What behavior change techniques are associated with effective interventions to reduce screen time in 0-5 year olds? A narrative systematic review

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Review article

What behavior change techniques are associated with effective interventions to reduce screen time in 0–5 year olds? A narrative systematic review

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ABSTRACT

Screen time has been linked to obesity in young children. Therefore, this systematic review aims to investigate which Behavior Change Techniques (BCTs) are associated with the effectiveness of interventions to reduce screen time in 0–5 year olds.

Seven databases were searched, including PsycInfo, PubMed, and Medline. Grey literature searches were conducted. Inclusion criteria were interventions reporting pre- and post- outcomes with the primary objective of reducing screen time in 0-5 year olds. Studies were quality assessed using the Effective Public Health Practice Project criteria. Data extracted included participant characteristics, intervention characteristics and screen time outcomes. The BCT Taxonomy was used to extract BCTs. Interventions were categorised as "very", "quite" or "non" promising based on effect sizes. BCTs were deemed promising if they were in twice as many very/quite promising interventions as non-promising interventions.

Seven randomised controlled trials were included, involving 642 participants between 2.5 and 5.0 years old. One very promising, four quite promising, and two non-promising interventions were identified. Screen time decreased by 25-39 min per day in very/quite promising interventions. Eleven BCTs were deemed promising, including "behavior substitution" and "information about social and environmental consequences".

This review identified eleven promising BCTs, which should be incorporated into future screen time interventions with young children. However, most included studies were of weak quality and limited by the populations targeted. Therefore, future methodologically rigorous interventions targeting at-risk populations with higher screen time, such as those of a low socioeconomic status and children with a high BMI, should be prioritized.

1. Introduction

Obesity is a wide scale public health problem affecting all age groups, contributing to cardiovascular disease and diabetes mellitus, amongst many other health conditions (World Health Organization, 2020). Over 38 million 0-5 year olds across the world are overweight (United Nations Children's Fund, 2020), with obesity prevalence rates within this age group at 9% and 14% in the UK and USA, respectively (Hales et al., 2017; Public Health England, 2019). Further, evidence suggests that obese 4–5 year olds are more likely to be obese in later childhood and consequently adulthood (Broccoli et al., 2020; Monasta et al., 2010). The behaviors established in the early years, and consequently the associated health outcomes, can prevail throughout life (Jones et al., 2013). Therefore, in an attempt to prevent ill health in the future, it is important to target and reduce obesity-related behaviors in this young population.

Screen time, classed as a sedentary behavior, is one such behavior that is linked to obesity in the early years and young childhood (LeBlanc et al., 2012; Poitras et al., 2017; Stiglic and Viner, 2019). Screen time has been linked to lower levels of physical activity, arguably displacing

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it (Royal College of Paediatrics and Child Health, 2019), whilst also being associated with an increase in dietary intake and a reduced healthy diet through acting as a cue to eat and a distraction whilst eating (Hobbs et al., 2015; Marsh, 2013; Stiglic and Viner, 2019). It is also related to children's mental wellbeing, being associated with higher depressive symptoms and a lower quality-of-life (Stiglic and Viner, 2019). Although the extent and casualty of these associations has been questioned (Orben, 2020) this research indicates that, overall, higher levels of screen time are associated with negative outcomes on children's health. Importantly, most of this research relates to screen time duration, rather than the content or context.

For the purpose of this review, screen time is defined as behaviors such as watching television, playing computer and video games, and using mobile phones and electronic tablets, in line with World Health Organization (WHO) definitions on sedentary screen time (World Health Organization, 2019). It is estimated that in the UK, 96% of 3-4 year olds spend 14 hours per week watching TV, over half (52%) go online for nearly nine hours a week, and nearly 20% of 3-4 year olds own an electronic tablet device (Ofcom, 2018). Recent WHO guidelines advise that children aged under one year old should have no screen time, while children aged 2-5 years are recommended to have no more than 1 hour of sedentary screen time per day (World Health Organization, 2019). As it is evident that the majority of 0-5 year olds considerably exceed the recommended guidelines, there is a clear need to reduce this behavior. Furthermore, some populations demonstrate higher screen time use, for example lower socioeconomic households (Cillero and Jago, 2010), indicating that interventions may need to be targeted in an attempt to decrease health inequalities.

It is therefore unsurprising that a variety of interventions have attempted to reduce screen time in children. However, such interventions have mainly targeted children over the age of five, with fewer targeting pre-schoolers (Biddle et al., 2011; Buchanan et al., 2016; Friedrich et al., 2014). A recent systematic review specifically targeting children aged under six years old found that interventions lasting greater than six months and conducted in a community, home, or pre-school setting were most effective at reducing screen time (Downing et al., 2018a). However, while it is useful to know these characteristics of effective interventions, it is important to know which strategies were effective in reducing screen time to facilitate the design of future interventions and health promotion campaigns.

A small number of systematic reviews have attempted to document the strategies used in interventions to reduce screen time in children across all ages. Goal setting, positive reinforcement, problem solving, and using electronic monitoring have been identified as strategies used in interventions targeting this behavior (Altenburg et al., 2016; Schmidt et al., 2012; Steeves et al., 2012). However, these findings are limited for the current study in that the reviews included a wide age range of children aged up to 18 years or included other sedentary behaviors (i.e., reading) as well as screen time behaviors. Recommendations from all reviews stated the need for more research in the 0-5 year old age group. Furthermore, the authors of these reviews did not use a standardised framework for coding the strategies. Standardised frameworks can provide more clarity about the definitions of identified strategies, allow findings to be more easily compared and contribute to a coherent evidence-base (Michie et al., 2015).

The Behavior Change Techniques (BCTs) Taxonomy (Michie et al., 2013) is a tool for coding the components of an intervention. Behavior Change Techniques are the "active ingredients" of interventions, which can be used to specify what the components of interventions are. The taxonomy was created to provide a shared and common terminology to use across behavior change interventions, allowing for more accurate replicability and evaluation of effective techniques. Recent research has investigated the use of effective BCTs within interventions across smoking, physical activity, and diet, demonstrating the growing need to examine not only the effectiveness of interventions, but also the techniques used within them (Brown et al., 2019; Cradock et al., 2017; Nyman et al., 2018).

To date, no published research has been conducted to investigate the effective components of interventions to reduce screen time in 0-5 year olds. This could provide valuable insight into which techniques may be effective in reducing screen time. This is important as the amount of time that young children spend engaged in sedentary screen time exceeds guidelines (Ofcom, 2018) and higher screen time is associated with negative health outcomes (LeBlanc et al., 2012; Poitras et al., 2017; Stiglic and Viner, 2019). Therefore, this systematic review aims to determine which components of interventions are used to reduce screen time in 0-5 year olds and to investigate the BCTs associated with the effectiveness of these interventions. Focussing on screen time as a primary outcome can improve understanding of the components of an intervention which may influence screen time specifically, which can then be integrated into larger interventions targeting multiple behaviours. The results will inform the future development of screen time reduction interventions to prevent obesity-related behaviors in this young population.

2. Method

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher and Liberati, 2009). A protocol was registered with PROSPERO, available online at https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019129235.

2.1. Eligibility criteria

Inclusion criteria were classed according to PICO (Methley et al., 2014), specifying the population, intervention, comparison and outcomes:

- Population: children aged 0-5.0 years old.
- Intervention: primary objective of reducing screen time, any length of follow-up, randomised or non-randomised controlled trials with pre- and post- comparisons.
- Comparison: any comparator or control group, comparison not required.
- Outcome: change in screen time.

Studies were included if there was a broad age range of children but only if a separate analysis was conducted for 0-5 year olds. Studies were excluded if they were observational or if the primary objective was to increase physical activity or to reduce weight (Altenburg et al., 2016; Buchanan et al., 2016). Only English language studies were included as there were no resources for translation. No limits were placed on country or year of publication.

2.2. Information sources

A comprehensive search was conducted in seven databases in August 2019: PsycINFO, Medline, PubMed, SportDiscus, CINAHL, Cochrane Library and Scopus. Searches were also conducted in OpenGrey, Mednar, ETHOS, DART-EUROPE and STORE for grey literature. All authors from the included studies were contacted for potential information about unpublished studies. Backwards and forwards reference list searching of included studies and related systematic reviews was also conducted. A final search was conducted in May 2020, which did not find any further studies to include.

2.3. Search strategy

An example of the electronic search strategy can be found in Appendix A. Keywords relating to screen time, young children, and interventions were searched. Searches in databases used the same free text

terms and used MESH or Thesaurus terms relevant to that database.

2.4. Study selection

After duplicates were removed in Mendeley, all articles were uploaded to Rayyan, (Ouzzani et al., 2016) for study screening. The titles and abstracts of all identified studies were screened by the first author (LL), with 10% screened by a second reviewer (AC). Following this, the first author (LL) screened all full texts of included studies, with a third reviewer (RP) screening 10% of articles. Inter-rater reliability (Cohen's kappa; McHugh, 2012; Appendix B) showed substantial agreement ($k = 0.60$, 98% agreement) for titles and abstract screening, and perfect agreement ($k = 1$, 100% agreement) for full text screening. Any disagreements were resolved through discussion.

2.5. Data collection process and data items

Data were extracted from the included studies by the first author, using the Cochrane data extraction form as a guide (Cochrane, 2020). Data extracted included study characteristics, participant characteristics, intervention and control group details, screen time measures, screen time outcomes, and BCTs. Behavior Change Techniques were extracted and coded from all included studies by the first author (LL) and an independent reviewer (RP), who had both undertaken BCT coding training (Behavior Change Techniques Taxonomy, 2020). Three protocols were used to code the BCTs in addition to the published manuscripts. Authors were contacted and two additional intervention manuals were obtained. All 93 BCTs were considered. The BCTs deemed as "present" were coded next to the relevant text in the article. Inter-rater reliability was high ($k = 0.89$, 81% agreement; Appendix B). The intervention manuals were coded only by the first author (LL) and discussed with the second reviewer (RP). Any disagreements were resolved through discussion.

The relevant data from study outcomes were extracted to calculate effect sizes (Cohen's *d;* Cohen, 1988). Authors were contacted to provide additional information if these data were not published, however no further data were acquired this way.

2.6. Quality assessment

The Effective Public Health Practice Project tool (EPHPP; Armijo-Olivo et al., 2012) was used to assess the risk of bias in the included studies. The EPHPP is appropriate for use in public health interventions and has been used in other similar systematic reviews (Downing et al., 2018a). The tool classifies studies as strong, moderate, or weak. The first author (LL) assessed all included studies and, due to the small number of studies, an independent reviewer assessed 43% (HS). Cohen's kappa for inter-rater reliability was 0.79 (83% agreement; Appendix B), indicating substantial agreement between raters. Any disagreements were resolved through discussion.

2.7. Summary measures

The main summary measure was the ratio of BCTs in promising interventions compared to non-promising interventions. To determine whether an intervention was promising, effect sizes were calculated on the difference in screen time between intervention and control groups post-intervention, and within the intervention group.

2.8. Synthesis of results

Due to heterogeneity between studies a meta-analysis or meta-regression was not appropriate; studies mainly differed on intervention settings and mode of delivery. Consequently, a narrative synthesis of the results was conducted, with a focus on BCTs used. Effect sizes were calculated based on post-intervention means between intervention and control groups and between baseline and post-intervention outcomes for intervention groups.

Interventions were categorised as either very, quite, or non-promising, in line with approaches used in existing systematic reviews investigating the effectiveness of BCTs in interventions (Nyman et al., 2018). While other systematic reviews have used significance levels ($p < 0.05$) to categorise interventions, this review used effect sizes since, unlike significance tests, they are much less dependent on sample sizes (Clark-Carter, 2019). As such, interventions categorised as "very promising" demonstrated a medium or large effect size in the intervention group compared to baseline (within) *and* a comparator (between); "quite promising" interventions demonstrated a medium or large effect size in the intervention group compared to baseline *or* compared to a comparator; "non-promising" interventions demonstrated small effect sizes only.

In line with existing systematic reviews (Nyman et al., 2018), a promise ratio was calculated to determine the potential effectiveness of BCTs. The ratio was calculated based on the number of times a BCT was present in very/quite promising interventions divided by the number of times that BCT was present in non-promising interventions. Furthermore, similar to Nyman et al. (2018), BCTs were required to be present in two or more interventions to be considered and BCTs with a ratio of 2 and above were deemed "promising". Ratios were not calculated for those BCTs which were either only included in very/quite promising interventions or only included in non-promising interventions. Instead, the number of times a BCT was present in very/quite promising interventions was presented and left blank for non-promising interventions.

3. Results

3.1. Study selection

Study selection is illustrated in Fig. 1. A total of 4243 records were identified through database searches. After duplicates were removed, 2339 records were screened by title and abstract, leaving 102 full text studies to be screened for inclusion. A total of seven studies were included in the review. One of these studies was identified through forward reference list searching of an included study and one through contact with an author of a study protocol retrieved in the search results.

3.2. Study characteristics

Table 1 shows a summary of the intervention characteristics and results. A total of 642 participants took part across all studies, with 329 in intervention groups. The ages of pre-schoolers ranged from 2 to 5 years, with the lowest and highest mean ages being 2.5 and 4.5 years old respectively (Mendoza et al., 2016; S. Marsh, personal communication, February 3, 2020). Just over half of the studies were conducted either in the USA or Australia (USA = 2, Australia = 2). Most studies targeted multiple screen behaviors including TV watching, computer/internet use, playing video games, and using handheld devices (n = 5). Two studies targeted TV viewing only (Mendoza et al., 2016; Zimmerman et al., 2012). The majority of studies reported their intervention to be based on a theory (n = 5), with the most common being Social Cognitive Theory (n = 4; Bandura, 1986). The reporting of demographics varied across studies. Child ethnicity was reported in only three studies (Mendoza et al., 2016; Zimmerman et al., 2012; S. Marsh, personal communication, February 3, 2020), only two studies reported the weight status of the children (Downing et al., 2018b; Mendoza et al., 2016), and three studies reported parents' level of education (Birken et al., 2012; Downing et al., 2018b; Zimmerman et al., 2012). Screen time in intervention groups ranged from 76 to 122 minutes per day at baseline and 52–85 minutes per day post-intervention. One study did not report screen time averages (Yee et al., 2018).

All studies reported their interventions to be randomised controlled

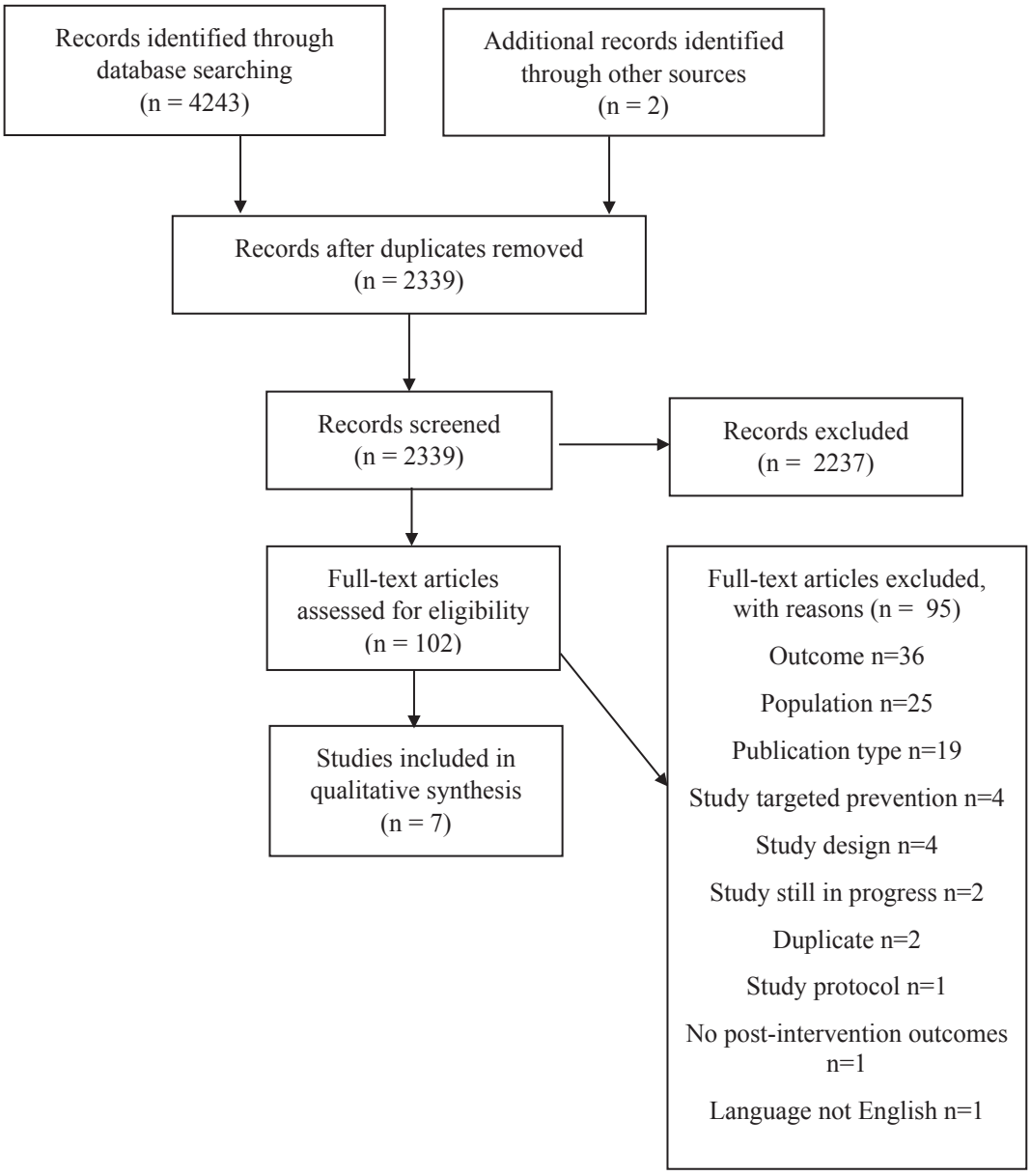

Fig. 1. PRISMA flow chart.

trials; however one did not report what the control group was (Yee et al., 2018). Interventions took place in the home (n = 2), community (n = 1), a mixture of home and community (n = 1), pre-school settings (n = 2) and primary care (n = 1). Interventions were delivered to parents (n = 5), children (n = 1) or both children and parents (n = 1). The length of interventions ranged from 10 minutes (Birken et al., 2012) to 4 months (Zimmerman et al., 2012). One study did not state the length of the intervention (Yee et al., 2018) and only one study included a follow-up period (S. Marsh, personal communication, February 3, 2020). Screen time was measured through time use diaries in three studies, which one study reported as reliable and valid (Mendoza et al., 2016), one as reliable only (Hinkley et al., 2015), and one as valid only (Zimmerman et al., 2012) with all studies reporting evidence on the measures used. Four studies reported using parent-reported questionnaires, with only two reporting the measures as reliable (Downing et al., 2018b; Yee et al., 2018). One study was classified as very promising (Mendoza et al., 2016), four classified as quite promising (Downing et al., 2018b; Hinkley et al., 2015; Yee et al., 2018; Zimmerman et al., 2012), and two classified as non-promising (Birken et al., 2012; S. Marsh, personal communication, February 3, 2020).

3.3. *Quality assessment*

Table 2 shows the overall risk of bias ratings. One study was classified as strong (Mendoza et al., 2016), two classified as moderate (Birken et al., 2012; Zimmerman et al., 2012), and four classified as weak (Downing et al., 2018b; Hinkley et al., 2015; Yee et al., 2018; S. Marsh, personal communication, February 3, 2020). Overall, study strengths included the study design and confounders, whereas studies generally scored weaker on selection bias, blinding, and data collection particularly in relation to the primary outcome of screen time. Furthermore, the strong study was classified as very promising (Mendoza et al., 2016), one moderate and three weak studies were classed as quite promising (Downing et al., 2018b; Hinkley et al., 2015; Yee et al., 2018; Zimmerman et al., 2012), and one moderate and one weak study were classed as non-promising (Birken et al., 2012; S. Marsh, personal communication, February 3, 2020).

Table 1
Summary of interventions.

Author/ country/ quality rating	Mean age of participants in years (*SD*) and sample size	Screen behaviors and average screen time (minutes p/day)	Intervention detail (theory, setting, length, mode of delivery, recipient)	Comparator	Intervention findings and intervention promise
Birken et al. (2012) USA Quality: Moderate	Mean age: Intervention: 3.12 (0.19) Control 3.08 (0.12) Sample size: Intervention: 81 Control: 79	TV, video/DVD, video games, using internet Intervention group screen time: Baseline: 94 Post-intervention: 85	Theory: None Setting: Primary care Length: 10 minutes Delivered face-to-face at health maintenance visit. Recipient: Parents	Counselling on safe media use e.g. internet safety, exposure to violent programmes	No significant difference in adjusted mean difference between intervention and control (−7, 95% CI [−38, 23], p=−.65). Small effect sizes between post intervention and post control (d=0.05) and within intervention group (d=0.1). Intervention promise: Non-promising
Downing et al. (2018) Australia Quality: Weak	Mean age: Intervention: 3.2 (0.8) Control: 2.9 (0.7) Sample size: Intervention: 30 Control: 27	TV, computer, electronic games, handheld electronic games, smartphone use, tablet computer use Intervention group screen time: Baseline: 110 Post-intervention: 79	Theory: Social cognitive theory Setting: Home Length: 6 weeks via predefined text messages (4 text messages per week). Participants received information booklet Recipient: Parents	Wait list	Intervention reduced total screen time by 30.5 minutes per day. Significance not reported. Large effect size (d=0.82) for adjusted mean difference (−35.0, 95% CI [−64.1, −5.9]). Small effect size between post intervention and control (d=0.35) and medium effect size within intervention group (d=0.52) Intervention promise: Quite promising
Hinkley et al. (2015) Australia Quality: Weak	Mean age: Intervention: 2.94 (0.61) Control: 2.85 (0.63) Sample size: Intervention: 12 Control: 10	TV, DVD, computer, electronic games, handheld devices Intervention group screen time: Baseline: 118 Post-intervention: 79	Theory: Social cognitive theory; Family Systems Theory Setting: Community Length: 6 weeks (six, one-hour group sessions) Delivered face-to-face group sessions. Recipient: Parents	Wait list	Intervention reduced total screen time by 39 minutes per day. Medium effect size (d=0.70) for adjusted mean difference between intervention and control (−31.2, 95% CI [−71.0, 8.6]). Significance not reported. Small effect size between post intervention and post control (d=0.36) and medium effect size within intervention group (d=0.63) Intervention promise: Quite promising
Marsh et al. (2020) New Zealand Quality: Weak	Mean age: Intervention: 2.6 yrs (0.7) Control: 2.5 (0.7) Sample size: Intervention: 27 Control: 27	TV, other screen behaviors not specified Intervention group screen time: Baseline: 96 Post-intervention: 84	Theory: Attachment Theory Setting: Community and home Length: 6 weeks Face-to-face half-day workshop delivered and digital access to study website. Recipient: Parents	Wait list	No significant difference in mean change between intervention and control (p=0.374) Small effect sizes between post intervention and post control (d=0.36) and within intervention group (d=0.25) Intervention promise: Non-promising
Mendoza et al. (2016) USA Quality: Strong	Mean age: Intervention: 4.5 yrs (0.5) Control: 4.4 (0.6) Sample size: Intervention: 6 classes, n=99 preschoolers Control: 6 classes, n=84 preschoolers	TV Intervention group screen time: Baseline: 76 Post-intervention: 52	Theory: Social cognitive theory Setting: Preschool Length: 7–8 weeks Delivered weekly face-to-face sessions to children and weekly newsletter sent home to parents Recipient: Children and parents	Usual "Head Start" curriculum	Intervention reduced daily TV viewing by 24.1 minutes. Significant interaction between intervention groups and time (−25.3, 95% CI [−45.2, −5.4], p=0.01) Large effect sizes between post intervention and post control (d=3.23) and within intervention group (d=2.42) Intervention promise: Very promising
Yee et al. (2018) Malaysia Quality: Weak	Mean age not reported. Targeted 4-year olds Sample size: Intervention: 46 Control: 53	TV, DVD, video, electronic games, recreational computer use Intervention group screen time not reported	Theory: None Setting: Preschool Length: Not reported Delivered face-to-face in school. Recipient: Children	Not reported	No significant difference between post-intervention screen time (Z=−0.974, p=0.056) Significant difference pre-post in intervention group (Z=−5.491, p<0.001) Small effect size between post intervention and post control (d=0.19) and medium effect size within intervention group (d=0.55) Intervention promise: Quite promising
Zimmerman et al. (2012)	Mean age not reported. Targeted	TV	Theory: Social cognitive theory	Child safety e.g. bike helmet use, car seats	Intervention significantly reduced screen time by 37 minutes per day (β=−37.1,

(*continued on next page*)

Table 1 (*continued*)

Author/ country/ quality rating	Mean age of participants in years (*SD*) and sample size	Screen behaviors and average screen time (minutes p/day)	Intervention detail (theory, setting, length, mode of delivery, recipient)	Comparator	Intervention findings and intervention promise
USA Quality: Moderate	2.5–4.5 year olds Sample size: Intervention: 34 Control: 33	Intervention group screen time: Baseline: 122 Post-intervention: 85	Setting: Home Length: 4 months Delivered remotely through written materials and monthly newsletter. Monthly phone and e-mail contact. Recipient: Parents		95% CI [−68.7, −5.6], $p<0.05$) Medium effect size ($d=0.63$) (between post intervention and post control). Data not available to calculate within Intervention promise: Quite promising

Table 2
Risk of bias in individual studies.

	Selection bias	Study design	Confound-ers	Blinding	Data collecti-on and methods	Withdrawals and dropouts	Overall rating
Birken et al. (2012)	Moderate	Strong	Strong	Strong	Weak	Moderate	Moderate
Downing et al. (2018)	Weak	Strong	Moderate	Weak	Moderate	Moderate	Weak
Hinkley et al. (2015)	Weak	Strong	Moderate	Moderate	Moderate	Weak	Weak
Marsh et al. (2013)	Weak	Strong	Moderate	Moderate	Weak	Strong	Weak
Mendoza et al. (2016)	Moderate	Strong	Strong	Moderate	Strong	Strong	Strong
Yee et al. (2018)	Weak	Strong	Weak	Weak	Moderate	Weak	Weak
Zimmerman et al. (2012)	Weak	Strong	Strong	Moderate	Strong	Moderate	Moderate

3.4. Intervention effects on main outcomes

The studies varied on how they reported the effects of the intervention. Two studies reported a significant decrease in screen time between the intervention and control group (Mendoza et al., 2016; Zimmerman et al., 2012) and one reported a significant change only within the intervention group from baseline to post-intervention (Yee et al., 2018). Two studies did not report significance levels but reported moderate to large effect sizes on the mean difference in change due to small sample sizes (Downing et al., 2018b; Hinkley et al., 2015). Finally, two studies did not find any significant effects of the intervention (Birken et al., 2012; S. Marsh, personal communication, February 3, 2020).

Effect sizes were calculated on post-intervention outcomes between

Table 3
Behavior change techniques and promise ratios.

Behavior Change Technique	BCT Category	Number of BCTs in very/quite promising interventions	Number of BCTs in non-promising interventions	Promise ratio[a]
1.2 Problem solving	Goals and planning	1	1	1
1.1 Goal setting (behavior)	Goals and planning	3	–	3*
1.3 Goal setting (outcome)	Goals and planning	–	1	–
1.4 Action planning	Goals and planning	3	–	3*
2.2 Feedback on behavior	Feedback and monitoring	3	–	3*
2.4 Self–monitoring of outcome(s) of behavior	Feedback and monitoring	3	–	3*
3.1 Social support (unspecified)	Social support	3	1	3
4.1 Instruction on how to perform the behavior	Shaping knowledge	4	2	2
5.1 Information about health consequences	Natural consequences	2	2	1
5.3 Information about social and environmental consequences	Natural consequences	4	1	4
6.1 Demonstration of the behavior	Comparison of behavior	4	–	4*
6.2 Social comparison	Comparison of behavior	1	–	–
8.1 Behavioral practice/rehearsal	Repetition and substitution	3	1	3
8.2 Behavior substitution	Repetition and substitution	5	1	5
9.1 Credible source	Comparison of outcomes	3	2	1.5
9.2 Pros and cons	Comparison of outcomes	1	–	–
10.2 Material reward (behavior)	Reward and threat	1	1	1
10.3 Non–specific reward	Reward and threat	1	–	–
10.4 Social reward	Reward and threat	2	1	2
12.1 Restructuring the physical environment	Antecedents	3	2	1.5
12.5 Adding objects to the environment	Antecedents	1	–	–
12.3. Avoidance/reducing exposure to cues for the behavior	Antecedents	–	1	–
13.2 Framing/reframing	Identity	1	2	0.5
13.3 Incompatible beliefs	Identity	1	–	–

[a]Ratio not calculated if BCT only in one intervention or if only in non-promising interventions.
*BCT in promising interventions only, n = number of times BCT present.

the intervention and control group and also between baseline and post-intervention outcomes within the intervention group. Effect sizes for the difference in mean change in five of the studies were not calculated due to inadequate data. The effect sizes between groups demonstrated small to large effects, ranging from 0.05 to 3.2, with most effect sizes being small. Within intervention groups small to large effects were also demonstrated ranging from 0.1 to 2.4, with most effect sizes being of moderate size. In very/quite promising studies, screen time reduced by between 25 and 39 minutes in the intervention group.

3.5. Behavior change techniques

Interventions contained an average of ten BCTs. Very/quite promising interventions contained slightly more BCTs on average compared to non-promising interventions (10.6 and 9.5, respectively). The minimum number of BCTs used in an intervention was seven and the maximum number was 16. Twenty-four different BCTs were used across all interventions. The BCTs used across the interventions were drawn from 11 out of the 16 different categories of BCTs within the taxonomy.

Table 3 shows the BCTs and the promise ratios. In total, 11 BCTs were considered promising. Seven BCTs had a promise ratio of at least 2, indicating that they were reported in at least double the number of very/quite promising interventions as non-promising interventions. Four BCTs were found solely in very/quite promising interventions. The BCTs with the highest promise ratios (ratios of 3-5, or present in more than three promising interventions) were: "behavior substitution", "information about social and environmental consequences", "demonstration of the behavior", "behavioral practice/rehearsal", "social support (unspecified)", "action planning", and "goal setting (behavior)". Due to the heterogeneity and small number of studies it was not possible to determine the promise ratio of BCTs used in sub-groups, for example by intervention setting or by intervention quality.

4. Discussion

The aim of this review was to investigate the components of interventions used to reduce screen time in 0-5 year olds. From 2339 initially identified studies, seven were included. Five of these interventions showed a very or quite promising reduction in screen time, with 11 BCTs identified as potentially promising, as highlighted at the end of results section.

4.1. Screen time reduction

In the promising studies, a daily reduction in screen time of 25-39 minutes was found. When taken over a week this can result in a reduction of nearly three hours per week. However, only one study (Mendoza et al., 2016) managed to reduce screen time to meet the WHO guidelines of no more than one hour per day for 2-5 year olds (World Health Organization, 2019). It is possible, therefore, that additional techniques could play a role in screen time reduction. Additionally, other intervention characteristics such as intervention length should also be considered, which was not possible to differentiate between in this review due to the limited number of studies.

This review found larger reductions in screen time compared to the results of a recent meta-analysis on interventions to reduce screen time (Downing et al., 2018b), which found an overall significant reduction in screen time of 17 minutes per day. Key differences were that the previous review targeted children aged up to six years old and included physical activity as a primary outcome in interventions. However, the findings are in line with other research, which suggests that targeting screen time alone may be more effective than interventions targeting multiple behaviors (Martin et al., 2015; Prince et al., 2014).

4.2. Behavior change techniques

This review found an additional five BCTs, which had not been cited in previous systematic reviews identifying strategies in interventions to reduce screen time in children: "demonstration of the behavior", "behavior substitution", "information about social and environmental consequences", "instruction on how to perform the behavior", and "feedback on behavior". It is possible that the four behavior focused novel BCTs may reflect the target age group as these children's cognitive skills are less developed. In particular "behavior substitution" and "instruction on how to perform the behavior" were identified in both interventions targeting children. The other six promising BCTs found in this review appear to map on to the strategies found in other systematic reviews, which mostly focus on older children (Altenburg et al., 2016; Schmidt et al., 2012; Steeves et al., 2012). Therefore, it is possible that similar strategies might be effective to reduce screen time across the age ranges of children. Additionally, the BCTs found in this review align with strategies found in other behavioural interventions targeting 0-5 year olds, suggesting that similar techniques may be effective across different behaviours in this age group (Laws et al., 2014; 2012). However, it should be noted that the standardized BCT coding was not conducted in previous reviews. Additional research to code BCTs in other interventions would therefore be useful to explore these links further.

Most of the promising BCTs identified relate to wider research investigating influences on children's screen time. Higher parental screen use, lower parental self-efficacy to reduce screen time and parental perceptions that screen time is helpful are all associated with increased screen time in young children (De Craemer et al., 2012; Duch and Harrington, 2013; Xu et al., 2015). The promising BCTs of "behavioral practice/rehearsal", "demonstration of the behavior" and "instruction on how to perform the behavior" have all been linked to self-efficacy (Carey et al., 2019), while the BCT "demonstration of the behavior" targeted parental screen use and role modelling. Additionally, interventions included in this review provided information about the effects of screen use on outcomes other than health (BCT "information about social and environmental consequences"). This included the negative impact of screen time on child development and sleep, and the beneficial effects on physical activity from reducing screen time. As the BCT "information about social and environmental consequences" had one of the highest promise ratios, it suggests that targeting parental perceptions about the effects of screen time on outcomes other than health may be important. Focussing on the wider implications of screen time on a child's development rather than focussing solely on health consequences could influence parental positive beliefs regarding screen time. As these BCTs appear to target some of the determinants of young children's screen time, this offers an explanation as to why they were found to be promising.

However, there are other factors to consider. Other BCTs linked to self-efficacy in the BCT category "self-belief" were not coded in any of the interventions, suggesting that these may potentially be effective BCTs to include. Additionally, several studies reported encouraging parents to set rules and boundaries on screen time, though due to the lack of detail in the studies these could not be accurately coded as a BCT. There have been mixed results in whether setting rules and limitations is associated with screen use (Xu et al., 2015) so it would be useful to know whether BCTs targeting this are considered promising.

While this review investigated BCTs to reduce overall screen time due to negative associations between high screen time use and children's health, it is important to consider that there may be some positive benefits of screen time on children's development. For example, there is evidence that screen time aids young children's knowledge and learning, can affect racial attitudes and increases imaginativeness (Kostyrka-Allchorne et al., 2017; Thakker et al., 2006). However, there are mixed findings as other research has found detrimental or no effects of screen time on cognitive development (Carson et al., 2015).

Nevertheless, the consistent conclusions are that the type of content that children watch is more important than the total amount of screen time, with entertainment and commercial screen time being more strongly associated with negative outcomes compared to more educational screen time. (Kostyrka-Allchorne et al., 2017). In this review, only one study had a specific objective to reduce total screen time *and* commercial screen time (Zimmerman et al., 2012), indicating that this is yet to be consistently evaluated in interventions. The results in this review are therefore limited as it is not known what type of content reduced within the interventions. Furthermore, the identified promising BCTs relate to overall reduction in screen time and therefore potentially beneficial screen time, rather than harmful screen time, might have been reduced.

4.3. Limitations of studies

There are several limitations of the studies included in this review. Many of the studies had very low sample sizes and contained differing, and sometimes limited, details about the participants. Determinants associated with higher levels of screen time in young children include having a low socioeconomic status, being non-Caucasian, and children with a high BMI (Cillero and Jago, 2010; De Craemer et al., 2012; Duch and Harrington, 2013). Fewer than half of the studies reported on these important factors and those that did, reported samples which were predominantly in favour of determinants associated with lower screen time such as lower weight status and being Caucasian, aside from one which targeted Latino children (Mendoza et al., 2016). This indicates that these studies' findings may not be generalizable to a wider population and, it could be argued, to those who are in most need of it. Interventions should target these at-risk populations to reduce health inequalities, but it is unknown whether the promising BCTs found in this review would result in similar outcomes amongst diverse populations. More research is therefore needed to target populations where screen time is most problematic.

Furthermore, considering parental screen time has been consistently positively associated with child screen time (De Craemer et al., 2012; Duch and Harrington, 2013), it was surprising and perhaps a missed opportunity that none of the studies measured the amount of time parents spent using screens and only focussed on the child's screen time. Given the influence that parents' own behavior appears to have on their child's behavior, it would be useful to know whether the interventions reduced parental screen time or whether different BCTs would be effective to do this.

4.4. Strengths and limitations of the systematic review

A strength of the review is that a wide search was conducted and multiple screen behaviors were targeted. Other reviews have looked only at TV viewing, while this review searched for other types of screen time behaviors such as electronic media and mobile phone use. This is especially relevant given the current prevalence of mobile media use (Ofcom, 2018). Additionally, four of the included studies were published after Downing, Salmon, Hinkley, Hnatiuk, and Hesketh (2018b) had completed their review searches, indicating that this a growing research area of interest.

A further strength is the use of the BCT taxonomy to code the components of the interventions. The taxonomy aims to standardise terminology across research and intervention development and so was a useful method to categorise the components of the interventions. This has been a limitation of previous systematic reviews on this topic, which cited no coding framework; therefore this review has improved on existing methodologies.

A limitation, however, is that the coding of BCTs was limited to what was reported in the published studies and protocols, if available. Only two intervention manuals were obtained. Consequently, some potential BCTs were not coded due to there being inadequate detail reported. For example, although setting limitations and boundaries was reported within different studies, it was not coded as a BCT due to limited detail provided. This therefore might mean that some BCTs were present and used within the interventions but have not been described in this review. This is in line with calls for more clarity and transparency in the reporting of interventions (Michie et al., 2009). Additionally, while the findings indicate promising components of interventions, causal links between the BCTs used and the outcomes reported cannot be made.

A final limitation is linked to the effectiveness of interventions and the quality of the studies. Only one study was categorised as a very promising intervention and three out of the five promising interventions were classed as weak on the quality appraisal tool. The quality of screen time interventions has been raised in other reviews, which have also used the EPHPP (Altenburg et al., 2016; Downing et al., 2018a) and calls for stronger evidence within this area, particularly in relation to selection bias, blinding and outcome measures.

4.5. Implications for practice and future research

The results of this review can inform future interventions aiming to reduce screen time in 0-5 years, which can be applied to health promotion and public health practice to target children at this early age. It is recommended that public health interventions use a range of BCTs such as parental role modelling, substituting screen time for other activities, and providing information on the consequences of screen time on child development. While the results are limited due to the low number of studies, sample sizes and quality ratings they provide an indication as to what techniques may contribute to screen time reduction.

Future research should aim to be of greater methodological rigour, include larger sample sizes, and include a measure of parental screen time. Furthermore, interventions which target at-risk populations with higher screen time such as those of a low socioeconomic status, non-Caucasians, and children with a high BMI should be prioritized. The promising BCTs identified in this review could be used to inform the design of these future interventions.

5. Conclusions

Although there are a limited number of studies solely targeting screen time in 0-5 year olds, this review found that interventions can reduce screen time by 25 to 39 minutes per day in this age group. Eleven promising BCTs were identified, of which the most promising were "behavior substitution", "information about social and environmental consequences", "demonstration of the behavior", "behavioral practice/rehearsal", "social support (unspecified)", "action planning", and "goal setting (behavior)". Future health promotion practice and research should incorporate the BCTs found in this review into the development of screen time interventions. Further empirical research with higher quality methodologies is needed alongside targeting more diverse populations to investigate the applicability of these results across a wider population.

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Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: LL is employed by Public Health Wales where this project was developed.

Appendix A

PubMed search strategy

("screen-time" OR "screen time" OR "TV time" OR "TV view*" OR "television view*" OR "television time" OR "computer time" OR "computer use" OR "computer game*" OR "video game*" OR "videogame*" OR "DVD" OR "smartphone use" OR "mobile phone use" OR "cell phone use" OR "electronic media" OR "Screen Time"[Mesh] OR "Video Games"[Mesh] OR "Smartphone"[Mesh] OR "Cell Phone Use"[Mesh]) AND ("infant*) OR "baby" OR "babies" OR "toddler*" OR "early child*" OR "preschool*" OR "pre-school*" OR "young child*" OR "Child, Preschool"[Mesh] OR "Infant"[Mesh]) AND ("randomized controlled trial" OR "intervention" OR "Randomized Controlled Trials as Topic"[Mesh] OR "Randomized Controlled Trial" [Publication Type]).

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2021.101429.

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