regular basis (n = 4) (38,43,46,51); improving general eating behaviours (e.g. increase daily nutritional recommended intake of carbohydrates, fibre minerals, protein, and vitamins, n = 5) (42,51,54,55,58), and reducing daily fat and sugar intake (n = 3) (31,32,37). A number of studies (n = 13) targeted more than one dietary behaviour in their intervention (e.g. increasing fruit and vegetable consumption, decreasing SSB and unhealthy snacks consumption (47)) (13,31–34,37,38,43,46,47,50,51,58).

In terms of eating behaviour assessments, behavioural measures included food frequency questionnaires (FFQ) (n = 24) (13,43,36,29,30,57,46,32–34,49,39,52,55,42,48,45,44,51,38,50,53, 54,58), food diaries over periods of time ranging from 24 hrs to 7 days (n = 3; including one online) (41,42,57), dietary interviews including general structured interviews on daily dietary consumption (n = 2) (32,41), a paired food questionnaire (one healthy and one unhealthy option; n = 2 (44,52)), and a 'true or false' food statement questionnaire (would you eat a foodstuff, 'true or false'; n = 1 (38)). All of the reviewed studies had a 'before and after' measurement of dietary behaviour and 14 studies included a longer-term follow-up assessment (ranging from 6 weeks - 4 years) (13,30–33,35,38,39,42,47,51,54,56,59), while two studies also included a measure mid-intervention (42,47).

The majority of the studies (n = 22) included at least one other measure that was not dietary behaviour, such as: the amount of physical activity (n = 14) (30,31,33,35,37,38,43,46,47,49,51–53,58), anthropometric assessment (body mass index; n = 8) (13,35,43,47,49–51,53), physical and dietary social norms (subjective and group; n = 4) (13,30,54,57), self-efficacy (n = 3) (30,38,50), perceived behavioural control (n = 3) (13,54,57), behaviour intention (physical activity and dietary) (n = 5) (38,46,52,54,57), sedentary behaviours (including television viewing; n = 5) (33,35,37,43,46), habit

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strength (n = 1) (13), blood pressure (n = 1) (53), tobacco use (n = 1) (56), and self-perception (self-esteem and body dissatisfaction measures; n = 1) (51).

Intervention components

The main intervention components of the 29 studies are outlined in Table 2 (see below). The majority of studies included a healthy eating lesson component (n = 20) (13,30,32–34,37–40,42,44,45,47,49–56), healthy eating activities (e.g. practical activities – role-playing; n = 13) (13,32,38,39,41,42,44–46,50,52,54,56), a worksheet (e.g. problem solving; n = 16) (13,33,34,38–42,44,45,47,50,52,54,56,57), and/or a practical lesson (n = 11) (34,39–45,47,50,52). Ten studies included a combination of healthy eating lesson, activities and a worksheet (13,38,39,42,44,45,50,52,54,56). Only one study described providing students with homework (32) whilst two changed the cafeteria food provided for students in school (37,53). Some interventional studies involved third parties, such as peers (n = 9) (32,39,43,44,46,49,52,55,56) and parents (n = 10) (31,33,34,40,44,47,50,53,56,60).

Intervention delivery

Interventions were delivered by one or a combination of school staff (n = 15) (13,31–34,37,39–42,44,45,47,49,58), researchers (n = 4) (13,35,47,54), trained project staff (e.g. volunteers; n = 6) (30,37,38,53,58,59), peers (n = 9) (32,39,43,44,46,49,52,55,56), nutritional professional (n = 2) (51,55), a professional cook (n = 1) (45), or a nurse (n = 1) (47), whilst one intervention was self-directed (n = 1) (50).

---- Table 2 about here ----

Intervention effectiveness

Of the 29 studies identified for review, twenty-four were successful in promoting dietary behaviour change (13,31–33,35–40,42–46,49,51–58). One of the main contributing factors to a successful

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intervention was peer involvement. Of the studies that included peer involvement (n = 9) (32,39,43,44,46,49,52,55,56), such as discussion groups and small group projects, *all* were successful at promoting behaviour change within the target population. In addition, interventions that included media content (n = 7; for example, in-school pre-recorded radio or television shows promoting healthy eating behaviours) (13,31,32,43,44,46,52), or increased the availability of healthy foods in the school (n = 6) (13,31,37,44,49,59), also reported showing significant positive change in dietary behaviours (for example, increase in fruit and vegetable consumption (49)). Three studies used focused interventions to target specific behaviours, through increasing the availability of fruit (36), asking participants to form implementation intentions about fruit and vegetable consumption (57), and using computer-based feedback (35); All three studies reported significant increases in fruit and/or vegetable intake post-intervention.

Discussion

The aim of this systematic review was to provide an evaluation of school-based healthy eating interventions for 11 to 16 year olds. This review is the first to our knowledge to primarily focus on children's dietary behaviour change in this important age range within a school setting. The current review includes studies that demonstrate a wide range of interventions that have diverse components, measurements and target behaviours.

Summary of main findings

The review identified twenty-nine studies that attempted to modify adolescents' dietary behaviours through school-based interventions, with twenty-four interventions reporting positive changes in dietary behaviour outcomes. The intervention components (different behaviour change strategies) that seemed to be associated with improvements in dietary behaviour amongst this age group included: peer involvement; educational media; increasing in-school availability of healthy foods; and tailored

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computer-based feedback. Practical lessons, for example how to prepare food and/or cooking, only appeared to be an effective component in just over half the studies that utilized them. The inclusion of nutritional handbooks (including knowledge, dietary guidelines and self-motivated activities) in studies was associated with *less* effective dietary behaviour change. In addition, four out of the five studies that were *not* successful at improving dietary behaviour targeted more than one dietary behaviour (30,34,47,50).

Dietary behaviours targeted and types of interventions delivered

The review included a range of interventions that targeted both single and multiple dietary behaviours. Increasing fruit and/or vegetable consumption was targeted by over half of all the studies reviewed (n = 19) (30,31,33–35,37,38,40,43,44,46,47,49,50,53,56–59). Fruit and vegetables have many health benefits and adolescents are well documented as not eating the recommended daily amount (61); however, there is no agreed strategy to improve these behaviours (18). A number of studies within the review aimed to increase fruit and vegetables consumption to reach the recommended guidance (30,33,35,36,38,40,43,44,46,47,49,50,56,57). However, caution should be observed when comparing such studies, as the recommended guideline amounts for fruit and vegetable consumption can differ between countries (ranging from 5 to 10 portions dependent on country) (62). There is some disagreement in the literature about whether the consumption of fruit and vegetables should be considered as the same or as separate behaviours and so be independently targeted in interventions (63) as fruit and vegetables have different nutritional value (64). Future interventional research should evaluate whether targeting multiple dietary behaviours (e.g. fruit and vegetable consumption), or focusing on a single dietary behaviour, would be more effective in improving dietary behaviours amongst adolescents.

The types of interventions included in the review were, firstly, single-component (i.e. featured a single behaviour change strategy) (35,57,59); these three studies were all successful at improving behaviour, potentially because interventions that are more targeted are simpler to adopt (65). Secondly,

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there were multiple-component interventions (i.e. included multiple behaviour change strategies); out of these twenty-six studies, (13,43,36,37,29,30,57,46,32,33,49,39,52,55,42,48,45,44,51,38, 50,53,41,31,40), only five were *not* successful at changing dietary behaviour (30,34,41,47,50). It has been argued that to change adolescents' dietary behaviour, interventions should use multiple strategies simultaneously (44). However, this can be challenging as it can be unclear which components are effective in eliciting behaviour change, and also it is difficult to assess if all components have been properly implemented, which could affect the intended outcomes (66,67).

Duration of interventions and how they were measured

The duration of the delivery of interventions varied within the review ranging from two weeks to three school years. Research has suggested that changing children's dietary behaviours can be difficult using short-term interventions (in terms of the duration of intervention itself) (48). However, four out of the five reviewed studies that were *not* successful at changing behaviour ranged in duration from 8 months to 2 years (30,41,47,50). This lack of success may be explained by the frequency of structured contact sessions (intensity) related to the intervention; three of the studies that were not successful had physical contact once per month or less frequently (e.g. every other month) (30,47,50). Also, one unsuccessful study which had contact time on average of once per week divided in four blocks of 5 weeks duration (total of 20 sessions) over seven months, found that only 6 students out of 84 that consented to take part actually attended all of the intervention sessions (41). It has been suggested for a dietary behaviour change intervention that the level of exposure of the intervention can affect its intended outcome (68). Authors inconsistently reported the uptake and retention for each intervention, which can make it challenging to analyse the exposure to (or dose of) a dietary behaviour intervention and whether this influences behaviour change (69). Overall, the results showed that longer interventions are not necessarily more effective, it is important to take into consideration other factors such as uptake of intervention, and exposure to the intervention.

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All the studies in the review involved at least one self-report measure of dietary behaviour. The majority, twenty-four studies, utilised a food frequency questionnaire (FFQ). As school-based studies often have large sample sizes, self-report measures allow the collection of a large amount of data that is comparable in an efficient manner (70). A number of studies in the review indicate that using a self-report measure such as FFQ can be limiting as individuals can over- or underestimate dietary behaviours (31,34,35,37–39,43,49,50,53,56). One study argued that FFQs are not sensitive enough to detect immediate slight dietary changes, and perhaps repetition of the measurement is needed at a longer-term follow-up (50). Moreover, researchers have suggested that the most effective tool in which to measure adolescents' dietary behaviours is a combination of both a FFQ and multiple 24-hour recall diaries (71,72), to document both the frequency of consumption (using a FFQ) and also more precise details of foods consumed (via 24-hour recall). Therefore, it is recommended that there needs to be a repeated use within research of a validated measure of dietary behaviour to be able to compare studies.

Effectiveness of improving dietary behaviour for 11- to 16-year-olds

Of the twenty-nine studies included in this review, twenty-four studies reported significant improvements in dietary behaviour. It was notable that the five studies which reported non-significant results, only included follow-up assessments taken immediately after the intervention (30,34,41,47,50,73), which may not be sufficient time to evidence possible changes in behaviour. It has been argued that longer-term follow-ups are needed following interventional studies as dietary behaviour change may not be apparent immediately (74). Shepherd and Shepherd (2002) (75) argue that even when dietary changes do occur, they may be slower and less evident than is expected, potentially because habits change at a gradual pace and eating behaviour is in large part habitual (75,76). A recommendation based on this review, supported by prior reviews (63), is that future studies need to include follow-up assessments at both the short and longer term to better account for possible changes in dietary behaviour. In the present review, short-term measures were collected in the period of 1 – 6 weeks post-intervention whilst longer-term measures were collected from 7 weeks to 4 years post-

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intervention. Ensuring that both short and longer-term follow-ups are included in studies will mean that the possible effects of the intervention on outcomes are appropriately documented.

Gender differences

It is noteworthy that four studies targeted a female-only population (38,42,51,73), but no studies targeted a male-only population amongst this 11-16 year old age group. These studies justified their use of a female-only population based on previously reported gender-differences in dietary behaviours, such as female students often having unhealthy dietary patterns, skipping meals, and eating unhealthy foods often lacking in protein, calcium and iron (77). Sweeting (2007) (78) suggested that obesity prevention interventions are more likely to be developed for adolescent girls, as girls in adolescence become increasingly concerned about body image and body weight management. Girls in this age bracket also decrease their involvement in physical activity (79) and often lack important nutrients required for a healthy diet (80). Seven studies within the present review noted that there were gender differences in the results (13,31,33,43,46,52,58). For example, within one reviewed study males were reported to significantly decrease snacking behaviours whereas females increased fruit consumption (33). One study suggested that girls were more concerned about health than boys at baseline assessment; therefore, girls were more motivated to make dietary changes leading into the intervention (52). Future interventions with this age group may need to include gender-specific interventional components (strategies) to target the same unhealthy dietary behaviours (13) as it is suggested that different genders respond to and are motivated by different components of an intervention (81).

Effective intervention characteristics

The involvement of peers within the studies seemed to be effective in producing positive changes in dietary behaviour amongst 11-16 year olds (32,39,43,44,46,49,52,55,56). Five out of the nine studies that included peers had a quality assessment rating of moderate to strong (32,43,44,46,49). Peer

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involvement ranged from actively delivering the dietary behaviour intervention including group discussions and activities (44), to less intensive peer support offering monthly sessions (55). Research has suggested that peer education methods are more effective than traditional methods of delivering interventions (82). Peer education is seen to be useful in promoting healthy behaviours and positive behaviour change (83), as it provides opportunities for social learning (peer modelling) and social support (84,85). It has been suggested that peer relationships offer the opportunity to develop personal relationships, help define social behaviours, and create a sense of belonging within a social group (84), with peer involvement increasing the effectiveness of health promotion interventions (86). The inclusion of peer-led activities within an intervention may be beneficial in helping to improve adolescents' dietary behaviours, as individuals in this age group may model their behaviours according to those of their peers, and to what is perceived to be socially acceptable.

Media campaigns have been previously used to disseminate health-promoting messages to a wide community (87). Raising awareness has been suggested as a mechanism to improve behaviour (88); however, improving individuals' knowledge alone has been suggested to be insufficient to change health behaviours including dietary change (88–90). Studies within the review which included educational media (media that assist in conveying educational information for example, via videos) within the intervention appeared to be successful in changing dietary behaviours (13,32,42–44,49,52); however, it was unclear in the study descriptions what specific content was featured in these media-based information-focused interventions. Most of the studies that included media to promote health related messages were rated as being of moderate to strong quality (13,32,43,44,46). Use of educational media within these studies was not the only method of delivering diet-promoting messages; rather, it was part of a multifaceted approach, for example, alongside activity sheets or as part of a healthy eating lesson (13,44). It has been argued that the same messages delivered by multiple methods can have greater impact on behaviour than messages delivered by media alone (91). Therefore, it is recommended that interventions should employ multiple strategies to deliver the same interventional messages to produce the greatest impact on dietary behaviour outcomes.

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Increasing the availability or affordability of healthy food was a feature of six interventions associated with improving dietary behaviour (13,31,36,37,44,49). Half of the studies that increased availability or affordability of healthy food had a moderate to strong quality rating (13,44,49). Adolescents' eating behaviours are ultimately influenced by what is available and accessible to them (92), this is important as accessibility to healthy foods is suggested to be effective in improving their long term consumption (93). Research shows that improved dietary behaviours following increased food availability continues even when the free food provided in the original interventions is no longer available (94,95). Changing adolescents' immediate food environments to provide healthy options may encourage healthy behaviours (93); however, further research needs to consider types of exposure and the amount of time spent in the environment and what effect this has on dietary behaviours.

Lastly, the incorporation of tailored or personalised computer-based feedback was indicated as being successful in changing dietary behaviours in four of the five studies that employed it (13,31,35,42). Tailored computer-based feedback has been suggested to be an effective tool in improving dietary behaviour, as individuals often lack an awareness of recommended healthy behaviours compared to their own behaviour (96). Research has suggested that by tailoring feedback, it provides individuals with guidance on their own dietary behaviours, as well as identifying personal goals and individual motivations to change health-related behaviour (97). Four studies within the review that utilised tailored computer-based feedback, which included a comparison with normative behaviour, reported successful changes in dietary behaviours (13,31,35,42), including reducing sugar-sweetened beverages (13) and unhealthy food intake (31), and increasing fruit and vegetables (35) and dairy, protein and fruit intake (42). However, studies which only gave information about recommended intake of foods, without a comparison to the individuals' own behaviours, appeared to be less effective (30,34,41,50). Three of the computer-based studies which used tailored computer-based feedback included comparisons to recommended consumption (government guidelines) and peers' behaviours (social norms) (13,35,42), the other provided individualized-computer feedback about individuals' behaviours compared to recommended consumption but also asked individuals to discuss their feedback with a parent (31): two out of these three studies had strong quality ratings (13,35). The one study that

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was *not* successful at changing behaviour gave normative feedback compared to recommended consumption only (47). It has been suggested that providing a person with normative feedback can help improve behaviour as individuals will adjust their behaviour accordingly (i.e. to match the perceived appropriate norm) (98). Furthermore, the advantages of tailored feedback are that it can be self-directed, target school-specific behaviours and norms, and it can address multiple behaviours within a short session (35).

Strengths and limitations

A strength of the present review is the comparison of different intervention components that are employed to change dietary behaviours amongst 11- to 16-year-olds in a school setting. To our knowledge, there is no existing review for in-school dietary behaviour change interventions with this age group. A further strength of this review is that the searches were comprehensive, resulting in a substantial number of studies, which used different types of interventions, targeted a number of dietary behaviours from a variety of countries, and utilised different study designs. This has helped to identify recommendations for future interventional research, within this age range, in a school setting and has decreased the possibility of excluding relevant studies. Although the review has several strengths, some limitations should be noted before concluding the review. One limitation, that is not just limited to this individual review but has been documented in other reviews (99) (Dempsey, McAlaney & Bewick – unpublished), is the lack of description or selective reporting in the original studies of the implemented intervention; this includes, but is not restricted to, the inadequate description of some intervention components (e.g. the specific feedback messages incorporated in the intervention), the intervention and study design, and levels of exposure of the intervention to participants. This makes it difficult to draw conclusions from some studies because of the lack of specific detail in the descriptions of interventional components, as well as difficulty in identifying what was successful at changing dietary behaviours, and how and why this was effective. A further potential limitation was the non-feasibility of conducting a meta-analysis owing to the heterogeneity of the behaviour measurements used, behaviour targeted,

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and results reported; however, to try to reduce the bias, a grey literature database was also searched. The review also was limited to studies published in 'English language only', which potentially could have limited the studies retrieved and the generalisability; however, the current review did include studies from a wide variety of countries.

Conclusion

School-based interventions which aim to improve dietary behaviours amongst 11- to 16-year-olds are important, given that this is a key time for the formation of dietary habits. School settings represent a controlled environmental setting suitable for interventions, and positive behaviour change can be encouraged before unhealthy behaviours become habitual and more resistant to change with age. The findings of this systematic review suggest that interventions that aim to improve dietary behaviours in 11- to 16-year-olds within a school setting should potentially consider the following components: involve peers in the delivery of the intervention; include educational media to deliver intervention messages; increase the availability of healthy foods in the school environment; and incorporate computerised tailored feedback that includes normative behaviours. More research is needed to evaluate these individual intervention components and their effects on dietary behaviours. The findings also suggest that there is also a need for interventional studies to include both short- and long-term follow-ups to better model and identify possible changes in dietary behaviour, especially as some behaviour changes may not be apparent immediately post-intervention. Given that there appear to be some gender differences in dietary behaviours in this age group, future interventions should also consider the use of tailored gender-specific feedback to increase the personal relevance and possible effectiveness of interventions for girls and boys respectively.

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Table 1. Description of studies included in the review.

Author(s) and Year	*Target dietary behaviour*	*Context and Sample size (at baseline)*	*Design*	*Behaviour measure(s)*	*Dietary behaviour results*	*Description of intervention**	*Quality assessment*
Aceves-Martins et al. (2017)	Fruit and vegetable consumption and eating breakfast on a regular basis	4 schools in Spain. (n) 393	Random control trial (RCT). Intervention groups compared to control groups.	Participants completed online questionnaires to measure: Food frequency (FFQ), physical activity levels and amount of screen time. These measurements were taken at two time points (baseline and post).	The intervention schools showed a significant increase compared to the control in:- • Increased fruit consumption ($p < 0.01$). • Males also increased vegetable consumption ($p < 0.01$). In-group change (intervention group):- • Increased breakfast consumption ($p < 0.01$).	• 2 school years • 13-16 years old (14.69 intervention and 14.63 control (mean)) • No specific theoretical base identified	Moderate

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Bere et al.(2006)	Fruit and vegetable consumption	38 Norwegian schools. (n) 1950	RCT. Intervention group compared to a control.	Past 24-hour recall of fruit and vegetable consumption, along with a FFQ at three time points (baseline, 8 months and 4 years) to investigate the intervention (school fruit programme – free fruit)	The intervention schools showed a significant increase at 8 months and sustained at three year follow-up compared to the control in :- • Fruit and vegetable intake ($p < 0.001$).	• 1 school year • 11.8 years old (mean) • Ecological model	Weak
Birnbaum et al. (2002)	Fruit and vegetable consumption	16 schools in the USA. (n)3878	RCT. Four groups:- 1) Control, 2) School environment 3) Classroom plus school environment	FFQ, Paired food questionnaire and a theory of planned behaviour questionnaire (eating behaviour change) were completed at baseline and 1-year follow-up.	A significant effect was seen in group 4 compared to the other groups results showed an increase in:- • Number of servings of fruit and vegetables ($p = 0.012$). • Tendency to choose low-fat foods ($p = 0.002$).	• 1 school year • 12-13 years old • Social Cognitive theory	Moderate

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			4) Peer leaders, classroom and school environment		Also, group 3 showed an significant effect of a tendency to choose low-fat foods ($p < 0.001$)		
Bukhari et al, (2011)	To increase healthy snacking	1 school in the USA. (n)98	RCT. Intervention group compared to a control (art class)	FFQs were completed at baseline and post-measure of dietary behaviour, the questionnaire also included questions about attitude and culinary skills.	Compared to the control intervention class showed significant increases in: • Eating vegetables as snacks ($p < 0.001$) • Preparing snacks for self ($p < 0.01$) • Having sit-down meals with family ($p < 0.004$).	• 19 weeks • Grade 9 (14-15 years old) • Social Cognitive theory and Social Ecological model	Weak
Chin A Paw et al.(2008)	To reduce the consumption of sugar-sweetened	18 schools in the Netherlands.	RCT. Intervention	DOit questionnaires were completed at baseline, and after 8, 12 and 20 months (paper only includes baseline and	The intervention school compared to the control at 8 months compared to the	• 8 months (Sept 03-May 04) • 12-13 years old	Strong

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beverages (SSB) and unhealthy snacks	(n) 854	group compared to a control.	8month data). The questionnaire measured dietary intake (FFQ), physical activity, behaviour-specific cognition and habit strength	baseline showed significant result in:- • Reduction of sugar-sweetened beverages (SSB) ($p < 0.05$). In the intervention schools males significantly improved (hypothesized mediators) ($p < 0.05$):- • Subjective norms regarding 'active transport' (actively commuting to school) • Snacking consumption • Improved attitude • Decreased habit strength regarding SSB.	• Theory of Planned behaviour and Habit Strength theory

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de Visser et al. (2016)	Fruit and vegetable consumption and reduce the consumption of SSB, sugar and fat.	20 schools in the USA. (n) 2315	Quasi-experimental design.	SPAN questionnaire was completed at baseline and post (within 6 weeks after intervention). The questionnaire measured dietary behaviours (FFQ), SSB consumption, physical activity and sedentary behaviours.	The intervention schools, compared to the other schools, significantly:- • Increased fruit intake (p = 0.046) • Fewer sugary/fatty foods (p = 0.002)	• 1 school year • 11-12 years old • Socioecological models	Weak
Dowd et al. (2015)	Increase healthy snacking, fruit and vegetable consumption, and eating breakfast on a regular basis.	38 schools in Canada. (n) 344 female students	Cross-sectional study	Participants completed questionnaires investigating cognition (attitudes, self-regulatory efficacy and intentions) and behaviours (physical and dietary) (true or false responses) at four time points (two pre-baseline, post-	Participants significantly improved at 7-weeks compared to the mean of time 1 and 2:- • Healthy eating behaviours (p < 0.05).	• 7 weeks (7 sessions) • 11-14 years old (mean 11.68) • Social Cognitive model	Weak

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				programme and at 7-week follow-up)			
Dzewaltowski et al. (2009)	Fruit and vegetable consumption	16 schools in the USA. (n)2211	RCT. Intervention group compared to a control	Participants completed questionnaires measuring psychosocial variables, a FFQ and self-report physical activity measure, which were taken at baseline, post-intervention and at 2 years.	No interventional effect on dietary behaviour change.	• 2 school years • 11-12 years old (mean 12.36) • Social Cognitive model	Strong
Foley at al. (2017)	Fruit and vegetable consumption, increase	23 schools in Australia. (n) 519	Quasi-experimental design.	Participants completed online questionnaires to measure: FFQ, physical activity levels, school-day recreation screen	Peer leaders significantly improved:-	• 4 x 70 minute sessions (delivered over 25 days)	Moderate

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	regular breakfast consumption, and reduce SSB.			time, and intentions regarding these. Data was collected at baseline and post intervention.	• The amount of fruit ($p < 0.01$) and vegetable portions a day ($p < 0.01$). • By reducing SSB ($p < 0.01$) Males also significantly increased:- • Regular breakfast consumption ($p < 0.05$)	• 15-16 years old • Social cognitive theory and Empowerment education approach.	
Gratton et al. (2007)	Fruit and vegetable consumption	1 school in the United Kingdom. (n)198	RCT. Three groups:- 1)Received only the volitional intervention,	Participants were asked to complete a 7-day food diary and a questionnaire (measuring attitude, subjective norms, perceived behavioural control	There was a significant difference between groups ($p < 0.001$) :- • Group 1 and 2 showed significant increase in fruit	• 3 weeks • 11-16 years old (mean 13.1)	Moderate

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			2)Received only the motivational intervention, 3) Control (received a volitional intervention about homework not fruit and vegetables)	and behavioural intention). Data was collected at baseline and post intervention.	and vegetable consumption ($p < 0.001$) between the time points. • The volitional intervention increased intake only over the control group ($p < 0.001$)	• Theory of Planned Behaviour	
Haerens et al. (2006)	Increase fruit and water intake and decrease SSB and fat intake.	15 schools in Belgium. (n)2840	RCT. Three groups:- 1) Intervention with parental involvement,	FFQ were completed along with physical activity questionnaire at baseline, 1 year, and 2 years.	There was a significant positive intervention effect compared to the control at baseline to 2-year follow up (female only):- • Decreasing unhealthy fat intake ($p < 0.05$)	• Two school years • 11-15 years old (mean 13.1) • Social Cognitive theory and Theory of	Weak

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			2) Intervention alone, 3) Control			Planned Behaviour	
Hölund (1990)	Reduce sugar and unhealthy fat consumption.	4 schools in the Netherlands. (n)127	RCT. Intervention group compared to a control	Diet history was taken by interview at baseline and post programme. Social and psychological data were collected at baseline, post, and 2-month follow-up.	Intervention group compared to the control significantly:- • Reduced sugar intake (p = 0.05) and maintained 1 month after, compared to the control group.	• 25 lessons (did not specify duration) • 14 years old • The Heath Belief model, Social Learning theory, Theory of Reasoned Action, Problem Behaviour theory, Group	Strong

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						Dynamics approach.	
Hoelscher et al. (2016)	Increase fruit and vegetables, whole grains, low fat and fat-free dairy foods.	72 schools in the USA. (n) 32,482	Cross-sectional study.	Dietary behaviour (FFQ) and physical activity questionnaire were completed at baseline and post intervention	Participants significantly increased from baseline to follow-up in :- • Fruit (95% CI; 1.08-1.19) and vegetable (95% CI; 1.06-1.14) consumption • Whole grain consumption (95% CI; 1.21-1.34) Males, also significantly increased:- • Low-fat (95% CI; 1.00-1.10) and fat-free dairy (95% CI; 1.08-1.14) foods consumption.	• 9 months • 12.33 years old (mean) • No specific theoretical base identified	Weak

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Lien et al. (2010)	Fruit and vegetable consumption. Decrease SSB and unhealthy snacks consumption.	37 schools in Norway. (n)1580	Cluster RCT. Intervention group compared to a control.	FFQ, BMI and physical activity measures were collected at baseline, after year 1 and post-intervention.	No intervention effect on any of the measures.	• 2 school years • 11-13 years old • Dual Process model and Social ecological framework	Weak
Lo et al. (2008)	To decrease SSB	2 schools in Canada. (n)113	RCT. Four groups:- A) multiple peer educators and intervention (school 1), B) Control (received only student handouts	Nutrition knowledge, attitude towards SSB (FQ) and self-report beverage consumption were completed at baseline, post intervention and 3-month follow-up. There was a 1 year follow-up questionnaire for group A and B.	Within Group A there was a significant:- • Decrease in SSB intake and this was sustained after 3 months ($p < 0.02$). Within Group B there was a significant:- • Increased fruit juice consumption ($p < 0.02$).	• 6 weeks • 14 years old (mean) • Constructivist theory of learning	Weak

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			from the intervention) (school 1), C) Only one peer educator and intervention (school 2). D)Control (received only student handouts from the intervention) (school 2)		Within Group D there was a significant:- • Decrease in SSB intake ($p < 0.02$), but it was not sustained at 3-month follow-up.		
Lubans et al. (2009)	Fruit and vegetable consumption.	6 schools in Australia (n)124	RCT. Intervention	Physical activity, self-reported sedentary behaviour and dietary habits(FFQ) were completed at	There was a significant interventional result within	• 6 months • 14.1 years old (mean)	Weak

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	Decrease SSB and unhealthy snacks.		group compared to a control.	baseline, post and 6 months follow-up	groups but not compared to the control:- • Males decreased their snacking (p = 0.043) • Females increased fruit intake (p = 0.028).	• Social Cognitive model	
Maatoug et al. (2015)	Fruit and vegetable consumption.	15 schools in Tunisia. (n) 4003	Quasi-experimental design.	FFQ, physical activity questionnaires, and BMI were collected at baseline and post intervention.	Significant in- group changes (intervention group):- • Increased recommended fruit and vegetable consumption (p = 0.03).	• 3 school years • 11-16 years old • No specific theoretical base identified	Moderate
Martens et al. (2010)	Fruit consumption and improve snacking behaviours	10 Danish schools. (n) 879 students 1110 parents	Cross-sectional design	Two FFQ were used to measure dietary intake. They were completed at baseline and post intervention.	Non-significant result. However, there was a small increase in fruit consumption per day and a decrease of snacks per day (these were	• 3 months • 12-14 years old • No specific theoretical base identified	Weak

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					comparisons for pre- to post-test)		
Mauriello et al. (2010)	Fruit and vegetable consumption.	8 schools in USA. (n)1800	RCT. Intervention group compared to a control.	FFQ, amount of physical activity and television viewing were collected at baseline, 2, 6 and 12 months.	There was a significant interventional result compared to control:- • Participants in the treatment group were 'in action', or 'maintenance' at 2 months, for fruit and vegetable consumption ($p < 0.001$) • There was sustained significant increase at 6 ($p < 0.01$) and 12 months ($p < 0.01$) for fruit and vegetable consumption.	• 2 months • 15.97 years old (mean) (9^{th}-11^{th} grade) • Transtheoretical Model of Behaviour Change	Strong

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McCabe et al. (2015)	Fruit and vegetable consumption. Reduce SSB and unhealthy snacks.	12 schools in Australia. (n) 294. Female students	RCT. Intervention group compared to a control.	The Australian Eating Survey (AES) was completed (FFQ) at baseline and 12 months, it also included measures of intention, self-efficacy, outcome expectations, and the home environment.	No interventional effect on dietary behaviour change.	• 12 months • 13.20 years old (mean) • Social Cognitive theory	Weak
Neumark-Sztainer et al. (1995)	Increase regular meals and increase healthier food choices.	3 schools in Jerusalem. (n)341 female students	Quasi-experimental design.	Questionnaires were completed to measure nutritional knowledge; dietary behaviour (FFQ); self-esteem; body dissatisfaction; attitudes and quality of recent weight loss methods at baseline, 6 months and 2 years.	There was a significant interventional result:- • Participants at 6-month follow-up with an increase in regular meal-taking ($p < 0.01$) • Increased nutritional knowledge ($p < 0.05$).	• 10 weeks • 15.3 years old (mean) • Social Cognitive theory	Strong

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Perry et al. (1987).	Increase healthy snacking	1 school in the USA. (n)270	RCT. Intervention group compared to a control.	Self-report survey measuring behaviour (FFQ), knowledge, intention and skills related to 'heart health' and eating. Measurements were completed at baseline and 1-year follow-up.	There was a significant interventional result compared to the control:- Females • Showed improvement in knowledge ($p < 0.001$) and awareness ($p = 0.001$) regarding their diet • Improved actual eating habits ($p = 0.001$). Males • Gained nutrition knowledge ($p < 0.05$) • Modified their salt use ($p < 0.05$)	• 10 lessons (Fall of 1984 and repeated in Winter 1985) • Grade 9 (14-15 years old) • Social Learning theory	Weak

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Ratcliffe (2011)	Vegetable consumption	3 schools in the USA. (n)302	Quasi-experiment with a control	A vegetable frequency questionnaire was completed at baseline and post intervention. Also a taste test – to name, taste and rate their preferences.	There was a significant interventional result:- • Children could correctly identify more vegetables ($p = 0.02$) • Increased preference for vegetables ($p = 0.029$) • Increased willingness to taste vegetables ($p < 0.001$). • Increased the number and variety of vegetables they consumed per month ($p < 0.001$).	• 4 months • 11-13 years old • Social Cognitive theory	Weak

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Revill (2004)	To increase healthy food consumption	10 schools in the United Kingdom. (n)171	RCT. Intervention group compared to a control.	Intake was measured at baseline and post intervention using 3-day self-report dietary intake diary, interview about food consumed, and a nutritional knowledge questionnaire.	There were no significant changes between the intervention group compared to the control.	• 20 weeks • Year 8 (12-13 years old) • No specific theoretical base identified	Weak
Siega-Riz et al. (2011)	Fruit and vegetable consumption	42 schools in the USA. (n)4603	Cluster RCT. Intervention group compared to a control.	Self-report dietary intake using the Block Kids' questionnaire (FFQ). Measurements completed at baseline and post intervention.	Intervention group compared to the control significantly increased:- • Water consumption (p = 0.008) • Daily fruit consumption (p = 0.002)	• 5 school semesters • 10-11 years old (11.3 years old) • Social Ecological model	Moderate

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Tsorbatzoudis (2005)	To increase general healthy eating behaviours	5 schools in Greece. (n)335	Quasi-experiment with a control.	FFQ were completed at the beginning of the second semester, after the intervention was completed and then at 2-month follow-up. Participants also answered questions about intention, attitude, subjective norms, perceived behaviour control, role identity and attitude strength.	There were significant changes between groups in:- • Attitudes towards healthy eating and attitude strength ($p < 0.001$), • Intention ($p < 0.001$), perceived behavioural control ($p < 0.001$). • Healthy eating behaviours ($p < 0.05$).	• 12 weeks • 14.8 years old (mean) • Theory of Planned Behaviour	Weak
Wang et al. (2015)	To increase general healthy eating behaviours	3 schools in China. (n)195 students 195 parents 60 staff	RCT. Three groups:- 1) The health promotion school (HPS),	A self-report measurement of healthy eating behaviours (FFQ) and knowledge was completed at baseline and 3-month follow-up.	HPS had the largest significant improvement in eating behaviours (students) ($p < 0.001$) and knowledge ($p < 0.001$) when compared to the other two groups.	• 3 months • 12-14 years old (12.8 years old) • Bronfenbrenner's Ecological theory	Weak

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			2) school with improved health education only, 3) Control.				
Wilson (2012)	Fruit and vegetables consumption	10 schools in the USA. (n)1119	RCT. Intervention group compared to a control.	Students completed self-reports assessing different healthy behaviours (FFQ), knowledge, and psychosocial variables. Measurements were taken baseline, post intervention and 1-year follow-up.	Intervention group compared to the control significantly increased:- • Fruit and vegetable consumption immediately after intervention (p = 0.039) and at 1-year follow-up (p = 0.040). • Knowledge of 5-a-day recommendation was significantly higher in intervention school	• 8 weeks • 12-15 years old (12.7 years old) • Social Cognitive theory and Theory of Reasoned Action	Weak

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					immediately post intervention ($p = 0.002$) but not at 1 year follow-up.		
Yang et al. (2015)	To increase general healthy eating behaviours	1 school in North Taiwan. (n) 88 female students	Quasi-experiment with three groups:- 1) cognitive-based instruction, 2) 'Cloud' diet assessment system 3) 'Cloud' diet assessment system and	Participants completed an online daily diet assessment: this was completed at baseline and post intervention	Group 3 had significant improvement in:- • Consumption of food groups (including dairy ($p < 0.01$), meats and proteins ($p = 0.01$), vegetables ($p < 0.01$) and fruit ($p < 0.01$) and micronutrients ($p < 0.01$).	10 weeks 15-16 years old Social-Interdependence theory	Weak

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	game-based group learning.

Key: FFQ = Food Frequency Questionnaire; RCT = Randomised Controlled Trial; SSB = Sugar-sweetened beverage.

*Intervention description – duration of intervention, age of participants (range and/or mean at baseline), theoretical base (if presented)

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Table 2. Summary table of key information of intervention components across studies.

Study reference	*Aceves-Martins et al.*	*Bere et al.*	*Birnbaum et al.*	*Bukhari et al.*	*Chin A Paw et al.*	*de Visser*	*Dowd et al.*	*Dzewaltowsk et al.*	*Foley et al.*	*Gratton et al.*	*Haerens et al.*	*Holund*	*Hoelscher et al.*	*Lien et al.*	*Lo et al.*	*Lubans et al.*	*Maatoug et al.*	*Martens et al.*	*Mauriello et al.*	*McCabe et al.*	*Neumark-Sztainer et al.*	*Perry et al.*	*Ratcliffe et al.*	*Revill et al.*	*Siega-Riz et al.*	*Tsorbatzoudis*	*Wang et al.*	*Wilson et al.*	*Yang et al.*
Intervention components																													
In the classroom																													
Healthy eating lessons Teacher-led			X	X	X	X	X	X				X		X	X	X	X	X		X	X	X	X		X	X	X		X
Activities e.g. Role play Quizzes			X	X	X		X		X			X			X					X		X		X		X		X	X
Worksheets in lesson e.g. Problem solving Goal setting			X	X	X		X			X				X	X	X		X		X		X	X	X		X		X	X
Handbooks														X		X				X									
Self-evaluation Diary Self-assessment			X													X													
Homework												X																	
Educational Media e.g. Radio/TV shows	X		X		X				X			X										X							X
Prizes/competitions	X					X							X				X												
Computerised feedback(personalised)					X						X			X					X										X
Practical lessons e.g. Cooking	X		X	X										X	X			X		X		X	X	X					X
In the school																													
Increased exposure to healthy foods. e.g. Posters	X		X		X	X		X			X		X	X	X		X	X							X	X	X		
Increased availability of healthy foods in school		X	X		X	X					X						X												
Peer involvement																													
Peer-led activities	X		X						X			X			X		X					X					X	X	
Teacher involvement																													
Training/workshops						X		X						X												X	X		
Parent involvement																													
Information			X								X					X		X							X		X		
Newsletters			X								X							X		X									
Coupons			X																										
Text/emails																X				X									
In-school learning sessions											X					X	X						X				X		
Home activities																												X	
School canteen staff																													
Food provided revised						X																			X				

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Table 3 - Table showing forms of risk bias across studies (adapted from the Cochrane Risk of Bias Tool)

	Selection Bias	Study design*	Confounding variables	Blinding	Data collection methods	Withdrawal and dropout rates
Aceves-Martins et al. (2017)	-	-	?	-	+	-
Bere et al. (2006)	-	-	+	-	-	+
Birnbaum et al. (2002)	-	-	-	?	+	-
Bukhari et al, (2011)	-	-	+	-	?	?
Chin A Paw et al. (2008)	-	-	-	-	?	-
de Visser et al. (2016)	-	+	?	?	+	-
Dowd et al. (2015)	-	+	?	?	+	-
Dzewaltowski et al. (2009)	-	-	-	?	-	-
Foley at al. (2017)	-	+	?	-	?	-
Gratton et al. (2007)	-	-	+	-	-	-
Haerens et al. (2006)	-	-	?	?	-	-
Hölund (1990)	-	-	-	?	-	-
Hoelscher et al. (2016)	-	+	-	-	-	-
Lien et al. (2010)	+	-	-	?	?	-
Lo et al. (2008)	-	+	-	?	+	-
Lubans et al. (2009)	-	-	-	?	?	-
Maatoug et al. (2015)	-	+	-	-	?	-
Martens et al. (2010)	-	-	-	?	?	-
Mauriello et al. (2010)	-	-	-	-	?	-
McCabe et al. (2015)	+	-	-	?	-	-
Neumark-Sztainer et al. (1995)	-	+	-	-	?	-
Perry et al. (1987).	-	-	?	?	-	+
Ratcliffe (2011)	-	+	?	?	+	-
Revill (2004)	-	+	-	?	?	+
Siega-Riz et al. (2011)	-	-	-	?	+	-
Tsorbatzoudis (2005)	-	+	-	?	?	-
Wang et al. (2015)	-	-	-	?	+	-
Wilson (2012)	-	-	?	?	+	-
Yang et al. (2015)	-	+	+	?	?	?

Key: (+) High risk of bias, (-) Low risk of bias, (?) Unclear risk of bias

*Study design – will be indicated as high risk (+) if the design was not a Randomised control trial (note within the quality assessment tool some designs would be rated as moderate e,g, Cohort)

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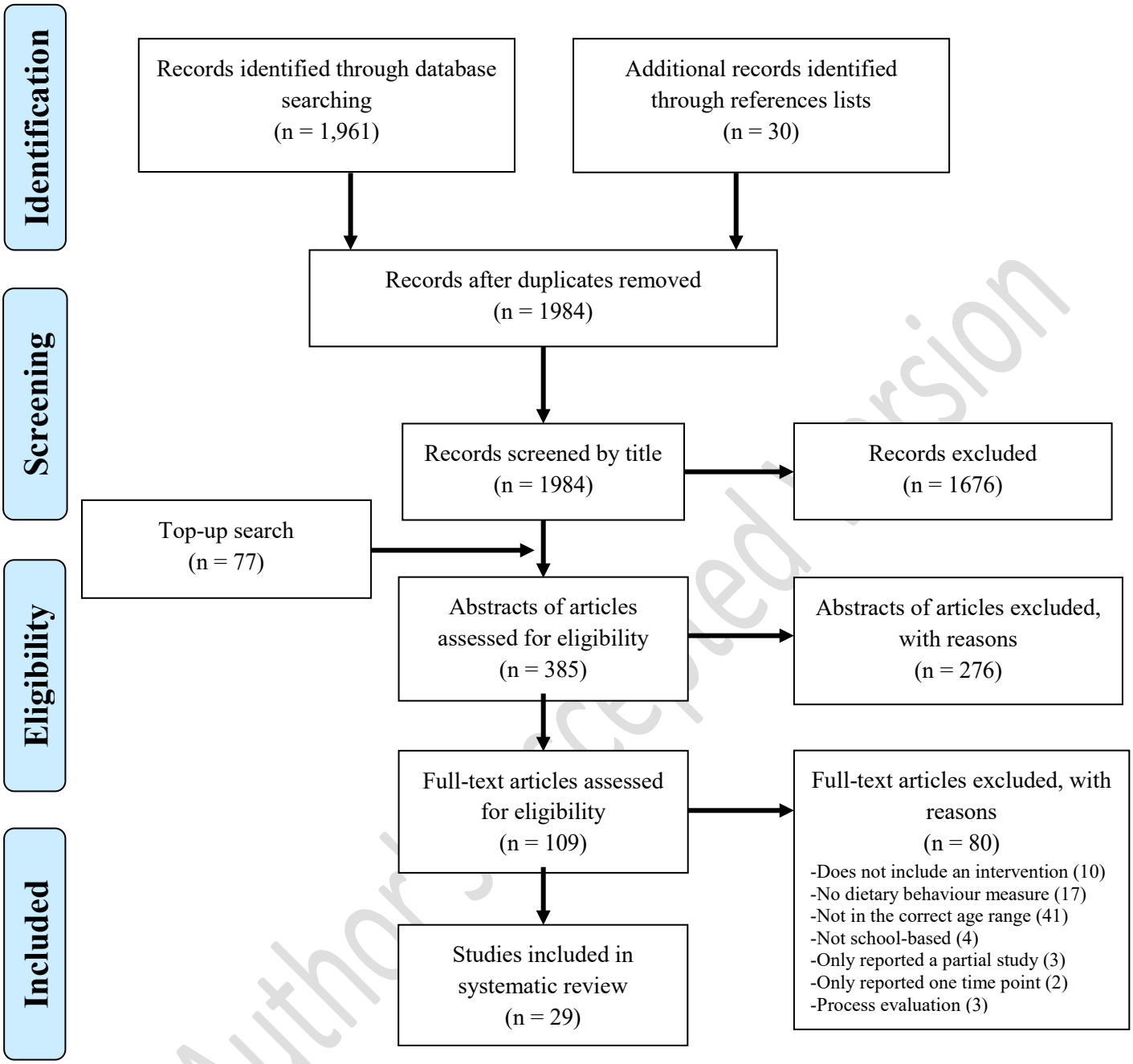
Figure 1. Flow diagram of selection of studies



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