

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

3 Taren Sanders¹, Michael Noetel², Philip Parker¹, Borja Del Pozo Cruz³, Stuart Biddle⁴,
4 Rimante Ronto⁵, Ryan Hulteen⁶, Rhiannon Parker⁷, George Thomas⁸, Katrien De Cocker⁹,
5 Jo Salmon¹⁰, Kylie Hesketh¹⁰, Nicole Weeks¹, Hugh Arnott¹, Emma Devine¹¹, Roberta
6 Vasconcellos¹, Rebecca Pagano¹², Jamie Sherson¹², James Conigrave¹, & Chris Lonsdale¹

7 ¹ Institute for Positive Psychology and Education, Australian Catholic University

8 ² School of Health and Behavioural Sciences, Australian Catholic University

9 ³ Department of Sport Science and Clinical Biomechanics, University of Southern Denmark

10 ⁴ Centre for Health Research, University of Southern Queensland

11 ⁵ Department of Health Systems and Populations, Faculty of Medicine, Health and Human
12 Sciences, Macquarie University

13 ⁶ School of Kinesiology, Louisiana State University

14 ⁷ School of Medicine and Health, Sydney University

15 ⁸ Health and Wellbeing Centre for Research Innovation, School of Human Movement and
16 Nutrition Sciences, University of Queensland

17 ⁹ Department of Movement and Sport Science, Ghent University

18 ¹⁰ Institute for Physical Activity and Nutrition, Deakin University

19 ¹¹ The Matilda Centre for Research in Mental Health and Substance Use, University of
20 Sydney

²¹

¹² School of Education, Australian Catholic University

²²

Author Note

²³ The authors made the following contributions. Taren Sanders: Conceptualization,
²⁴ Data curation, Writing - Original Draft; Michael Noetel: Conceptualization, Writing -
²⁵ Original Draft; Philip Parker: Conceptualization, Writing - Original Draft; Borja Del Pozo
²⁶ Cruz: Writing - Review & Editing; Stuart Biddle: Writing - Review & Editing; Rimante
²⁷ Ronto: Writing - Review & Editing; Ryan Hulteen: Writing - Review & Editing; Rhianon
²⁸ Parker: Writing - Review & Editing; George Thomas: Writing - Review & Editing; Katrien
²⁹ De Cocker: Writing - Review & Editing; Jo Salmon: Writing - Review & Editing; Kylie
³⁰ Hesketh: Writing - Review & Editing; Nicole Weeks: Writing - Review & Editing; Hugh
³¹ Arnott: Writing - Review & Editing; Emma Devine: Writing - Review & Editing; Roberta
³² Vasconcellos: Writing - Review & Editing; Rebecca Pagano: Writing - Review & Editing;
³³ Jamie Sherson: Writing - Review & Editing; James Conigrave: Writing - Review & Editing;
³⁴ Chris Lonsdale: Conceptualization, Writing - Original Draft, Project Administration.

³⁵

Correspondence concerning this article should be addressed to Taren Sanders, 33 Berry
³⁶ St, North Sydney, NSW, Australia. E-mail: Taren.Sanders@acu.edu.au

37

Abstract

38 Children's engagement in screen time is a complex issue. While some forms of screen time
39 have consistently been associated with harm, others have been associated with gains, making
40 it difficult to weigh the risks and benefits of use. In this umbrella review, we systematically
41 collate and examined meta-analyses examining the effects of screen use on children and
42 youth. We converted results onto a common metric (Pearson's r) to make comparisons
43 simple, and where possible we reanalysed study-level data to standardise the approach across
44 meta-analyses. We identified 218 meta-analyses, and extracted 275 unique combinations of
45 exposures and outcomes. If duplicate effect sizes from the same combination of exposure and
46 outcome were drawn from different age groups or study designs we retained them, otherwise
47 we chose the effect size with the largest total sample size. We removed effect sizes that could
48 not be harmonized, resulting in 255 from 103 reviews. These effects represent the findings of
49 2,496 primary studies comprised of 2,026,054 participants. When focusing on the
50 meta-analyses with the most statistically robust evidence, we found that general screen use
51 (when content was not indicated), was associated with potential harm on learning, literacy,
52 body composition, and depression. Like-wise, social media was consistently associated with
53 risks to health, with no identified benefits. However, we also found that these harms could
54 often be mitigated by certain kinds of content (e.g., educational), or by modifying the context
55 (e.g., co-viewing with a parent). In summary, our findings point to the need for careful and
56 nuanced guidelines that support parents to make the best decisions for their children.

57

Keywords: screen time; youth; health; education

58

Word count: 5048

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

61 **Summary**

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

77 **Background**

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

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

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

99 Citing the negative effects of screens on health (e.g., increased risk of obesity) and
100 health-related behaviours (e.g., sleep), guidelines from the World Health Organisation¹² and
101 numerous government agencies^{13,14} and statements by expert groups¹⁵ have recommended
102 that young people’s time spent using electronic media devices for entertainment purposes

103 should be limited. For example, the Australian Government guidelines regarding sedentary
104 behaviour recommend that young children (under the age of two) should not spend any time
105 watching screens. They also recommend that children aged 2-5 years should spend a
106 maximum of one hour engaged in recreational sedentary screen use per day, while children
107 aged 5-12 and adolescents should spend no more than two hours. In contrast, some recent
108 evidence suggests that exposure to electronic entertainment media that exceeds these
109 guidelines (e.g., 3-4 hours per day) may not have meaningful adverse effects on children's
110 behaviour or mental health, and might, in fact, benefit their well-being, as long as this
111 exposure does not reach extreme levels (e.g., 7 hours per day)¹⁶. Some research also
112 indicates that content (e.g., video games vs television programs) plays an important role in
113 determining the potential benefit or harm of youths' exposure to screen-based media.¹⁷
114 Indeed, educational screen time is positively related to educational outcomes.¹⁸ This
115 evidence has led some researchers to argue that a more nuanced approach to screen time
116 guidelines is required.¹⁹

117 In 2016, the American Academy of Pediatrics used a narrative review to examine the
118 benefits and risks of children and adolescents' electronic media²⁰ as a basis for updating their
119 guidelines about screen use.¹⁵ Since then, a large number of systematic reviews and
120 meta-analyses have provided evidence about the potential benefits and risks of screen use.

121 While there have been other overviews of reviews on screen time, these have tended to focus
122 on a single domain (e.g., health²¹), focus on a particular exposure (e.g., social media^{22,23}) or
123 provide only a narrative summary of the literature.²⁴ No review has yet examined the
124 evidence available across a broad range of outcome domains, such as physical health,
125 education, physical and cognitive development, behaviour, and well-being. By summarising
126 and synthesising all evidence in one overview, we provide a reference point for the field and
127 allow for easier comparison of risks and benefits for the same behaviour.

128 In order to synthesise the evidence and support further evidence-based guideline
129 development and refinement, we reviewed published meta-analyses examining the effects of

130 screen use on children and youth. This review synthesises evidence on any outcome of
131 electronic media exposure. We deliberately do not pre-specify outcomes, in order to get a
132 comprehensive list of areas where there is meta-analytical evidence. Adopting this broad
133 approach allowed us to provide a holistic perspective on the influence of screens on children's
134 lives. By synthesising across life domains (e.g., school and home), this review provides
135 evidence to inform guidelines and advice for parents, teachers, pediatricians and other
136 professionals in order to maximise human functioning.

137

Methods

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

176 meta-analyses that were unpublished.

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

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

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

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

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

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

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

184 published.

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

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

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

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

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

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

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

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

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

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

215 **Synthesis methods.** After extracting data, we examined the combinations of

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

222 We descriptively present the remaining meta-analytic effect sizes. To remove the
223 differences in approach to meta-analyses across the reviews, we reran the effect size estimate
224 using a random effects meta-analysis via the metafor package³¹ in R³² (version 4.2.2) when
225 the meta-analysis's authors provided primary study data associated with these effects. When
226 required, we imputed missing sample sizes using mean imputation from the other studies
227 within that review. From our reanalysis we also extracted I^2 values. To test for publication
228 bias, we conducted Egger's test³³ when the number of studies within the review was ten or
229 more,³⁴ and conducted a test of excess significance.³⁵ We contacted authors who did not
230 provide primary study data in their published article. Where authors did not provide data in
231 a format that could be re-analysed, we used the published results of their original
232 meta-analysis.

233 **Evidence assessment criteria.** *Statistical Credibility.* We employed a statistical
234 classification approach to grade the credibility of the effect sizes in the literature. To be
235 considered 'credible' an effect needed to be derived from a combined sample of >1,000³⁶ and
236 have non-significant tests of publication bias (i.e., Egger's test and excess significance test).
237 We performed these analyses, and therefore the review needed to provide usable study-level
238 data in order to be included.

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

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

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

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

259 Results

260 **Search Results.** The searches yielded 50,649 results, of which 28,675 were
261 duplicates. After screening titles and abstracts, we assessed 2,557 full-texts for inclusion. Of
262 those, 218 met the inclusion criteria and we extracted the data from all of these
263 meta-analyses. Figure 1 presents the full results of the selection process.

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

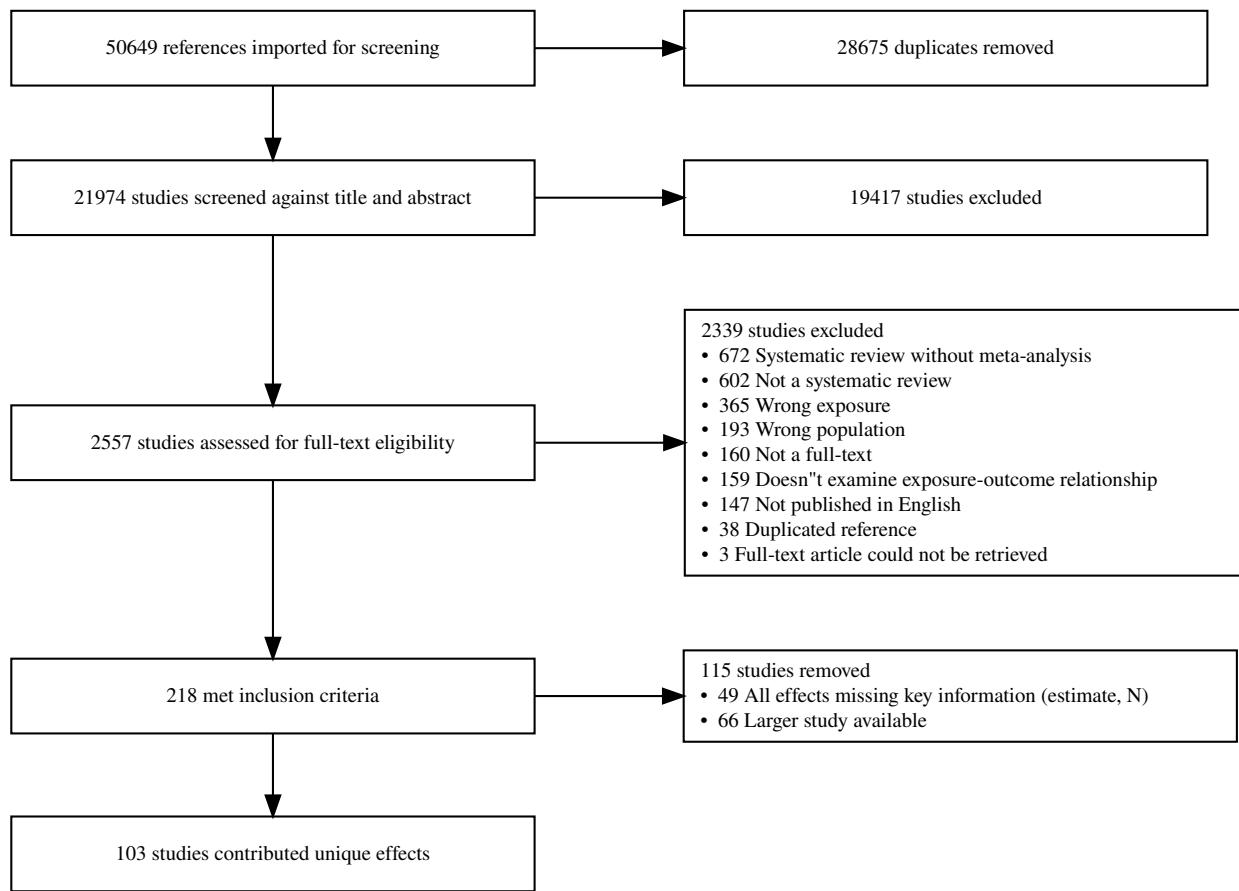


Figure 1. PRISMA Diagram

268 30), general learning ($n = 25$), depression ($n = 13$), and general literacy ($n = 12$). Of the 275
 269 unique exposure/outcome combinations, 244 occurred in only one review, with 22 appearing
 270 twice, and 9 appearing three or more times. Full characteristics of the included studies are
 271 provided in Table 1. After removing reviews with duplicate exposure/outcome combinations,
 272 our process yielded 255 unique effect/outcome combinations (retaining multiple effects for
 273 different age groups or study designs) contributed from 103 reviews. These effects represent
 274 the findings of 2,496 primary studies comprised of 2,026,054 participants.

275 **TABLE 1**

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

278 the included studies (n low risk = 87/103, 84%), and used a comprehensive and systematic
279 search strategy (n low risk = 72/103, 70%). Most reviews did not clearly report if their
280 eligibility criteria were predefined (n unclear = 72/103, 70%). Many papers also did not
281 complete dual independent screening of abstracts and full text (n high risk = 20/103, 19%)
282 or did not clearly report the method of screening (n unclear = 38/103, 37%). A similar trend
283 was observed for dual independent quality assessment (n high risk = 53/103, 51%; n high risk
284 = 19/103, 18%). Overall, only 7 meta-analyses were graded as low risk of bias on all criteria.

285 **Education Outcomes.** There were 89 unique effects associated with education
286 outcomes, including general learning outcomes, literacy, numeracy, and science. We removed
287 28 effects that did not provide individual study-level data, 19 effects with samples < 1,000,
288 and 19 effects with a significant Egger's test or insufficient studies to conduct the test.
289 Effects not meeting one or more of these standards are presented in Supplementary File 5.
290 The remaining 23 effects met our criteria for statistical credibility and are described in
291 Figure 2. These 23 effects came from 18 meta-analytic reviews analysing data from 338
292 empirical studies with 262,537 individual participants.

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

302 As shown in Figure 2, most of the credible results (14 of 23 effects) showed statistically
303 significant associations, with 99.9% confidence intervals not encompassing zero (strong
304 evidence). The remaining six associations were significant at the 95% confidence level (weak

Associations Between Exposures and Education Outcomes

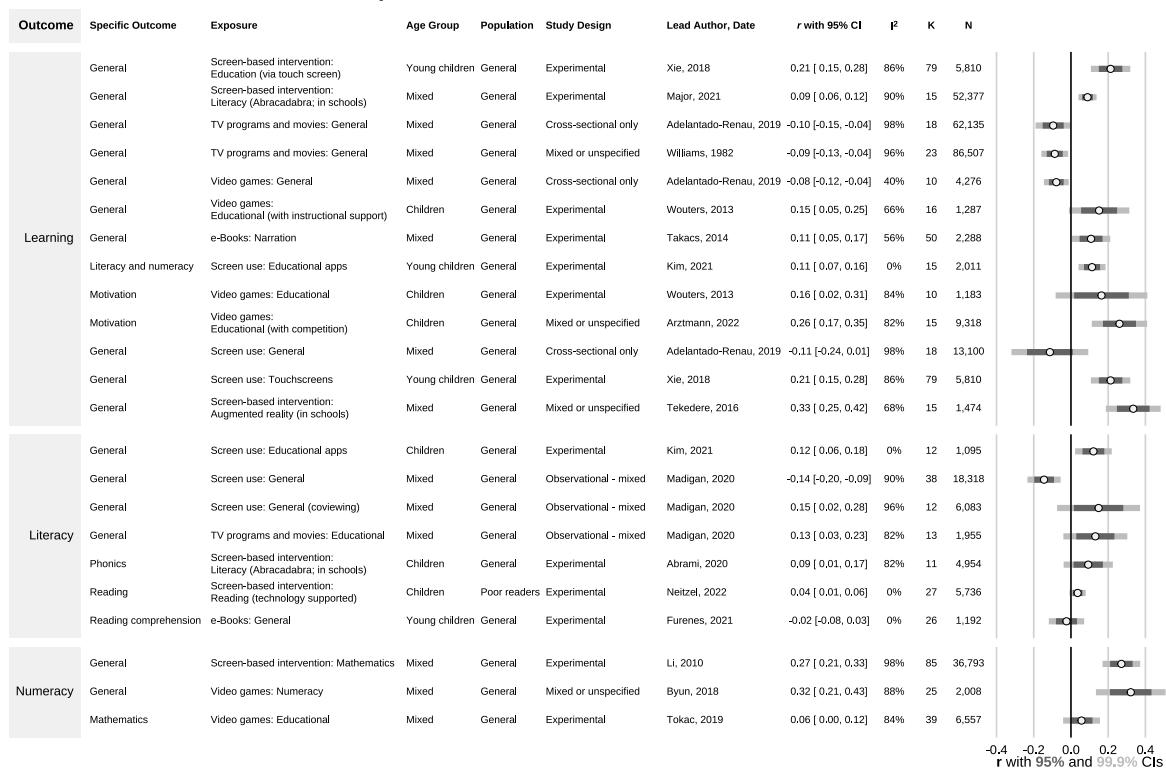


Figure 2. Education outcomes

305 evidence). All credible effects related to education outcomes were small-to-moderate.
 306 Screen-based interventions designed to influence an outcome (e.g., a computer based
 307 program designed to enhance learning³⁷) tended to have larger effect sizes than exposures
 308 that were not specifically intended to influence any of the measured outcomes (e.g., the
 309 association between television viewing and learning³⁸). The largest effect size observed was
 310 for augmented reality-based education interventions on general learning
 311 ($r = 0.33, k = 15, N = 1,474$). Most effects showed high levels of heterogeneity (18 of 23
 312 with $I^2 > 50\%$).

313 **Health and Health-related Behaviours.** We identified 166 unique
 314 outcome-exposure combinations associated with health or health-related behaviour outcomes.
 315 We removed 41 effects that did not provide individual study-level data, 50 effects with
 316 samples $< 1,000$, and 54 effects with a significant Egger's test or insufficient studies to

317 conduct the test. No remaining studies showed evidence of excessive significance. Effects not
 318 meeting one or more of these standards are presented in Supplementary File 6. The
 319 remaining 21 meta-analytic associations met our criteria for credible evidence and are
 320 described below (see also Figure 3). These 21 effects came from 15 meta-analytic reviews
 321 analysing data from 344 empirical studies with 859,562 individual participants.

Associations Between Exposures and Health-related Outcomes

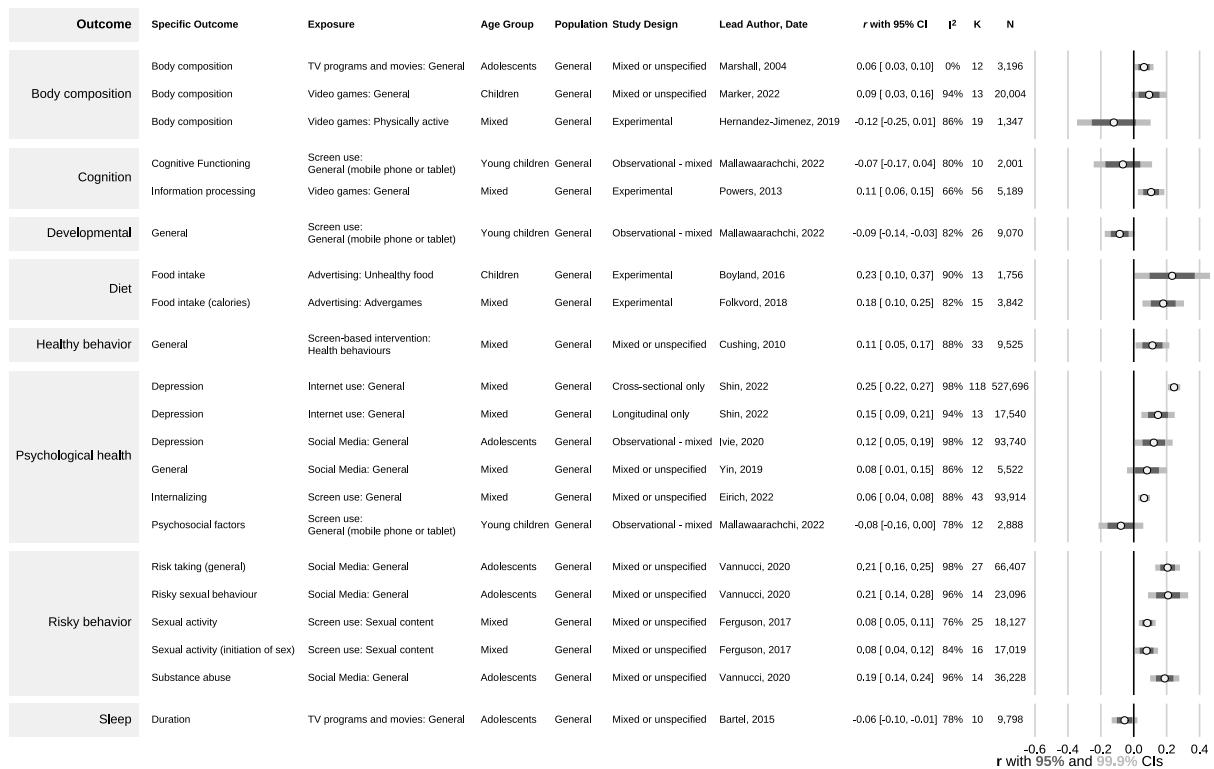


Figure 3. Health and health-related behaviour outcomes

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

329 video games) were associated with body composition (e.g., higher BMI). Screen-based
330 interventions which target health behaviours appeared mostly effective.

331 Across the health outcomes, most (14 of 21) effects were statistically significant at the
332 99.9% confidence interval level, with the remaining four significant at 95% confidence.

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

337

Discussion

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

344 As an example, consider children watching television programs—an often cited form of
345 screen time harm. We found statistically robust evidence for a small association with poorer
346 academic performance and literacy skills for general television watching³⁸. However, we also
347 found evidence that if the content of the program was educational, or the child was watching
348 the program with a parent (i.e., co-viewing), this exposure was instead associated with
349 better literacy.³⁹ Thus, parents may play an important role in selecting content that is likely
350 to benefit their children or, perhaps, interact with their children in ways that may foster
351 literacy (e.g., asking their children questions about the program). Similar nuanced findings
352 were observed for video games. The credible evidence we identified showed that video game
353 playing was associated with poorer body composition and learning.^{38,40} However, when the

354 video game were designed specifically to teach numeracy, playing these games showed
355 learning benefits.⁴¹ One might expect that video games designed to be physically active
356 could confer health benefits, but none of the meta-analyses examining this hypothesis met
357 our thresholds for statistical credibility (see Supplementary Files 5 & 6) therefore this
358 hypothesis could not be addressed.

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

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

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

380 statistically significant for other age groups.⁴⁷ Conversely, TV programs and movies were
381 more strongly associated with lower physical activity for adolescents than for younger age
382 groups.⁴⁸

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

388 Implications for Policy and Practice

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

398 Implications for Future Research

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

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

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

416 Screen time research has a well-established measurement problem, which impacts the
417 individual studies of this umbrella review. The vast majority of screen time research relies on
418 self-reported data, which not only lacks the nuance required for understanding the effects of
419 screen time, but may also be inaccurate. In one systematic review on screen time and sleep,⁷
420 66 of the 67 included studies used self-reported data for *both* the exposure and outcome
421 variable. It has been established that self-reported screen time data has questionable validity.
422 In a meta-analysis of 47 studies comparing self-reported media use with logged measures,
423 Parry et al⁵² found that the measures were only moderately correlated ($r = 0.38$), with
424 self-reported problematic usage fairing worse ($r = 0.25$). Indeed, of 622 studies which
425 measured the screen time of 0—6 year-olds, only 69 provided any sort of psychometric
426 properties for their measure, with only 19 studies reporting validity.⁵³ While some
427 researchers have started using newer methods of capturing screen behaviours—such as
428 wearable cameras⁵⁴ or device-based loggers⁵⁵—these are still not widely adopted. It may be
429 that the field of screen time research cannot be sufficiently advanced until accurate,
430 validated, and nuanced measures are more widely available and adopted.

431 Strengths and Limitations

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

437 Our high-level approach limits the feasibility of examining fine-grained details of the
438 individual studies. For example, we did not examine moderators beyond age, nor did we rate
439 the risk of bias for the individual studies. Thus, our assessment of evidence quality was
440 restricted to statistical credibility, rather than a more complete assessment of quality (e.g.,
441 GRADE⁵⁶). As such, we made decisions regarding the credibility of evidence, where others
442 may have used different thresholds or metrics. For this reason, we provide the complete
443 results in the supplementary material, along with the dataset for others to consider
444 alternative criteria.

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

457 synthesis of the existing evidence provides information about how screens might have
458 influenced children in the past, it is difficult to know if these findings will translate to new
459 forms of technology in the future.

460 **Conclusions**

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

472

References

- 473 1. The Lancet. Social media, screen time, and young people's mental health. *The
474 Lancet* **393**, 611 (2019).
- 475 2. Blair, A. Reading Strategies for Coping With Information Overload ca.1550-1700.
476 *Journal of the History of Ideas* **64**, 11–28 (2003).
- 477 3. Bell, A. N. *The sanitarian*. vol. 11 (AN Bell, 1883).
- 478 4. Dill, K. E. *The Oxford handbook of media psychology*. (Oxford University Press,
479 2013).
- 480 5. Wartella, E. A. & Jennings, N. Children and computers: New technology. Old
481 concerns. *The future of children* 31–43 (2000).
- 482 6. Rhodes, A. *Top ten child health problems: What the public thinks*. (2015).
- 483 7. Hale, L. & Guan, S. Screen time and sleep among school-aged children and
484 adolescents: A systematic literature review. *Sleep Medicine Reviews* **21**, 50–58 (2015).
- 485 8. Sweetser, P., Johnson, D., Ozdowska, A. & Wyeth, P. Active versus passive screen
486 time for young children. *Australasian Journal of Early Childhood* **37**, 94–98 (2012).
- 487 9. Li, X. & Atkins, M. S. Early childhood computer experience and cognitive and
488 motor development. *Pediatrics* **113**, 1715–1722 (2004).
- 489 10. Warburton, W. & Highfield, K. Children and technology in a smart device world.
490 in *Children, Families and Communities* 195–221 (Oxford University Press, 2017).
- 491 11. Nature Human Behaviour. Screen time: How much is too much? *Nature* **565**,
492 265–266 (2019).
- 493 12. World Health Organization. *Guidelines on physical activity, sedentary behaviour
494 and sleep for children under 5 years of age*. 33 p. (World Health Organization, 2019).

495 13. Australian Government. *Physical activity and exercise guidelines for all*

496 *Australians*. (2021).

497 14. Canadian Society for Exercise Physiology. *Canadian 24-Hour Movement*

498 *Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour,*

499 *and Sleep*. (2016).

500 15. Council On Communication and Media. Media Use in School-Aged Children and

501 Adolescents. *Pediatrics* **138**, e20162592 (2016).

502 16. Ferguson, C. J. Everything in Moderation: Moderate Use of Screens Unassociated

503 with Child Behavior Problems. *Psychiatric Quarterly* **88**, 797–805 (2017).

504 17. Przybylski, A. K. & Weinstein, N. A Large-Scale Test of the Goldilocks Hypothesis:

505 Quantifying the Relations Between Digital-Screen Use and the Mental Well-Being of

506 Adolescents. *Psychological Science* **28**, 204–215 (2017).

507 18. Sanders, T., Parker, P. D., del Pozo-Cruz, B., Noetel, M. & Lonsdale, C. Type of

508 screen time moderates effects on outcomes in 4013 children: Evidence from the Longitudinal

509 Study of Australian Children. *International Journal of Behavioral Nutrition and Physical*

510 *Activity* **16**, 117 (2019).

511 19. Kaye, L. K., Orben, A., Ellis, D. A., Hunter, S. C. & Houghton, S. The Conceptual

512 and Methodological Mayhem of ‘Screen Time’. *International Journal of Environmental*

513 *Research and Public Health* **17**, 3661 (2020).

514 20. Chassiakos, Y. L. R. *et al.* Children and Adolescents and Digital Media. *Pediatrics*

515 **138**, e20162593 (2016).

516 21. Stiglic, N. & Viner, R. M. Effects of screentime on the health and well-being of

517 children and adolescents: A systematic review of reviews. *BMJ Open* **9**, e023191 (2019).

518 22. Valkenburg, P. M., Meier, A. & Beyens, I. Social media use and its impact on

519 adolescent mental health: An umbrella review of the evidence. *Current Opinion in*

- 520 *Psychology* **44**, 58–68 (2022).
- 521 23. Arias-de la Torre, J. *et al.* Relationship Between Depression and the Use of Mobile
522 Technologies and Social Media Among Adolescents: Umbrella Review. *Journal of Medical
523 Internet Research* **22**, e16388 (2020).
- 524 24. Orben, A. Teenagers, screens and social media: A narrative review of reviews and
525 key studies. *Social Psychiatry and Psychiatric Epidemiology* **55**, 407–414 (2020).
- 526 25. Page, M. J. *et al.* *The PRISMA 2020 statement: An updated guideline for
527 reporting systematic reviews*. (2020) doi:10.31222/osf.io/v7gm2.
- 528 26. National Health, Lung, and Blood Institute. *Quality Assessment of Systematic
529 Reviews and Meta-Analyses*. (2014).
- 530 27. Bowman, N. A. Effect Sizes and Statistical Methods for Meta-Analysis in Higher
531 Education. *Research in Higher Education* **53**, 375–382 (2012).
- 532 28. Jacobs, P. & Viechtbauer, W. Estimation of the biserial correlation and its
533 sampling variance for use in meta-analysis: Biserial Correlation. *Research Synthesis Methods*
534 **8**, 161–180 (2017).
- 535 29. Funder, D. C. & Ozer, D. J. Evaluating Effect Size in Psychological Research:
536 Sense and Nonsense. *Advances in Methods and Practices in Psychological Science* **2**, 156–168
537 (2019).
- 538 30. Gignac, G. E. & Szodorai, E. T. Effect size guidelines for individual differences
539 researchers. *Personality and Individual Differences* **102**, 74–78 (2016).
- 540 31. Viechtbauer, W. *Metafor: Meta-analysis package for r*. (2022).
- 541 32. R Core Team. *R: A language and environment for statistical computing*. (R
542 Foundation for Statistical Computing, 2022).
- 543 33. Egger, M., Smith, G. D., Schneider, M. & Minder, C. Bias in meta-analysis
544 detected by a simple, graphical test. *BMJ* **315**, 629–634 (1997).

545 34. Page, M. J., Higgins, J. P. & Sterne, J. A. Chapter 13: Assessing risk of bias due

546 to missing results in a synthesis. in *Cochrane Handbook for Systematic Reviews of*

547 *Interventions* (eds. Higgins, J. P. et al.) (Cochrane, 2021).

548 35. Ioannidis, J. P. & Trikalinos, T. A. An exploratory test for an excess of significant

549 findings. *Clinical Trials* **4**, 245–253 (2007).

550 36. Papadimitriou, N. *et al.* An umbrella review of the evidence associating diet and

551 cancer risk at 11 anatomical sites. *Nature Communications* **12**, 4579 (2021).

552 37. Xie, H. *et al.* Can Touchscreen Devices be Used to Facilitate Young Children's

553 Learning? A Meta-Analysis of Touchscreen Learning Effect. *Frontiers in Psychology* **9**, 2580

554 (2018).

555 38. Adelantado-Renau, M. *et al.* Association Between Screen Media Use and Academic

556 Performance Among Children and Adolescents: A Systematic Review and Meta-analysis.

557 *JAMA Pediatrics* **173**, 1058 (2019).

558 39. Madigan, S., McArthur, B. A., Anhorn, C., Eirich, R. & Christakis, D. A.

559 Associations Between Screen Use and Child Language Skills: A Systematic Review and

560 Meta-analysis. *JAMA Pediatrics* **174**, 665 (2020).

561 40. Poorolajal, J., Sahraei, F., Mohammadi, Y., Doosti-Irani, A. & Moradi, L.

562 Behavioral factors influencing childhood obesity: A systematic review and meta-analysis.

563 *Obesity Research & Clinical Practice* **14**, 109–118 (2020).

564 41. Byun, J. & Joung, E. Digital game-based learning for K-12 mathematics education:

565 A meta-analysis. *School Science and Mathematics* **118**, 113–126 (2018).

566 42. Vannucci, A., Simpson, E. G., Gagnon, S. & Ohannessian, C. M. Social media use

567 and risky behaviors in adolescents: A meta-analysis. *Journal of Adolescence* **79**, 258–274

568 (2020).

569 43. Yoon, S., Kleinman, M., Mertz, J. & Brannick, M. Is social network site usage

- 570 related to depression? A meta-analysis of FacebookDepression relations. *Journal of Affective*
571 *Disorders* **248**, 65–72 (2019).
- 572 44. Vahedi, Z. & Zannella, L. The association between self-reported depressive
573 symptoms and the use of social networking sites (SNS): A meta-analysis. *Current Psychology*
574 **40**, 2174–2189 (2021).
- 575 45. Seetharaman, G. W., Jeff Horwitz and Deepa. Facebook Knows Instagram Is Toxic
576 for Teen Girls, Company Documents Show. *Wall Street Journal* (2021).
- 577 46. Tekedere, H. & Göke, H. Examining the Effectiveness of Augmented Reality
578 Applications in Education: A Meta-Analysis. *International Journal of Environmental and*
579 *Science Education* **11**, 9469–9481 (2016).
- 580 47. Sadeghirad, B., Duhaney, T., Motaghpisheh, S., Campbell, N. R. C. & Johnston,
581 B. C. Influence of unhealthy food and beverage marketing on children's dietary intake and
582 preference: A systematic review and meta-analysis of randomized trials. *Obesity Reviews* **17**,
583 945–959 (2016).
- 584 48. Marshall, S. J., Biddle, S. J. H., Gorely, T., Cameron, N. & Murdey, I.
585 Relationships between media use, body fatness and physical activity in children and youth:
586 A meta-analysis. *International Journal of Obesity* **28**, 1238–1246 (2004).
- 587 49. Elson, M. *et al.* Do policy statements on media effects faithfully represent the
588 science? *Advances in Methods and Practices in Psychological Science* **2**, 12–25 (2019).
- 589 50. Ashton, J. J. & Beattie, R. M. Screen time in children and adolescents: Is there
590 evidence to guide parents and policy? *The Lancet Child & Adolescent Health* **3**, 292–294
591 (2019).
- 592 51. Royal College of Paediatrics and Child Health. *The health impacts of screen time:*
593 *A guide for clinicians and parents.* (2019).
- 594 52. Parry, D. A. *et al.* A systematic review and meta-analysis of discrepancies between

- 595 logged and self-reported digital media use. *Nature Human Behaviour* **5**, 1535–1547 (2021).
- 596 53. Byrne, R., Terranova, C. O. & Trost, S. G. Measurement of screen time among
597 young children aged 0 years: A systematic review. *Obesity Reviews* **22**, (2021).
- 598 54. Smith, C., Galland, B. C., de Bruin, W. E. & Taylor, R. W. Feasibility of
599 automated cameras to measure screen use in adolescents. *American journal of preventive
600 medicine* **57**, 417–424 (2019).
- 601 55. Ryding, F. C. & Kuss, D. J. Passive objective measures in the assessment of
602 problematic smartphone use: A systematic review. *Addictive Behaviors Reports* **11**, 100257
603 (2020).
- 604 56. Guyatt, G. *et al.* GRADE guidelines: 1. IntroductionGRADE evidence profiles
605 and summary of findings tables. *Journal of Clinical Epidemiology* **64**, 383–394 (2011).
- 606 57. Twenge, J. M. More Time on Technology, Less Happiness? Associations Between
607 Digital-Media Use and Psychological Well-Being. *Current Directions in Psychological
608 Science* **28**, 372–379 (2019).
- 609 58. Kelly, Y., Zilanawala, A., Booker, C. & Sacker, A. Social Media Use and
610 Adolescent Mental Health: Findings From the UK Millennium Cohort Study.
611 *EClinicalMedicine* **6**, 59–68 (2018).