

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 241 unique exposure/outcome
44 combinations from 102 reviews. These effects represent the findings of 2,218 primary studies
45 comprised of 1,921,743 participants. When focusing on the meta-analyses with the most
46 statistically robust evidence, we found that general screen use (when content was not
47 indicated), was associated with potential harm on learning, literacy, body composition, and
48 depression. Like-wise, social media was consistently associated with risks to health, with no
49 identified benefits. However, we also found that these harms could often be mitigated by
50 certain kinds of content (e.g., educational), or by modifying the context (e.g., co-viewing
51 with a parent). In summary, our findings point to the need for careful and nuanced
52 guidelines that support parents to make the best decisions for their children.

53

Keywords: screen time; youth; health; education

54

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56 screens: An umbrella review

57 **Summary**

58 Children's engagement in screen time is a complex issue. Parents, policymakers, and
59 educators needing to weigh the risks that sedentary use of screens present alongside the
60 potential benefits for learning and social connectedness. The lack of comprehensive evidence
61 hampers efforts to make an informed decision. As a Lancet editorial¹ suggested, "Our
62 understanding of the benefits, harms, and risks of our rapidly changing digital landscape is
63 sorely lacking." In this study, we systematically harmonize data from existing meta-analyses
64 of screen time on a range of outcomes, including health, education, and psychology, and
65 identify the most statistically robust relationships. We show that some forms of screen
66 time—such as social media—show consistent evidence of harm for children, with no clear
67 evidence of a benefit. Other relationships are more complex. Video games, for example, are
68 associated with poorer body composition and learning outcomes. However, video games for a
69 specific educational purpose (such as numeracy) are associated with improvements in that
70 subject area. Caregivers must therefore weigh the health risk against the educational benefit.
71 The findings of this study provide parents and other caregivers with the information to make
72 these informed decisions.

Background

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

82 Today, the same arguments that were once leveled against reading, schooling, and radio
83 are being made about screen use (e.g., television, mobile phones, and computers).⁵ Excessive
84 screen time use is the number one concern parents have about their children’s health and
85 behaviour, ahead of nutrition, bullying, and physical inactivity.⁶ Yet, the evidence to support
86 parents’ concerns is inadequate. A Lancet editorial¹ suggested that, “Our understanding of
87 the benefits, harms, and risks of our rapidly changing digital landscape is sorely lacking.”

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

96 Citing the negative effects of screens on health (e.g., increased risk of obesity) and
97 health-related behaviours (e.g., sleep), guidelines from the World Health Organisation¹² and

numerous government agencies^{13,14} and statements by expert groups¹⁵ 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)¹⁶. 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.¹⁷ Indeed, educational screen time is positively related to educational outcomes.¹⁸ This evidence has led some researchers to argue that a more nuanced approach to screen time guidelines is required.¹⁹

In 2016, the American Academy of Pediatrics used a narrative review to examine the benefits and risks of children and adolescents' electronic media²⁰ as a basis for updating their guidelines about screen use.¹⁵ 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),²¹ focus on a particular exposure (e.g., social media)^{22,23} or provide only a narrative summary of the literature.²⁴ 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.

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

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

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

128 electronic media exposure. Adopting this broad approach allowed us to provide a holistic

129 perspective on the influence of screens on children's lives. By synthesising across life domains

130 (e.g., school and home), this review provides evidence to inform guidelines and advice for

131 parents, teachers, pediatricians and other professionals in order to maximise human

132 functioning.

133

Methods

134 We prospectively registered our methods on the International Prospective Register of
135 Systematic Reviews (PROSPERO; CRD42017076051). We followed the Preferred Reporting
136 Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.²⁵

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

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

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 September 27, 2022. 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 in Supplementary File 1. 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

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

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

194 **Study risk of bias assessment.** For each meta-analysis, two researchers
195 independently completed the National Health, Lung and Blood Institute's Quality
196 Assessment of Systematic Reviews and Meta-Analyses tool²⁶ (see Table 1). We resolved
197 disagreements by consensus, with a third researcher employed when needed. We did not
198 assess risk of bias in the individual studies that were included in each meta-analysis.

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

205 To facilitate comparisons, we converted effect sizes to Pearson's r using established
206 formulae.^{27,28} Effect sizes on the original metric are provided in Supplementary File 2.

207 **Synthesis methods.** After extracting data, we examined the combinations of
208 exposure and outcomes and removed any effects that appeared multiple times (i.e., in
209 multiple meta-analyses, or with multiple sub-groups in the same meta-analysis), keeping the
210 effect with the largest total sample size. In instances where effect sizes from the same
211 combination of exposure and outcome were drawn from different populations (e.g., children
212 vs adolescents) we retained both estimates in our dataset.

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 package²⁹ in R³⁰ (version 4.2.2) 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 test³¹ when the number of studies within the review was ten or more,³² and conducted a test of excess significance.³³ 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 $>1,000$ ³⁴ 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 with statistical credibility but with $P > .05$ 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

241 compare relative strength of associations more easily. Readers interested in the relevant

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

²⁴³ Supplementary File 3.

We altered our evidence assessment plan when we identified that, as written, it could

²⁴⁵ not classify precise evidence or null effects (i.e., from large reviews with low heterogeneity)

²⁴⁶ and low risk of publication bias) as 'credible' because a highly-significant *F*-value was a

²⁴⁷ criteria. This would have significantly harmed knowledge gained from our review as it would

²⁴⁸ have restricted our ability to show where the empirical evidence strongly indicated that there

²⁴⁹ was no association between screen time and a given outcome.

Results

Search Results. The searches yielded 50,656 results, of which 28,675 were

252 duplicates. After screening titles and abstracts, we assessed 2,557 full-texts for inclusion. Of

253 those, 224 met the inclusion criteria and we extracted the data from all of these

254 meta-analyses. Figure 1 presents the full results of the selection process.

255 The most frequently reported exposures were general screen use ($n = 47$), physically

256 active video games ($n = 34$), general TV programs and movies ($n = 28$), and to promote

257 health intervention ($n = 18$). Supplementary File 4 provides a list of all exposures identified.

²⁵⁸ The most frequently reported outcomes were general learning ($n = 47$), body composition

²⁵⁹ = 43), general physical activity ($n = 25$), depression psychological health ($n = 19$), and

general literacy ($n = 15$). In 201 cases there was only one exposure/outcome combination for

²⁶¹ an age group, with 43 appearing twice, and 30 appearing three or more times. Full

characteristics of the included studies are provided in Table 1. After removing reviews with

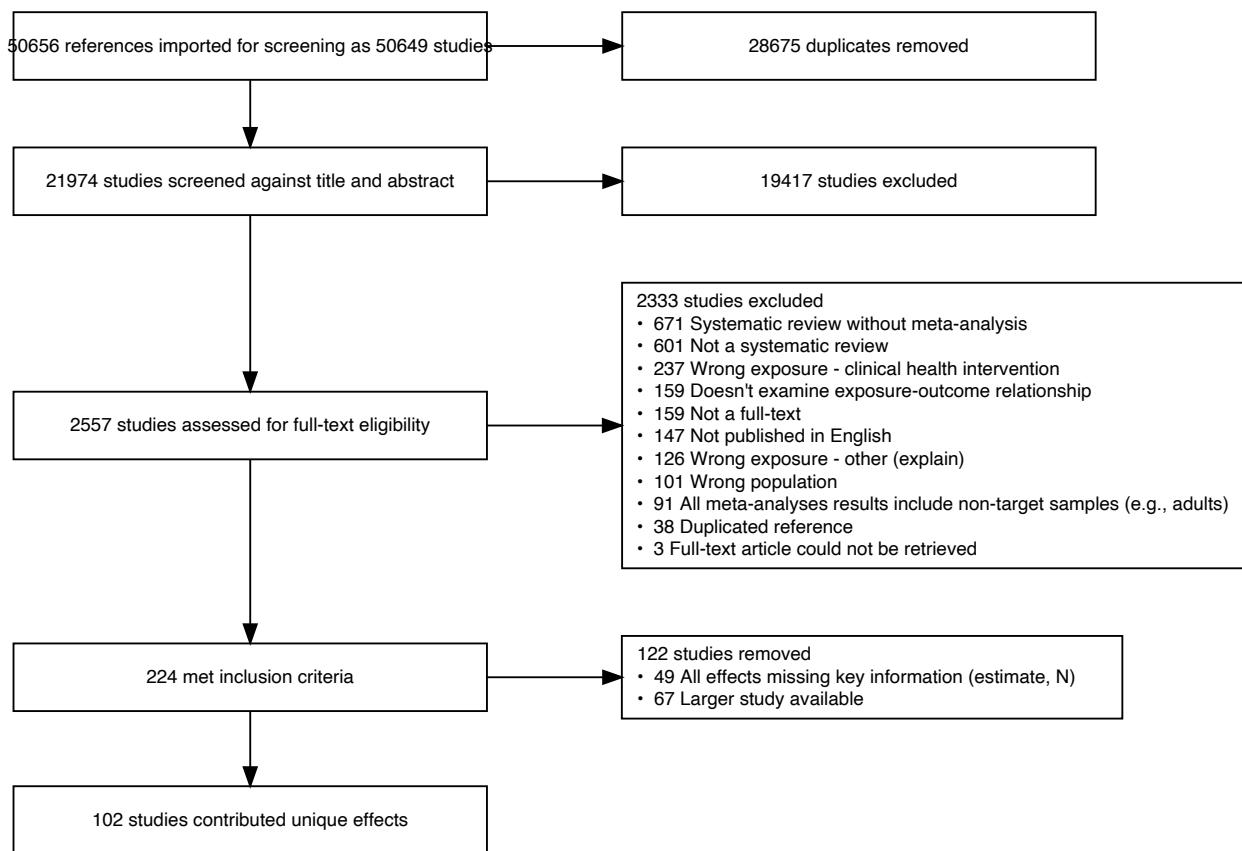


Figure 1. PRISMA Diagram

263 duplicate exposure/outcome combinations, our process yielded 241 unique effect/outcome
 264 combinations contributed from 102 reviews. These effects represent the findings of 2,218
 265 primary studies comprised of 1,921,743 participants.

266 **TABLE 1**

267 The quality of the included meta-analyses was mixed (see Table 1). Most assessed
 268 heterogeneity (n low risk = 94/102, 92% of meta-analyses), reported the characteristics of
 269 the included studies (n low risk = 86/102, 84%), and used a comprehensive and systematic
 270 search strategy (n low risk = 74/102, 73%). Most reviews did not clearly report if their
 271 eligibility criteria were predefined (n unclear = 70/102, 69%). Many papers also did not
 272 complete dual independent screening of abstracts and full text (n high risk = 20/102, 20%)

273 or did not clearly report the method of screening (n unclear = 38/102, 37%). A similar trend
 274 was observed for dual independent quality assessment (n high risk = 54/102, 53%; n high risk
 275 = 17/102, 17%). Overall, only 7 meta-analyses were graded as low risk of bias on all criteria.

276 **Education Outcomes.** There were 80 unique effects associated with education
 277 outcomes, including general learning outcomes, literacy, numeracy, and science. We removed
 278 20 effects that did not provide individual study-level data, 19 effects with samples < 1,000,
 279 and 17 effects with a significant Egger's test or insufficient studies to conduct the test.
 280 Effects not meeting one or more of these standards are presented in Supplementary File 5.
 281 The remaining 24 effects met our criteria for statistical credibility and are described in
 282 Figure 2. These 24 effects came from 17 meta-analytic reviews analysing data from 328
 283 empirical studies with 181,214 individual participants.

Associations Between Exposures and Education Outcomes

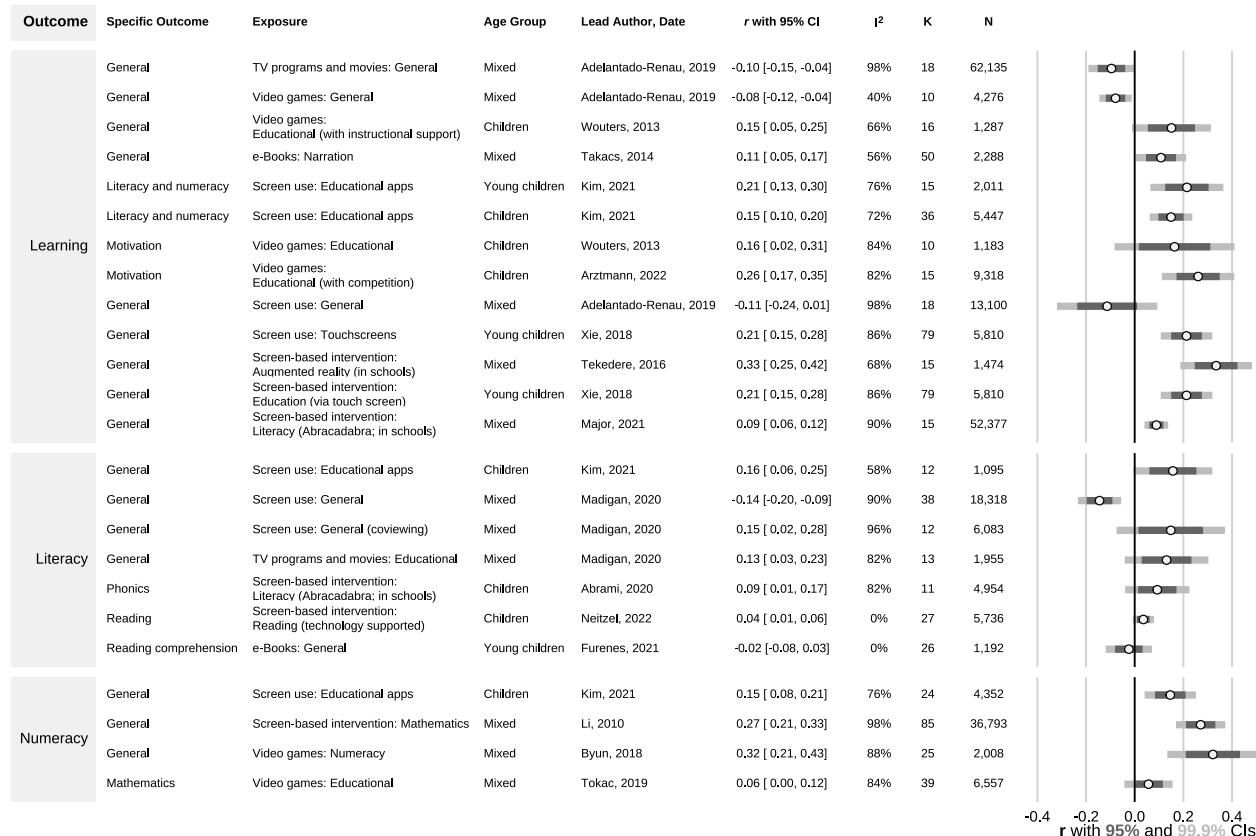


Figure 2. Education outcomes

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

293 As shown in Figure 2, most of the credible results (14 of 24 effects) showed statistically
294 significant associations, with 99.9% confidence intervals not encompassing zero (strong
295 evidence). The remaining seven associations were significant at the 95% confidence level
296 (weak evidence). All credible effects related to education outcomes were small-to-moderate.
297 Screen-based interventions designed to influence an outcome (e.g., a computer based
298 program designed to enhance learning)³⁵ tended to have larger effect sizes than exposures
299 that were not specifically intended to influence any of the measured outcomes (e.g., the
300 association between television viewing and learning).³⁶ The largest effect size observed was
301 for augmented reality-based education interventions on general learning
302 ($r = 0.33, k = 15, N = 1,474$). Most effects showed high levels of heterogeneity (21 of 24
303 with $I^2 > 50\%$).

304 **Health and Health-related Behaviours.** We identified 161 unique
305 outcome-exposure combinations associated with health or health-related behaviour outcomes.
306 We removed 38 effects that did not provide individual study-level data, 50 effects with
307 samples $< 1,000$, and 53 effects with a significant Egger's test or insufficient studies to
308 conduct the test. No remaining studies showed evidence of excessive significance. Effects not
309 meeting one or more of these standards are presented in Supplementary File 6. The
310 remaining 20 meta-analytic associations met our criteria for credible evidence and are

described below (see also Figure 3). These 20 effects came from 15 meta-analytic reviews analysing data from 339 empirical studies with 851,375 individual participants.

Associations Between Exposures and Health-related Outcomes

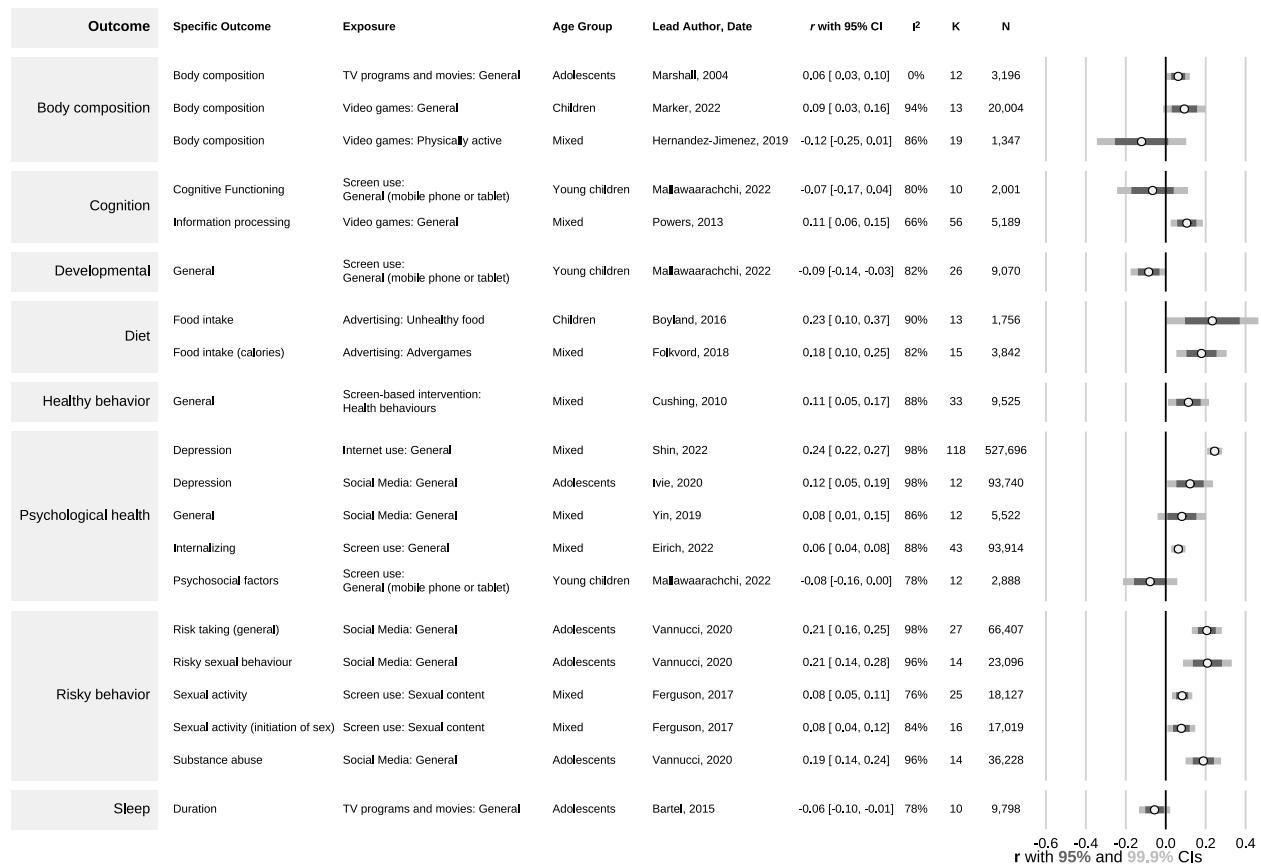


Figure 3. Health and health-related behaviour outcomes

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

322 Across the health outcomes, most (13 of 20) effects were statistically significant at the
323 99.9% confidence interval level, with the remaining four significant at 95% confidence.
324 However, most of the credible effects exhibited high levels of heterogeneity, with all but two
325 having $I^2 > 75\%$. Additionally, most effects were small, with the association between screen
326 use and sleep duration the largest at $r = -0.37$ ($k = 10, N = 56,720$). Most of the effect
327 sizes (16/20) had an absolute value of $r < 0.2$.

328 Discussion

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

335 As an example, consider children watching television programs—an often cited form of
336 screen time harm. We found statistically robust evidence for a small association with poorer
337 academic performance and literacy skills for general television watching³⁶. However, we also
338 found evidence that if the content of the program was educational, or the child was watching
339 the program with a parent (i.e., co-viewing), this exposure was instead associated with
340 better literacy.³⁷ Thus, parents may play an important role in selecting content that is likely
341 to benefit their children or, perhaps, interact with their children in ways that may foster
342 literacy (e.g., asking their children questions about the program). Similar nuanced findings
343 were observed for video games. The credible evidence we identified showed that video game
344 playing was associated with poorer body composition and learning.^{36,38} However, when the
345 video game were designed specifically to teach numeracy, playing these games showed
346 learning benefits.³⁹ One might expect that video games designed to be physically active
347 could confer health benefits, but none of the meta-analyses examining this hypothesis met

348 our thresholds for statistical credibility (see Supplementary Files 5 & 6) therefore this
349 hypothesis could not be addressed.

350 Social media was one type of exposure that showed consistent associations with poor
351 health, with no indication of potential benefit. Social media showed strong evidence of
352 harmful associations with risk taking in general, as well as unsafe sex and substance abuse.⁴⁰
353 These results align with meta-analytic evidence from adults indicating that social media use
354 is also associated with increased risk of depression.^{41,42} Recent evidence from social media
355 companies themselves suggest there may also be negative effects of social media on the
356 mental health of young people, especially teenage girls.⁴³

357 One category of exposure appeared to consistently associated with benefits:
358 screen-based interventions designed to promote learning or health behaviours. This finding
359 indicates that interventions can be effectively delivered using electronic media platforms, but
360 does not necessarily indicate that screens are more effective than other methods (e.g.,
361 face-to-face, printed material). Rather, it reinforces that the content of the screen time may
362 be the most important aspect. The way that a young person interacts with digital screens
363 may also be important. We found evidence that touch screens had strong evidence for
364 benefits on learning,³⁵ as did augmented reality.⁴⁴

365 Largely owing to a small number of studies or missing individual study data, there
366 were few age-based conclusions that could be drawn from reviews which met our criteria for
367 statistical certainty. If we expand to include those reviews which did not meet this threshold,
368 there remained no clear pattern although there were some age-specific differences in
369 associations (data available in Supplementary Materials). For example, advertising of
370 unhealthy food was associated with unhealthy food choice for young children, but was not
371 statistically significant for other age groups.⁴⁵ Conversely, TV programs and movies were
372 more strongly associated with lower physical activity for adolescents than for younger age
373 groups.⁴⁶

374 Among studies that met our criteria for statistical certainty heterogeneity was high,

375 with almost all effects having $I^2 > 50\%$. Much of this heterogeneity is likely explained by

376 differences in measures across pooled studies, or in some cases, the generic nature of some of

377 the exposures. For example, “TV programs and movies” covers a substantial range of

378 content, which may explain the heterogeneous association with education outcomes.

379 **Implications for Policy and Practice**

380 Broadly, our findings align with the recommendations of others who suggest that

381 current guidelines may be too simplistic, mischaracterise the strength of the evidence, or do

382 not acknowledge the important nuances of the issue.^{47–49} Our findings suggest that screen

383 use is a complex issue, with associations based not just on duration and device type, but also

384 on the content and the environment in which the exposure occurs. Many current guidelines

385 simplify this complex relationship as something that should be minimised in all

386 instances.^{12,13} We suggest that future guidelines need to embrace the complexity of the issue,

387 to give parents and clinicians specific information to weigh the pros and cons of interactions

388 with screens.

389 **Implications for Future Research**

390 Screen use research is extensive, varied, and rapidly growing. Reviews tended to be

391 general (e.g., all screen time) and even when more targeted (e.g., social media) nuances

392 related to specific content (e.g., Instagram vs Facebook) have not been meta-analysed or

393 have not produced credible evidence. Fewer than 20% of the effects identified met our

394 criteria for statistical credibility. Most studies which did not meet our critiera failed to

395 provide study-level data (or did not provide sufficient data, such as including effect estimates

396 but not sample sizes). Newer reviews were more likely to provide this information than older

397 reviews, but it highlights the importance of data and code sharing as recommended in the

398 PRISMA guidelines.²⁵ When study level data was available, many effects were removed

399 because the pooled sample size was small, or because there were fewer than ten studies on

400 which to perform an Egger's test. It seems that much of the current screen time research is
401 small in scale, and there is a need for larger, high-quality studies.

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

407 Screen time research has a well-established measurement problem, which impacts the
408 individual studies of this umbrella review. The vast majority of screen time research relies on
409 self-reported data, which not only lacks the nuance required for understanding the effects of
410 screen time, but may also be inaccurate. In one systematic review on screen time and sleep,⁷
411 66 of the 67 included studies used self-reported data for *both* the exposure and outcome
412 variable. It has been established that self-reported screen time data has questionable
413 validity. In a meta-analysis of 47 studies comparing self-reported media use with logged
414 measures, Parry et al⁵⁰ found that the measures were only moderately correlated ($r = 0.38$),
415 with self-reported problematic usage fairing worse ($r = 0.25$). Indeed, of 622 studies which
416 measured the screen time of 0—6 year-olds, only 69 provided any sort of psychometric
417 properties for their measure, with only 19 studies reporting validity.⁵¹ While some
418 researchers have started using newer methods of capturing screen behaviours—such as
419 wearable cameras⁵² or device-based loggers—⁵³these are still not widely adopted. It may be
420 that the field of screen time research cannot be sufficiently advanced until accurate,
421 validated, and nuanced measures are more widely available and adopted.

422 **Strengths and Limitations**

423 Our primary goal for this umbrella review was to provide a high-level synthesis of
424 screen time research, by examining a range of exposures and the associations with a broad

425 scope of outcomes. Our results represent the findings from 2,218 primary studies comprised
426 of 1,921,743 participants. To ensure findings could be compared on a common metric, we
427 extracted and reanalysed individual study data where possible.

428 Our high-level approach limits the feasibility of examining fine-grained details of the
429 individual studies. For example, we did not examine moderators beyond age, nor did we rate
430 the risk of bias for the individual studies. Thus, our assessment of evidence quality was
431 restricted to statistical credibility, rather than a more complete assessment of quality (e.g.,
432 GRADE).⁵⁴ As such, we made decisions regarding the credibility of evidence, where others
433 may have used different thresholds or metrics. For this reason, we provide the complete
434 results in the supplementary material, along with the dataset for others to consider
435 alternative criteria.

436 Our high-level approach also means that we could not engage with the specific
437 mechanisms behind each association, and as such, we cannot comment on the evidence for
438 causality. Instead, readers who wish to more deeply understand one specific relationship are
439 directed to the cited review for that effect, where the authors could engage more deeply with
440 the mechanisms. We converted all effect sizes to a common metric (Pearson's r) to allow for
441 comparisons of magnitude, but acknowledge that this assumes a linear relationship. Some
442 previous research suggests that associations are typically linear.¹⁸ However, others have
443 identified instances where non-linear relationships exist, especially for very high levels of
444 screen time.^{17,55,56} In addition, reviews provide only historical evidence which may not keep
445 up with the changing ways children can engage with screens. While our synthesis of the
446 existing evidence provides information about how screens might have influenced children in
447 the past, it is difficult to know if these findings will translate to new forms of technology in
448 the future.

449 Conclusions

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

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