

Benefits and risks associated with children's and adolescents' interactions with electronic  
screens: An umbrella review

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19

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33

Abstract

34 Can i have here?

35 *Keywords:* keywords

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## Summary

Children’s engagement in screen time is a complex issue. Parents, policymakers, and  
educators needing to weigh the risks that sedentary use of screens present alongside the  
potential benefits for learning and social connectedness. Hampering efforts to make an  
informed decision is the lack of comprehensive evidence. As a Lancet editorial<sup>1</sup> suggested,  
“Our understanding of the benefits, harms, and risks of our rapidly changing digital  
landscape is sorely lacking.” In this study, we systematically harmonize data from existing  
meta-analyses of screen time on a range of outcomes, including health, education, and  
psychology, and identify the most statistically robust relationships. We show that some  
forms of screen time—such as social media—show consistent evidence of harm for children,  
with no clear evidence of a benefit. Other relationships are more complex. Video games, for  
example, are associated with poorer body composition and learning outcomes. However,  
video games for a specific educational purpose (such as numeracy) are associated with  
improvements in that subject area. Caregivers must therefore weigh the health risk against  
the educational benefit. The findings of this study provide parents and other caregivers with  
the information to make these informed decisions.

## Background

In the 16th century, hysteria reigned around a new technology that threatened to be “confusing and harmful” to the mind. The cause of such concern? The widespread availability of books brought about by the invention of the printing press.<sup>2</sup> In the early 19th century, concerns about schooling “exhausting the children’s brains” followed, with the medical community accepting that excessive study could be a cause of madness.<sup>3</sup> By the 20th century, the invention of the radio was accompanied by assertions that it would distract children from their reading (which by this point was no longer considered confusing and harmful) leading to impaired learning.<sup>4</sup>

Today, the same arguments that were once leveled against reading, schooling, and radio are being made about screen use (e.g., television, mobile phones, and computers).<sup>5</sup> Excessive screen time use is the number one concern parents have about their children’s health and behaviour, ahead of nutrition, bullying, and physical inactivity.<sup>6</sup> Yet, the evidence to support parents’ concerns is inadequate. A Lancet editorial<sup>1</sup> suggested that, “Our understanding of the benefits, harms, and risks of our rapidly changing digital landscape is sorely lacking.”

While some forms of screen use (e.g., television viewing) may be detrimental to health and wellbeing,<sup>7,8</sup> evidence for other forms of screen exposure (e.g., video games or online communication, such as Zoom<sup>TM</sup>) remains less certain and, in some cases, may even be beneficial.<sup>9,10</sup> Thus, according to a Nature Human Behaviour editorial, research to determine the effect of screen exposure on youth is “a defining question of our age”.<sup>11</sup> With concerns over the impact of screen use including education, health, social development, and psychological well-being, a broad overview that identifies potential benefits and risks is needed.

Citing the negative effects of screens on health (e.g., increased risk of obesity) and health-related behaviours (e.g., sleep), guidelines from the World Health Organisation<sup>12</sup> and

numerous government agencies<sup>13,14</sup> and statements by expert groups<sup>15</sup> have recommended that young people's time spent using electronic media devices for entertainment purposes should be limited. For example, the Australian Government guidelines regarding sedentary behaviour recommend that young children (under the age of two) should not spend any time watching screens. They also recommend that children aged 2-5 years should spend a maximum of one hour engaged in recreational sedentary screen use per day, while children aged 5-12 and adolescents should spend no more than two hours. In contrast, some recent evidence suggests that exposure to electronic entertainment media that exceeds these guidelines (e.g., 3-4 hours per day) may not have meaningful adverse effects on children's behaviour or mental health, and might, in fact, benefit their well-being, as long as this exposure does not reach extreme levels (e.g., 7 hours per day)<sup>16</sup>. Some research also indicates that content (e.g., video games vs television programs) plays an important role in determining the potential benefit or harm of youths' exposure to screen-based media.<sup>17</sup> Indeed, educational screen time is positively related to educational outcomes.<sup>18</sup> This evidence has led some researchers to argue that a more nuanced approach to screen time guidelines is required.<sup>19</sup>

In 2016, the American Academy of Pediatrics used a narrative review to examine the benefits and risks of children and adolescents' electronic media<sup>20</sup> as a basis for updating their guidelines about screen use.<sup>15</sup> Since then, a large number of systematic reviews and meta-analyses have provided evidence about the potential benefits and risks of screen use. Yet, no review has synthesised the evidence available across a broad range of outcome domains, such as physical health, education, physical and cognitive development, behaviour, and well-being.

In order to synthesise the evidence and support further evidence-based guideline development and refinement, we reviewed published meta-analyses examining the effects of screen use on children and youth. This review synthesises evidence on any plausible outcome

105 of electronic media exposure. Adopting this broad approach allowed us to provide a holistic  
106 perspective on the influence of screens on children's lives. By synthesising across life domains  
107 (e.g., school and home), this review provides evidence to inform guidelines and advice for  
108 parents, teachers, pediatricians and other professionals in order to maximise human  
109 functioning.

## Methods

**Eligibility criteria.** *Population:* To be eligible for inclusion, meta-analyses needed to include meta-analytic effect sizes for children or adolescents (age 0-18 years). We included meta-analyses containing studies that combined data from adults and youth if meta-analytic effect size estimates specific to participants aged 18 years or less could be extracted (i.e., the highest individual study from the meta-analysis had a mean age was  $< 18$  years). We excluded meta-analyses that only contained evidence gathered from adults (age  $> 18$  years).

*Exposure:* We included meta-analyses examining all types of electronic screens including (but not necessarily limited to) television, gaming consoles, computers, tablets, and mobile phones. We also included analyses of all types of content on these devices, including (but not necessarily limited to) recreational content (e.g., television programs, movies, games), homework, and communication (e.g., video chat). In this review we adopted a population-level perspective, meaning that we examined electronic media exposure that occurs during typical daily living activities (e.g., home, school-based electronic media exposure). Consistent with this population-level approach, we excluded technology-based treatments for clinical conditions. However, we included studies examining the effect of screen exposure on non-clinical outcomes (e.g., learning) for children and youth with a clinical condition. For example, a meta-analysis of the effect of television watching on learning among adolescents diagnosed with depression would be included. However, a meta-analysis of interventions designed to *treat* clinical depression delivered by a mobile phone app would be excluded.

*Outcomes:* We included all reported outcomes.

*Publications:* We included meta-analyses (or meta-regressions) of quantitative evidence. To be included, meta-analyses needed to analyse data from studies identified in a systematic review. For our purposes, a systematic review was one in which the authors attempted to



acquire all the research evidence that pertained to their research question(s). We excluded meta-analyses that did not attempt to summarise all the available evidence (e.g., a meta-analysis of all studies from one laboratory). We included meta-analyses regardless of the study designs included in the review (e.g., laboratory-based experimental studies, randomised controlled trials, non-randomised controlled trials, longitudinal, cross-sectional, case studies), as long as the studies in the review collected quantitative evidence. We excluded systematic reviews of qualitative evidence. We did not formulate inclusion/exclusion criteria related to the risk of bias of the review. We did, however, employ a risk of bias tool to help interpret the results. We included full-text, peer-reviewed meta-analyses published or ‘in-press’ in English. We excluded conference abstracts and meta-analyses that were unpublished.

**Information sources.** We searched records contained in the following databases: Pubmed, MEDLINE, CINAHL, PsycINFO, SPORTDiscus, Education Source, Embase, Cochrane Library, Scopus, Web of Science, ProQuest Social Science Premium Collection, and ERIC. We conducted an initial search on August 17, 2018 and refreshed the search on May 13, 2020. We searched reference lists of included papers in order to identify additional eligible meta-analyses. We also searched PROSPERO to identify relevant protocols and contacted authors to determine if these reviews have been completed and published.

**Search strategy.** The search strategy associated with each of the 12 databases can be found here. We hand searched reference lists from any relevant umbrella reviews to identify systematic meta-analyses that our search may have missed.

**Selection process.** Using Covidence software (Veritas Health Innovation, Melbourne, Australia), two researchers independently screened all titles and abstracts. Two researchers then independently reviewed full-text articles. We resolved disagreements at each stage of the process by consensus, with a third researcher employed, when needed.

**Data collection process.** From each included meta-analysis, two researchers independently extracted data into a custom-designed database.

**Data items.** From each meta-analysis we extracted the following items: First author, year of publication, study design restrictions (e.g., cross-sectional, observational, experimental), region restrictions (e.g., specific countries), earliest and latest study publication dates, sample age (mean), lowest and highest mean age reported, outcomes reported, and exposures reported.

**Study risk of bias assessment.** For each meta-analysis, two researchers independently completed the National Health, Lung and Blood Institute’s Quality Assessment of Systematic Reviews and Meta-Analyses tool<sup>21</sup> (see Table 1). We resolved disagreements by consensus, with a third researcher employed when needed. We did not assess risk of bias in the individual studies that were included in each meta-analysis.

**Effect measures.** Two researchers independently extracted all quantitative meta-analytic effect sizes, including moderation results. Where possible, they also extracted effect sizes from primary studies included in each meta-analysis. To facilitate comparisons, we converted effect sizes to Pearson’s  $r$  using established formulae.<sup>22–24</sup> We excluded relative risk ratios from this conversion because meta-analyses did not contain sufficient information to meaningfully convert. Effect sizes on the original metric are provided in Supplementary File 1.

**Synthesis methods.** After extracting data, we examined the combinations of exposure and outcomes and removed any effects that appeared more than once, keeping the effect with the largest total sample size. In instances where effect sizes from the same combination of exposure and outcome were drawn from different populations (e.g., children vs adolescents) we retained both estimates in our dataset.

We excluded effect size estimates when the authors did not provide a sample size. We descriptively present the remaining meta-analytic effect sizes. To remove the differences in approach to meta-analyses across the reviews, we reran the effect size estimate using a random effects meta-analysis via the metafor package<sup>25</sup> in R<sup>26</sup> (version 4.1.3) when the meta-analysis’s authors provided primary study data associated with these effects. When

required, we imputed missing sample sizes using mean imputation from the other studies within that review. From our reanalysis we also extracted  $I^2$  values. To test for publication bias, we conducted Egger's test<sup>27</sup> when the number of studies within the review was ten or more,<sup>28</sup> and conducted a test of excess significance.<sup>29</sup> We contacted authors who did not provide primary study data in their published article. Where authors did not provide data in a format that could be re-analysed, we used the published results of their original meta-analysis.

**Evidence assessment criteria.** *Statistical Credibility.* We employed a statistical classification approach to grade the credibility of the effect sizes in the literature. To be considered 'credible' an effect needed to be derived from a combined sample of  $>1,000$ <sup>30</sup> and have non-significant tests of publication bias (i.e., Egger's test and excess significance test). We performed these analyses, and therefore the review needed to provide usable study-level data in order to be included.

*Consistency of Effect within the Population.* We also examined the consistency of the effect size using the  $I^2$  measure. We considered  $I^2 < 50\%$  to indicate effects that were relatively consistent across the population of interest.  $I^2$  values of  $> 50\%$  were taken to indicate an effect was potentially heterogeneous within the population.

*Direction of Effect.* Finally, we examined the extent to which significance testing suggested screen exposure was associated with benefit, harm, or no effect on outcomes. We used thresholds of  $P < .05$  for weak evidence and  $P < 10^{-3}$  for strong evidence. An effect that was neither significant at  $P < .05$  or  $10^{-3}$  that also passed the criteria for statistical credibility was taken to indicate no association of interest.

**Deviations from protocol.** We initially planned to include systematic reviews without meta-analyses in a narrative summary alongside the main meta-analytic findings. However, we determined that combining results from the meta-analyses allowed readers to compare relative strength of associations more easily. Readers interested in the relevant

systematic reviews (i.e., without meta-analysis) can consult the list of references in  
Supplementary File 2.

We altered our evidence assessment plan when we identified that, as written, it could  
not classify precise evidence of null effects (i.e., from large reviews with low heterogeneity  
and low risk of publication bias) as ‘credible’ because a highly-significant  $P$ -value was a  
criteria. This would have significantly harmed knowledge gained from our review as it would  
have restricted our ability to show where the empirical evidence strongly indicated that there  
was no association between screen time and a given outcome.

## Results

**Search Results.** The searches yielded 41,928 results, of which 24,023 were  
duplicates. After screening titles and abstracts, we assessed 1,964 full-texts for inclusion. Of  
those, 116 met the inclusion criteria and we extracted the data from all of these  
meta-analyses. Figure 1 presents the full results of the selection process.

The most frequently reported exposures were general TV programs and movies ( $n =$   
26), physically active video games ( $n = 15$ ), screen-based lifestyle risk behaviour  
interventions (at school) ( $n = 14$ ), and general screen use ( $n = 13$ ). Supplementary File 3  
provides a list of all exposures identified. The most frequently reported outcomes were body  
composition ( $n = 34$ ), general physical activity ( $n = 15$ ), general literacy ( $n = 13$ ), general  
learning ( $n = 12$ ), and sleep duration ( $n = 9$ ). In most cases (121/197), there was only one  
exposure/outcome combination for an age group, with 20 appearing twice, and 8 appearing  
three or more times. Full characteristics of the included studies are provided in Table 1.  
After removing reviews with duplicate exposure/outcome combinations, our process yielded  
165 unique effect/outcome combinations contributed from 50 reviews. These effects represent  
the findings of 2,171 primary studies comprised of 1,652,944 participants.

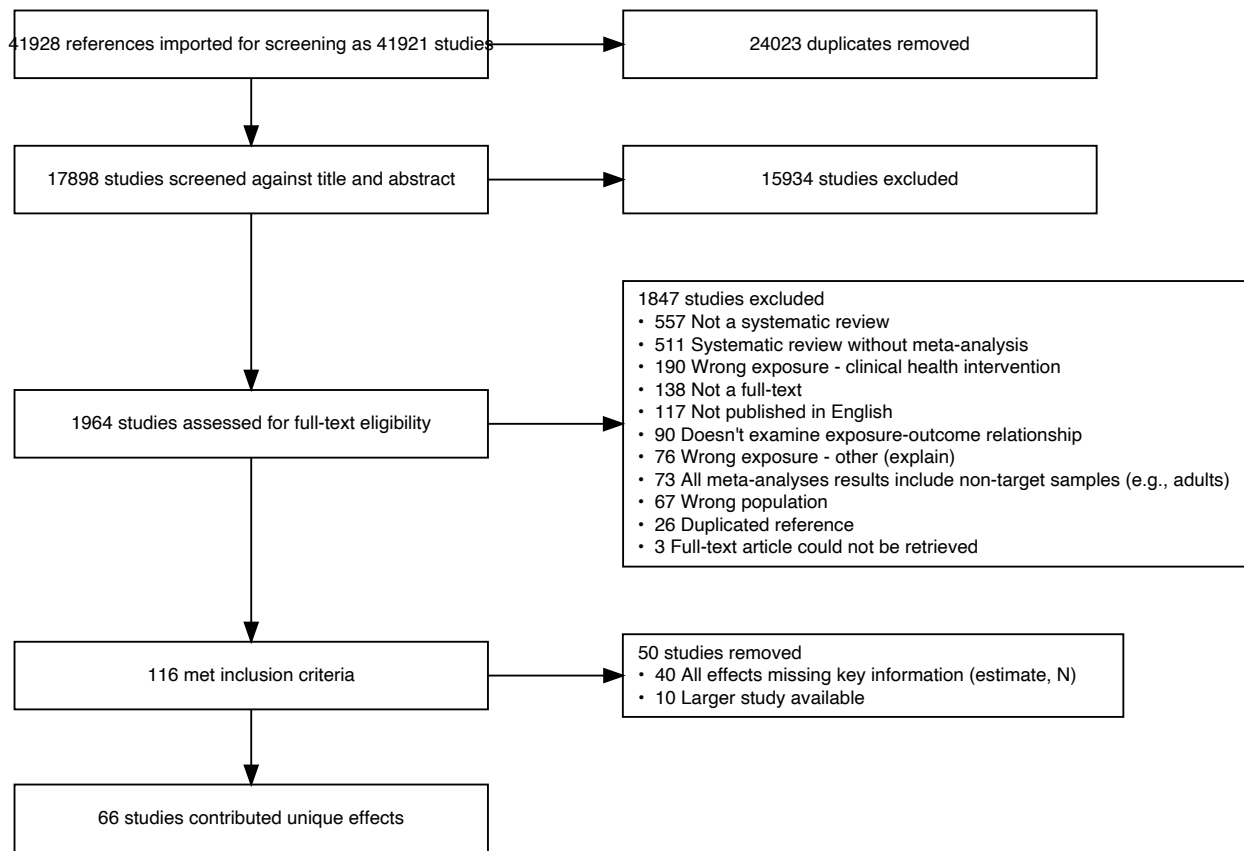


Figure 1. PRISMA Diagram

Table 1  
*Review characteristics for studies providing unique effects*

| First Author     | Year | Design<br>Restrictions                              | Regions<br>Restrictions | Study Range | Sample Age Restrictions   | Outcomes Assessed  | Exposures Assessed  |
|------------------|------|---|-------------------------|-------------|---|--|---|
| Abrami           | 2015 | Include:<br>Experimental;<br>Quasi-<br>experimental | None specified          | 2009 - 2015 | Early childhood; School-age<br>Children<br>(Primary/Elementary) | Literacy: Listening<br>comprehension                       | Intervention: Literacy<br>(Abracadabra; in schools)   |
|                  |      |   |                         |             |   | Literacy: Phonics  |   |
|                  |      |   |                         |             |   | Literacy: Phonic<br>awareness                              |   |
|                  |      |   |                         |             |   | Literacy: Reading<br>comprehension                         |   |
|                  |      |   |                         |             |   | Literacy: Reading fluency                                  |   |
|                  |      |   |                         |             |   | Literacy: Vocabulary<br>knowledge                          |   |
| Adelantado-Renau | 2019 | Include:<br>Cross-sectional<br>studies              | None specified          | 1982 - 2019 | Children; Adolescents   | Learning: General  | Screen use: General<br>TV programs and movies:<br>General<br>Video games: General   |
|                  |      |   |                         |             |   | Literacy: General  |   |
|                  |      |   |                         |             |   | Numeracy: General  |   |
| Aghasi           | 2020 | Include:<br>Observational                           | None specified          | 2007 - 2016 | All   | Body composition   | Internet use: General   |
| Andrade          | 2019 | Include:<br>Interventions                           | None specified          | 2010 - 2017 | Children; Adolescents   | Healthy behavior:<br>Self-efficacy                         | Video games: Physically<br>active   |
|                  |      |   |                         |             |   | Psychological health:<br>Depression                        |   |
|                  |      |   |                         |             |   | Psychological health:<br>Enjoyment                         |   |
| Bartel           | 2015 | None  | None specified          | 2004 - 2014 | Adolescents   | Self-perceptions: General<br>Self-perceptions: Self-esteem | Computer use: General<br>Internet use: General<br>Screen use: General (mobile<br>phone)<br>TV programs and movies:<br>General<br>Video games: General |
|                  |      |   |                         |             |   | Sleep: Bedtime   |   |
|                  |      |   |                         |             |   | Sleep: Duration<br>Sleep: Time to fall asleep              |   |

Table 1

*Review characteristics for studies providing unique effects (continued)*

| First Author | Year | Design Restrictions                   | Regions Restrictions | Study Range | Sample Age Restrictions | Outcomes Assessed  | Exposures Assessed                                 |
|--------------|------|---------------------------------------|----------------------|-------------|-------------------------|--|--|
| Blok         | 2002 | None                                  | None specified       | 1990 - 2000 | All                     | Literacy: Reading fluency  | Intervention: Literacy                             |
| Bossen       | 2020 | Include: Randomised controlled trials | None specified       | 2011 - 2018 | Children                | Body composition<br>Cardiometabolic health: Fitness<br>Physical activity: General<br>Physical health: Muscular fitness   | Video games: Health promoting content              |
| Boyland      | 2016 | Include: Experimental                 | None specified       | 2004 - 2015 | Children; Adolescents   | Diet: Food intake  | Advertising: Unhealthy food                        |
| Byun         | 2018 | Include: All quantitative designs     | None specified       | 2006 - 2014 | School-age Children     | Numeracy: General  | Video games: Numeracy                              |
| Carter       | 2016 | Include: All quantitative designs     | None specified       | 2011 - 2015 | Children; Adolescents   | Sleep: Inadequate duration<br>Sleep: Lethargy<br>Sleep: Poor quality   | Screen use: General (mobile phone at bed time)     |
| Champion     | 2019 | Include: Randomised controlled trials | None specified       | 2003 - 2017 | School-age Children     | Body composition<br>Diet: Fat consumption<br>Diet: Fruit and vegetable intake<br>Diet: Fruit intake<br>Diet: Sugary drinks and snacks<br>Physical activity: General<br>Physical activity: Moderate-to-vigorous intensity<br>Risky behavior: Alcohol consumption<br>Risky behavior: Smoking<br>Screen time: General | Intervention: Lifestyle risk behaviour (at school) |

Table 1

*Review characteristics for studies providing unique effects (continued)*

| First Author | Year | Design Restrictions                             | Regions Restrictions | Study Range | Sample Age Restrictions | Outcomes Assessed   | Exposures Assessed  |
|--------------|------|---|----------------------|-------------|-------------------------|---|---|
| Chan         | 2014 | Include: Experimental; Quasi-experimental       | None specified       | 2002 - 2012 | School-age Children     | Numeracy: General   | Intervention: Dynamic geometry software   |
| Cheung       | 2012 | Include: Randomised controlled trials           | None specified       | 1982 - 2010 | School-age Children     | Literacy: Reading   | Intervention: Reading (in schools)  |
| Cheung       | 2013 | Include: Experimental; Quasi-experimental       | None specified       | 1980 - 2010 | School-age Children     | Numeracy: General   | Intervention: Mathematics (in schools)  |
| Coyne        | 2018 | None  | None specified       | 1975 - 2017 | Children; Adolescents   | Prosocial Behavior: General   | Screen use: Prosocial content   |
| Cushing      | 2010 | Include: All quantitative designs; Experimental | None specified       | 1989 - 2009 | Children; Adolescents   | Healthy behavior: General   | Intervention: Health behaviours   |
| Darling      | 2017 | Include: Intervention                           | None specified       | 2006 - 2016 | Children; Adolescents   | Body composition<br>Diet: Healthy dietary behaviour<br>Physical activity: General | Intervention: To promote health (via mobile phone)                              |
| de Oliveira  | 2016 | Include: Observational                          | None specified       | 2010 - 2014 | Adolescents             | Cardiometabolic health: Metabolic Syndrome  | Screen use: General   |
| Fang         | 2019 | Include: Cohort; Case-control; Cross-sectional  | None specified       | 2006 - 2019 | Children; Adolescents   | Body composition  | Computer use: General<br>Screen use: General<br>TV programs and movies: General |



Table 1

*Review characteristics for studies providing unique effects (continued)*

| First Author | Year | Design Restrictions  | Regions Restrictions   | Study Range | Sample Age Restrictions                                | Outcomes Assessed  | Exposures Assessed   |
|--------------|------|--|------------------------|-------------|--|--|--|
| Ferguson     | 2017 | None   | None specified         | 2005 - 2017 | Children; Adolescents                                  | Risky behavior: Sexual activity<br>Risky behavior: Sexual activity (initiation of sex) | Screen use: Sexual content                                   |
| Folkvord     | 2018 | Include: Interventions   | None specified         | 2007 - 2018 | Children; Adolescents                                  | Diet: Food intake (calories)   | Advertising: Advergaming                                     |
| Gardella     | 2017 | Include: Cross-sectional   | Include: North America | 2006 - 2014 | Adolescents  | Learning: Educational achievement problems<br>Learning: School attendance problems     | Internet use: Cyberbullying victimization                    |
| Ghobadi      | 2018 | Include: Cohort; Case-control; Cross-sectional<br>Exclude: Interventions | None specified         | 2009 - 2014 | Children; Adolescents                                  | Body composition   | TV programs and movies: Mealtime                             |
| Graham       | 2015 | Include: Experimental; Quasi-experimental                                | None specified         | 2004 - 2011 | School-age Children (Primary/Elementary/Middle School) | Literacy: Writing  | Intervention: Writing feedback                               |
| Hammersley   | 2016 | Include: Randomised controlled trials                                    | None specified         | 2003 - 2013 | Children; Adolescents                                  | Body composition   | Intervention: To promote healthy weight (obesity prevention) |
| Hassan-Saleh | 2019 | Include: Experimental; Quasi-experimental                                | None specified         | 2008 - 2016 | Children; Adolescents                                  | Literacy: Pronunciation  | Intervention: Pronunciation                                  |

Table 1

*Review characteristics for studies providing unique effects (continued)*

| First Author      | Year | Design Restrictions  | Regions Restrictions   | Study Range | Sample Age Restrictions  | Outcomes Assessed  | Exposures Assessed                                     |
|-------------------|------|--|------------------------|-------------|--|--------------------|--|
| Hernandez-Jimenez | 2019 | Include: Experimental; Quasi-experimental  | None specified         | 2009 - 2017 | Children; Adolescents  | Body composition   | Video games: Physically active                         |
| Hurwitz           | 2018 | None   | Include: North America | 1997 - 2018 | Early childhood/pre-school; School-age Children (Early Primary/Elementary) | Literacy: General  | Intervention: Literacy videos                          |
| Janssen           | 2020 | Include: Experimental; Cross-sectional; Longitudinal   | None specified         | 2007 - 2019 | Children   | Sleep: Duration    | Screen use: General                                    |
| Kates             | 2018 | None   | None specified         | 2008 - 2016 | School-age Children  | Learning: General  | Screen use: General (mobile phone)                     |
| Kroesbergen       | 2003 | Include: Within subject design; between subject design   | None specified         | 1985 - 1999 | School-age Children (Primary/Elementary)                                   | Numeracy: General  | Intervention: Mathematics (via computer in classrooms) |
| Kucukalkan        | 2019 | Include: Experimental  | None specified         | 2007 - 2016 | School-age Children (Primary/Elementary)                                   | Numeracy: General  | Intervention: Mathematics                              |
| Lauca             | 2020 | Include: Cohort; Case-control; Cross-sectional; Intervention trials. Exclude: Case reports; Retrospective studies. | None specified         | 2007 - 2016 | Children; Adolescents  | Eye health: Myopia | Screen use: General                                    |

Table 1

*Review characteristics for studies providing unique effects (continued)*

| First Author | Year | Design<br>Restrictions  | Regions<br>Restrictions | Study Range | Sample Age Restrictions                     | Outcomes Assessed  | Exposures Assessed   |
|--------------|------|---|-------------------------|-------------|---|--|--|
| Li           | 2010 | Include:<br>Experimental;<br>Quasi-<br>experimental           | None specified          | 1991 - 2005 | School-age Children                         | Numeracy: General  | Intervention: Mathematics                                  |
| Liao         | 2008 | Include: All<br>quantitative<br>designs                       | Include: Taiwan         | 1990 - 2003 | School-age Children<br>(Primary/Elementary) | Learning: General  | Intervention: Education (via<br>computer)                  |
| Liao         | 2014 | Include:<br>Randomised<br>controlled trials                   | None specified          | 1999 - 2012 | Children; Adolescents                       | Body composition   | Intervention: Screenshot<br>reduction                      |
| Liu          | 2016 | Include:<br>Cross-sectional;<br>Case-control;<br>Longitudinal | None specified          | 2001 - 2014 | All   | Psychological health:<br>Depression  | Screen use: General  |
| Liu          | 2019 | Include: All<br>quantitative<br>designs                       | None specified          | 2007 - 2014 | All   | Psychological health:<br>Anxiety<br>Psychological health:<br>Depression<br>Psychological health:<br>Satisfaction | Social Media: Instant<br>messaging<br>Video games: General |

Table 1  
*Review characteristics for studies providing unique effects (continued)*

| First Author | Year | Design<br>Restrictions                               | Regions<br>Restrictions   | Study Range | Sample Age            | Restrictions | Outcomes Assessed   | Exposures Assessed  |
|--------------|------|--|---------------------------|-------------|-----------------------|--------------|---|---|
| Madigan      | 2020 | Include:<br>Observational<br>Exclude:<br>Qualitative | None specified            | 1973 - 2019 | Children              |              | Literacy: General   | Intervention: Education<br>(general)<br>Screen use: General<br>Screen use: General<br>(covieving)<br>TV programs and movies:<br>Covieving<br>TV programs and movies:<br>Educational<br>TV programs and movies:<br>General<br>TV programs and movies:<br>General (in background) |
| Mares        | 2005 | None   | None specified            | 1969 - 1989 | Children              |              | Aggression: Towards peers<br>Cognition: Reducing<br>stereotypes<br>Prosocial Behavior:<br>Altruism<br>Social interactions: General                                    | TV programs and movies:<br>General  |
| Mares        | 2013 | Exclude:<br>Experimental                             | Exclude: North<br>America | 1973 - 2010 | Children              |              | Cognition: Moral reasoning<br>and perception of out-groups<br>Learning: General<br>Learning: Literacy and<br>numeracy<br>Learning: Physical and<br>social environment | Intervention: Sesame Street   |
| Marshall     | 2004 | None   | None specified            | 1985 - 2002 | Children; Adolescents |              | Body composition<br>Physical activity: General  | TV programs and movies:<br>General<br>Video games: General  |

Table 1

*Review characteristics for studies providing unique effects (continued)*

| First Author | Year | Design Restrictions                                   | Regions Restrictions                | Study Range | Sample Age Restrictions | Outcomes Assessed   | Exposures Assessed                             |
|--------------|------|---|-------------------------------------|-------------|-------------------------|---|--|
| Martins      | 2019 | Include: All quantitative designs                     | None specified                      | 2003 - 2018 | All                     | Aggression: Towards peers   | Screen use: General                            |
| McArthur     | 2012 | Include: Randomised controlled trials and quasi-RCTs. | None specified                      | 1994 - 2009 | All                     | Literacy: Phonics   | Intervention: Literacy (phonics; via computer) |
| McArthur     | 2018 | Include: Randomised controlled trials and quasi-RCTs. | Include: English speaking countries | 1994 - 2015 | Children; Adolescents   | Literacy: General   | Intervention: Literacy                         |
| Oldrati      | 2020 | Include: Group-control experimental design            | None specified                      | 2006 - 2018 | School-age Children     | Cognition: Cognitive Functioning<br>Cognition: Executive Functioning<br>Cognition: Verbal skills<br>Cognition: Visuospatial skills<br>Numeracy: General<br>Psychological health: Adjustment | Intervention: Cognitive training               |
| Palk         | 1994 | None  | None specified                      | NA - NA     | Children; Adolescents   | Antisocial Behaviour: General   | TV programs and movies: Violent content        |
| Pearce       | 2016 | Include: All quantitative designs                     | None specified                      | 1986 - 2012 | Children; Adolescents   | Psychological health: Internalizing   | TV programs and movies: Scary content          |

Table 1

*Review characteristics for studies providing unique effects (continued)*

| First Author    | Year | Design<br>Restrictions                              | Regions<br>Restrictions | Study Range | Sample Age Restrictions | Outcomes Assessed   | Exposures Assessed   |
|-----------------|------|---|-------------------------|-------------|-------------------------|---|--|
| Peng            | 2011 | None  | None specified          | 2001 - 2010 | Children; Adolescents   | Cardiometabolic health:<br>Maximum oxygen<br>consumption<br>Physical activity: Energy<br>expenditure<br>Physical activity: Heart rate | Video games: Physically<br>active                          |
| Poorolajal      | 2020 | Include:<br>Observational                           | None specified          | 1995 - 2018 | Children; Adolescents   | Body composition  | TV programs and movies:<br>General<br>Video games: General |
| Prescott        | 2018 | Include:<br>Longitudinal                            | None specified          | 2008 - 2017 | All                     | Aggression: Towards peers   | Video games: Violent<br>content                            |
| Rodriguez-Rocha | 2019 | Include:<br>Experimental;<br>Quasi-<br>experimental | None specified          | 1999 - 2018 | All                     | Diet: Fruit and vegetable<br>intake   | Intervention: Fruit and<br>vegetable                       |
| Sadeghirad      | 2016 | Include:<br>Randomised<br>controlled trials         | None specified          | 1978 - 2014 | Children; Adolescents   | Diet: Unhealthy food choice   | Advertising: Unhealthy food                                |
| Schroeder       | 2013 | Include:<br>Experimental;<br>Quasi-<br>experimental | None specified          | 2001 - 2009 | All                     | Learning: General   | Intervention: With digital<br>characters                   |
| Scioni          | 2019 | Include:<br>Interventions                           | None specified          | 2009 - 2019 | Children                | Cognition: Executive<br>functioning   | Intervention: Cognitive<br>training                        |

Table 1  
*Review characteristics for studies providing unique effects (continued)*

| First Author | Year | Design Restrictions   | Regions Restrictions | Study Range | Sample Age Restrictions                  | Outcomes Assessed   | Exposures Assessed   |
|--------------|------|---|----------------------|-------------|--|---|--|
| Shin         | 2019 | Include:<br>Interventions   | None specified       | 2013 - 2018 | Children; Adolescents                    | Body composition<br>Diet: Sugary drinks<br>Physical activity: General<br>Screen time: General   | Intervention: To promote health (via mobile phone app)<br>Intervention: To promote health (via mobile phone)<br>Intervention: To promote health (via text message) |
| Slavin       | 2014 | Include:<br>Randomised controlled trials;<br>Quasi-experimental;<br>Observational | None specified       | 2000 - 2011 | School-age Children (Primary/Elementary) | Science: General  | Intervention: Science (in schools)   |
| Takacs       | 2014 | Include:<br>Experimental;<br>Quasi-experimental                                   | None specified       | 1980 - 2014 | NA                                       | Learning: General   | e-Books: Narration   |
| Takacs       | 2019 | Include:<br>Randomised controlled trials and quasi-RCTs.                          | None specified       | 2001 - 2016 | Children                                 | Cognition: Executive Functioning (accuracy)<br>Cognition: Executive Functioning (cognitive flexibility)<br>Cognition: Executive Functioning (inhibition)<br>Cognition: Executive Functioning (working memory) | Intervention: Education (via computer)   |
| Tekeidere    | 2016 | None  | None specified       | 2010 - 2015 | All                                      | Learning: General   | Intervention: Augmented reality (in schools)   |

Review characteristics for studies providing unique effects (continued)

| First Author | Year | Design Restrictions  | Regions Restrictions | Study Range | Sample Age Restrictions                  | Outcomes Assessed  | Exposures Assessed                         |
|--------------|------|--|----------------------|-------------|--|--|--|
| Vahedi       | 2018 | Include: Interventions (pre-post or controlled).<br>Exclude: Cross-sectional     | None specified       | 2015 - 2016 | School-age Children (Middle/High School) | Risky behavior: Media literacy<br><br>Risky behavior: Risk taking (attitude)   | Intervention: Media literacy (web-based)   |
| Vannucci     | 2020 | Exclude: Qualitative; Case studies   | None specified       | 2011 - 2018 | Adolescents                              | Risky behavior: Risk taking (general)<br><br>Risky behavior: Risky sexual behaviour<br><br>Risky behavior: Substance abuse | Social Media: General                      |
| Xie          | 2018 | Include: Experimental; Quasi-experimental; Pre-test post-test                    | None specified       | 2010 - 2018 | Children                                 | Learning: General  | Intervention: Education (via touch screen) |
| Zhang        | 2016 | Include: Cohort; Case-control; Cross-sectional                                   | None specified       | 2001 - 2014 | Children                                 | Body composition   | TV programs and movies: General            |
| Zhou         | 2020 | Exclude: Non-empirical studies; Qualitative; Systematic reviews or meta-analyses | None specified       | 2009 - 2018 | All                                      | Healthy behavior: General<br>Healthy behavior: Self-efficacy<br>Psychological health: Enjoyment                            | Video games: Health promoting content      |



Review characteristics for studies providing unique effects (continued)

| First Author | Year | Design Restrictions   | Regions Restrictions | Study Range | Sample Age Restrictions                  | Outcomes Assessed                                     | Exposures Assessed |
|--------------|------|---|----------------------|-------------|--|---|--------------------|
| Zucker       | 2009 | Include:<br>Randomised controlled trials;<br>Quasi-experimental;<br>Observational | None specified       | 1997 - 2006 | School-age Children (Primary/Elementary) | Literacy: Decoding<br>Literacy: Reading comprehension | e-Books: General   |

The quality of the included meta-analyses was mixed (see Table 1). Most assessed heterogeneity ( $n$  low risk = 59/66, 89% of meta-analyses), reported the characteristics of the included studies ( $n$  low risk = 57/66, 86%), and used a comprehensive and systematic search strategy ( $n$  low risk = 56/66, 85%). Most reviews did not clearly report if their eligibility criteria were predefined ( $n$  unclear = 45/66, 68%). Many papers also did not complete dual independent screening of abstracts and full text ( $n$  high risk = 16/66, 24%) or did not clearly report the method of screening ( $n$  unclear = 21/66, 32%). A similar trend was observed for dual independent quality assessment ( $n$  high risk = 31/66, 47%;  $n$  high risk = 19/66, 29%). Overall, only 5 meta-analyses were graded as low risk of bias on all criteria.

**Education Outcomes.** There were 46 unique effects associated with education outcomes, including general learning outcomes, literacy, numeracy, and science. We removed 20 effects that did not provide individual study-level data, 7 effects with samples < 1,000, and 8 effects with a significant Egger's test or insufficient studies to conduct the test. Effects not meeting one or more of these standards are presented in Supplementary File 4. The remaining 12 effects met our criteria for statistical credibility and are described in Figure 2. These 12 effects came from 8 meta-analytic reviews analysing data from 226 empirical studies with 186,631 individual participants.

Among the statistically credible effects, general screen use, television viewing, and video games were all negatively associated with learning. E-books that included narration, as well as touch screen education interventions, and augmented reality education interventions were positively associated with learning. General screen use was negatively associated with literacy outcomes. However, if the screen use involved co-viewing (e.g., watching with a parent), or the content of television programs was educational, the association with literacy was positive and significant at the 95% confidence level (weak evidence). Numeracy outcomes were positively associated with screen-based mathematics interventions and video games that contained numeracy content.

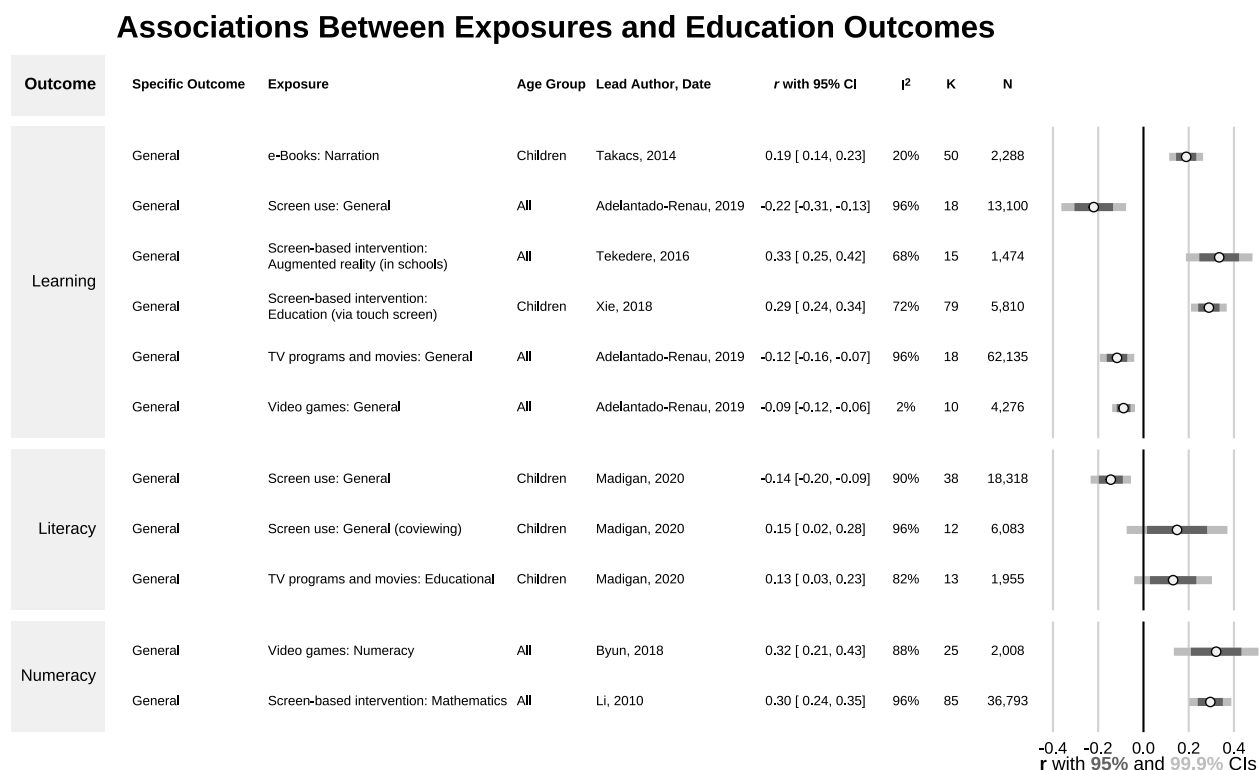


Figure 2. Education outcomes

As shown in Figure 2, most of the credible results (10 of 12 effects) showed statistically significant associations, with 99.9% confidence intervals not encompassing zero (strong evidence). The remaining two associations were significant at the 95% confidence level (weak evidence). All credible effects related to education outcomes were small-to-moderate. Screen-based interventions designed to influence an outcome (e.g., a computer based program designed to enhance learning)<sup>31</sup> tended to have larger effect sizes than exposures that were not specifically intended to influence any of the measured outcomes (e.g., the association between television viewing and learning).<sup>32</sup> The largest effect size observed was for augmented reality-based education interventions on general learning ( $r = 0.33, k = 15, N = 1,474$ ). Most effects showed high levels of heterogeneity (10 of 12 with  $I^2 > 50\%$ ).

**Health and Health-related Behaviours.** We identified 119 unique outcome-exposure combinations associated with health or health-related behaviour outcomes.

278 We removed 31 effects that did not provide individual study-level data, 30 effects with  
279 samples < 1,000, and 43 effects with a significant Egger’s test or insufficient studies to  
280 conduct the test. No remaining studies showed evidence of excessive significance. Effects not  
281 meeting one or more of these standards are presented in Supplementary File 5. The  
282 remaining 17 meta-analytic associations met our criteria for credible evidence and are  
283 described below (see also Figure 3). These 17 effects came from 12 meta-analytic reviews  
284 analysing data from 231 empirical studies with 676,331 individual participants.

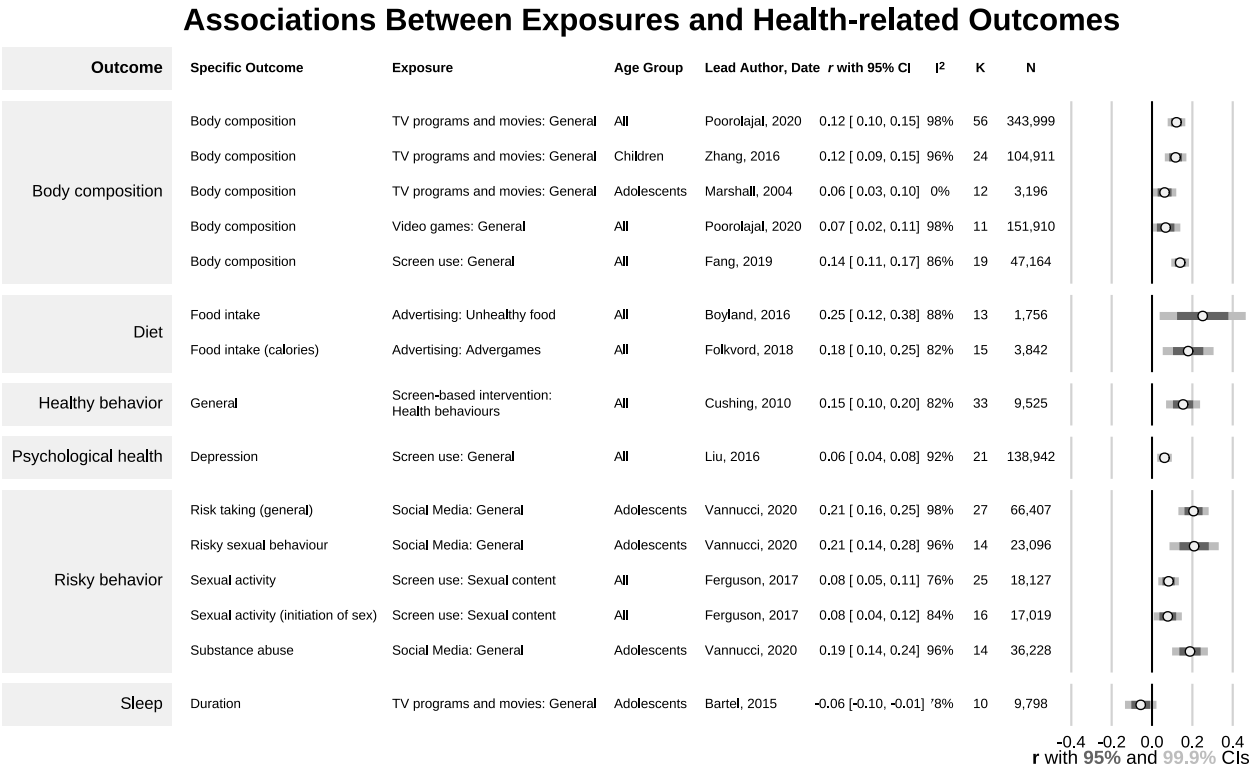


Figure 3. Health and health-related behaviour outcomes

285 Digital advertising of unhealthy foods—both traditional advertising and video games  
286 developed by a brand for promotion—were associated with higher unhealthy food intake.  
287 Social media use and sexual content were positively associated with risky behaviors (e.g.,  
288 sexual activity, risk taking, and substance abuse). General screen use was positively  
289 associated with depression. Television viewing was negatively correlated with sleep duration,  
290 but only at the 95% confidence level (weak evidence). All forms of screen use (general,

television, and video games) were associated with body composition (e.g., higher BMI), although the association was smaller for children than for adolescents or for combined populations. Screen-based interventions which target health behaviours appeared effective.

Across the health outcomes, most (14 of 17) effects were statistically significant at the 99.9% confidence interval level, with the remaining three significant at 95% confidence. However, most of the credible effects exhibited high levels of heterogeneity, with all but one having  $I^2 > 75\%$ . Additionally, most effects were small, with the association between unhealthy food advertising and intake the largest at  $r = 0.25$  ( $k = 13, N = 1,756$ ). Most of the effect sizes (14/17) had an absolute value of  $r < 0.2$ .

## Discussion

The primary goal of this review was to provide a holistic perspective on the influence of screens on children's lives across a broad range of outcomes. We found that when meta-analyses examined general screen use, and did not specify the content, context or device, there was strong evidence showing potentially harmful associations with general learning, literacy, body composition, and depression. However, when meta-analyses included a more nuanced examination of exposures, a more complex picture appeared.

As an example, consider children watching television programs—an often cited form of screen time harm. We found robust evidence for a small association with poorer academic performance and literacy skills.<sup>32</sup> However, we also found evidence that if the content of the program was educational, or the child was watching the program with a parent (i.e., co-viewing), this exposure was instead associated with better literacy.<sup>33</sup> Thus, parents may play an important role in selecting content that is likely to benefit their children or, perhaps, interact with their children in ways that may foster literacy (e.g., asking their children questions about the program). Similar nuanced findings were observed for video games. The credible evidence we identified showed that video game playing was associated with poorer

body composition and learning.<sup>32,34</sup> However, when the video game were designed specifically to teach numeracy, playing these games showed learning benefits.<sup>35</sup> One might expect that video games designed to be physically active could confer health benefits, but none of the meta-analyses examining this hypothesis met our thresholds for statistical credibility (see Supplementary Files 4 & 5) therefore this hypothesis could not be addressed.

Social media was one type of exposure that showed consistent risks to health, with no indication of potential benefit. Social media showed strong evidence of harmful associations with risk taking in general, as well as unsafe sex and substance abuse.<sup>36</sup> These results align with meta-analytic evidence from adults indicating that social media use is also associated with increased risk of depression.<sup>37,38</sup> Recent evidence from social media companies themselves suggest there may also be negative effects of social media on the mental health of young people, especially teenage girls.<sup>39</sup>

One category of exposure appeared to consistently confer benefits: screen-based interventions designed to promote learning or health behaviours. This finding indicates that interventions can be effectively delivered using electronic media platforms, but does not necessarily indicate that screens are more effective than other methods (e.g., face-to-face, printed material). Rather, it reinforces that the content of the screen time may be the most important aspect. The way that a young person interacts with digital screens may also be important. We found evidence that touch screens had strong evidence for benefits on learning,<sup>31</sup> as did augmented reality.<sup>40</sup>

Largely owing to a small number of studies or missing individual study data, there were few age-based conclusions that could be drawn from reviews which met our criteria for statistical certainty. If we expand to include those reviews which did not meet this threshold, there remained no clear pattern although there were some age-specific differences in associations (data available in Supplementary Materials). For example, advertising of unhealthy food was associated with unhealthy food choice for young children, but was not

statistically significant for other age groups.<sup>41</sup> Conversely, TV programs and movies were more strongly associated with lower physical activity for adolescents than for younger age groups.<sup>42</sup>

Among studies that met our criteria for statistical certainty heterogeneity was high, with almost all effects having  $I^2 > 50\%$ . Much of this heterogeneity is likely explained by differences in measures across pooled studies, or in some cases, the generic nature of some of the exposures. For example, “TV programs and movies” covers a substantial range of content, which may explain the heterogeneous association with education outcomes.

### Implications for Policy and Practice

Broadly, our findings align with the recommendations of others who suggest that current guidelines may be too simplistic, mischaracterise the strength of the evidence, or do not acknowledge the important nuances of the issue.<sup>43–45</sup> Our findings suggest that screen use is a complex issue, with associations based not just on duration and device type, but also on the content and the environment in which the exposure occurs. Many current guidelines simplify this complex relationship as something that should be minimised in all instances.<sup>12,13</sup> We suggest that future guidelines need to embrace the complexity of the issue, to give parents and clinicians specific information to weigh the pros and cons of interactions with screens.

### Implications for Future Research

Screen use research is extensive, varied, and rapidly growing. Reviews tended to be general (e.g., all screen time) and even when more targeted (e.g., social media) nuances related to specific content (e.g., Instagram vs Facebook) have not been meta-analysed or have not produced credible evidence. Fewer than 20% of the effects identified met our criteria for statistical credibility. Most studies which did not meet our criteria failed to provide study-level data (or did not provide sufficient data, such as including effect estimates

but not sample sizes). Newer reviews were more likely to provide this information than older reviews, but it highlights the importance of data and code sharing as recommended in the PRISMA guidelines.<sup>46</sup> When study level data was available, many effects were removed because the pooled sample size was small, or because there were fewer than ten studies on which to perform an Egger's test. It seems that much of the current screen time research is small in scale, and there is a need for larger, high-quality studies.

Screen time research has a well-established measurement problem, which impacts the individual studies of this umbrella review. The vast majority of screen time research relies on self-reported data, which not only lacks the nuance required for understanding the effects of screen time, but may also be inaccurate. In one systematic review on screen time and sleep,<sup>7</sup> 66 of the 67 included studies used self-reported data for *both* the exposure and outcome variable. It has been established that self-reported screen time data has questionable validity. In a meta-analysis of 47 studies comparing self-reported media use with logged measures, Parry et al<sup>47</sup> found that the measures were only moderately correlated ( $r = 0.38$ ), with self-reported problematic usage fairing worse ( $r = 0.25$ ). Indeed, of 622 studies which measured the screen time of 0–6 year-olds, only 69 provided any sort of psychometric properties for their measure, with only 19 studies reporting validity.<sup>48</sup> While some researchers have started using newer methods of capturing screen behaviours—such as wearable cameras<sup>49</sup> or device-based loggers—<sup>50</sup>these are still not widely adopted. It may be that the field of screen time research cannot be sufficiently advanced until accurate, validated, and nuanced measures are more widely available and adopted.

## Strengths and Limitations

Our primary goal for this umbrella review was to provide a high-level synthesis of screen time research, by examining a range of exposures and the associations with a broad scope of outcomes. Our results represent the findings from 2,171 primary studies comprised of 1,652,944 participants. To ensure findings could be compared on a common metric, we



393 extracted and reanalysed individual study data where possible.

394 Our high-level approach limits the feasibility of examining fine-grained details of the  
395 individual studies. For example, we did not examine moderators beyond age, nor did we rate  
396 the risk of bias for the individual studies. Thus, our assessment of evidence quality was  
397 restricted to statistical credibility, rather than a more complete assessment of quality (e.g.,  
398 GRADE).<sup>51</sup> As such, we made decisions regarding the credibility of evidence, where others  
399 may have used different thresholds or metrics. For this reason, we provide the complete  
400 results in the supplementary material, along with the dataset for others to consider  
401 alternative criteria. In addition, reviews provide only historical evidence which may not keep  
402 up with the changing ways children can engage with screens. While our synthesis of the  
403 existing evidence provides information about how screens might have influenced children in  
404 the past, it is difficult to know if these findings will translate to new forms of technology in  
405 the future.

## 406 Conclusions

407 Screen time is a topic of significant interest, as shown by the wide variety of academic  
408 domains involved, parents' concerns, and the growing pervasiveness into society. Our  
409 findings showed that the impact of screen time can be both positive (e.g., educational video  
410 games were associated with improved literacy) and negative (e.g., general screen use was  
411 associated with poorer body composition). The interplay of these findings show that parents,  
412 teachers, and other caregivers need to carefully weigh the pros and cons of each specific  
413 activity for potential harms and benefits. However, our findings also suggest that in order to  
414 aid caregivers to make this judgement, researchers need to conduct more careful and nuanced  
415 measurement and analysis of screen time, with less emphasis on measures that aggregate  
416 screen time and instead focus on the content, context, and environment in which the  
417 exposure occurs.

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