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Effectiveness of family-based eHealth interventions in cardiovascular disease risk reduction: a systematic review

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Abbreviations: BMI, Body Mass Index; CVD, Cardiovascular Disease; HbA1c, Glycated Haemoglobin; PICOS, Population, Intervention, Comparison, Outcomes, Study design; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROSPERO, Prospective Register of Systematic Reviews; RCT, Randomised Controlled Trial

ABSTRACT

Family-based eHealth interventions to reduce cardiovascular disease risk have potential as a primary prevention strategy to improve the health of parents and their children. This systematic review evaluated the effectiveness of such interventions in modifying parent and child/adolescent risk factors such as body mass index, physical activity, dietary intakes and alcohol use. Five electronic databases were searched up to April 2020. Of 2193 articles identified, seven randomised controlled trials met inclusion criteria and were reviewed. Data were extracted regarding study setting, design, methods, eHealth technology used, intervention and control group components, retention rates, outcome measures, incentives and limitations. Risk of bias and quality assessment were carried out using Cochrane methods. A qualitative narrative data synthesis of the studies was conducted. Our review found that three studies showed an improvement in alcohol use among parents and adolescents as a result of the eHealth intervention. Among children/adolescents, two studies showed an improvement in dietary intake, one study showed an improvement in physical activity, and one study showed an improvement in body mass index as a result of the eHealth intervention. Interventions appeared more likely to be effective if they were theory-based, had longer follow-up periods, were incentivised and included regular interaction. Our findings suggest that, despite a paucity of high-quality trials, there is some evidence that family-based eHealth interventions have potential to reduce cardiovascular disease risk. However, more sufficiently powered, higher-quality trials with theory driven, clearly described interventions and unambiguous outcomes are needed.

Introduction

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality worldwide [1]. Of the major risk factors associated with CVD many, including smoking, high blood pressure, high blood cholesterol, alcohol consumption, HbA1c, anxiety and depression, low levels of physical activity, diet/nutrition and overweight or obesity, are controllable through lifestyle modification [2]. However, some such as family history of CVD, are not controllable and a family's shared lifestyle and home environment can increase CVD risk. For example, growing up in a household with a steady diet of fast-food meals or parents who are smokers can potentially increase blood pressure and cholesterol levels [3]. Of importance, the rate of CVD risk is significantly increased if an individual has more than one risk factor [4].

Most studies of interventions designed to reduce CVD risk have targeted individual adults, including men [5] or obese adults [6]. Comparatively few studies of interventions have targeted the whole family, including partners and children. Yet children of parents at risk of CVD are themselves at increased risk. For instance, children with a familial CVD risk factor such as obesity have a substantially higher risk of developing obesity and CVD across their lifetime [7-12].

The influence of parental or primary-caregiver health behaviours plays an important role in future health behaviours of children, especially as most health behaviours are experienced or learned within the household setting [13-16]. Thus, a holistic family-based approach to CVD risk reduction would take account of a particular risk factor, e.g. obesity, and show its potential association with poor health behaviours linked to food choices, eating habits and physical activity. Family interventions, therefore, offer appeal and show promise in improving health outcomes among those living with illness or a chronic health condition or disorder by involving the whole family to learn how to confront and conquer the challenges presented [17]. Thus, family-based interventions are ideally placed to act as primary prevention strategies for CVD: they target more than one person at a time and they can challenge and change current poor health behaviours by informing, supporting and facilitating the adoption of healthier ones by the whole family.

Health behaviour change is being aided markedly by the advent of electronic health (eHealth), defined as 'the cost-effective and secure use of information and communications technologies in support of health and health-related field' [18]. There is emerging evidence that eHealth interventions, defined as 'eHealth technology specifically focused on intervening in an existing context by changing behaviour and/or cognitions' [19], may be feasible, acceptable and possibly effective, in improving behaviours such as healthy eating and physical activity amongst children and adolescents living with their parents within the home environment [20-22]. In view of the lack of clear evidence, we conducted a systematic review to evaluate the effectiveness of family-based eHealth interventions in CVD risk reduction.

Methods

Guidance and registration

This systematic review of randomised controlled trials (RCTs) adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [23]. The review was registered on the international Prospective Register of Systematic Reviews (PROSPERO) and accepted on 16 March 2020 (CRD42020168203).

Study eligibility

The review followed the Population, Intervention, Comparison, Outcomes and Study design (PICOS) format for inclusion and exclusion criteria.

Inclusion criteria: Population - families (at least one parent/primary-caregiver and one child or adolescent (5-17 years) that live in the same household); Intervention - eHealth, family-based aimed at CVD risk factor modification; Comparison - control or usual-care group; Outcomes - body weight/body mass index (BMI), diet/nutrition, physical activity, cholesterol, blood pressure, smoking, alcohol consumption, fasting glucose/HbA1c, anxiety/depression; Study design - RCT with follow-up of $\geq$12 weeks and $\leq$24.

Exclusion criteria: study protocols; studies with incomplete data.

Search strategy

Databases searched within this review were: Cochrane Library and Central Register of Controlled Trials; MEDLINE; CINAHL; EMBASE and PsycINFO. No limitation of study publication date was applied, with RCTs published until April 2020 included. We also hand searched forward citations, references of included studies, and clinical trial databases such as clinicaltrials.gov.

Appropriate keywords and medical subject heading (MeSH) terms of relevant RCTs that were family-based, eHealth and focused on CVD risk factor reduction (Supplementary material 1) were verified by a university subject librarian.

Study selection process

Eligible studies were imported into Covidence online software (https://www.covidence.org/) and duplicates removed. The lead author (BJK) screened all titles and abstracts (n=2193); two independent reviewers (DRT and CJW) each screened half of the titles and abstracts (n=1096); and two independent reviewers (BJK and KMG) each screened all full texts.

Data extraction

Data were extracted independently by two reviewers (BJK and KMG) with any disagreements resolved through discussion or by consultation with a third reviewer (CFS). A standardised data extraction form was designed, piloted and used manually for the purpose of this review. Key data extracted from each study were: country of origin, study setting and design, sample size, participant characteristics including demographics and baseline measurements, type of eHealth technology used, components of the intervention and control group, recruitment, retention/attrition rates, outcome measures, timing of measurements, incentives, limitations and strengths.

Risk of bias and quality assessment

Risk of bias was judged by the same two independent reviewers as for data extraction (BJK and KMG) and was carried out using the Cochrane risk of bias tool (2.00) [24]. Quality assessment of studies were also determined through this tool based on their methodological rigour, intervention reporting, validity and reliability. The tool assesses risk of bias across six domains: 1) arising from the randomisation process; 2) due to deviations from the intended interventions (effect of assignment to intervention); 3) missing outcome data; 4) in measurement of the outcome; 5) in selection of the reported result; and 6) overall. Other data evaluated included heterogeneity, participants, intervention, outcomes, study design and publication bias.

Data analysis and synthesis

Due to the presence of substantial heterogeneity, performing a meta-analysis was deemed inappropriate. Therefore, a qualitative narrative data synthesis of studies was conducted. Study characteristics, context, quality and findings were reported according to a standard format and similarities and differences compared across studies [25]. Importantly, this scrutiny of studies was undertaken to elicit insights into directions for future research.

Results

Study selection

Following title and abstract screening of 2193 articles and hand searching clinical trial registers, reference lists and forward citations, seven studies (all RCTs) were identified for inclusion in the systematic review. Figure 1 displays the PRISMA flow diagram for study inclusion.

Study characteristics

All seven studies [26-32] were conducted in the USA, reported in English and published between 2005 and 2019. Six studies targeted parent-child dyads and one involved the whole family unit (at least one adult/parent and at least one child/adolescent). The total sample comprised 1727 parent-child dyads/families (Table 1). Sample sizes of included studies ranged from 50 to 916 families.

Population characteristics

Parents (77% female) had a mean age of 41 (39.7 to 43.7) years, with a mean age of 12 (9.9 to 16.4) years among children/adolescents (65% female). Of note, two studies reported the population as mothers and daughters in their inclusion criteria [29,31]. Six studies reported participant ethnicity as white [26,27,30,31], black/African-American [26,27,31], Asian/Asian-descent [27-29,31], Hispanic/Latina [26,31], Native-America [27], multiracial [27], other [26,27,30,31]; one study did not report this characteristic [32]. Five studies reported that most parents were married [26,29-32] and five reported that most parents were at least high-school level educated [26,28,29,31,32].

Intervention characteristics

The interventions lasted from eight to 12 weeks in duration, with follow-up periods ranging from three months to two years. The interventions used a variety of technologies, mainly computers or smartphones/mobile phones, and were delivered in community-based settings (Table 1). Descriptions of each intervention are shown in Table 2.

Comparator characteristics

Six studies [26-31] had a control group that received either usual care or no intervention. In two studies [27,28] basic information was provided to the control groups via a website login, and one study [32] had a waitlist control group.

Outcomes measured

Three studies targeted families where the child was considered to have obesity and a BMI exceeding the 84th percentile [26,30,32]. Of the remaining four studies, one required participants to be of normal weight or overweight [28], and three did not specify adolescent weight or BMI in the eligibility criteria [27,29,31]. All studies predominantly measured child/adolescent outcomes with only some measuring parents. The most commonly assessed CVD risk factors were child/adolescent BMI [26,28,30,32], child/adolescent fruit and vegetable intake [26,28,32], child/adolescent physical activity [26,28], adolescent depression [29,31], adolescent alcohol use [27,29,31], adolescent cigarette use [29,31], parent BMI [26,32], and parent alcohol use [27,31]. All outcomes measured in both children/adolescents and parents can be found in Table 3.

Risk of bias and quality assessment

Figures 2 and 3 present risk of bias results for the included studies. Four studies had an overall low risk of bias [26,27,29,32], one an unclear risk [28], and two [30,31] a high risk of bias. Two studies did not report the randomisation procedure but reported having significant differences between groups at baseline [30,31]. Only two studies reported blinding of research staff [26,29]. Six studies used self-reported outcome measures [26-31]. Two studies reported no deviations from the intended protocol

[26,27] and four reported intention-to-treat analysis [26,27,29,32]. All seven studies reported on all outcomes, including missing data.

Narrative synthesis

Overall changes

Significant improvements in at least one CVD outcome were reported in five [27-29,31,32] of the seven studies (Table 2). The remaining two studies [26,28] reported no significant changes in CVD outcomes from baseline to follow-up. Two studies reported a significant improvement in a non-CVD outcome - self-efficacy [29,30]. Only one study [28] presented confidence intervals. Not all studies reported raw data at baseline and follow-up, or all outcome data from the instruments used [26,28,30,32].

BMI

Four studies measured child/adolescent BMI as a primary outcome [26,28,30,32], though only one [28] reported a significant reduction from baseline to follow-up. Two of the studies [26,32] also measured parent BMI, but reported no significant change from baseline to follow-up. The three studies [26,30,32] that reported no significant changes for child BMI measured this in children between the age of five and 12 years, whereas the study [28] that reported a significant reduction in BMI measured it in adolescents aged between 12 and 15 years.

Diet

Three studies measured child/adolescent [26,28, 32] and/or parent dietary intake [32], nutrition knowledge [28] or self-efficacy [26,28] regarding their diet and nutrition. Two [28,32] of the studies reported a significant improvement in child/adolescent [28,32] and parent [32] daily dietary intake of fruit and vegetables. The study [28] that measured adolescent nutrition knowledge reported a significant improvement from baseline to follow-up. One study [32] measured child daily total calorie intake and reported a significant improvement from baseline to follow-up.

Physical activity

Two studies measured child/adolescent physical activity [26,28], one of which also measured adolescent physical activity knowledge and physical activity self-efficacy [28]. The latter study [28] reported a significant improvement for physical activity and physical activity knowledge from baseline to follow-up.

Alcohol use

Three studies measured adolescent alcohol use [27,29,31] and two parent alcohol use [27,31]. All studies reported a significant reduction in alcohol use from baseline to follow-up.

Use of theory

Five studies reported a theoretical basis to their intervention [26,28,29,31,32]. This included, alone or in combination, motivational interviewing [26], trans-theoretical model stages of change [28], social cognitive theory [28,32], or family interaction theory [29,31]. Four of these studies reported significant improvements in CVD outcomes [26].

Intervention co-production

Only one of the seven studies reported some form of co-production of their intervention [27]. Whilst this study was not theory-based, significant reductions were reported in adolescent alcohol use.

Intervention delivery

All interventions were education-focused, except one [26] that used daily goal setting text messages solely to parents, but yielded no significant benefits. Three studies had separate child/adolescent and parent elements in their intervention [27,28,32]. In one study adolescents completed the same intervention as their parents but at separate times, and though there was no timeframe for completion, each module had to be completed by both parties before moving onto the next [27]. This study yielded significant improvements in alcohol use in both adolescents and parents. In the second study adolescents and parents completed separate modules with adolescents completing more than the parents [28]. This study also yielded significant improvements in BMI, dietary and physical activity outcomes, though only adolescent data were reported. In the third study children and parents completed the same quantity of modules, but with different content [32]. This study yielded a significant reduction in calorie intake, though for children only.

Two studies delivered the intervention to adolescents and parents together [29,31]. Both studies reported significant reductions in alcohol/substance use, in one study [31] for both parents and adolescents, and in the other [29] for adolescents only, as data for parents were not reported. In one study, the whole family completed the intervention together; however, there were two intervention groups [30]: one completed education sessions about nutrition, physical activity and other parenting issues as well as recording steps on a pedometer; the other only recorded their steps. No significant findings were reported for either group.

The four studies that used a computer/tablet as the mode of intervention delivery reported significant improvements in a variety of CVD outcomes [27-29,31], whereas the two studies that used a smartphone/mobile phone [26,32] or a pedometer [28,30] reported mixed findings.

Intervention frequency

Six studies reported the frequency of intervention delivery. One study reported a daily frequency [26] but found no significant results. Another study reported a daily frequency, but one of the two intervention groups also completed six bi-weekly education sessions [30], though neither intervention groups yielded significant results. The remaining four studies reported a weekly frequency. In two of these studies, there were significant improvements in only adolescent BMI [28], nutrition [28], physical activity [28], blood pressure [28] and alcohol use [29] as parental data were unreported. In the remaining two studies, there were improvements in parental fruit and vegetable intake [32], adolescent alcohol use [31] and child total calorie intake [32]. The one study that did not report intervention frequency had no specific timeframe for completion, only the average time taken by both parents and adolescents to complete three modules [27].

Goal setting

Goal setting was reported as a behaviour change technique used in three studies [26,28,32], only two of which yielded significant results [28,32]. In the study that reported insignificant findings, participants set their own goals each week [26], whereas the other two studies had pre-specified goals to match the weekly information provided through the sessions/modules.

Incentives

Incentives were used as a behaviour change technique to encourage participation. Monetary incentives ranged from $10-$50, with five studies increasing the amount with completion of each intervention assessment [26-29,31]. Four studies provided gift certificates [26,28,29,31], two cash [27,32] and one a stipend and the chance to win a trip to Disneyland worth $4000 [30]. In five studies incentives of equal value were received by both parent and child/adolescent [26-29,31], in one study payment was made to the whole family [30], and in the remaining study parents and children separately received payment in differing amounts [32]. The two studies that offered the least in terms of monetary incentives reported non-significant findings [26,30]. Incentive timing ranged from enrolment [26], after baseline data collection [27-29,31,32], after follow-up data collection [27,29-32] and after study completion [26,28,30].

Intervention retention

All seven studies reported intervention retention rates, which ranged from 86% to 92.5% (mean = 86.5%), indicating attrition rates of 7.5% to 14% (mean = 10.4%).

Limitations of included studies

Study limitations included the use of self-report data [28,30,31], lack of generalisability [26,28,29], too short/few follow-ups to detect potential benefits [26,28,31], insufficient intervention length [26,27], and potential lack of access to specific [29,31] or preferred technology [32].

Discussion

Summary of findings

To our knowledge, this is the first systematic review to evaluate RCTs of family-based eHealth interventions to reduce CVD risk. Our findings suggest that, despite a paucity of high-quality trials, there is some evidence that such interventions have the potential to reduce CVD risk amongst children/adolescents and their parents. Specifically, we found that three studies showed an improvement in alcohol use among parents and adolescents as a result of the eHealth intervention. Among children/adolescents, two studies showed an improvement in dietary intake, one study showed an improvement in physical activity, and one study showed an improvement in body mass index as a result of the eHealth intervention.

Though only seven RCTs were identified, they were rigorously assessed in terms of risk of bias and quality. Four studies were judged to have a low risk of bias [26,27,29,32] and three studies [28,30,31] to be of lower quality due to unclear methods and/or inadequate reporting. More sufficiently powered, high-quality clinical trials with clearly described methods, interventions, and unambiguous, appropriate and measurable outcomes are needed. Until then, our findings provide useful insights and directions for future research.

Our finding of an improvement in alcohol use in parents and adolescents (aged 10 to 17 years) as a result of the eHealth intervention is consistent with a systematic review of parenting interventions to reduce alcohol and substance use in youth [33]. In contrast, despite being measured in children and adolescents in four studies [26,28,30,32], including parents in two of them [26,32], only one study reported a significant improvement in BMI, and that was among adolescents aged 12 to 15 years [28]. This suggests that the use of family-based eHealth interventions to reduce BMI in children under 12 years of age is less likely to be effective, a finding consistent with that of a pilot RCT involving young children and parents [20].

When reviewing dietary intake and physical activity levels, only one study measured knowledge of both [28], and reported significant improvements in dietary intake and physical activity and their respective knowledge, but not in self-efficacy (a person's belief in their capabilities) [34]. Capability reflects knowledge and skills: if knowledge increases but skills do not, then actions should be taken to improve skills. For example, using videos or a virtual workshop to demonstrate tasks such as meal preparation or exercises could increase self-efficacy with regards to dietary intake and physical activity, an approach well received in a recent study aimed at encouraging a calcium-rich food intake in young adults [35]. Incorporating components such as instructions or demonstrations into family-based eHealth interventions may enhance self-efficacy [34], build skills and boost confidence to improve health behaviours.

Most studies used self-report measures [26-31], and this may be seen as a limitation. Additionally, not all measurements were reported for each outcome [26,28,30,32]. It is recommended that careful consideration be given to the use of measurement tools in order to increase confidence in the veracity of study findings.

Trials that used theory-based interventions in their design and delivery appeared to be associated with more significant CVD risk factor changes than in those that did not. The Behaviour

Change Wheel, for example, provides a useful framework to achieve behavioural change [34]. In striving to change behaviour in participants through eHealth technologies [19], behaviour change theory should be at the heart of eHealth intervention design, delivery and evaluation. This was demonstrated in a meta-analysis of family-based interventions targeting childhood obesity [36], and highlighted in a recent systematic review and meta-analysis of eHealth interventions to reduce CVD risk amongst men [5].

Using a computer/tablet as the mode of intervention delivery [27-29,31] appeared to be more effective than phone-based modes of intervention delivery [26,32] in influencing outcomes This is consistent with studies comparing eHealth with mobile health (mHealth) interventions [37]. However, the mode of eHealth intervention delivery warrants further investigation

Weekly interaction appeared to be a factor associated with successful behaviour change. Such frequency is likely to allow families ample time and opportunity to acquire the knowledge and skills to action a task or set and attain a goal. Whereas time burden was identified as a limitation of a study that involved daily interaction [26], but which found no significant effect on outcomes.

Goals are less likely to be achieved if they are too complex or burdensome, too numerous, or there are situational limitations [38,39]. Goal accomplishment is more likely if there is commitment, regular feedback for tracking progress, and minimal complexity and restrictions [39]. Such factors were found in the studies that yielded significant results [28,32]. Goal setting and pacing are important elements of behaviour change [34], suggesting that such factors and other behavioural change techniques should be incorporated into interventions targeting CVD risk reduction.

Goal achievement may also be enhanced by incentives, whether they are behavioural ones [40] (incentives dependent on performance or change in a health behaviour) or assessment completion incentives. Each study in this review offered financial incentives for assessment completion. Incentives proved successful in the five studies [27-29,31,32] that had the highest monetary value. Two UK government programmes established an incentivised weight loss challenge for people with obesity [41,42]. One programme appeared successful over a 12-month period, with an average of 29 pounds (13 kg) being lost per person, each receiving an incentive of up to £425 [42]. The other programme set a target weight loss of 15 pounds in three months or 50 pounds in seven months with the same incentive, the estimated mean weight loss by 12 months being 8 pounds (4 kg) [41]. These findings indicate inconsistencies in whether financial incentives (behavioural or assessment completion) yield weight loss and BMI reduction. An alternative to financial incentives in such interventions may need to be explored in co-design and production.

Although only one study indicated any form of intervention co-production [27], a significant reduction in alcohol use amongst older adolescents was reported. Utilising the target audience and other appropriate stakeholders in the design, implementation and evaluation of an eHealth intervention is considered imperative to optimise usability, functionality and overall effectiveness [19,43]. Examples of co-designed interventions are 'Vegethon' [44], a successfully developed app designed to increase end-user fruit and vegetable intakes, and a community-based participatory research-designed pilot family-based intervention which showed promising outcomes for both children and parents in weight-related outcomes, CVD outcomes and self-efficacy [45].

In this review, the five studies that had parent and child/adolescent participation in the family-based interventions reported significant findings [27-29,31,32]. This suggests that family-based interventions work best when parents and children/adolescents participate. Interestingly, a three-arm RCT comparing a parent-only with a family-based intervention for children with overweight reported no significant differences [46], though this was not an eHealth intervention.

Our review indicates the dearth of studies that measure parent *and* child/adolescent outcomes in family-based eHealth interventions. Despite being termed family-based, all the studies had a primary focus on modifying CVD outcomes in children/adolescents. This is exemplified in the available family-based literature [36,47,48]. Thus, our review highlights the need for interventions that are truly family-based and aim to improve CVD outcomes among parents *and* children/adolescents.

Retention rates reported in the reviewed studies exceeded 80% from baseline to follow-up, indicating good acceptability of these family-based eHealth interventions. However, the risk of attrition in web-based programmes increases over time due to disengagement or loss of motivation or interest among participants, particularly if they perceive they are not accruing benefits [6], not uncommon in weight-loss interventions [49-51]. None of the interventions in this review exceeded a duration of 12 weeks or a follow-up of two years. Intervention duration and follow-up period are important factors in relation to study retention rates. Related to this are consideration of intervention fidelity in conjunction with intervention acceptability.

Limitations

This review followed best practice guidance and reporting methods, but several potential limitations were identified. Firstly, only seven RCTs met the inclusion criteria, limiting the generalisability of our findings. Secondly, one study was assessed as having 'some concerns' and two studies were assessed as having a 'high risk' of bias; randomisation, blinding and reporting of intention-to-treat analysis were considered areas for improvement. Thirdly, the lack of both parent *and* child/adolescent outcome assessment of interventions raises questions about the notion of 'family-based' studies. Fourthly, the high proportion of female parents in this review may have influenced the results. This gender imbalance may partly be explained by intervention-specific inclusion criteria, such as mother-daughter dyads only [29,31]. Lastly, as there was substantial heterogeneity across the included studies, we were unable to conduct a meta-analysis.

Conclusion

This review of seven trials of family-based eHealth interventions to reduce CVD risk found that three studies showed an improvement in alcohol use among parents and adolescents as a result of the eHealth intervention. Among children/adolescents, two studies showed an improvement in dietary intake, one study showed an improvement in physical activity, and one study showed an improvement in body mass index as a result of the eHealth intervention. However, more sufficiently powered, higher-quality trials with theory driven, clearly described interventions and unambiguous outcomes are needed to determine the effectiveness of eHealth interventions in reducing cardiovascular risk.

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TABLE 1. Key study and intervention characteristics of included randomised controlled trials

Study	Location	Population	Study design, sample (N=family), age of children (M±SD)	Technology delivery mode	Intervention setting	Intervention duration	Intervention follow-up	Targeted behaviours
[26]Armstrong et al. 2018	USA	Parent-child dyads: obese children with BMI >95th percentile enrolled in tertiary-care obesity treatment with parent or guardian	2-arm parallel group (intervention/control) RCT N=101 5-12 years (Median 9.9, IQR 7.9, 11.9)	Smartphone/ mobile phone	Primary care + community-based	12 weeks	3 Months	Reduce child obesity
[27]Byrnes et al. 2019	USA	Parent-child dyads: older adolescents and parent	2-arm parallel group (intervention/control) RCT N=411 16-17 years (16.4 ± 0.5)	Computer/ tablet	Community-based	NR	6, 12 Months	Reduce alcohol use and related behaviours
[28]Chen et al. 2011	USA	Parent-child dyads: Chinese adolescents who were normal weight or overweight and parent	2-arm parallel group (intervention/control) RCT N=54 12-15 years (12.52 ± 3.15)	Device that can access the internet and Pedometer	Community-based	8 weeks	2, 6, 8 Months	Promote healthy lifestyles and healthy weight

[29]Fang and Schinke 2013	USA	Parent-child dyads: Asian American adolescent females and parent (mother)	2-arm parallel group (intervention/control) RCT N=108 10-14 years (13.10 ± 0.96)	Computer	Community-based	9 weeks (plus annual booster)	12, 24 Months	Reduce substance use behaviours (tobacco and alcohol)
[30]Rooney et al. 2005	USA	Whole family: at least 1 child with a BMI >84th percentile and at least 1 adult within the family	3-arm parallel groups (2 intervention/control) RCT N=87 5-12 years (9.7 ± NR)	Pedometer	Community-based	12 weeks	9 Months	Increase confidence in ability to exercise, increase activity, reduce BMI
[31]Schinke et al. 2009	USA	Parent-child dyads: adolescent females and parent (mother)	2-arm parallel group (intervention/control) RCT N=916 11-13 years (12.76 ± 1.0)	Computer	Community-based	9 weeks (plus annual booster)	12, 24 Months	Reduce tobacco, alcohol, and other substance use
[32]Wright et al. 2013	USA	Parent-child dyads: obese children with BMI >95th percentile participating in an obesity treatment program and parent	2-arm waitlist (intervention/ waitlist control) RCT N=50 9-12 years (10.3 ± 1.1)	Smartphone/ mobile phone	Primary care + community-based	12 weeks	3 Months	Reduce child obesity

Footnote: The terms 'children' and 'adolescents' were used as per the included study's description of the age group.

Key: BMI, Body Mass Index; IQR, Interquartile Range; M, Mean; N, Sample Size; NR, Not Reported; RCT, Randomised Controlled Trial; SD, Standard Deviation

TABLE 2. Detailed descriptions of the included interventions

Study	Intervention description
[26]Armstrong et al. 2018	Each week parents identified and set a health goal for the family by selecting a self-determined behavioural change e.g. sugar-sweetened beverage reduction, increased physical activity, eating meals at home, increased vegetable consumption. Successive daily texts that week encouraged parents to self-monitor adherence to the family goal.
[27]Byrnes et al. 2019	Smart Choices 4 Teens required parents and teens to undergo activities online separately and then come together to complete a discussion activity at the end. For the alcohol prevention component (main focus), an overview and statistics about teen alcohol use and information about peer pressure and the consequences of drinking were given. Then there were several activities and videos highlighting social host laws in each state, physical and social consequences of drinking, signs of alcohol poisoning, a BAC calculator activity, myths about sobering up, parental influences important to address teen alcohol use, refusal skills, and indicators of problem drinking. The discussion activity described real-life scenarios relating to teen drinking. Families chose one scenario to discuss off-line. The discussion was focused on decisions for the teen in the scenario.
[28]Chen et al. 2011	Web ABC was exclusively personalised to the behavioural phase of the involved adolescent. Adolescents and their parents were taught to set realistic and attainable goals in an area (e.g. nutrition, physical activity) and provided with the essential skills to achieve mastery and increase self-efficacy in maintaining a healthy lifestyle. Adolescent sessions: The program involved activities to improve adolescents' self-efficacy and enabled their understanding and use of problem-solving skills related to nutrition, physical activity, and coping. Adolescents learned to set a realistic goal and plan each week to help improve their behaviours. Information presented over the Internet included text, graphics, comics, and voice over. Physical activity was also included in the program, to increase adolescents' energy expenditure. Adolescents were encouraged to participate in different types of non-competitive activities, learn different activities they could do during break and at home, and learn replacements to watching television. Each adolescent was given a pedometer and completed an online activity diary to display their activity levels. Adolescents entered their average steps average servings of fruit and veg they consumed daily. The figures were transformed into two graphics to display progress. Parent sessions: To increase a healthy family environment, parents were coached over three sessions to learn skills to help with their adolescent in cultivating a healthy lifestyle and healthy weight. A family component (three Internet sessions) that was adolescent-specific provided reinforcement and social support at home for the education learned throughout the study. The Internet sessions comprised of exercises to grow parents' knowledge and skills concerning healthy food preparation, dialogue associated with dealing with adolescents' eating habits and difficulties, and advice about fun family/adolescent activities to improve dietary intake and physical activity.

[29]Fang and Schinke 2013	Asian American girls and their mothers took part in the family-based prevention program at home. The program combined developmentally personalised audio, animation, graphics, and activities and involved mothers and daughters through skill demonstrations, guided rehearsal, and immediate feedback. Components included conflict management, substance use, body image, mood management, stress management, problem solving, social influences, and self-efficacy. One booster session reviewing initial program material and highlighting the issue on self-efficacy, problem solving, refusal skills, parent monitoring, parent-child communication, and parent-child closeness was delivered to all intervention dyads one year after they completed the initial program.
[30]Rooney et al. 2005	Participants in the Pedometer and Pedometer & Education groups were instructed to wear the pedometer and walk 10,000 steps daily. To measure activities that the pedometer registers poorly (e.g., swimming), families received a minutes-to-steps conversion table. Families kept track of their steps and returned step logs every 2 weeks. Pedometer & Education group families were also required to attend 6 one-hour biweekly sessions concerning nutrition, physical activity, or other parenting issues. Additionally, both the Pedometer and Pedometer & Education groups were given a biweekly newsletter that supplemented the education and included fun activity tips.
[31]Schinke et al. 2009	In the program, girls learned to manage stress, conflict, and mood; refuse peer pressure; enhance their body esteem and self-efficacy; and accurately assess the prevalence of cigarette, alcohol, and drug use among their age-mates. Mothers learned to better communicate with their daughters, monitor their daughters' activities, build their daughters' self-image and self-esteem, establish rules about and consequences for substance use, create family rituals, and refrain from placing unrealistic expectations on their daughters. Each session was delivered through voice-over narration, skills demonstrations by animated characters, and interactive exercises for mothers and daughters to complete jointly. Two annual booster sessions covered mother-daughter communication, mother-daughter closeness, self-efficacy, coping skills, parental monitoring, rules against use, body and self-esteem.
[32]Wright et al. 2013	Healthy Eating and Activity Today (HEAT) parents and children used interactive voice technology (IVR) via two weekly incoming telephone calls. The first call focused on education and behaviour change content: 1) greetings; 2) review of the goal set the previous week and feedback on self-reported progress, 3) education, 4) goal setting, and 5) closing summary of call. The second call was a monitoring call that requested parents and children to self-report weight, green and red foods eaten, and hours of TV watched. Each participant was also given either a child or parent guidebook intended to support the calls. Children: The core concepts from the Traffic Light Diet (TLD) and Student Media Awareness to Reduce Television (SMART) media program directed the development of the child conversations which aimed to increase consumption of green foods (low calorie, nutrient dense) and decrease red foods (high fat and/or high calorie) to four per day and reduce TV time to less than two hours per day. Parent: Designed on four goals: 1) creating a health-supportive home, 2) being a good role model (using constructive talk and eating healthy foods in front of the child, watching less than two hours of TV), 3) building a respectful relationship with the child, and 4) using praise and encouragement to motivate the child to do healthy things. The content of the parent conversations ran parallel with the child's conversation to promote support and teamwork in the effort to eat healthier and watch less TV.

TABLE 3. Cardiovascular disease risk factor outcome changes from baseline to follow-up

Study	Order of outcome	Outcome	Unit	Change in mean from baseline to follow-up	Significant difference from baseline to follow-up
[26]Armstrong et al. 2018	Primary	Child BMI z-score	NR	0.0 [a]	ns
[26]Armstrong et al. 2018	Primary	Child BMI centile	NR	0.1 [a]	ns
[26]Armstrong et al. 2018	Secondary	Parent BMI	kg/m^2	0.3 [a]	ns
[26]Armstrong et al. 2018	Secondary	Parent self-efficacy	NR	-1.0 [a]	ns
[26]Armstrong et al. 2018	Secondary	Child sugar sweetened beverage intakes	NR	-1.0 [a]	ns
[26]Armstrong et al. 2018	Secondary	Child fruit intakes	NR	0.0 [a]	ns
[26]Armstrong et al. 2018	Secondary	Child vegetable intakes	NR	0.0 [a]	ns
[26]Armstrong et al. 2018	Secondary	Child sugary snack intakes	NR	0.0 [a]	ns
[26]Armstrong et al. 2018	Secondary	Child minutes of moderate-vigorous activity	per week	10.0 [a]	ns
[26]Armstrong et al. 2018	Secondary	Child hours of screen time	per day	-0.5 [a]	ns
[26]Armstrong et al. 2018	Secondary	Child cardiovascular fitness	beats per minute	3.5 [a]	ns
[27]Byrnes et al. 2019	Primary	Adolescent alcohol use in past 30 days	n	NR [b]	***
[27]Byrnes et al. 2019	Primary	Adolescent quantity frequency of alcohol in past 30 days	n	NR [b]	***
[27]Byrnes et al. 2019	Primary	Adolescent problem/binge drinking in past 30 days	n	NR [b]	***
[27]Byrnes et al. 2019	Primary	Adolescent drunkenness in past 30 days	n	NR [b]	***

[27]Byrnes et al. 2019	Secondary	Parent drinking	n	NR [b]	***
[28]Chen et al. 2011	Primary	Adolescent BMI	kg/m^2	-0.03	***
[28]Chen et al. 2011	Primary	Adolescent waist-to-hip ratio	cm	-0.03	*
[28]Chen et al. 2011	Primary	Adolescent BP (systolic)	mmHg	-0.9	ns
[28]Chen et al. 2011	Primary	Adolescent BP (diastolic)	mmHg	-2.06	*
[28]Chen et al. 2011	Primary	Adolescent PA	counts per minute	39.52	*
[28]Chen et al. 2011	Primary	Adolescent fruit and vegetable servings	n/day	0.44	***
[28]Chen et al. 2011	Primary	Adolescent PA knowledge	NR	0.59	**
[28]Chen et al. 2011	Primary	Adolescent dietary/nutrition knowledge	NR	0.3	***
[28]Chen et al. 2011	Primary	Adolescent PA self-efficacy	NR	-0.35	ns
[28]Chen et al. 2011	Primary	Adolescent dietary self-efficacy	NR	0.0	ns
[29]Fang and Schinke 2013	Primary	Adolescent depression	NR	-0.13	ns
[29]Fang and Schinke 2013	Primary	Adolescent substance/alcohol use in past 30-days	n	0.01	*
[29]Fang and Schinke 2013	Primary	Adolescent substance use/cigarettes in past 30-days	n	-0.05	ns
[29]Fang and Schinke 2013	Secondary	Adolescent self-efficacy	NR	-0.02	*
[30]Rooney et al. 2005	Primary	Child BMI percentile	NR	0.31	ns
[30]Rooney et al. 2005	Primary	Child hours per week in sedentary activity	%	-4.1	ns
[30]Rooney et al. 2005	Primary	Parent hours per week in sedentary activity	%	-1.2	ns
[30]Rooney et al. 2005	Secondary	Child self-efficacy	NR	2.65	ns

[30]Rooney et al. 2005	Secondary	Parent self-efficacy	NR	0.85	*
[31]Schinke et al. 2009	Primary	Adolescent depression	NR	0.06	ns
[31]Schinke et al. 2009	Primary	Adolescent substance/alcohol use in past 30-days	n	0.03	**
[31]Schinke et al. 2009	Primary	Adolescent substance use/cigarettes in past 30-days	n	0.03	ns
[31]Schinke et al. 2009	Primary	Parent alcohol use	n	-0.34	***
[32]Wright et al. 2013	Primary	Child BMI	kg/m^2	0.0	ns
[32]Wright et al. 2013	Primary	Child BMI z-score	NR	0.0	ns
[32]Wright et al. 2013	Primary	Child BMI percentile	NR	-0.8	ns
[32]Wright et al. 2013	Primary	Child total calories	Kcal/day	-202.0	*
[32]Wright et al. 2013	Primary	Child fruit intake	cups/day	-0.4	ns
[32]Wright et al. 2013	Primary	Child vegetable intake	cups/day	-0.1	ns
[32]Wright et al. 2013	Primary	Child saturated fat intake	grams/day	-4.5	ns
[32]Wright et al. 2013	Primary	Child total fat intake	grams/day	-8.0	ns
[32]Wright et al. 2013	Primary	Child school day TV screen time	hours/day	-0.6	ns
[32]Wright et al. 2013	Primary	Child TV screen time	hours/day	-0.6	ns
[32]Wright et al. 2013	Primary	Child parent reported TV screen time	hours per day	-0.6	ns
[32]Wright et al. 2013	Primary	Child screen time	hours per day	-1.1	*
[32]Wright et al. 2013	Primary	Child parent reported screen time	hours per day	0.1	ns
[32]Wright et al. 2013	Primary	Parent BMI	kg/m^2	-0.1	ns
[32]Wright et al. 2013	Primary	Parent total calories	kcal/day	-63.0	ns

[32]Wright et al. 2013	Primary	Parent fruit intake	cups/day	0.8	*
[32]Wright et al. 2013	Primary	Parent vegetable intake	cups/day	-0.4	*
[32]Wright et al. 2013	Primary	Parent saturated fat intake	grams/day	-0.9	ns
[32]Wright et al. 2013	Primary	Parent total fat	grams/day	0.0	ns
[32]Wright et al. 2013	Primary	Parent TV screen time	hours/day	0.2	ns

Footnote: The terms ’children’ and ‘adolescents’ were used as per the included study’s description of the age group

[a] Measured as change in median (not mean); [b] Reported as dosage effect (not change in mean); * = p<0.05; **= p<0.01; *** = p<0.001; ns = not significant

Key: BMI, Body Mass Index; BP, Blood Pressure; cm, centimetres; Kcal, kilocalories; kg/m^2, kilograms/metre$^{2;}$; mmHg, millimetres of mercury; NR, Not Reported; ns, not significant; PA, Physical Activity

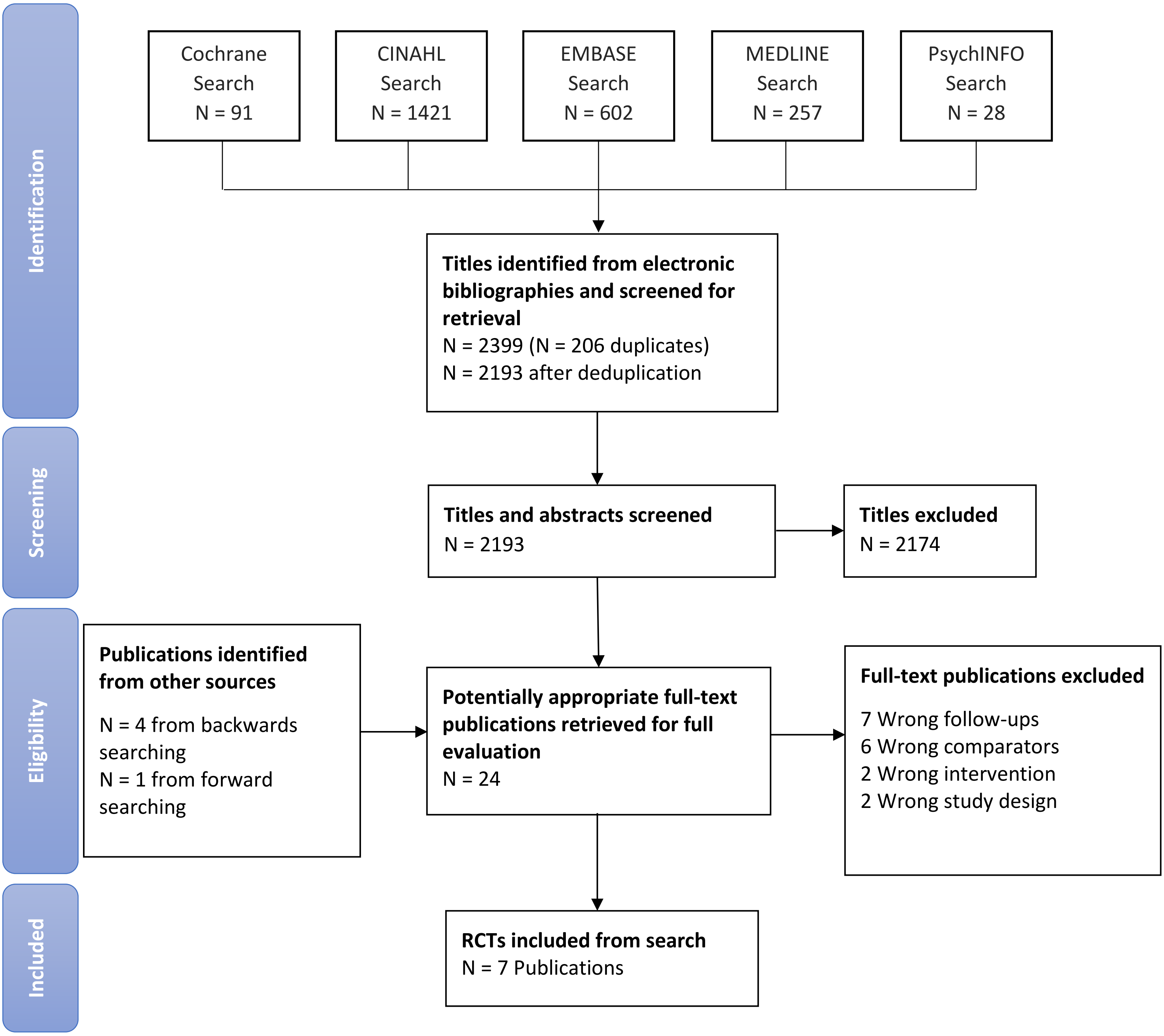

FIGURE 1. PRISMA diagram of study selection

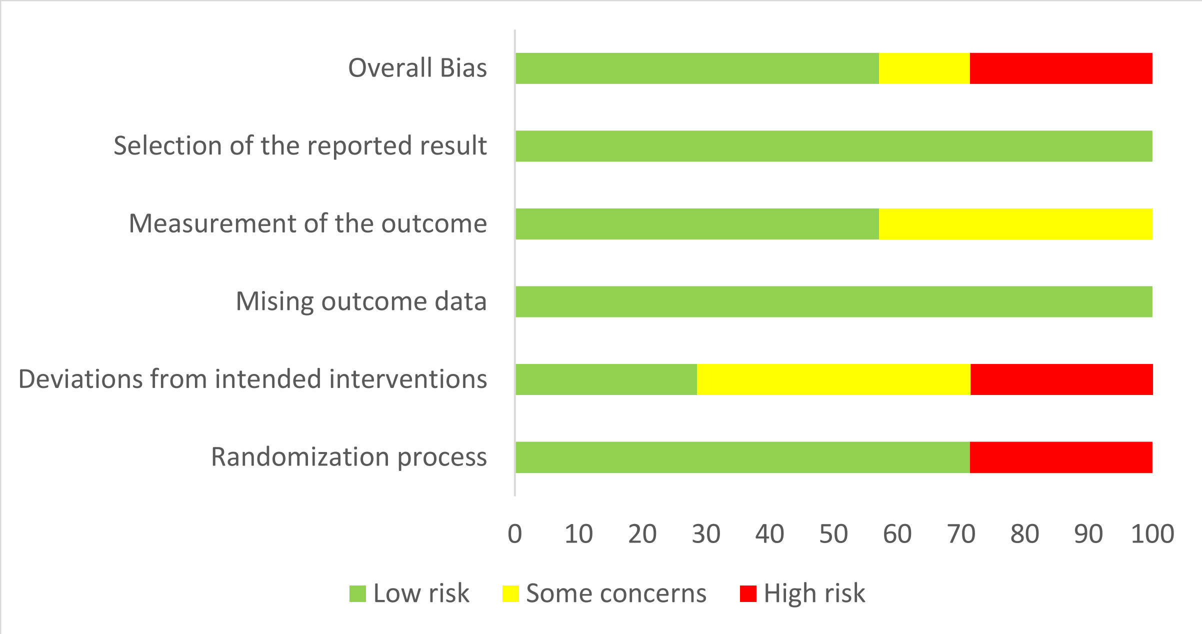

FIGURE 2. Cochrane risk of bias tool version 2.0: summary of bias across all included studies

Study/Risk of Bias Domain	1	2	3	4	5	6
[26]Armstrong et al. 2018	+	+	+	?	+	+
[27]Byrnes et al. 2019	+	+	+	?	+	+
[28]Chen et al. 2011	+	?	+	?	+	!
[29]Fang and Schinke, 2013	+	?	+	+	+	+
[30]Rooney et al. 2005	–	–	+	+	+	–
[31]Schinke et al. 2009	–	–	+	+	+	–
[32]Wright et al. 2013	+	?	+	+	+	+

Level of Risk

+	Low risk
?	Unclear risk
–	High risk

Risk of Bias Domains

1: Randomization process
2: Deviations from intended interventions
3: Missing outcome data
4: Measurement of the outcome
5: Selection of the reported result
6: Overall risk

FIGURE 3. Cochrane risk of bias tool version 2.0: summary of bias per included study