

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 275 unique exposure/outcome
44 combinations from 118. These effects represent the findings of 3,103 primary studies
45 comprised of 3,141,213 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

Word count: 4767

55 Benefits and risks associated with children's and adolescents' interactions with electronic
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
98 numerous government agencies^{13,14} and statements by expert groups¹⁵ have recommended

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

114 In 2016, the American Academy of Pediatrics used a narrative review to examine the
115 benefits and risks of children and adolescents' electronic media²⁰ as a basis for updating their
116 guidelines about screen use.¹⁵ Since then, a large number of systematic reviews and
117 meta-analyses have provided evidence about the potential benefits and risks of screen use.
118 Yet, no review has examined the evidence available across a broad range of outcome
119 domains, such as physical health, education, physical and cognitive development, behaviour,
120 and well-being. By summarising and synthesising all evidence in one overview, we provide a
121 reference point for the field and allow for easier comparison of risks and benefits for the same
122 behaviour.

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

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

131

Methods

132 We prospectively registered our methods on the International Prospective Register of
133 Systematic Reviews (PROSPERO; CRD42017076051).

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

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

154 *Outcomes:* We included all reported outcomes.

155 *Publications:* We included meta-analyses (or meta-regressions) of quantitative evidence.
156 To be included, meta-analyses needed to analyse data from studies identified in a systematic

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

169 **Information sources.** We searched records contained in the following databases:
170 Pubmed, MEDLINE, CINAHL, PsycINFO, SPORTDiscus, Education Source, Embase,
171 Cochrane Library, Scopus, Web of Science, ProQuest Social Science Premium Collection, and
172 ERIC. We conducted an initial search on August 17, 2018 and refreshed the search on May
173 13, 2020. We searched reference lists of included papers in order to identify additional
174 eligible meta-analyses. We also searched PROSPERO to identify relevant protocols and
175 contacted authors to determine if these reviews have been completed and published.

176 **Search strategy.** The search strategy associated with each of the 12 databases can
177 be found in Supplementary File 1. We hand searched reference lists from any relevant
178 umbrella reviews to identify systematic meta-analyses that our search may have missed.

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

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

189 **Study risk of bias assessment.** For each meta-analysis, two researchers
190 independently completed the National Health, Lung and Blood Institute's Quality
191 Assessment of Systematic Reviews and Meta-Analyses tool²¹ (see Table 1). We resolved
192 disagreements by consensus, with a third researcher employed when needed. We did not
193 assess risk of bias in the individual studies that were included in each meta-analysis.

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

200 To facilitate comparisons, we converted effect sizes to Pearson's r using established
201 formulae.²²⁻²⁴ Effect sizes on the original metric are provided in Supplementary File 2.

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

207 We descriptively present the remaining meta-analytic effect sizes. To remove the
208 differences in approach to meta-analyses across the reviews, we reran the effect size estimate

209 using a random effects meta-analysis via the metafor package²⁵ in R²⁶ (version 4.2.2) when
210 the meta-analysis's authors provided primary study data associated with these effects. When
211 required, we imputed missing sample sizes using mean imputation from the other studies
212 within that review. From our reanalysis we also extracted I^2 values. To test for publication
213 bias, we conducted Egger's test²⁷ when the number of studies within the review was ten or
214 more,²⁸ and conducted a test of excess significance.²⁹ We contacted authors who did not
215 provide primary study data in their published article. Where authors did not provide data in
216 a format that could be re-analysed, we used the published results of their original
217 meta-analysis.

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

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

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

232 **Deviations from protocol.** We initially planned to include systematic reviews
233 without meta-analyses in a narrative summary alongside the main meta-analytic findings.
234 However, we determined that combining results from the meta-analyses allowed readers to

235 compare relative strength of associations more easily. Readers interested in the relevant
236 systematic reviews (i.e., without meta-analysis) can consult the list of references in
237 Supplementary File 3.

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

244 **Results**

245 **Search Results.** The searches yielded 50,656 results, of which 28,675 were
246 duplicates. After screening titles and abstracts, we assessed 2,557 full-texts for inclusion. Of
247 those, 224 met the inclusion criteria and we extracted the data from all of these
248 meta-analyses. Figure 1 presents the full results of the selection process.

249 The most frequently reported exposures were general screen use ($n = 45$), general TV
250 programs and movies ($n = 28$), physically active video games ($n = 22$), and literacy
251 (abracadabra; in schools) intervention ($n = 15$). Supplementary File 4 provides a list of all
252 exposures identified. The most frequently reported outcomes were general learning ($n = 46$),
253 body composition ($n = 37$), general physical activity ($n = 22$), depression psychological
254 health ($n = 17$), and sleep duration ($n = 15$). In 175 cases there was only one
255 exposure/outcome combination for an age group, with 37 appearing twice, and 26 appearing
256 three or more times. Full characteristics of the included studies are provided in Table 1.
257 After removing reviews with duplicate exposure/outcome combinations, our process yielded
258 275 unique effect/outcome combinations contributed from 118 reviews. These effects
259 represent the findings of 3,103 primary studies comprised of 3,141,213 participants.

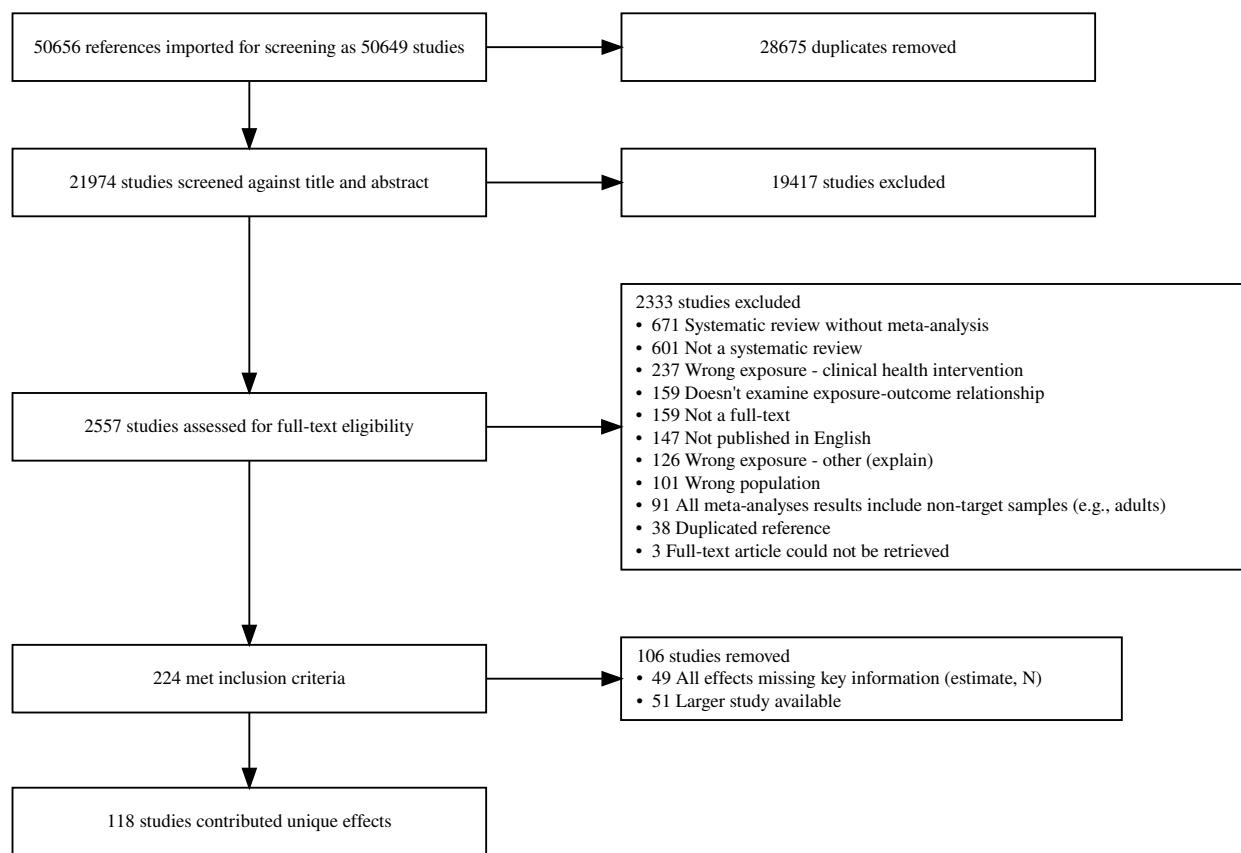


Figure 1. PRISMA Diagram

Review characteristics for studies providing unique effects

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Abrami	2020	Include: Experimental designs	None specified	2009 - 2019	Pre K to Grade 3	Literacy: Listening comprehension Literacy: Phonics Literacy: Phonemic awareness Literacy: Reading comprehension Literacy: Reading fluency Literacy: Vocabulary knowledge	Intervention: Literacy (Abracadabra; in schools)
Adelantado-Renau	2019	Include: Cross-sectional studies	None specified	1982 - 2019	Children; Adolescents	Learning: General Literacy: General Numeracy: General Video games: General	Screen use: General TV programs and movies; General Video games: General
Aghassi	2020	Include: Observational	None specified	2007 - 2016	All	Body composition	Internet use: General
Andrade	2019	Include: Interventions	None specified	2010 - 2017	Children; Adolescents	Healthy behavior: Self-efficacy Psychological health: Depression Psychological health: Enjoyment Self-perceptions: General Self-perceptions: Self-esteem	Video games: Physically active Video games: Educational (with competition)
Arztmann	2022	None specified	None specified	2008 - 2020	K - Grade 8	Learning: Behavior Learning: Motivation	Video games: Educational (with competition)
Aspiranti	2020	Include: Interventions	None specified	2013 - 2015	School-age Children (Primary /Elementary)	Learning: General	Intervention: Education (via touch screen)

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Baradaran Mahdavi	2021	Include: Observational Exclude: Experimental	None specified	1999 - 2019	None specified	Physical health: Lower back pain	Screen use: General (excluding TV) TV programs and movies; General
Bartel	2015	None	None specified	2004 - 2014	Adolescents	Sleep: Bedtime Sleep: Duration Sleep: Time to fall asleep	Computer use: General Internet use: General Screen use: General (mobile phone) TV programs and movies; General Video games: General
Beck Silva	2022	Include: Randomised controlled trials and quasi-RCTs.	None specified	1999 - 2019	10 - 19 years	Diet: Fat consumption	Intervention: Nutrition (in schools)
Benavides-Varela	2020	Include: Randomised controlled trials	None specified	2006 - 2018	Children	Numeracy: Mathematics	Intervention: Mathematics
Blok	2002	None	None specified	1990 - 2000	All	Literacy: Reading fluency	Intervention: Literacy
Bossem	2020	Include: Randomised controlled trials	None specified	2011 - 2018	Children	Body composition Cardiometabolic health: Fitness Physical activity: General Physical health: Muscular fitness	Video games: Health promoting content
Boyland	2016	Include: Experimental	None specified	2004 - 2015	Children; Adolescents	Diet: Food intake	Advertising: Unhealthy food

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Byun	2018	Include: All quantitative designs	None specified	2006 - 2014	School-age Children	Numeracy: General	Video games: Numeracy
Cao	2020	Include: designs with control groups	None specified	2002 - 2019	3-12 years	Cognition: Executive functioning Cognition: Executive Functioning (cognitive flexibility) Cognition: Executive Functioning (inhibition) Cognition: Executive Functioning (working memory)	Computer use: Executive functioning training
Carter	2016	Include: All quantitative designs	None specified	2011 - 2015	Children; Adolescents	Sleep: Inadequate duration Sleep: Lethargy Sleep: Poor quality	Screen use: General (mobile phone at bed time)
Champion	2019	Include: Randomised controlled trials	None specified	2003 - 2017	School-age Children	Body composition Diet: Fat consumption Diet: Fruit and vegetable intake Diet: Fruit intake Diet: Sugary drinks and snacks	Intervention: Lifestyle risk behaviour (at school)

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Chan	2014	Include: Experimental; Quasi-experimental	None specified	2002 - 2012	School-age Children	Numeracy: General	Intervention: Dynamic geometry software
Chauhan	2017	Include: pre-post designs with or without control group	None specified	2001 - 2016	Elementary school students	Learning: General	Screen use: General (in schools)
Chen	2020	Include: Experimental designs	None specified	2008 - 2019	None specified	Learning: General (with competition)	Video games: Educational (with competition)
Cheung	2012	Include: Randomised controlled trials	None specified	1982 - 2010	School-age Children	Literacy: Reading	Intervention: Reading (in schools)
Cheung	2013	Include: Quasi-experimental	None specified	1980 - 2010	School-age Children	Numeracy: General	Intervention: Mathematics (in schools)
Cho	2018	Include: Experimental;	None specified	2008 - 2013	None specified	Learning: Second language	Screen use: General (mobile phone for language learning)
Claussen	2022	Include: Longitudinal; Retrospective	None specified	2004 - 2018	None specified	Psychological health: ADHD Psychological health: ADHD Symptoms (Inattention)	Screen use: General Screen use: General
Clinton	2019	Include: randomised experimental designs	None specified	2011 - 2016	None specified	Literacy: Reading performance	Screen use: Reading (vs paper)

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Comeras-Chueca	2021	include: randomized and non-randomized controlled trials (control group with no intervention or traditional exercise intervention)	None specified	2008 - 2019	Under 18	Body composition: BMI Cardiometabolic health: Fitness	Video games: Physically active
Comeras-Chueca	2021	Include: randomized and non-randomized controlled with control group with no intervention or traditional exercise intervention	None specified	2010 - 2020	Under 18	Body composition: BMI Body composition: BMI z-score	Video games: Physically active
Coyne	2018	None	None specified	1975 - 2017	Children; Adolescents	Prosocial Behavior: General content	Screen use: Prosocial content
Cushing	2010	Include: All quantitative designs; Experimental	None specified	1989 - 2009	Children; Adolescents	Healthy behavior: General behaviours	Intervention: Health behaviours
Darling	2017	Include: Intervention	None specified	2006 - 2016	Children; Adolescents	Body composition Diet: Healthy dietary behaviour	Intervention: To promote health (via mobile phone) Physical activity: General

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Eirich	2022	Include: experimental or observational	None specified	1978 - 2021	12 or under	Psychological health: Externalizing Psychological health: Internalizing	Screen use: General
Fang	2019	Include: Cohort; Case-control; Cross-sectional	None specified	2006 - 2019	Children; Adolescents	Body composition	Computer use: General
Feng	2021	Include: Quantitative designs	None specified	2017 - 2019	1 month - 4.99 years old	Body composition: BMI z-score	Screen use: General (meeting guidelines)
Ferguson	2017	None	None specified	2005 - 2017	Children; Adolescents	Risky behavior: Sexual activity Risky behavior: Sexual activity (initiation of sex)	Screen use: Sexual content
Ferguson	2020	Include: Experimental, correlational, or longitudinal	None specified	2009 - 2013	None specified	Aggression: General	Video games: Violent content
Folkvord	2018	Include: Interventions	None specified	2007 - 2018	Children; Adolescents	Diet: Food intake (calories)	Advertising: Advergames
Foreman	2021	Include: observational and intervention studies	None specified	2015 - 2020	None specified	Eye health: Myopia	Screen use: General Screen use: General (phone or tablet)
Furenes	2021	Include: experimental or quasi-experimental	None specified	2002 - 2019	1-8 years old	Literacy: Reading comprehension Literacy: Vocabulary learning	e-Books: General

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
Restrictions							
Gardella	2017	Include: Cross-sectional	Include: North America	2006 - 2014	Adolescents	Learning: Educational achievement problems Learning: School attendance problems	Internet use: Cyberbullying victimization
Garzón	2019	Include: Experimental with control group	None specified	NA - NA	None specified	Learning: General reality (in schools)	Intervention: Augmented reality (in schools)
Globaadi	2018	Include: Cohort; Case-control; Cross-sectional Exclude: Interventions	None specified	2009 - 2014	Children; Adolescents	Body composition	TV programs and movies; Mealtime
Graham	2015	Include: Experimental; Quasi-experimental	None specified	2004 - 2011	School-age Children (Primary/Elementary/Middle School)	Literacy: Writing feedback	Intervention: Writing feedback
Haghjooy	2022	Include: observational designs	None specified	2008 - 2021	10-20 years old	Body composition: Overweight/obesity	Screen use: General
Hammersley	2016	Include: Randomised controlled trials	None specified	2003 - 2013	Children; Adolescents	Body composition	Intervention: To promote healthy weight (obesity prevention)
Hao	2021	Include: Experimental with control group	None specified	2012 - 2018	preschool-college	Learning: Second language vocabulary	Intervention: English as foreign language
Hassan-Saleh	2019	Include: Experimental; Quasi-experimental	None specified	2008 - 2016	Children; Adolescents	Literacy: Pronunciation	Intervention: Pronunciation

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
He	2021	Include: Randomised controlled trials	None specified	2009 - 2018	6-18 years	Physical activity: General	Intervention: To promote physical activity (via mobile phone)
Hernandez-Jimenez	2019	Include: Experimental; Quasi-experimental	None specified	2009 - 2017	Children; Adolescents	Body composition	Video games: Physically active
Hurwitz	2018	None	Include: North America	1997 - 2018	Early childhood/pre-school; School-age Children (Early Primary/Elementary)	Literacy: General	Intervention: Literacy videos
Ivie	2020	Include: Correlational studies	None specified	2012 - 2019	11-18 years	Psychological health: Depression	Social Media: General
Janssen	2020	Include: Experimental; Cross-sectional; Longitudinal	None specified	2007 - 2019	Children	Sleep: Duration	Screen use: General
Kates	2018	None	None specified	2008 - 2016	School-age Children	Learning: General	Screen use: General (mobile phone)
Kim	2021	Include: experimental or quasi-experimental	None specified	2010 - 2018	Preschool to Grade 3 (3-9 years old)	Learning: Literacy and numeracy Literacy: General	Screen use: Educational apps Numeracy: General
Kroesbergen	2003	Include: Within subject design; between subject design	None specified	1985 - 1999	School-age Children (Primary/Elementary)	Numeracy: General	Intervention: Mathematics (via computer in classrooms)
Kucukalkan	2019	Include: Experimental	None specified	2007 - 2016	School-age Children (Primary/Elementary)	Numeracy: General	Intervention: Mathematics

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Lanca	2020	Include: Cohort; Case-control; Cross-sectional; Intervention trials. Exclude: Case reports; Retrospective studies.	None specified	2007 - 2016	Children; Adolescents	Eye health: Myopia	Screen use: General
Li	2010	Include: Experimental; Quasi-experimental	None specified	1991 - 2005	School-age Children	Numeracy: General	Intervention: Mathematics
Li	2020	None specified	None specified	2005 - 2019	Infants, toddlers, and preschoolers (0-7 years)	Body composition: Overweight/obesity Sleep: Duration	Screen use: General
Li	2022	Include: Randomised controlled trials	None specified	2012 - 2020	3-18 years	Developmental: Gross motor (locomotor) Developmental: Gross motor (non-locomotor) Developmental: Gross motor (object control skills)	Intervention: Active video games for motor skills
Li	2022	Include: experimental or quasi-experimental	None specified	2014 - 2021	None specified	Learning: Computational thinking	Computer use: Programming exercises
Liao	2008	Include: All quantitative designs	Include: Taiwan	1990 - 2003	School-age Children (Primary/Elementary)	Learning: General	Intervention: Education (via computer)
Liao	2014	Include: Randomised controlled trials	None specified	1999 - 2012	Children; Adolescents	Body composition	Intervention: Screen time reduction

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Liu	2016	Include: Cross-sectional; Case-control; Longitudinal	None specified	2001 - 2014	All	Psychological health: Depression	Screen use: General
Liu	2019	Include: All quantitative designs	None specified	2007 - 2014	All	Psychological health: Anxiety Psychological health: Depression Psychological health: Satisfaction	Social Media: Instant messaging Video games: General
Liu	2022	Include: studies with control group	None specified	NA - NA	None specified	Cognition: Creativity	Screen use: General
Liu	2022	Include: Observational	None specified	2012 - 2021	10-19 years	Psychological health: Depression	Social Media: General (duration)
Lu	2021	Include: Cross-sectional only	China	2014 - 2018	Adolescents	Psychological health: Negative coping style Psychological health: Positive coping style	Screen use: General (mobile phone addiction)
Madigan	2020	Include: Observational Exclude: Qualitative	None specified	1973 - 2019	Children	Literacy: General	Intervention: Education (general) Screen use: General (coviewing) TV programs and movies; Educational TV programs and movies; General TV programs and movies; General (in background)

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Major	2021	Include: Randomised controlled trials	Low- or middle-income per World Bank	2007 - 2020	5-18 years	Learning: General	Intervention: Literacy (Abracadabra; in schools)
Mallawaarachchi	2022	Include: Cross-sectional or longitudinal	None specified	2014 - 2020	1-6 years and prior to school entry	Cognition: Cognitive Functioning Cognition: Executive Functioning Developmental: General Developmental: Language or speech Psychological health: Psychosocial factors Psychosocial factors Psychological health: Psychosocial factors Self-regulation Sleep: General	Screen use: General (mobile phone or tablet)
Mares	2005	None	None specified	1969 - 1989	Children	Aggression: Towards peers Cognition: Reducing stereotypes Prosocial Behavior: Altruism Social interactions: General	TV programs and movies; General
Mares	2013	Exclude: Experimental	Exclude: North America	1973 - 2010	Children	Cognition: Moral reasoning and perception of out-groups Learning: General Learning: Literacy and numeracy Learning: Physical and social environment	Intervention: Sesame Street
Marker	2022	None specified	None specified	2001 - 15	None specified	Body composition	Video games: General

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Marshall	2004	None	None specified	1985 - 2002	Children; Adolescents	Body composition Physical activity: General	TV programs and movies; General Video games: General
Martins	2019	Include: All quantitative designs	None specified	2003 - 2018	All	Aggression: Towards peers	Screen use: General
Martins	2022	Include: Cross-over or parallel randomized controlled trials	None specified	2006 - 2017	1-18 years	Diet: Food intake (calories)	TV programs and movies; Mealtime
Mazeas	2022	Include: Randomised controlled trials	None specified	2015 - 2019	None specified	Physical activity: General	Intervention: To promote physical activity (via gamification)
McArthur	2012	Include: Randomised controlled trials and quasi-RCTs.	None specified	1994 - 2009	All	Literacy: Phonics	Intervention: Literacy (phonics; via computer)
McArthur	2018	Include: Randomised controlled trials and quasi-RCTs.	Include: English speaking countries	1994 - 2015	Children; Adolescents	Literacy: General	Intervention: Literacy
Mei	2018	Include: cross-sectional, case-control, and cohort studies	None specified	2004 - 2018	11-20	Sleep: Duration Sleep: Problems Sleep: Time to fall asleep	Screen use: General (excessive)

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Merchant	2014	Include: Experimental with control group	None specified	NA - NA	K-12	Learning: General Screen use: Virtual reality simulations (Educational) Screen use: Virtual reality worlds (Educational) Video games: Virtual reality (Educational)	Screen use: Virtual reality simulations (Educational)
Mori	2019	None specified	None specified	2013 - 2018	<18 years	Psychological health: Internalizing Risky behavior: Alcohol consumption Risky behavior: Delinquency Risky behavior: Drug use activity Risky behavior: Sexual activity (contraception use) Risky behavior: Sexual activity (multiple partners) Risky behavior: Smoking	Screen use: Sexting
Neitzel	2022	Include: random assignment or quasi-experimental	Include: United States, Europe, Israel, Australia, and New Zealand	2004 - 2020	Kindergarten- Grade 6	Literacy: Reading	Intervention: Reading (technology supported)

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Oldrati	2020	Include: Group-control experimental design	None specified	2006 - 2018	School-age Children	Cognition: Cognitive Functioning Cognition: Executive Functioning Cognition: Verbal skills Cognition: Visuospatial skills Numeracy: General Psychological health: Adjustment	Intervention: Cognitive training
Pak	1994	None	None specified	NA - NA	Children; Adolescents	Antisocial Behaviour: General	TV programs and movies; Violent content
Pearce	2016	Include: All quantitative designs	None specified	1986 - 2012	Children; Adolescents	Psychological health: Internalizing	TV programs and movies; Scary content
Peng	2011	None	None specified	2001 - 2010	Children; Adolescents	Cardiometabolic health: Maximum oxygen consumption Physical activity: Energy expenditure Physical activity: Heart rate	Video games: Physically active Video games: General
Poorolajai	2020	Include: Observational	None specified	1995 - 2018	Children; Adolescents	Body composition	TV programs and movies; General Video games: General
Powers	2013	Include: Experimental or quasi-experimental designs	None specified	1985 - 2012	None specified	Cognition: Information processing	Video games: General
Prescott	2018	Include: Longitudinal	None specified	2008 - 2017	All	Aggression: Towards peers	Video games: Violent content

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Reynard	2022	None specified	None specified	2016 - 2020	8-14 years	Psychological health: Emotion experience Psychological health: Emotion regulation	Intervention: To improve emotional regulation Intervention: To improve emotional regulation (via digital games)
Rodriguez-Rocha	2019	Include: Experimental; Quasi-experimental	None specified	1999 - 2018	All	Diet: Fruit and vegetable intake	Intervention: Fruit and vegetable
Sadeghirad	2016	Include: Randomised controlled trials	None specified	1978 - 2014	Children; Adolescents	Diet: Unhealthy food choice	Advertising: Unhealthy food
Scherer	2020	Include: Experimental or quasi-experimental designs	None specified	1973 - 2017	None specified	Learning: Programming skills	Intervention: Education (programming)
Schroeder	2013	Include: Experimental; Quasi-experimental	None specified	2001 - 2009	All	Learning: General characters	Intervention: With digital characters
Scionti	2019	Include: Interventions	None specified	2009 - 2019	Children	Cognition: Executive functioning	Intervention: Cognitive training
Shin	2019	Include: Interventions	None specified	2013 - 2018	Children; Adolescents	Body composition Diet: Sugary drinks Physical activity: General Screen time: General	Intervention: To promote health (via mobile phone app) Intervention: To promote health (via mobile phone) Intervention: To promote health (via text message)

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Slavin	2014	Include: Randomised controlled trials; Quasi- experimental; Observational	None specified	2000 - 2011 (Primary/Elementary)	School-age Children (Primary/Elementary)	Science: General	Intervention: Science (in schools)
Strouse	2021	Include: experimental and quasi-experimental designs	None specified	1994 - 2019 less than 8 years	Average 6 years, all must be less than 8 years	Learning: General	Screen use: Video (vs face-to-face)
Takacs	2014	Include: Experimental; Quasi- experimental	None specified	1980 - 2014	All	Learning: General	e-Books: Narration
Takacs	2019	Include: Randomised controlled trials and quasi-RCTs.	None specified	2001 - 2016	Children	Cognition: Executive Functioning (accuracy) Cognition: Executive Functioning (cognitive flexibility) Cognition: Executive Functioning (inhibition) Cognition: Executive Functioning (working memory)	Intervention: Education (via computer)
Tekedere	2016	None	None specified	2010 - 2015	All	Learning: General	Intervention: Augmented reality (in schools)
Tokac	2019	Include: designs with a control group	None specified	2006 - 2016	PreK-12th grade	Numeracy: Mathematics Video games: Educational	Video games: Educational

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
Restrictions							
Vahedi	2018	Include: Interventions (pre-post or controlled). Exclude: Cross-sectional	None specified	2015 - 2016	School-age Children (Middle/High School)	Risky behavior: Media literacy	Intervention: Media literacy (web-based)
						Risky behavior: Risk taking (attitude)	
Vannucci	2020	Exclude: Qualitative; Case studies	None specified	2011 - 2018	Adolescents	Risky behavior: Risk taking (general)	Social Media: General
						Risky behavior: Risky sexual behaviour	
						Risky behavior: Substance abuse	
Wang	2020	Include: longitudinal, cohort, case-control, cross-sectional, or controlled trials	None specified	2016 - 2020	<=18 years	Eye health: Visual impairment	Screen use: General (mobile phone)
Wouters	2013	Include: experimental designs	None specified	2005 - 2012	None specified	Learning: Motivation	Video games: Educational
Wouters	2013	Include: Experimental with control group	None specified	1993 - 2007	None specified	Learning: General	Video games: Educational (with instructional support)
Xie	2018	Include: Experimental; Quasi- experimental; Pre-test post-test	None specified	2010 - 2018	Children	Learning: General	Intervention: Education (via touch screen)

Table 1

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Xie	2018	Include: experimental, quasi-experimental, or pre-post test	None specified	2010 - 2018	0-5	Learning: General	Screen use: Touchscreens
Yin	2019	None specified	None specified	2006 - 2016	None specified	Psychological health: General Psychological health: Positive mental health	Social Media: General
Zhang	2016	Include: Cohort; Case-control; Cross-sectional	None specified	2001 - 2014	Children	Body composition	TV programs and movies; General
Zhang	2022	Include: longitudinal or cohort designs	None specified	2001 - 2021	2-19 years	Psychological health: Other mental health problems	Screen use: General
Zhang	2022	Include: Observational or experimental designs	Mainland China, Hong Kong, Macau and Taiwan	2009 - 2020	6-18 years (or grade 1-12)	Body composition Cardiometabolic health: Poor fitness Risks Eye health: Myopia Physical health: Health Issues Psychological health: Emotion problems	Screen use: General
Zhou	2020	Exclude: Non-empirical studies; Qualitative: Systematic reviews or meta-analyses	None specified	2009 - 2018	All	Healthy behavior: General Healthy behavior: Self-efficacy Psychological health: Enjoyment	Video games: Health promoting content

Review characteristics for studies providing unique effects (continued)

First Author	Year	Design	Regions	Study Range	Sample Age Restrictions	Outcomes Assessed	Exposures Assessed
		Restrictions	Restrictions				
Zou	2021	Include: observational cross-sectional, case-control, or longitudinal designs	None specified	2009 - 2021	<20 years	Psychological health: Depression	Computer use: General Screen use: General
Zucker	2009	Include: Randomised controlled trials; Quasi- experimental; Observational	None specified	1997 - 2006	School-age Children (Primary/Elementary)	Literacy: Decoding Literacy: Reading comprehension	e-Books: General
de Oliveira	2016	Include: Observational	None specified	2010 - 2014	Adolescents	Cardiometabolic health: Metabolic Syndrome	Screen use: General

*

The quality of the included meta-analyses was mixed (see Table 1). Most assessed heterogeneity (n low risk = 110/118, 93% of meta-analyses), reported the characteristics of the included studies (n low risk = 102/118, 86%), and used a comprehensive and systematic search strategy (n low risk = 86/118, 73%). Most reviews did not clearly report if their eligibility criteria were predefined (n unclear = 84/118, 71%). Many papers also did not complete dual independent screening of abstracts and full text (n high risk = 21/118, 18%) or did not clearly report the method of screening (n unclear = 42/118, 36%). A similar trend was observed for dual independent quality assessment (n high risk = 54/118, 46%; n high risk = 28/118, 24%). Overall, only 8 meta-analyses were graded as low risk of bias on all criteria.

Education Outcomes. There were 80 unique effects associated with education outcomes, including general learning outcomes, literacy, numeracy, and science. We removed 20 effects that did not provide individual study-level data, 19 effects with samples < 1,000, and 17 effects with a significant Egger's test or insufficient studies to conduct the test. Effects not meeting one or more of these standards are presented in Supplementary File 5. The remaining 28 effects met our criteria for statistical credibility and are described in Figure 2. These 28 effects came from 19 meta-analytic reviews analysing data from 372 empirical studies with 265,648 individual participants.

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

As shown in Figure 2, most of the credible results (16 of 28 effects) showed statistically

Associations Between Exposures and Education Outcomes

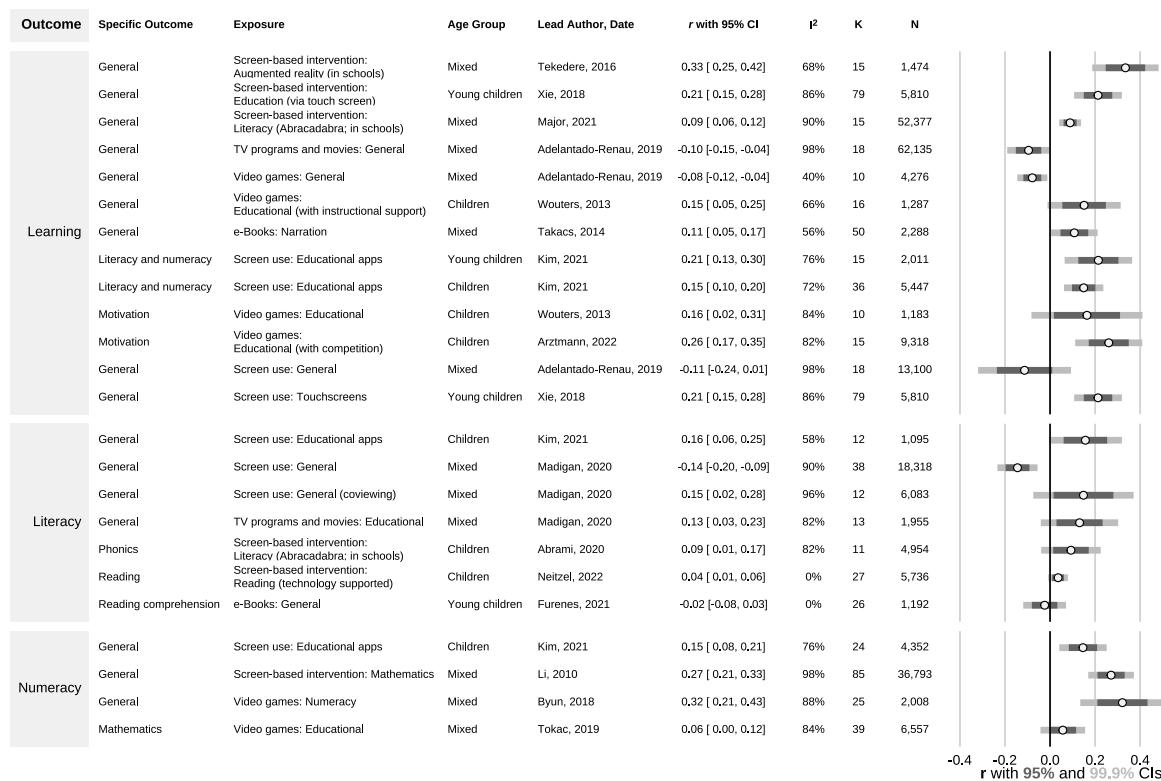


Figure 2. Education outcomes

287 significant associations, with 99.9% confidence intervals not encompassing zero (strong
 288 evidence). The remaining nine associations were significant at the 95% confidence level
 289 (weak evidence). All credible effects related to education outcomes were small-to-moderate.
 290 Screen-based interventions designed to influence an outcome (e.g., a computer based
 291 program designed to enhance learning³¹) tended to have larger effect sizes than exposures
 292 that were not specifically intended to influence any of the measured outcomes (e.g., the
 293 association between television viewing and learning³²). The largest effect size observed was
 294 for augmented reality-based education interventions on general learning
 295 ($r = 0.33, k = 15, N = 1,474$). Most effects showed high levels of heterogeneity (24 of 28
 296 with $I^2 > 50\%$).

297 **Health and Health-related Behaviours.** We identified 195 unique

298 outcome-exposure combinations associated with health or health-related behaviour outcomes.

299 We removed 35 effects that did not provide individual study-level data, 50 effects with

300 samples < 1,000, and 81 effects with a significant Egger's test or insufficient studies to

301 conduct the test. No remaining studies showed evidence of excessive significance. Effects not

302 meeting one or more of these standards are presented in Supplementary File 6. The

303 remaining 40 meta-analytic associations met our criteria for credible evidence and are

304 described below (see also Figure 3). These 40 effects came from 24 meta-analytic reviews

305 analysing data from 449 empirical studies with 1,293,284 individual participants.

Associations Between Exposures and Health-related Outcomes

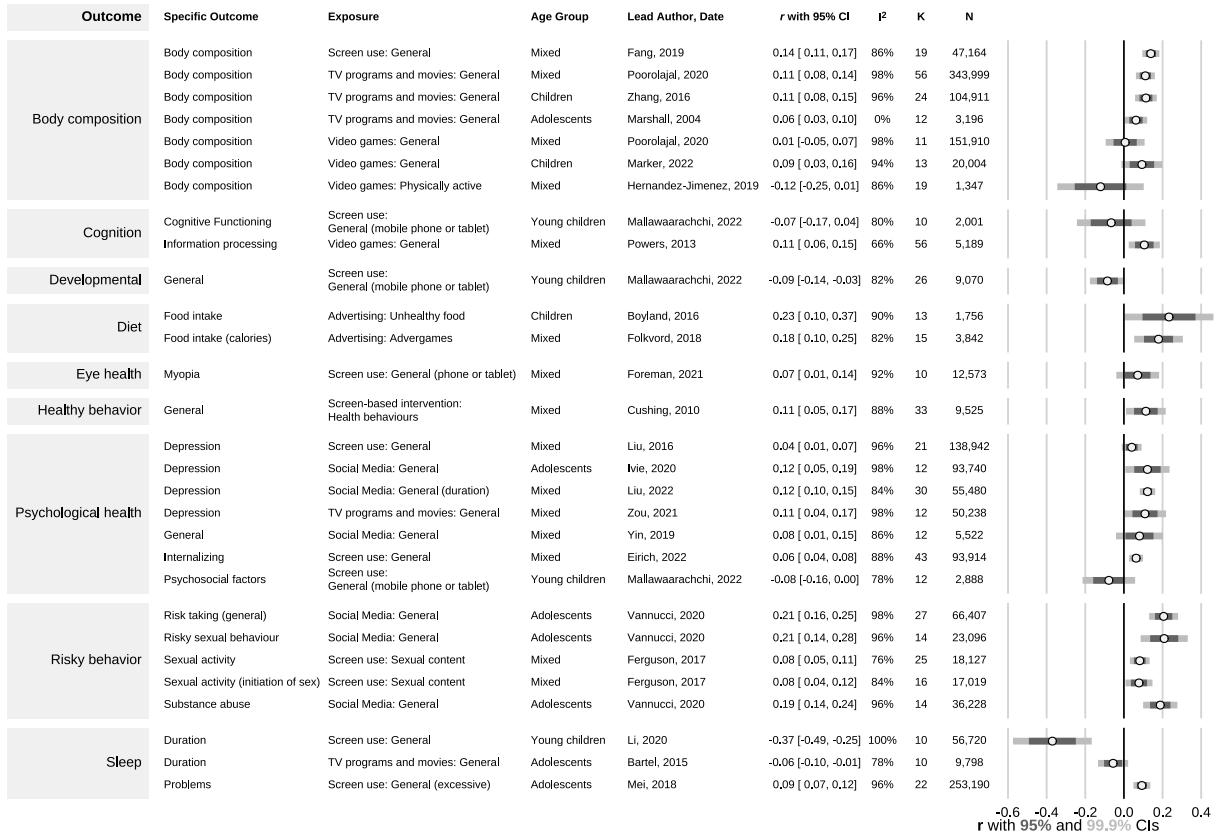


Figure 3. Health and health-related behaviour outcomes

306 Digital advertising of unhealthy foods—both traditional advertising and video games

307 developed by a brand for promotion—were associated with higher unhealthy food intake.

308 Social media use and sexual content were positively associated with risky behaviors (e.g.,
309 sexual activity, risk taking, and substance abuse). General screen use was positively
310 associated with depression, with stronger associations observed for adolescents than other
311 groups. Television viewing was negatively correlated with sleep duration, but with stronger
312 evidence only observed for younger children. All forms of screen use (general, television, and
313 video games) were associated with body composition (e.g., higher BMI). Screen-based
314 interventions which target health behaviours appeared mostly effective.

315 Across the health outcomes, most (25 of 40) effects were statistically significant at the
316 99.9% confidence interval level, with the remaining ten significant at 95% confidence.
317 However, most of the credible effects exhibited high levels of heterogeneity, with all but two
318 having $I^2 > 75\%$. Additionally, most effects were small, with the association between screen
319 use and sleep duration the largest at $r = -0.37$ ($k = 10, N = 56,720$). Most of the effect
320 sizes (36/40) had an absolute value of $r < 0.2$.

321 Discussion

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

328 As an example, consider children watching television programs—an often cited form of
329 screen time harm. We found robust evidence for a small association with poorer academic
330 performance and literacy skills for general television watching³². However, we also found
331 evidence that if the content of the program was educational, or the child was watching the
332 program with a parent (i.e., co-viewing), this exposure was instead associated with better

literacy.³³ Thus, parents may play an important role in selecting content that is likely to benefit their children or, perhaps, interact with their children in ways that may foster literacy (e.g., asking their children questions about the program). Similar nuanced findings were observed for video games. The credible evidence we identified showed that video game playing was associated with poorer body composition and learning.^{32,34} However, when the video game were designed specifically to teach numeracy, playing these games showed learning benefits.³⁵ One might expect that video games designed to be physically active could confer health benefits, but none of the meta-analyses examining this hypothesis met our thresholds for statistical credibility (see Supplementary Files 5 & 6) therefore this hypothesis could not be addressed.

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

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

Largely owing to a small number of studies or missing individual study data, there

359 were few age-based conclusions that could be drawn from reviews which met our criteria for
360 statistical certainty. If we expand to include those reviews which did not meet this threshold,
361 there remained no clear pattern although there were some age-specific differences in
362 associations (data available in Supplementary Materials). For example, advertising of
363 unhealthy food was associated with unhealthy food choice for young children, but was not
364 statistically significant for other age groups.⁴¹ Conversely, TV programs and movies were
365 more strongly associated with lower physical activity for adolescents than for younger age
366 groups.⁴²

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

372 Implications for Policy and Practice

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

382 Implications for Future Research

383 Screen use research is extensive, varied, and rapidly growing. Reviews tended to be
384 general (e.g., all screen time) and even when more targeted (e.g., social media) nuances
385 related to specific content (e.g., Instagram vs Facebook) have not been meta-analysed or
386 have not produced credible evidence. Fewer than 20% of the effects identified met our
387 criteria for statistical credibility. Most studies which did not meet our critiera failed to
388 provide study-level data (or did not provide sufficient data, such as including effect estimates
389 but not sample sizes). Newer reviews were more likely to provide this information than older
390 reviews, but it highlights the importance of data and code sharing as recommended in the
391 PRISMA guidelines.⁴⁶ When study level data was available, many effects were removed
392 because the pooled sample size was small, or because there were fewer than ten studies on
393 which to perform an Egger's test. It seems that much of the current screen time research is
394 small in scale, and there is a need for larger, high-quality studies.

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

400 Screen time research has a well-established measurement problem, which impacts the
401 individual studies of this umbrella review. The vast majority of screen time research relies on
402 self-reported data, which not only lacks the nuance required for understanding the effects of
403 screen time, but may also be inaccurate. In one systematic review on screen time and sleep,⁷
404 66 of the 67 included studies used self-reported data for *both* the exposure and outcome
405 variable. It has been established that self-reported screen time data has questionable
406 validity. In a meta-analysis of 47 studies comparing self-reported media use with logged
407 measures, Parry et al⁴⁷ found that the measures were only moderately correlated ($r = 0.38$),

408 with self-reported problematic usage fairing worse ($r = 0.25$). Indeed, of 622 studies which
409 measured the screen time of 0—6 year-olds, only 69 provided any sort of psychometric
410 properties for their measure, with only 19 studies reporting validity.⁴⁸ While some
411 researchers have started using newer methods of capturing screen behaviours—such as
412 wearable cameras⁴⁹ or device-based loggers⁵⁰—these are still not widely adopted. It may be
413 that the field of screen time research cannot be sufficiently advanced until accurate,
414 validated, and nuanced measures are more widely available and adopted.

415 **Strengths and Limitations**

416 Our primary goal for this umbrella review was to provide a high-level synthesis of
417 screen time research, by examining a range of exposures and the associations with a broad
418 scope of outcomes. Our results represent the findings from 3,103 primary studies comprised
419 of 3,141,213 participants. To ensure findings could be compared on a common metric, we
420 extracted and reanalysed individual study data where possible.

421 Our high-level approach limits the feasibility of examining fine-grained details of the
422 individual studies. For example, we did not examine moderators beyond age, nor did we rate
423 the risk of bias for the individual studies. Thus, our assessment of evidence quality was
424 restricted to statistical credibility, rather than a more complete assessment of quality (e.g.,
425 GRADE⁵¹). As such, we made decisions regarding the credibility of evidence, where others
426 may have used different thresholds or metrics. For this reason, we provide the complete
427 results in the supplementary material, along with the dataset for others to consider
428 alternative criteria. Our high-level approach also means that we could not engage with the
429 specific mechanisms behind each association, and as such, we cannot comment on the
430 evidence for causality. Instead, readers who wish to more deeply understand one specific
431 relationship are directed to the cited review for that effect, where the authors could engage
432 more deeply with the mechanisms. In addition, reviews provide only historical evidence
433 which may not keep up with the changing ways children can engage with screens. While our

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

437 **Conclusions**

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

449

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