

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

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36

## Abstract

37 Children's engagement in screen time is a complex issue. While some forms of screen time  
38 have consistently been associated with harm, others have been associated with gains, making  
39 it difficult to weigh the risks and benefits of use. In this umbrella review, we systematically  
40 collate and examined meta-analyses examining the effects of screen use on children and  
41 youth. We converted results onto a common metric (Pearson's r) to make comparisons  
42 simple, and where possible we reanalysed study-level data to standardise the approach across  
43 meta-analyses. We identified 224 meta-analyses, and extracted 274 unique combinations of  
44 exposures and outcomes. If duplicate effect sizes from the same combination of exposure and  
45 outcome were drawn from different age groups or study designs we retained them, otherwise  
46 we chose the effect size with the largest total sample size. We removed effect sizes that could  
47 not be harmonized, resulting in 246 from 103 reviews. These effects represent the findings of  
48 2,496 primary studies comprised of 2,026,054 participants. When focusing on the  
49 meta-analyses with the most statistically robust evidence, we found that general screen use  
50 (when content was not indicated), was associated with potential harm on learning, literacy,  
51 body composition, and depression. Like-wise, social media was consistently associated with  
52 risks to health, with no identified benefits. However, we also found that these harms could  
53 often be mitigated by certain kinds of content (e.g., educational), or by modifying the context  
54 (e.g., co-viewing with a parent). In summary, our findings point to the need for careful and  
55 nuanced guidelines that support parents to make the best decisions for their children.

56

*Keywords:* screen time; youth; health; education

57

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59 screens: An umbrella review

60 **Summary**

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

76

## Background

77        In the 16th century, hysteria reigned around a new technology that threatened to be  
78        “confusing and harmful” to the mind. The cause of such concern? The widespread  
79        availability of books brought about by the invention of the printing press.<sup>2</sup> In the early 19th  
80        century, concerns about schooling “exhausting the children’s brains” followed, with the  
81        medical community accepting that excessive study could be a cause of madness.<sup>3</sup> By the  
82        20th century, the invention of the radio was accompanied by assertions that it would distract  
83        children from their reading (which by this point was no longer considered confusing and  
84        harmful) leading to impaired learning.<sup>4</sup>

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

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

98        Citing the negative effects of screens on health (e.g., increased risk of obesity) and  
99        health-related behaviours (e.g., sleep), guidelines from the World Health Organisation<sup>12</sup> and  
100       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. While there have been other overviews of reviews on screen time, these have tended to focus on a single domain (e.g., health),<sup>21</sup> focus on a particular exposure (e.g., social media)<sup>22,23</sup> or provide only a narrative summary of the literature.<sup>24</sup> No review has yet examined the evidence available across a broad range of outcome domains, such as physical health, education, physical and cognitive development, behaviour, and well-being. By summarising and synthesising all evidence in one overview, we provide a reference point for the field and allow for easier comparison of risks and benefits for the same behaviour.

127 In order to synthesise the evidence and support further evidence-based guideline

128 development and refinement, we reviewed published meta-analyses examining the effects of

129 screen use on children and youth. This review synthesises evidence on any outcome of

130 electronic media exposure. We deliberately do not pre-specify outcomes, in order to get a

131 comprehensive list of areas where there is meta-analytical evidence. Adopting this broad

132 approach allowed us to provide a holistic perspective on the influence of screens on children's

133 lives. By synthesising across life domains (e.g., school and home), this review provides

134 evidence to inform guidelines and advice for parents, teachers, pediatricians and other

135 professionals in order to maximise human functioning.

136

## Methods

137        We prospectively registered our methods on the International Prospective Register of  
138      Systematic Reviews (PROSPERO; CRD42017076051). We followed the Preferred Reporting  
139      Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>25</sup>

140        **Eligibility criteria.** *Population:* To be eligible for inclusion, meta-analyses needed  
141      to include meta-analytic effect sizes for children or adolescents (age 0-18 years). We included  
142      meta-analyses containing studies that combined data from adults and youth if meta-analytic  
143      effect size estimates specific to participants aged 18 years or less could be extracted (i.e., the  
144      highest mean age for any individual study included in the meta-analysis was < 18 years). A  
145      meta-analysis was still included if the age range exceed 18 years, provided that the mean age  
146      was less than 18. We excluded meta-analyses that only contained evidence gathered from  
147      adults (age >18 years).

148        *Exposure:* We included meta-analyses examining all types of electronic screens  
149      including (but not necessarily limited to) television, gaming consoles, computers, tablets,  
150      and mobile phones. We also included analyses of all types of content on these devices,  
151      including (but not necessarily limited to) recreational content (e.g., television programs,  
152      movies, games), homework, and communication (e.g., video chat). In this review we focused  
153      on electronic media exposure that would be considered typical for children and youth. That  
154      is, exposure that may occur in the home setting, or during schooling. Consistent with this  
155      approach, we excluded technology-based treatments for clinical conditions. However, we  
156      included studies examining the effect of screen exposure on non-clinical outcomes (e.g.,  
157      learning) for children and youth with a clinical condition. For example, a meta-analysis of  
158      the effect of television watching on learning among adolescents diagnosed with depression  
159      would be included. However, a meta-analysis of interventions designed to *treat* clinical  
160      depression delivered by a mobile phone app would be excluded. *Outcomes:* We included all  
161      reported outcomes on benefits and risks.

162        *Publications:* We included meta-analyses (or meta-regressions) of quantitative evidence.

163        To be included, meta-analyses needed to analyse data from studies identified in a systematic

164        review. For our purposes, a systematic review was one in which the authors attempted to

165        acquire all the research evidence that pertained to their research question(s). We excluded

166        meta-analyses that did not attempt to summarise all the available evidence (e.g., a

167        meta-analysis of all studies from one laboratory). We included meta-analyses regardless of

168        the study designs included in the review (e.g., laboratory-based experimental studies,

169        randomised controlled trials, non-randomised controlled trials, longitudinal, cross-sectional,

170        case studies), as long as the studies in the review collected quantitative evidence. We

171        excluded systematic reviews of qualitative evidence. We did not formulate

172        inclusion/exclusion criteria related to the risk of bias of the review. We did, however, employ

173        a risk of bias tool to help interpret the results. We included full-text, peer-reviewed

174        meta-analyses published or ‘in-press’ in English. We excluded conference abstracts and

175        meta-analyses that were unpublished.

176        **Information sources.** We searched records contained in the following databases:

177        Pubmed, MEDLINE, CINAHL, PsycINFO, SPORTDiscus, Education Source, Embase,

178        Cochrane Library, Scopus, Web of Science, ProQuest Social Science Premium Collection, and

179        ERIC. We conducted an initial search on August 17, 2018 and refreshed the search on

180        September 27, 2022. We searched reference lists of included papers in order to identify

181        additional eligible meta-analyses. We also searched PROSPERO to identify relevant

182        protocols and contacted authors to determine if these reviews have been completed and

183        published.

184        **Search strategy.** The search strategy associated with each of the 12 databases can

185        be found in Supplementary File 1. We hand searched reference lists from any relevant

186        umbrella reviews to identify systematic meta-analyses that our search may have missed.

187        **Selection process.** Using Covidence software (Veritas Health Innovation,

188        Melbourne, Australia), two researchers independently screened all titles and abstracts. Two

189 researchers then independently reviewed full-text articles. We resolved disagreements at each  
190 stage of the process by consensus, with a third researcher employed, when needed.

191 **Data items.** From each included meta-analysis, two researchers independently  
192 extracted data into a custom-designed database. We extracted the following items: First  
193 author, year of publication, study design restrictions (e.g., cross-sectional, observational,  
194 experimental), region restrictions (e.g., specific countries), earliest and latest study  
195 publication dates, sample age (mean), lowest and highest mean age reported, outcomes  
196 reported, and exposures reported.

197 **Study risk of bias assessment.** For each meta-analysis, two researchers  
198 independently completed the National Health, Lung and Blood Institute's Quality  
199 Assessment of Systematic Reviews and Meta-Analyses tool<sup>26</sup> (see Table 1). We resolved  
200 disagreements by consensus, with a third researcher employed when needed. We did not  
201 assess risk of bias in the individual studies that were included in each meta-analysis.

202 **Effect measures.** Two researchers independently extracted all quantitative  
203 meta-analytic effect sizes, including moderation results. We excluded effect sizes which were  
204 reported as relative risk ratios or odds ratios, as meta-analyses did not contain sufficient  
205 information to meaningfully convert to a correlation. We also excluded effect size estimates  
206 when the authors did not provide a sample size. Where possible, we also extracted effect  
207 sizes from the primary studies included in each meta-analysis.

208 To facilitate comparisons, we converted effect sizes to Pearson's  $r$  using established  
209 formulae.<sup>27,28</sup> Effect sizes on the original metric are provided in Supplementary File 2.  
210 Throughout the results section we interpret the size of the effects using Funder and Ozer's  
211 guidelines:<sup>29</sup> very small ( $0.05 < r \leq 0.1$ ), small ( $0.1 < r \leq 0.2$ ), medium ( $0.2 < r \leq 0.2$ ),  
212 large ( $0.3 < r \leq 0.4$ ), and very large ( $r \geq 0.4$ ). These are similar to other interpretations  
213 based on empirical data.<sup>30</sup>

214 **Synthesis methods.** After extracting data, we examined the combinations of  
215 exposure and outcomes and removed any effects that appeared multiple times (i.e., in

216 multiple meta-analyses, or with multiple sub-groups in the same meta-analysis), keeping the  
217 effect with the largest total sample size. In instances where effect sizes from the same  
218 combination of exposure and outcome were drawn from different age-groups (e.g., children vs  
219 adolescents), or were drawn using different study designs (e.g., cross-sectional vs  
220 longitudinal) we retained both estimates in our dataset.

221 We descriptively present the remaining meta-analytic effect sizes. To remove the  
222 differences in approach to meta-analyses across the reviews, we reran the effect size estimate  
223 using a random effects meta-analysis via the metafor package<sup>31</sup> in R<sup>32</sup> (version 4.2.2) when  
224 the meta-analysis's authors provided primary study data associated with these effects. When  
225 required, we imputed missing sample sizes using mean imputation from the other studies  
226 within that review. From our reanalysis we also extracted  $I^2$  values. To test for publication  
227 bias, we conducted Egger's test<sup>33</sup> when the number of studies within the review was ten or  
228 more,<sup>34</sup> and conducted a test of excess significance.<sup>35</sup> We contacted authors who did not  
229 provide primary study data in their published article. Where authors did not provide data in  
230 a format that could be re-analysed, we used the published results of their original  
231 meta-analysis.

232 **Evidence assessment criteria.** *Statistical Credibility.* We employed a statistical  
233 classification approach to grade the credibility of the effect sizes in the literature. To be  
234 considered 'credible' an effect needed to be derived from a combined sample of >1,000<sup>36</sup> and  
235 have non-significant tests of publication bias (i.e., Egger's test and excess significance test).  
236 We performed these analyses, and therefore the review needed to provide usable study-level  
237 data in order to be included.

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

242        *Direction of Effect.* Finally, we examined the extent to which significance testing  
243 suggested screen exposure was associated with benefit, harm, or no effect on outcomes. We  
244 used thresholds of  $P < .05$  for weak evidence and  $P < 10^{-3}$  for strong evidence. An effect  
245 with statistical credibility but with  $P > .05$  was taken to indicate no association of interest.

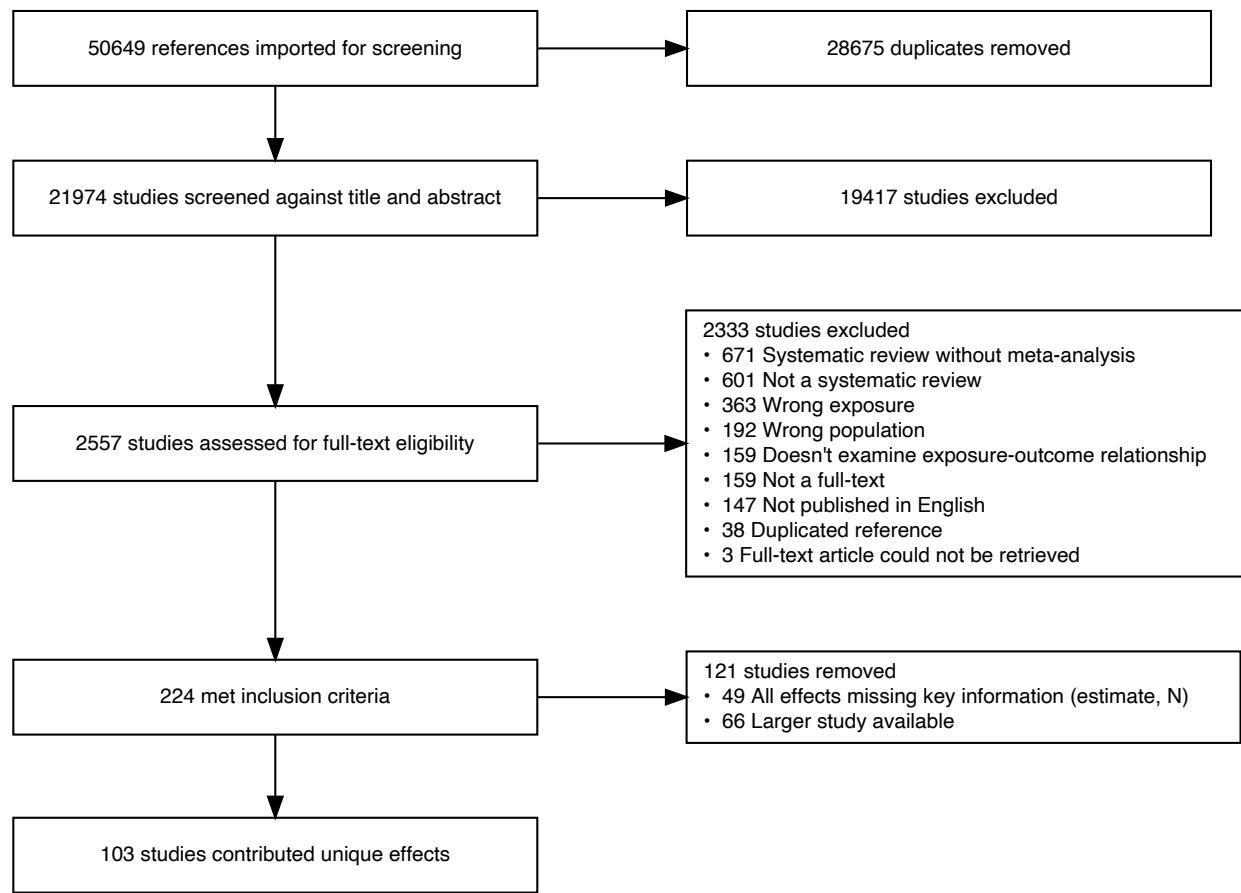
246        **Deviations from protocol.** We initially planned to include systematic reviews  
247 without meta-analyses in a narrative summary alongside the main meta-analytic findings.  
248 However, we determined that combining results from the meta-analyses allowed readers to  
249 compare relative strength of associations more easily. Readers interested in the relevant  
250 systematic reviews (i.e., without meta-analysis) can consult the list of references in  
251 Supplementary File 3.

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

## 258        Results

259        **Search Results.** The searches yielded 50,649 results, of which 28,675 were  
260 duplicates. After screening titles and abstracts, we assessed 2,557 full-texts for inclusion. Of  
261 those, 224 met the inclusion criteria and we extracted the data from all of these  
262 meta-analyses. Figure 1 presents the full results of the selection process.

263        The most frequently reported exposures were physically active video games ( $n = 31$ ),  
264 general screen use ( $n = 27$ ), general TV programs and movies ( $n = 20$ ), and screen-based  
265 interventions to promote health ( $n = 14$ ). Supplementary File 4 provides a list of all  
266 exposures identified. The most frequently reported outcomes were body composition ( $n =$



*Figure 1.* PRISMA Diagram

267 30), general learning ( $n = 24$ ), depression ( $n = 13$ ), and general literacy ( $n = 12$ ). Of the 274  
 268 unique exposure/outcome combinations, 243 occurred in only one review, with 22 appearing  
 269 twice, and 9 appearing three or more times. Full characteristics of the included studies are  
 270 provided in Table 1. After removing reviews with duplicate exposure/outcome combinations,  
 271 our process yielded 246 unique effect/outcome combinations (retaining multiple effects for  
 272 different age groups or study designs) contributed from 103 reviews. These effects represent  
 273 the findings of 2,496 primary studies comprised of 2,026,054 participants.

274 **TABLE 1**

275 The quality of the included meta-analyses was mixed (see Table 1). Most assessed  
 276 heterogeneity ( $n$  low risk = 94/103, 91% of meta-analyses), reported the characteristics of

277 the included studies ( $n$  low risk = 87/103, 84%), and used a comprehensive and systematic  
278 search strategy ( $n$  low risk = 74/103, 72%). Most reviews did not clearly report if their  
279 eligibility criteria were predefined ( $n$  unclear = 71/103, 69%). Many papers also did not  
280 complete dual independent screening of abstracts and full text ( $n$  high risk = 21/103, 20%)  
281 or did not clearly report the method of screening ( $n$  unclear = 38/103, 37%). A similar trend  
282 was observed for dual independent quality assessment ( $n$  high risk = 54/103, 52%;  $n$  high risk  
283 = 18/103, 17%). Overall, only 7 meta-analyses were graded as low risk of bias on all criteria.

284 **Education Outcomes.** There were 83 unique effects associated with education  
285 outcomes, including general learning outcomes, literacy, numeracy, and science. We removed  
286 22 effects that did not provide individual study-level data, 19 effects with samples < 1,000,  
287 and 17 effects with a significant Egger's test or insufficient studies to conduct the test.  
288 Effects not meeting one or more of these standards are presented in Supplementary File 5.  
289 The remaining 25 effects met our criteria for statistical credibility and are described in  
290 Figure 2. These 25 effects came from 18 meta-analytic reviews analysing data from 350  
291 empirical studies with 264,936 individual participants.

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

301 As shown in Figure 2, most of the credible results (15 of 25 effects) showed statistically  
302 significant associations, with 99.9% confidence intervals not encompassing zero (strong

### Associations Between Exposures and Education Outcomes

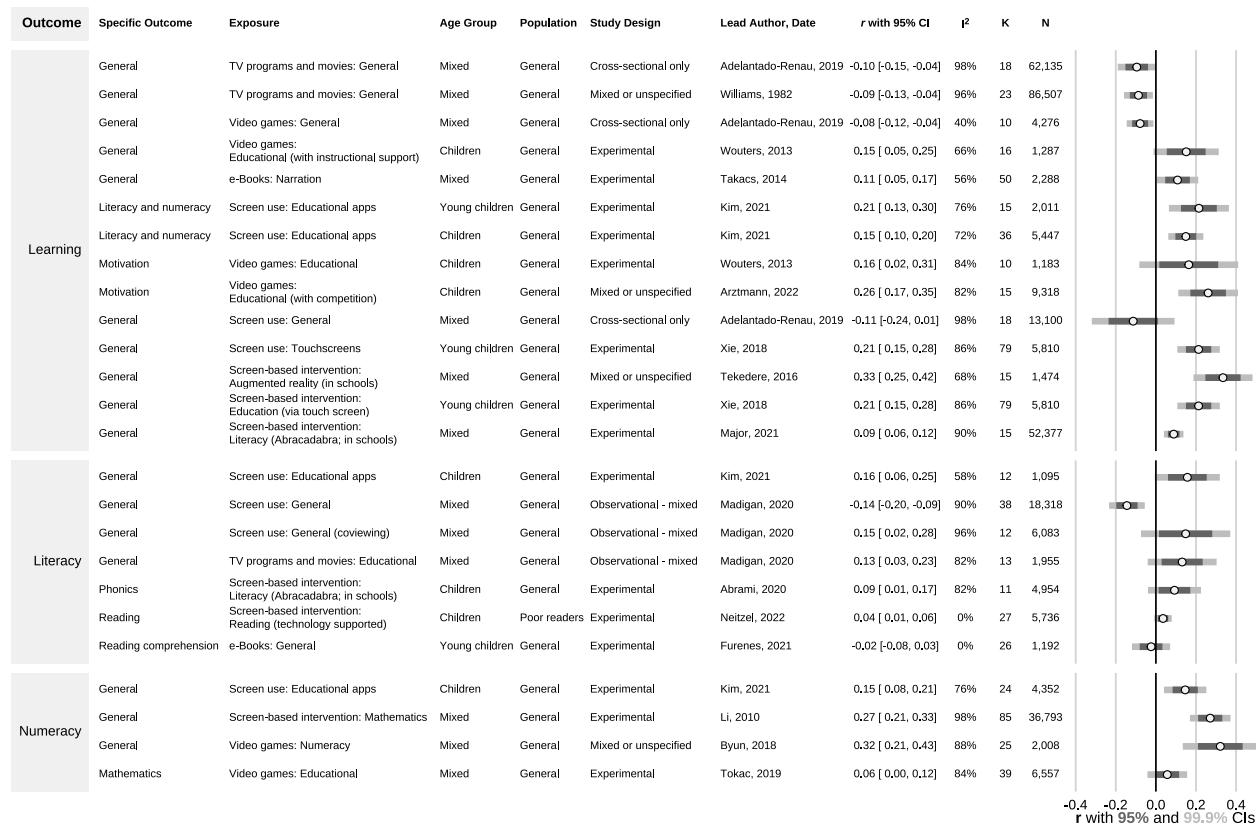


Figure 2. Education outcomes

303 evidence). The remaining seven associations were significant at the 95% confidence level  
 304 (weak evidence). All credible effects related to education outcomes were small-to-moderate.  
 305 Screen-based interventions designed to influence an outcome (e.g., a computer based  
 306 program designed to enhance learning)<sup>37</sup> tended to have larger effect sizes than exposures  
 307 that were not specifically intended to influence any of the measured outcomes (e.g., the  
 308 association between television viewing and learning).<sup>38</sup> The largest effect size observed was  
 309 for augmented reality-based education interventions on general learning  
 310 ( $r = 0.33, k = 15, N = 1,474$ ). Most effects showed high levels of heterogeneity (22 of 25  
 311 with  $I^2 > 50\%$ ).

312 **Health and Health-related Behaviours.** We identified 163 unique  
 313 outcome-exposure combinations associated with health or health-related behaviour outcomes.  
 314 We removed 38 effects that did not provide individual study-level data, 50 effects with

samples < 1,000, and 54 effects with a significant Egger's test or insufficient studies to conduct the test. No remaining studies showed evidence of excessive significance. Effects not meeting one or more of these standards are presented in Supplementary File 6. The remaining 21 meta-analytic associations met our criteria for credible evidence and are described below (see also Figure 3). These 21 effects came from 15 meta-analytic reviews analysing data from 344 empirical studies with 859,562 individual participants.



Figure 3. Health and health-related behaviour outcomes

Digital advertising of unhealthy foods—both traditional advertising and video games developed by a brand for promotion—were associated with higher unhealthy food intake. Social media use and sexual content were positively associated with risky behaviors (e.g., sexual activity, risk taking, and substance abuse). General screen use was positively associated with depression, with stronger associations observed for adolescents than other groups. Television viewing was negatively correlated with sleep duration, but with stronger

327 evidence only observed for younger children. All forms of screen use (general, television, and  
328 video games) were associated with body composition (e.g., higher BMI). Screen-based  
329 interventions which target health behaviours appeared mostly effective.

330 Across the health outcomes, most (14 of 21) effects were statistically significant at the  
331 99.9% confidence interval level, with the remaining four significant at 95% confidence.

332 However, most of the credible effects exhibited high levels of heterogeneity, with all but two  
333 having  $I^2 > 75\%$ . Additionally, most effects were small, with the association between screen  
334 use and sleep duration the largest at  $r = -0.37$  ( $k = 10, N = 56,720$ ). Most of the effect  
335 sizes (17/21) had an absolute value of  $r < 0.2$ .

336 **Discussion**

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

343 As an example, consider children watching television programs—an often cited form of  
344 screen time harm. We found statistically robust evidence for a small association with poorer  
345 academic performance and literacy skills for general television watching<sup>38</sup>. However, we also  
346 found evidence that if the content of the program was educational, or the child was watching  
347 the program with a parent (i.e., co-viewing), this exposure was instead associated with  
348 better literacy.<sup>39</sup> Thus, parents may play an important role in selecting content that is likely  
349 to benefit their children or, perhaps, interact with their children in ways that may foster  
350 literacy (e.g., asking their children questions about the program). Similar nuanced findings  
351 were observed for video games. The credible evidence we identified showed that video game

352 playing was associated with poorer body composition and learning.<sup>38,40</sup> However, when the  
353 video game were designed specifically to teach numeracy, playing these games showed  
354 learning benefits.<sup>41</sup> One might expect that video games designed to be physically active  
355 could confer health benefits, but none of the meta-analyses examining this hypothesis met  
356 our thresholds for statistical credibility (see Supplementary Files 5 & 6) therefore this  
357 hypothesis could not be addressed.

358 Social media was one type of exposure that showed consistent associations with poor  
359 health, with no indication of potential benefit. Social media showed strong evidence of  
360 harmful associations with risk taking in general, as well as unsafe sex and substance abuse.<sup>42</sup>  
361 These results align with meta-analytic evidence from adults indicating that social media use  
362 is also associated with increased risk of depression.<sup>43,44</sup> Recent evidence from social media  
363 companies themselves suggest there may also be negative effects of social media on the  
364 mental health of young people, especially teenage girls.<sup>45</sup>

365 One category of exposure appeared to consistently associated with benefits:  
366 screen-based interventions designed to promote learning or health behaviours. This finding  
367 indicates that interventions can be effectively delivered using electronic media platforms, but  
368 does not necessarily indicate that screens are more effective than other methods (e.g.,  
369 face-to-face, printed material). Rather, it reinforces that the content of the screen time may  
370 be the most important aspect. The way that a young person interacts with digital screens  
371 may also be important. We found evidence that touch screens had strong evidence for  
372 benefits on learning,<sup>37</sup> as did augmented reality.<sup>46</sup>

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

378 unhealthy food was associated with unhealthy food choice for young children, but was not  
379 statistically significant for other age groups.<sup>47</sup> Conversely, TV programs and movies were  
380 more strongly associated with lower physical activity for adolescents than for younger age  
381 groups.<sup>48</sup>

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

### 387 Implications for Policy and Practice

388 Broadly, our findings align with the recommendations of others who suggest that  
389 current guidelines may be too simplistic, mischaracterise the strength of the evidence, or do  
390 not acknowledge the important nuances of the issue.<sup>49–51</sup> Our findings suggest that screen  
391 use is a complex issue, with associations based not just on duration and device type, but also  
392 on the content and the environment in which the exposure occurs. Many current guidelines  
393 simplify this complex relationship as something that should be minimised in all  
394 instances.<sup>12,13</sup> We suggest that future guidelines need to embrace the complexity of the issue,  
395 to give parents and clinicians specific information to weigh the pros and cons of interactions  
396 with screens.

### 397 Implications for Future Research

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

403 provide study-level data (or did not provide sufficient data, such as including effect estimates  
404 but not sample sizes). Newer reviews were more likely to provide this information than older  
405 reviews, but it highlights the importance of data and code sharing as recommended in the  
406 PRISMA guidelines.<sup>25</sup> When study level data was available, many effects were removed  
407 because the pooled sample size was small, or because there were fewer than ten studies on  
408 which to perform an Egger's test. It seems that much of the current screen time research is  
409 small in scale, and there is a need for larger, high-quality studies.

410 Our results highlight the need for the field to more carefully consider if the term 'screen  
411 time' remains appropriate for providing advice to parents. Instead, our results suggest that  
412 more nuanced and detailed descriptions of the behaviours to be modified may be required.  
413 Rather than suggesting parents limit 'screen time', for example, it may be better to suggest  
414 that parents promote interactive educational experiences but limit exposure to advertising.

415 Screen time research has a well-established measurement problem, which impacts the  
416 individual studies of this umbrella review. The vast majority of screen time research relies on  
417 self-reported data, which not only lacks the nuance required for understanding the effects of  
418 screen time, but may also be inaccurate. In one systematic review on screen time and sleep,<sup>7</sup>  
419 66 of the 67 included studies used self-reported data for *both* the exposure and outcome  
420 variable. It has been established that self-reported screen time data has questionable  
421 validity. In a meta-analysis of 47 studies comparing self-reported media use with logged  
422 measures, Parry et al<sup>52</sup> found that the measures were only moderately correlated ( $r = 0.38$ ),  
423 with self-reported problematic usage fairing worse ( $r = 0.25$ ). Indeed, of 622 studies which  
424 measured the screen time of 0—6 year-olds, only 69 provided any sort of psychometric  
425 properties for their measure, with only 19 studies reporting validity.<sup>53</sup> While some  
426 researchers have started using newer methods of capturing screen behaviours—such as  
427 wearable cameras<sup>54</sup> or device-based loggers—<sup>55</sup>these are still not widely adopted. It may be  
428 that the field of screen time research cannot be sufficiently advanced until accurate,

429 validated, and nuanced measures are more widely available and adopted.

430 **Strengths and Limitations**

431 Our primary goal for this umbrella review was to provide a high-level synthesis of  
432 screen time research, by examining a range of exposures and the associations with a broad  
433 scope of outcomes. Our results represent the findings from 2,496 primary studies comprised  
434 of 2,026,054 participants. To ensure findings could be compared on a common metric, we  
435 extracted and reanalysed individual study data where possible.

436 Our high-level approach limits the feasibility of examining fine-grained details of the  
437 individual studies. For example, we did not examine moderators beyond age, nor did we rate  
438 the risk of bias for the individual studies. Thus, our assessment of evidence quality was  
439 restricted to statistical credibility, rather than a more complete assessment of quality (e.g.,  
440 GRADE).<sup>56</sup> As such, we made decisions regarding the credibility of evidence, where others  
441 may have used different thresholds or metrics. For this reason, we provide the complete  
442 results in the supplementary material, along with the dataset for others to consider  
443 alternative criteria.

444 Our high-level approach also means that we could not engage with the specific  
445 mechanisms behind each association, and as such, we cannot comment on the evidence for  
446 causality. Instead, readers who wish to more deeply understand one specific relationship are  
447 directed to the cited review for that effect, where the authors could engage more deeply with  
448 the mechanisms. We converted all effect sizes to a common metric (Pearson's r) to allow for  
449 comparisons of magnitude, but acknowledge that this assumes a linear relationship. Some  
450 previous research suggests that associations are typically linear.<sup>18</sup> However, others have  
451 identified instances where non-linear relationships exist, especially for very high levels of  
452 screen time.<sup>17,57,58</sup> Additionally, our conversion may not always adequately account for  
453 differences in study design or measures of exposures and outcomes. Care is needed, therefore,

454 when interpreting the effect sizes. In addition, reviews provide only historical evidence which  
455 may not keep up with the changing ways children can engage with screens. While our  
456 synthesis of the existing evidence provides information about how screens might have  
457 influenced children in the past, it is difficult to know if these findings will translate to new  
458 forms of technology in the future.

459 **Conclusions**

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

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