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Screen on = development off? A systematic scoping review and a developmental psychology perspective on the effects of screen time on early childhood development

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Research on the associations between screen time and child development suggests that various forms of screen time might pose a risk for various aspects of child development. However, data on the impact of exposure to screen media on the development of children under 3 years of age is comparatively scarce. Although the evidence available on the topic is evolving rapidly, no review of existing literature has yet encompassed a comprehensive set of developmental outcomes with a focus in the first 3 years of life. To address this research gap, the present literature review focused on the influences of screen time on various developmental outcomes of children aged zero to 36 months. These outcomes were sleep-related parameters, physical health, cognition, learning efficiency, language, motor skills, socio-emotional skills, social interaction, and overall development. To this end, ten databases were searched systematically, and 158 studies that were published between the launch of the iPhone in early 2007 until 2024 were included. Only studies that reported specific results for the age range of zero to 36 months were examined, including longitudinal studies with samples of children aged zero to 36 months at the first wave of assessment. For most outcomes, a comparable amount of undesirable and non-significant associations was found with children's screen time, while few desirable associations were reported. In line with the notion of resilience, these results indicate that characteristics of the child, the context, and/or the content moderate the associations between screen time and child development in early childhood, thus contributing to mitigating the potential of displacement of learning opportunities or even creating new learning opportunities. More studies with designs that can examine the causal effect of screen time on child development and that explicitly address the role of child, content, and context variables are needed.

KEYWORDS

screen time, early child development, review, scoping analysis, moderation, mediation

Introduction

Screen time in early childhood

Advances in empirical science have shown that early childhood is a particularly sensitive time for experiences that promote development (Black et al., 2017; Britto et al., 2017). Moreover, research indicates that promoting healthy development in early childhood has long-term benefits, not only from a medical and psychosocial point of view but also from an economic one, as early childhood has been shown to provide the greatest return on investment (Doyle et al., 2009; Heckman, 2011; Shonkoff et al., 2017). Thus, it is important to identify opportunities and risks of societal changes to early childhood development to best address them.

One such societal change is digitalization. Various studies highlighted a significant increase in screen media availability in households with young children over the past decade (Bernath et al., 2020; Kieninger et al., 2021; Rideout and Robb, 2020). This widespread availability is believed to contribute to increased usage of both foreground and background screen media among young children (Golden et al., 2020; Rodrigues et al., 2020). A study of 9–11-year-olds that was carried out in Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, the United Kingdom, and the United States reported that more than half of the sample failed to meet screen time guidelines (LeBlanc et al., 2015). The authors reported that average screen time (i.e., average TV hours plus average gaming and computes hours per day) varied from 1.8 h ($SD = 1.3$) in India, to 3.7 h ($SD = 2.3$) in Brazil. Indeed, children worldwide spend significant time with screens, with average daily screen time increasing as children age. By age seven, children have spent a full year of 24-h days watching screen media and are spending up to 3 years of 24-h days watching screen media by age 18 (Sigman, 2012).

In the US, children under two spend 49 min per day in front of a screen, mainly watching TV or videos/DVDs. Children aged two to four spend an average of 2.5 h a day with a screen, also mostly watching TV, videos, and DVDs (Rideout and Robb, 2020). Thus, children start using screen media from very early in life (Chonchaiya et al., 2011; Lawrence et al., 2020; Levine et al., 2019; Nathanson et al., 2014; Richert et al., 2010; Yang et al., 2017). The combination of the importance of (A) early childhood for lifelong development (Black et al., 2017; Britto et al., 2017) and (B) the increasing availability of and exposure to screens during early childhood, has led to increasing concerns about the impact of young children's screen time on various aspects of their development (Bleckmann et al., 2022). However, there are also studies that suggest that there worries in this regard might not be based on empirical data (Ferguson et al., 2024). To outline the relevance of the topic at hand, we will provide both a theoretical and empirical overview of the correlates of screen time in the following sections.

Theoretical perspective on the effects of screen time on child development

Some of the most central hypotheses about the effects of screen time on child development are outlined in the following. These hypotheses lack specificity as to which developmental aspect is likely to be affected. In fact, most hypotheses can be used to draw inferences about the effects of screen time on multiple interdependent aspects of child development.

The learning hypothesis (Bandura, 1994, 2001) and information processing theory (Huesmann, 1986) both support the idea that screen media can be a source of learning for children. On the one hand, exposure to a video displaying violent acts can lead a child to imitate such behaviors, as shown in the classic Bobo doll experiment (Bandura et al., 1961). On the other hand, screen media can also be a source of educational content, teaching children about numbers, letters, colors, and shapes (Anderson et al., 2001; Singer and Singer, 2001; Shin, 2004), along with more complex skills such as songs or prosocial behaviors, especially from content designed to be educational and informative.

The video deficit hypothesis (Barr, 2008; Anderson and Pempek, 2005) suggests that while young children can learn from screen media, they tend to be less effective at doing so compared to learning from real-life experiences. According to the video deficit hypothesis, young children are generally less effective at learning from screen media compared to real-life experiences (Barr and Wyss, 2008; Nielsen et al., 2008). The diminished learning from videos is attributed to the absence of important elements that facilitate information processing, including socially relevant signals, the direction of gaze, and the integration of visual, auditory, and spatial information that are present in live interactions (Jing and Kirkorian, 2020).

The displacement hypothesis (Mutz et al., 1993; Roberts et al., 1993) postulates that screen media would displace vital activities that are crucial for a child's healthy development. For example, the hours spent in front of a screen could otherwise be spent on interactions with parents, caregivers, and peers, which are key to developing socio-emotional abilities. As such, a rise in screen time among children is believed to potentially hinder their development by displacing these critical learning experiences (Oswald et al., 2020).

Furthermore, the mental-effort hypothesis (Koolstra and van der Voort, 1996) and the passivity hypothesis (Valkenburg and van der Voort, 1994) argue that passive engagement with screen media, such as television or videos, causes passivity in children. The mental-effort hypothesis (Koolstra and van der Voort, 1996) suggests that such passive use of screens could lead to a decrease in mental engagement. Similarly, the passivity hypothesis (Valkenburg and van der Voort, 1994) posits that the cognitive demands of processing information from passive screen use are lower compared to more active tasks such as reading. The fast pace of many programs may provide limited opportunities for deep thinking, which could hinder the development of critical and reflective thinking processes in children.

These hypotheses about potential negative consequences of too early consumption of screen media are reflected in some of the guidelines for parents. For example, in 2019, the World Health Organization (WHO) published recommendations for physical activity, sedentary activities, and sleep for children up to the age of 5 years (World Health Organization, 2019). For children younger than 2 years of age, sedentary screen time is discouraged entirely, and from 2 to 4 years of age, a maximum duration of sedentary screen time of 60 min per day is recommended, with the recommendation that less is better. Furthermore, the WHO emphasizes that its recommendations are based on a sparse and qualitatively very low evidence base: "The overall quality of evidence was rated as very low" (p. 8).

Empirical perspective on the effects of screen time on child development

In recent years, several literature reviews and meta-analyses have addressed the effects of young children's screen time on early childhood development (Stiglic and Viner, 2019). The vast majority of findings reported in these reviews and meta-analyses suggest that young children's screen time has undesirable associations with sleep-, body- and fitness-related parameters and on children's socio-emotional skills (Janssen et al., 2020; Mallawaarachchi et al., 2022; Puzio et al., 2022; Ren, 2023; Swider-Cios et al., 2023; Paulus et al., 2021), and the links between young children's screen time and their cognitive, language, and motor outcomes range from undesirable through insignificant to desirable (Mallawaarachchi et al., 2022; Puzio et al., 2022; Ren, 2023; Swider-Cios et al., 2023; Paulus et al., 2021; Guellai et al., 2022; Karani et al., 2022), as is outlined in the following.

Regarding sleep, Lund et al. (2021) reviewed 49 studies investigating the associations between electronic media use and sleep in children aged 0 to 15 years across European countries. They concluded that the evidence for an undesirable link to various sleep parameters, such as sleep duration, delayed bedtime, or sleep quality, was stronger among school-aged children compared to preschool children. In preschool children, televiewing appeared to be associated with less desirable sleep parameters, while evidence regarding the potential effects of video gaming, smartphone use, or the presence of media in the bedroom was deemed insufficient.

Several systematic reviews and meta-analyses indicated a potential for a negative impact of screen time on language development in early childhood. For instance, Massaroni et al. (2024) highlighted the risk of prolonged screen time on language. Further, Karani et al. (2022) emphasizes the multifactorial nature of this relationship, with the negative influences of screen time outweighing the positive. However, Madigan et al. (2019) also notes that the quality of screen use, such as educational programming and co-viewing, can have a positive impact on language skills. This suggests that while screen time should be limited, the type of content and the context of use can also play a role in language development.

Similarly, various literature reviews indicate that excessive screen time in early childhood increases the risk of undesirable associations with cognitive development, including language acquisition, attention, and learning (Kostyrka-Allchorne et al., 2017; Panjeti-Madan and Ranganathan, 2023). Again, the impact of screen time on cognition is influenced by contextual factors such as the behavior of adult caregivers, the content being viewed, and the interactivity of the screen (Guellai et al., 2022). Therefore, while some studies suggest the potential for a desirable link, the consensus is that excessive screen time can be detrimental to cognitive development in early childhood.

Research on early childhood screen time and its impact on socio-emotional development is mixed. In their systematic review, Panjeti-Madan and Ranganathan (2023) conclude that screen time can have both benefits and drawbacks for socio-emotional development. Results of a meta-analysis by Eirich et al. (2022) reveal that screen time is significantly but only weakly related to both internalizing and externalizing problems among children aged up to 11 years. Lissak (2018) further emphasizes the adverse physiological and psychological correlates of excessive screen time, including depressive symptoms and ADHD-related behavior.

Several of reviews on the correlates of screen time on child development have been published (Mallawaarachchi et al., 2022; Ren, 2023; Swider-Cios et al., 2023; Guellai et al., 2022; Karani et al., 2022; Lissak, 2018). However, these reviews mostly focused on selected developmental outcomes and do not provide insight into the overall impact of screen time across a wide range of developmental domains, including motor skills, cognitive skills, and socio-emotional skills. The inclusion of a broad range of development outcomes is crucial, as it has been shown that the different areas of development are interrelated and influence one another (Thelen and Smith, 2006). Furthermore, the age range considered in these reviews varies greatly, with some covering ages zero to three and others spanning from birth to late childhood or even adolescence. Additionally, the study design was not consistently addressed in some of these reviews. Thus, a review on studies about the correlates of all types of traditional and modern screen media on a comprehensive range of children's development in the first 3 years of life and addresses the study design of these studies is still missing.

The current study

The aim of the present study was thus to give an overview about the associations between screen time and multiple aspects of child development in the first 3 years of life. Herein, we aimed to consider both traditional and modern screen devices and to differentiate the results by study design. A review that covers all these aspects is necessary for three main reasons: First, rapid and crucial neural development takes place in the first 3 years of life, and this can have effects on other areas of development. Second, the technological development that has taken place since the invention of portable and smart devices has opened new possibilities that go far beyond passive, socially isolated television, and thus modern digital media cannot be assumed in principle to equate with television, especially for child development. Although young children may not fully grasp all aspects or functions of interactive devices, their experiences might still differ from traditional television, as even in instances where a child lacks understanding, they may still be learning. Third, the study design of the studies needs to be taken into consideration to enable more differentiated implications to be identified for parents, practitioners, researchers, and policy makers.

Regarding the time frame under consideration, we focused on studies published since 2007 because 2007 marked the release of the first iPhone, which revolutionized screen-based technology. By selecting this period, our review builds on earlier literature that primarily examined traditional screen media, such as television, and extends the focus to more recent developments in digital media use. Consequently, we posed two research questions for the present literature review: How is children's screen time with traditional and modern devices related to a broad range of developmental outcomes in the first 3 years of life? What are the prevailing methodological approaches and considerations in this specific field of research? To address these questions, we conducted a systematic scoping review by combining a scoping review with a systematic literature review. The characteristics of a scoping review include the non-systematic assessment of the quality of the studies, for instance using scoring grids, and thus incorporate all the empirical quantitative studies available regardless of their quality (Grant and Booth, 2009). In contrast, the characteristics of a systematic review include the systematic search and inclusion of evidence, such as inclusion and exclusion criteria, and the systematic evaluation of methodological approaches of the studies included (Grant and Booth, 2009). By combining these two approaches, the scope of quantitative research on this topic can be presented and critically evaluated methodologically.

Methods

Protocol

PRISMA-ScR guidelines for reporting scoping reviews (Tricco et al., 2018) were followed when preparing this manuscript (see Supplementary Table S.2).

Eligibility criteria

To be included in this review, studies had to fulfill five criteria (for further details see Supplementary Table S.3): (A) Studies had to be published between January 2007 and October 2024. This start date was chosen because the iPhone 1 was first presented by Apple on January 9th 2007; we take this date as marking the beginning of a revolution in the concept of digital media (Block, 2007). (B) The study sample had to include children between birth and 36 months of age, without clinical diagnoses, and from parents no younger than 18 years of age. For multiple age groups within a study, results needed to be reported specifically for the age group of birth to 36 months of age. In longitudinal studies, children needed to be the age of interest at the first measurement time point. (C) The study had to include an assessment of screen usage including time, content, and/or context. (D) The studies needed to include a measurement of at least one developmental outcome, such as sleep, physical health and diet, cognition, language, learning efficiency, motor skills, socio-emotional development, social interaction, or overall development. (E) The relationship between children's screen use and their development had been examined with quantitative research methods in an experimental, longitudinal, or cross-sectional study design. The study had to be an original study. Meta-analyses and reviews were excluded.

Search strategy and information sources

Four rounds of literature search were conducted. The first round was carried out on October 23, 2019, when ten databases were searched for peer-reviewed articles published between 2007 and 2019: PsycInfo, PsycArticles, PsycExtra, Psyndex, Medline, MIDIRS, ERIC, Web of Science, PubPsych, and PubMed. The keywords for this search were divided into three groups (see Table 1). The first group consisted of keywords that identified the age range of interest, and the second group, linked to the first block with "AND," included keywords that identified the behavior of interest, use of digital media. Finally, the third group, linked to the second block with "NOT," included keywords that would exclude irrelevant studies as efficiently as possible. A second round of literature search for peer-reviewed articles published between 2007 and 2019 was carried out on May 10th, 2021, because additional crucial keywords were identified during the review of the first batch of studies (e.g., DVD). A new set of keywords was used as a replacement for the second group of keywords. Four databases were systematically searched: PsycInfo, Medline, PubPsych, and Web of Science. Initial exploratory searches revealed that the remaining six databases primarily generated duplicates. In the third round of literature search, also conducted on May 10th, 2021, we compiled all keywords and searched for peer-reviewed articles published between 2019 and May 10th 2021 in PsycInfo, Medline, PubPsych, and Web of Science to ensure that the search results would be up to date. The fourth and final round of literature search was conducted on October 25th, 2024, we used the compiled keywords and searched for articles published between May 11th 2021 and October 25th, 2024 in PsycInfo and Medline. All searches were performed on the titles of articles. The full search strategy is provided in Supplementary Table S.5. Additional studies were identified by reviewing the reference lists of the key articles.

Selection process

The articles identified by the four search rounds were imported into the Zotero literature management software, and most duplicates were automatically deleted. Titles and abstract were then screened by two independent raters and remaining additional duplicates were deleted. Two undergraduate students assisted in this process. Articles found to be relevant in this initial screening were subsequently subjected to full text screening to determine final eligibility for inclusion in the review synthesis. Disagreements about study inclusion among reviewers were resolved through consultation of criteria in the protocol and critical discussion among the authors.

Data items

To interpret the results for various outcomes, studies identified by final screening were grouped into nine main developmental categories: sleep, physical health, cognition, learning efficiency, language, motor skills, socio-emotional skills, social interaction, and overall development. This final category included studies that

TABLE 1 Blocks of keywords.

Block of keywords	Keywords
1st Block: Age range of interest	(child$4 OR baby OR babies OR kid$1 OR infant* OR toddler* OR pre-school* OR preschool*).ti **AND**
2nd Block: Behavior of interest	(screen-time OR screen-use OR screen-view$3 OR media-use OR mobile-time OR media-time OR screen-based-media OR screen-media OR digital-media OR digital-play OR media-exposure OR tablet-use OR television-view$3 OR TV-view$3 OR television-watch$3 OR tv-watch$3 OR touch-screen$1 OR smart-phone* OR mobile-device$1 OR computer$1 OR PC$1 OR gaming OR video-gam$3).ti **NOT**
3rd Block: Exclusion of non-relevant studies	(malaria OR infection OR disease OR allergic OR diabet* OR cancer OR tumor OR asthma OR otitis media OR chronic medical conditions OR intima-media thickness OR heart disease OR cerebral palsy OR visual impair* OR hearing impair* OR hearing loss OR intellectual disabilit* OR disabilit* OR spinal muscular atrophy OR amblyopia OR cleft OR pharmacokinetics OR HIV OR autism spectrum disorder OR autism OR ASD OR ASC OR cognitive behavior* therapy OR compensatory training OR PTSD OR posttraumatic stress reaction OR trauma* OR assessment OR computer-aided OR computer-assisted OR computer-simulation OR computer-based OR computer-analysis OR computer-mediated OR non-contact monitoring OR automated OR computerized OR computer algorithm OR screening OR treatment OR computer tomography OR online surveillance OR sex offenders OR world cup OR wrestling OR Olympics).ti
New set of keywords: Behavior of interest	(background-media-exposure OR digital-games OR digital-media OR digital-screen-media OR DVD OR electronic-application-use OR handheld-screen-time OR media OR media-exposure OR media-use OR media-viewing OR mobile-media-use OR interactive-media-use OR mobile-screen-media-use OR screen-media-content OR screen-media-exposure OR screen-media-use OR screen-based-media OR video OR sedentary behavior).ti

Ti, title; the search for keywords was performed on the title.

described an overall development status as outcome. Further, the category of learning efficiency is a research branch of cognitive development. Given that this research branch is characterized by homogeneous experimental studies, it was analyzed separately. This review sample also included studies that examined other learning transfers from screens, such as word learning. Although these studies could have been included in the cognition category, we included them in the specific developmental area, such as language development. Furthermore, subcategories were defined where appropriate: for example, for cognition we subcategorized studies into general cognition, attention, executive functions, and other cognitive outcomes. An overview of the subcategories of these development areas can be found in Supplementary Table S.7.

Results

Figure 1 shows the PRISMA flowchart for study inclusion. An overview of all included studies is provided in Supplementary Table S.1.

Results are reported for nine development categories: (1) sleep, (2) physical health, (3) cognition, (4) learning efficiency, (5) language, (6) motor skills, (7) socio-emotional skills, (8) social interaction, and (9) overall development. The specific aspects that are subsumed to these categories are outlined in the results section of the respective developmental category. For each developmental category, we aimed to differentiate between experimental and correlational studies. Further, we divided studies with a correlational design, but not those with an experimental design to differentiate between correlational studies with a longitudinal and those with a cross-sectional design. In this review, the term "semi-longitudinal studies" is used for correlational studies that are longitudinal in nature but that measured the outcome variable only at one time point, usually the last one. In such cases, the baseline measurement for the outcome of interest is lacking, and thus no modeling of change in the outcome variable can be done. Cross-sectional findings reported in longitudinal studies are described in the cross-sectional studies section. Thus, the results of the studies are arranged in the following order: (1) experimental studies, including both longitudinal and cross-sectional designs, (2) correlational longitudinal studies, (3) correlational semi-longitudinal studies, and (4) correlational cross-sectional studies.

For some of the developmental categories, subcategories are presented separately (e.g., bedtime and sleep latency as subcategories of sleep), as associations vary among subcategories and must therefore be differentiated. An overall summary can be found after the presentation of the results for each developmental category. Herein a table showing the counts of all undesirable (–), non-significant (=), and (+) desirable associations that were reported in the studies (see Table 2 for an example).

The studies included in this review used a wide variety of terms for screen time: TV watching, televiewing, media exposure, screen exposure, viewing time, total screen time, touchscreen time, and foreground or background screen time; this variety indicates both the diversity of screen experiences for children and the complexity of screen time as a construct. The reporting of results uses the terms cited in the studies whenever possible. However, definitions of the same terms may vary across studies. For example, the term "total media exposure" may be understood as the sum of foreground and background screen time in one study and as total foreground screen time on various devices in another. The same issue applies to the variety of screen devices, which is why we adopt the terminology of the study in question whenever possible.

Sleep

Studies on the association between screen time and sleep-related parameters ($n = 23$) are reported in the following sections. One study was included even though the age range was up to 37 months instead of 36 (Hackl-Wimmer et al., 2021).

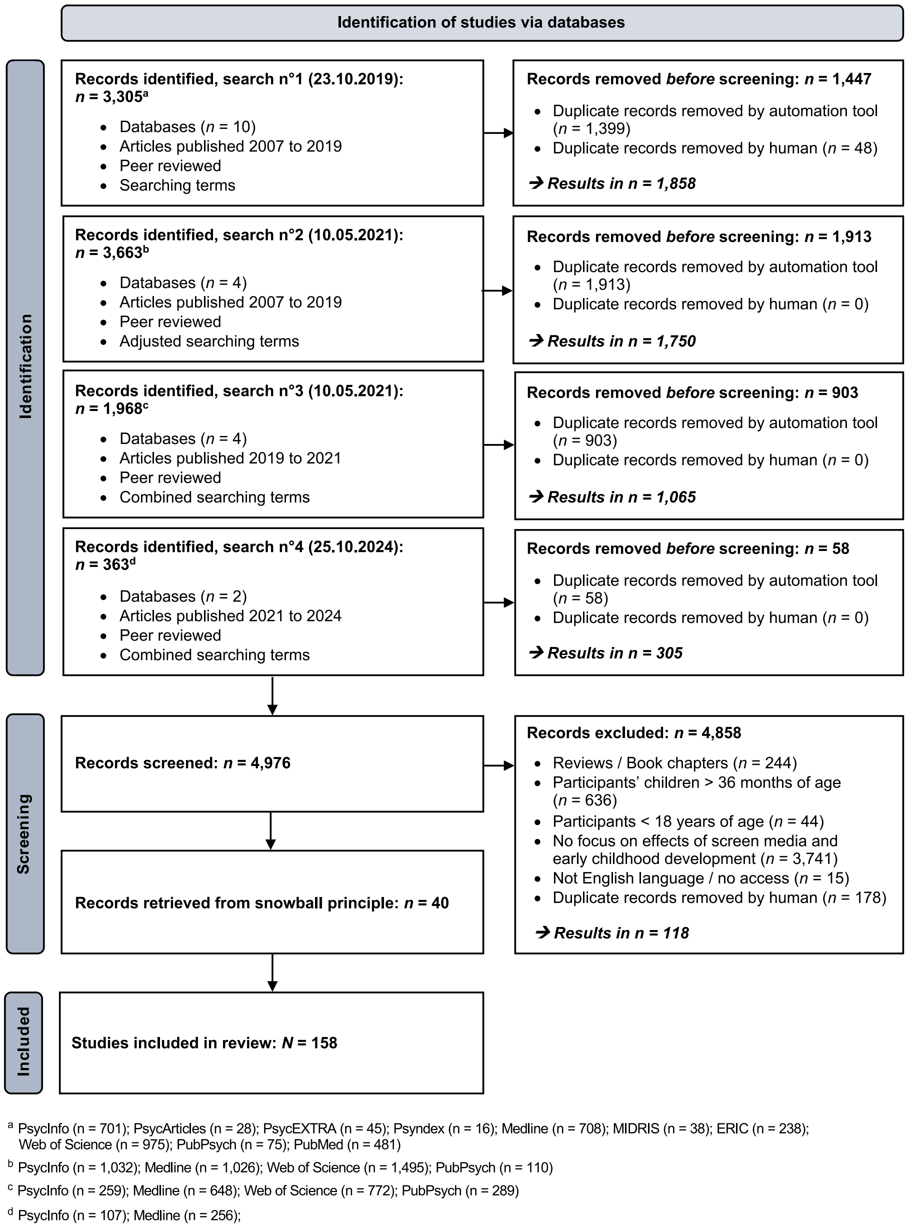

FIGURE 1
PRISMA flowchart of study selection.

TABLE 2 Sample summary of results.

Development area/ subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Outcome A	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*
Outcome B	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*
Total for outcome	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*

"−," undesirable association; "=," non-significant association; "+," desirable association; n, number of results.

Bedtime

Bedtime refers to the time when the child goes to bed. If bedtime is delayed due to screen time, this would indicate an undesirable correlate of screen time. A longitudinal study yielded an undesirable link between total screen time (Xu et al., 2016), and cross-sectional studies also found support for an undesirable association with screen time (Bellagamba et al., 2021) and TV viewing (Dong et al., 2015). No desirable associations were reported in any study. Neither experimental studies nor semi-longitudinal assessments were found that included bedtime.

Sleep latency

Sleep latency, or sleep onset latency, is the length of time someone takes to fall asleep. Increased children's sleep latency would be an undesirable correlate of children's screen time. One experimental study found no effects of a reduction of before bedtime screen time on sleep onset latency (Pickard et al., 2024). One longitudinal study pointed to undesirable correlates of screen time (Xu et al., 2016), but others found no significant associations with total media exposure, total viewing time, evening media use, onset of media use (Chonchaiya et al., 2017), or screen time (Benita et al., 2020). Results from cross-sectional studies and from cross-sectional components of longitudinal studies hint at undesirable associations with total screen time (Chonchaiya et al., 2017), screen time (Xu et al., 2016), time with portable screen devices (Cheung et al., 2017; Chindamo et al., 2019), and time spent watching adult programs (Chonchaiya et al., 2017). Shorter sleep latency was found to be linked to more screen use during bedtime routine but not to pre-bedtime screen use (Staples et al., 2021). Non-significant cross-sectional associations were found with overall digital media use including audio media (Hackl-Wimmer et al., 2021), time spent watching educational and non-educational programs targeted at children (Chonchaiya et al., 2017) and with TV exposure (Cheung et al., 2017). No experimental studies and no semi-longitudinal studies were found that included sleep latency.

Total sleep duration

Total sleep duration refers to the amount of time children spend sleeping during a 24 h period. Increased total sleep time as an association with screen time would indicate a desirable association. Longitudinal studies showed negative effects for total screen time (Xu et al., 2016), and TV viewing time (Cespedes et al., 2014; Marinelli et al., 2014). Cross-sectional findings yielded undesirable associations with television watching time (Marinelli et al., 2014; Twenge et al., 2019; Diler and Başkale, 2022), use of portable screen devices (Cheung et al., 2017; Chindamo et al., 2019; Twenge et al., 2019; Diler and Başkale, 2022), screen use during bedtime routine but not pre-bedtime screen use (Staples et al., 2021), and composite scores of screen time (Diler and Başkale, 2022; Chen et al., 2019). Non-significant cross-sectional associations were found with overall digital media use (Hackl-Wimmer et al., 2021), tablet use (Porter et al., 2022), onset of media use (Chonchaiya et al., 2017), duration of media exposure (Chonchaiya et al., 2017; Chen et al., 2019; Cartanya-Hueso et al., 2021), and TV exposure (Cheung et al., 2017). No desirable associations were reported in any study. No experimental studies and no semi-longitudinal studies were found that included total sleep duration.

Nighttime sleep duration

An experimental study found that reducing screen time before bed had no impact on the duration of nighttime sleep (Pickard et al., 2024). Two longitudinal studies found an undesirable effect of total screen time (Xu et al., 2016; Benita et al., 2020), and another one reported a non-significant effect (Vijakkhana et al., 2015). However, cross sectional results from a semi-longitudinal study showed that bedtime TV viewing was linked to shorter nighttime sleep duration among a sample of Medicaid-eligible racial/ethnic minorities (Miller et al., 2022). Results from cross-sectional studies indicate a negative link with tablet use (Porter et al., 2022), total screen time (Xu et al., 2016; Bellagamba et al., 2021; Vijakkhana et al., 2015), and touchscreen time (Cheung et al., 2017), while non-significant associations were found with overall digital media use (Hackl-Wimmer et al., 2021), onset of media use (Chonchaiya et al., 2017), duration of media exposure (Chonchaiya et al., 2017), bedroom media use (Vijakkhana et al., 2015), and TV exposure (Cheung et al., 2017). No desirable associations were reported in any study. No semi-longitudinal studies were found that included nighttime sleep duration.

Daytime sleep duration

An experimental study indicated that cutting down on screen time before bed had a minimal and non-significant effect on daytime sleep duration (Pickard et al., 2024). In cross-sectional studies, undesirable links were reported for TV exposure (Cheung et al., 2017), and non-significant associations were found with onset of media use (Chonchaiya et al., 2017), duration of media exposure (Chonchaiya et al., 2017), and touchscreen time (Cheung et al., 2017). No desirable associations were reported in any study.

Nighttime awakenings

Nighttime awakenings refer to how often a child wakes during the night. An increased number of nighttime awakenings would indicate an undesirable association with screen time. An experimental study indicated that cutting down on screen time before bed had a minimal and non-significant effect on nighttime awakenings as well as sleep efficiency, although sleep efficiency and to some degree also nighttime awakenings changed in a desirable direction for the intervention group that not only received a bedtime box but also was instructed to reduce before-bedtime screen time (Pickard et al., 2024). A single longitudinal study showed an undesirable effect for total screen time (Xu et al., 2016). Cross-sectional results indicate undesirable links with total screen time (Xu et al., 2016) and non-significant associations with onset of media use (Chonchaiya et al., 2017), duration of media exposure (Chonchaiya et al., 2017), TV exposure (Cheung et al., 2017), and touchscreen time (Cheung et al., 2017). No desirable associations were reported in any study. No semi-longitudinal studies were found that included nighttime awakenings.

Sleep problems

This section includes results from studies in which sleep problems were assessed more broadly using a specific sleep-related questionnaire such as the Children's Sleep Habits Questionnaire. Indications of worsening sleeping problems were reported in a study that assessed sleep problems at ages two and 3 years but only assessed screen use at age three (Genuneit et al., 2018). One semi-longitudinal study found that children who watched more than 2 h of TV both around the age of 30 months and at 5.5 years had more sleep problems at 5.5 years (Mistry et al., 2007), but another identified no association between increased TV exposure and adult TV programs with sleep problems at age 18 months (Chonchaiya et al., 2015). Cross-sectional results from a semi-longitudinal study showed bedtime TV viewing was associated with more sleep problems in Medicaid-eligible racial/ethnic minority children (Miller et al., 2022). Cross-sectional studies suggest undesirable links to pre-bedtime as well as bedtime routine screen use (Staples et al., 2021), TV and DVD watching (Genuneit et al., 2018; Chonchaiya et al., 2015), and other computer or internet use, but not to computer gaming (Genuneit et al., 2018), and touch screen usage (Lin et al., 2020), as well as between tablet use and parental concerns about their children's (Porter et al., 2022). Further, bedtime routine screen use was found to be linked to potential indicators of sleep problems such as sleep timing and variability but not to sleep activity or consolidation, and pre-bedtime screen use was found to be linked to sleep timing but not to sleep variability, consolidation, or activity (Staples et al., 2021). An undesirable association was also found between overall digital media use (including audio media) and heart rate during sleep (Hackl-Wimmer et al., 2021). However, it should be noted that some of these indicators are not necessarily considered sleep problems on their own, whereas a combination of multiple such indicators may provide a more robust indication of a sleep problem (Staples et al., 2021). No desirable associations were reported in any study.

Methodological considerations

Most sleep-related outcomes were assessed with parent-reported data collected in questionnaires. One study combined parent-reported data and actigraphs (Pickard et al., 2024; Staples et al., 2021), portable sensing devices assessing heart rate (Hackl-Wimmer et al., 2021), and another study used a 1-week sleep diary (Vijakkhana et al., 2015). Most studies assessed screen time from one-time parent reports (i.e., single retrospective assessment) with varying time frames of reference. Some studies used a single 24-h recall (Bellagamba et al., 2021; Chonchaiya et al., 2017; Vijakkhana et al., 2015) or a screen time diary (Pickard et al., 2024), whereas others assessed screen time for an average weekday and weekend day and then computed an average score for screen time (Hackl-Wimmer et al., 2021; Benita et al., 2020; Cespedes et al., 2014; Diler and Başkale, 2022; Chen et al., 2019; Cartanya-Hueso et al., 2021). Many studies relied on categorization procedures to examine the links between screen time and outcomes (Chonchaiya et al., 2017; Chindamo et al., 2019; Marinelli et al., 2014; Vijakkhana et al., 2015; Genuneit et al., 2018; Mistry et al., 2007; Hu et al., 2019). Extreme-group comparisons were also used in some studies to show the effects of extreme scores of screen time (Chindamo et al., 2019; Cespedes et al., 2014; Mistry et al., 2007). Moreover, several studies focused only on TV and DVD (Dong et al., 2015; Cespedes et al., 2014; Marinelli et al., 2014; Miller et al., 2022; Mistry et al., 2007; Chonchaiya et al., 2015; Hu et al., 2019), whereas one study assessed only touch screen use (Lin et al., 2020) and one focused on tablet use (Porter et al., 2022). Some studies considered the content of screen time as a predictor (Chonchaiya et al., 2017; Vijakkhana et al., 2015; Chonchaiya et al., 2015) and another considered the context in which screen time occurs (Bellagamba et al., 2021). Although some studies took parental involvement in children's activities (Mistry et al., 2007) and outdoor playtime into account (Xu et al., 2016), other non-digital activities were not taken into account in most studies. Further, few studies took active play or another indicator of physical activity into account (Cespedes et al., 2014; Marinelli et al., 2014; Twenge et al., 2019; Cartanya-Hueso et al., 2021; Hu et al., 2019).

Summary of evidence on sleep

Table 3 shows the summary of results for sleep. Overall, results show that there were mostly longitudinal and cross-sectional studies, while only few experimental or semi-longitudinal studies were found. The number of studies reporting undesirable associations was close to the number of studies reporting non-significant associations, while no desirable associations were found in any study. This overall pattern suggests that results on the links between screen time and sleep parameters are inconclusive, with a tendency to undesirable associations. Objective measurement of sleep might enhance the quality of the study, although perhaps

TABLE 3 Summary of results pertaining to sleep.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Bedtime	0	0	0	1	0	0	0	0	0	2	0	0	*3*	*0*	*0*
Sleep latency	0	1	0	1	5	0	0	0	0	6	5	0	*7*	*11*	*0*
Total sleep duration	0	0	0	2	0	0	0	0	0	7	7	0	*9*	*7*	*0*
Nighttime sleep duration	0	1	0	2	2	0	0	0	0	4	6	0	*6*	*9*	*0*
Daytime sleep duration	0	1	0	0	0	0	0	0	0	1	3	0	*1*	*4*	*0*
Nighttime awakenings	0	2	0	1	0	0	0	0	0	1	4	0	*2*	*6*	*0*
Sleep problems	0	0	0	0	2	0	1	0	0	10	9	0	*11*	*11*	*0*
Total	*0*	*5*	*0*	*7*	*9*	*0*	*1*	*0*	*0*	*31*	*34*	*0*	*39*	*48*	*0*

"–," undesirable association; "=," non-significant association; "+," desirable association.

reducing the feasibility of research in this area. Finally, other contextual aspects of screen time such as time of day and non-digital activities should be considered in future research.

Physical health

This section reports studies on the association between screen time and obesity and diet, blood pressure, and muscular fitness ($n = 17$). Given that the number of outcomes that were studied is comparatively limited, results are not divided by specific outcome.

Results of an experimental study revealed that watching a DVD leads to lower salivary cortisol levels than playing with blocks (Christakis et al., 2013), thus providing evidence of differing neurocognitive processes. An experimental study with preterm infants showed, that video calls combined with singing lullabies by the mothers had desirable effects on infants' respiratory rates, while only video calls (without singing lullabies) had no effect as compared to a no-video call control group (Kaynak and Yilmaz, 2024). In the same study, video calls both with and without singing lullabies had desirable effects on infants' oxygen saturation as compared to the no-video control group. Another experimental study was able to show that respiratory sinus arrhythmia increased while heart rate decreased during a co-viewing task as compared to a control baseline activity, which indicates that children were more relaxed while co-viewing educational content (Porter et al., 2022). Similarly, children's hearth rate variability was found to increase while co-viewing emotionally salient videos, which indicates better regulation as compared to a baseline measurement (Stockdale et al., 2023).

Longitudinal (Fuller-Tyszkiewicz et al., 2012; Saldanha-Gomes et al., 2017) and semi-longitudinal (Collings et al., 2018; Fitzpatrick et al., 2012; Padmapriya et al., 2019; Pagani et al., 2010) studies reported undesirable associations between TV viewing and body mass index (BMI) and waist circumference (Fuller-Tyszkiewicz et al., 2012; Collings et al., 2018; Fitzpatrick et al., 2012), general fitness (Pagani et al., 2010), and standing long jump performance (Fitzpatrick et al., 2012). Additionally, non-significant associations between TV viewing and BMI (Saldanha-Gomes et al., 2017; Collings et al., 2018), sum of skinfolds (Collings et al., 2018), and blood pressure (Padmapriya et al., 2019) were found. Furthermore, Padmapriya et al. (2019) found that total screen time, TV time, and handheld screen time were consistently linked to larger skinfolds and higher BMI scores only in boys. A positive link between TV and DVD time and body fat was reported only for boys (Saldanha-Gomes et al., 2017), while fat mass index was not systematically found to be linked to screen time in semi-longitudinal and cross-sectional models in another study, although some undesirable associations were found for boys and for girls (Kracht et al., 2023). A study examining the bidirectional link between televiewing and food intake in children aged up to 1 year found no relationship between food intake and more televiewing, nor was food intake found to be a mediator of the relationship between televiewing and BMI (Fuller-Tyszkiewicz et al., 2012).

Turning to cross-sectional studies, one study found overall screen time to have an undesirable association to diet in terms of higher odds of following a processed dietary pattern and lower odds of a following a healthy dietary pattern in children with screen time above 30 min per day as opposed to children with no screen time (Masztalerz-Kozubek et al., 2024). Moreover, cross-sectional studies found TV viewing not to be linked to overweight or obesity in children younger than 3 years of age (Hu et al., 2019; Saldanha-Gomes et al., 2017; Manios et al., 2009; Plitponkarnpim et al., 2018). Cross-sectional findings from a longitudinal study hint at undesirable correlates of TV viewing and BMI (Fuller-Tyszkiewicz et al., 2012). One study yielded no association between eating while watching TV and BMI, sum of skinfolds, or waist circumference (Collings et al., 2018). Another study found a link between having feeding difficulties and regularly using screen media while eating (Teekavanich et al., 2022). Other cross-sectional studies found no link between having a TV in children's bedrooms and the children's BMI, sum of skinfolds, or waist circumference (Collings et al., 2018). Children's televiewing during meals was found to be linked to consumption of unhealthy food (Manios et al., 2009; Horodynski et al., 2010), but only if mothers' consumption of unhealthy food was not taken into account (Horodynski et al., 2010). Further, televiewing for more than 1 h per day was found to be linked to more televiewing while having meals, having snacks while televiewing, and exposure to junk food advertising (Hu et al., 2019). No studies were found showing desirable correlates of screen time.

Methodological considerations

Outcomes were widely assessed during on-site visits by trained personnel. Screen time was assessed by parent reports in all non-experimental studies, mostly for an average weekday and weekend day. Data on screen time was categorized in some studies, and group comparisons were used to assess the effects of screen time (Hu et al., 2019; Saldanha-Gomes et al., 2017; Collings et al., 2018; Masztalerz-Kozubek et al., 2024; Manios et al., 2009). Most studies focused on TV and DVD viewing (Hu et al., 2019; Christakis et al., 2013; Stockdale et al., 2023; Fuller-Tyszkiewicz et al., 2012; Saldanha-Gomes et al., 2017; Collings et al., 2018; Fitzpatrick et al., 2012; Pagani et al., 2010; Kracht et al., 2023; Manios et al., 2009; Teekavanich et al., 2022; Horodynski et al., 2010), and one study reported separate but consistent results for total, TV, and handheld screen time (Padmapriya et al., 2019), while one experimental study focused on the effects of video calls of infants with their mothers as well as singing lullabies (Kaynak and Yilmaz, 2024), thus considering both the content and the context. One experimental study specifically focused on co-viewing educational content (Porter et al., 2022), while another focused on co-viewing emotionally salient content (Stockdale et al., 2023). Some studies examined TV watching during meals and snacks during screen time (Hu et al., 2019; Teekavanich et al., 2022). Two studies reported separate results for gender and found that boys seem to be more susceptible to the effects of screen time as measured by overweight, blood pressure (Padmapriya et al., 2019), and body fat (Saldanha-Gomes et al., 2017). One study did not find age to be a moderator (Collings et al., 2018), and another study reported undesirable effects only for older children (Hu et al., 2019). Food intake was not found to mediate the longitudinal link between TV viewing and BMI (Fuller-Tyszkiewicz et al., 2012).

TABLE 4 Summary of results pertaining to physical health.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Cortisol levels	1	0	0	0	0	0	0	0	0	0	0	0	*1*	*0*	*0*
Body fat (BMI, waist circumference etc.)	0	0	0	3	4	0	5	3	0	3	11	0	*11*	*18*	*0*
Diet	0	0	0	0	0	0	0	0	0	4	0	0	*4*	*0*	*0*
Respiratory rates	0	0	1	0	0	0	0	0	0	0	0	0	*0*	*0*	*1*
Oxygen saturation	0	0	1	0	0	0	0	0	0	0	0	0	*0*	*0*	*1*
Respiratory sinus arrhythmia	0	0	1	0	0	0	0	0	0	0	0	0	*0*	*0*	*1*
Heart rate	0	0	1	0	0	0	0	0	0	0	0	1	*0*	*0*	*2*
Feeding difficulties	0	0	0	0	0	0	0	0	0	1	0	0	*1*	*0*	*0*
Total	*1*	*0*	*4*	*3*	*4*	*0*	*5*	*3*	*0*	*8*	*11*	*1*	*17*	*18*	*5*

"−," undesirable association; "=," non-significant association; "+," desirable association.

Summary of evidence on physical health

Findings on associations between the use of screen media and body-related parameters and nutrition show a mixed pattern of undesirable and non-significant associations, while few desirable correlates were found (see Table 4). Studies were mostly cross-sectional or semi-longitudinal, which limits the potential for strong causal inferences. More longitudinal and experimental studies are needed, ideally focusing on the multidirectional relationship between screen time, body-related parameters, and diet. Another aspect that might be relevant is the type of content viewed, for instance whether unhealthy food advertising or interactive content is consumed. Further, most of the studies focused mostly on the associations with TV and DVD. Consequently, the role of modern screen devices has yet to be explored.

Cognition

Results from studies that examined the association between screen time and general cognition, attention problems, and executive functions as well on other cognitive outcomes ($n = 31$) are summarized here.

General cognition

The studies discussed here examined cognition in general. Their dependent variables comprise a cognition-related total score. Results from two experimental studies report no significant link to general cognition: Playing non-educational games on an iPad was found to lead to the same cognitive flexibility score in a card sorting test as physical play and to higher scores than drawing and coloring, but only for children who played the game on the iPad as a socially interactive game (Antrilli and Wang, 2018). Further, the link between watching a child-oriented DVD and cognition was not found to be significant (Richert et al., 2010). Only one longitudinal study was identified, and the results did not support the association between televiewing and composite IQ score at age 4.5 years (Aishworiya et al., 2019). Results from a semi-longitudinal study suggest that there is an undesirable association of being in the upper quartile of media exposure from 6 months to 2 years of age on early learning at age 2 years. This association appears to be more robust for older children and adult media content (Supanitayanon et al., 2020). Another study yielded an undesirable association between adult-oriented content at 6 months and cognition at 14 months (Tomopoulos et al., 2010). Further, screen media multitasking from age 18 months to 4 years was found to be linked to lower scores on cognition at age 4 years (Srisinghasongkram et al., 2020). Further, cognition was not systematically found to be linked to screen time in semi-longitudinal and cross-sectional models in another study (Kracht et al., 2023). Finally, two cross-sectional studies found an undesirable correlate of televiewing (Lin et al., 2015) in children 15 to 35 months of age and total screen time with traditional and modern devices (Plitponkarnpim et al., 2018) in children aged 6 months to 2 years on general cognition.

Attention

An experimental study found that reducing screen time before bed had no significant impact on number of indicators of attention as measured by eye-tracking (Pickard et al., 2024). In a longitudinal study, an undesirable association between cumulative media use at age 18 months and focused attention at 22 months was found, but the same path was non-significant from 22 months to 26 months (Gueron-Sela and Gordon-Hacker, 2020). In semi-longitudinal studies, an undesirable link was found between televiewing at ages 1 and 3 years and attention problems at age 7 years (Christakis et al., 2004). However, a reanalysis of the same data set with more thorough statistical controls failed to replicate the original finding (Foster and Watkins, 2010). Moreover, an undesirable link between more than 2 hours of sustained TV exposure at both 30–33 months and 5.5 years and attention problems at age 5.5 years was found, but not for children whose TV exposure declined with age from over 2 hours at age 30–33 months to below 2 hours at age 5.5 years (Mistry et al., 2007). Non-significant results were reported for televiewing for more than 4 hours per day (Cheng et al., 2010), of duration and media content exposure (Tomopoulos et al., 2007), of increased TV exposure and adult TV programs (Chonchaiya et al., 2015), and of educational television

(Zimmerman and Christakis, 2007). However, both violent and non-violent entertainment television before the age of 36 months were found to be linked to later attention problems (Zimmerman and Christakis, 2007). A semi-longitudinal study found that screen time at 12 months of age was linked to lower levels of teacher-reported attention by age nine (Law et al., 2023). Further, children with high touchscreen users from age 12 months to age 3.5 years reacted faster to external stimuli on a screen, but were slower in controlling their own attention without external stimuli (Portugal et al., 2021a) and high users showed higher attention performance in a single feature search task but not in a conjunction search task on screens (Portugal et al., 2021b). Cross-sectional studies found undesirable associations between attention problems and televiewing for more than 4 h per day (Cheng et al., 2010), for touch screen use (Lin et al., 2020), for increased television exposure at 18 months (Chonchaiya et al., 2015), and for total duration of media exposure as well as non-educational young child content exposure (Tomopoulos et al., 2007). However, no associations with attention-deficit or hyperactivity problems were found (Chonchaiya et al., 2015).

Executive functions

An experimental study found that reducing screen time before bed had no significant impact on effortful control and inhibitory control (Pickard et al., 2024). A longitudinal undesirable effect was found of screen time at 24 months on executive functioning at 36 months (McHarg et al., 2020a). Further, results from semi-longitudinal studies indicate an undesirable link between higher adult-directed televiewing during infancy and parent-reported executive functioning at age 4 years (Barr et al., 2010a). However, non-significant associations with total household television, overall television exposure, or child-directed exposure in infancy were found on parent-reported executive functioning, school readiness, vocabulary, IQ, or executive functioning (standardized test) at age 4 years (Barr et al., 2010a). Further, previous day total screen, TV/video, interactive media, and touchscreen time (as assessed through questionnaires) were found to have a non-significant correlation with working memory and search performance in an experimental task about contingency between a video and a subsequent real world search task (Choi et al., 2021). In a semi-longitudinal study, screen time at age 12 months was found to be negatively associated with executive functions at age 9 years (Law et al., 2023). Another undesirable association was identified between total TV exposure in infancy and hot executive functions, but not with cold executive functions (Corkin et al., 2021). Non-significant correlates of co-viewing or type of content were also reported (Corkin et al., 2021). A cross-sectional study found an undesirable association between screen time in minutes and inhibitory self-control as well as metacognition at age 24 months (McMath et al., 2022). In the same study, meeting screen time recommendations of <1 h per day had a desirable association with executive functions, inhibitory self-control as well as metacognition.

Other cognitive outcomes

Results from a longitudinal study suggest an undesirable effect of screen time in infancy on verbal IQ score at age 4.5 years (Aishworiya et al., 2019). Another longitudinal study found no direct but a small although not significant indirect undesirable association between screen time (watching shows/movies and gaming) and problem solving though peer play from age 12 to 36 months, with no moderation by gender (Putnick et al., 2023). In a semi-longitudinal study examining multiple developmental outcomes, screen time at 1 year of age was found to be associated with poorer problem-solving abilities at ages two and four, particularly when daily screen time exceeded 4 h (Takahashi et al., 2023). Further semi-longitudinal studies confirm an undesirable association between increased daily televiewing in children 29 months of age and numeracy and early arithmetic skills at age 65 months (Pagani et al., 2013) and screen time at 4 months was found to be undesirably linked to inhibition, but not to cognitive flexibility or working memory at 14 months (McHarg et al., 2020b). Another study also suggests an undesirable association between early televiewing at 29 months of age, but not between change in televiewing from 29 months to 53 months or of concurrent televiewing and mathematics success at age 10 years (Pagani et al., 2010). Finally, the link between televiewing and visual-motor abilities was found to be non-significant (Evans Schmidt et al., 2009). No experimental or cross-sectional studies were found that included other cognitive outcomes.

Methodological considerations

Outcomes were assessed with questionnaires and screenings (Mistry et al., 2007; Chonchaiya et al., 2015; Aishworiya et al., 2019; Srisinghasongkram et al., 2020; Gueron-Sela and Gordon-Hacker, 2020; Cheng et al., 2010; Tomopoulos et al., 2007; Zimmerman and Christakis, 2007; Law et al., 2023; Barr et al., 2010a; Corkin et al., 2021; McMath et al., 2022; Putnick et al., 2023; Takahashi et al., 2023; Evans Schmidt et al., 2009; Foster et al., 2010), standardized tests (Richert et al., 2010; Pickard et al., 2024; Kracht et al., 2023; Plitponkarnpim et al., 2018; Antrilli and Wang, 2018; Aishworiya et al., 2019; Supanitayanon et al., 2020; Tomopoulos et al., 2010; Srisinghasongkram et al., 2020; Lin et al., 2015; Law et al., 2023; Portugal et al., 2021a,b; McHarg et al., 2020a; Choi et al., 2021; Corkin et al., 2021; Pagani et al., 2013; McHarg et al., 2020b; Evans Schmidt et al., 2009), ratings from teachers (Pagani et al., 2010; Law et al., 2023), and behavioral observations (Antrilli and Wang, 2018). Screen time was mostly assessed as one-time parent report (Mistry et al., 2007; Lin et al., 2020; Pagani et al., 2010; Aishworiya et al., 2019; Lin et al., 2015; Christakis et al., 2004; Cheng et al., 2010; Portugal et al., 2021a,b; McHarg et al., 2020a; Choi et al., 2021; Corkin et al., 2021; McMath et al., 2022; Takahashi et al., 2023; Pagani et al., 2013; McHarg et al., 2020b; Evans Schmidt et al., 2009), but some studies employed 24 h-recall diaries or other diaries (Pickard et al., 2024; Chonchaiya et al., 2015; Plitponkarnpim et al., 2018; Supanitayanon et al., 2020; Tomopoulos et al., 2010; Srisinghasongkram et al., 2020; Tomopoulos et al., 2007; Zimmerman and Christakis, 2007; Barr et al., 2010a), while others measured screen time on multiple occasions (Putnick et al., 2023). Screen time was categorized in some studies, with varying degrees of extreme-group modeling (Mistry et al., 2007; Kracht et al., 2023; Supanitayanon et al., 2020; Lin et al., 2015; Cheng et al.,

TABLE 5 Summary of results pertaining to cognition.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
General cognition	0	2	0	0	1	0	3	1	0	2	1	0	*5*	*5*	*0*
Attention	0	1	0	1	1	0	5	8	2	4	1	0	*10*	*11*	*2*
Executive functions	0	1	0	1	0	0	3	8	0	0	7	0	*4*	*16*	*0*
Other cognitive outcomes	0	0	0	2	1	0	4	3	0	0	4	0	*6*	*7*	*0*
Total	*0*	*4*	*0*	*4*	*3*	*0*	*15*	*20*	*2*	*6*	*13*	*0*	*25*	*40*	*2*

"−," undesirable association; "=," non-significant association; "+," desirable association.

2010; Portugal et al., 2021a,b; Barr et al., 2010a; McMath et al., 2022; Takahashi et al., 2023). Most studies examined only the effects of televiewing or DVD watching (Richert et al., 2010; Mistry et al., 2007; Chonchaiya et al., 2015; Pagani et al., 2010; Kracht et al., 2023; Aishworiya et al., 2019; Lin et al., 2015; Foster and Watkins, 2010; Cheng et al., 2010; Zimmerman and Christakis, 2007; Barr et al., 2010a; Corkin et al., 2021; Pagani et al., 2013; Evans Schmidt et al., 2009), some studies examined only touchscreen use (Lin et al., 2020; Antrilli and Wang, 2018; Portugal et al., 2021a,b), and some examined multiple types of devices (Plitponkarnpim et al., 2018; Supanitayanon et al., 2020; Tomopoulos et al., 2010; Srisinghasongkram et al., 2020; Gueron-Sela and Gordon-Hacker, 2020; Law et al., 2023; McHarg et al., 2020a; Choi et al., 2021; McMath et al., 2022; Putnick et al., 2023; Takahashi et al., 2023; McHarg et al., 2020b). A number of studies addressed questions about the content of media (Richert et al., 2010; Chonchaiya et al., 2015; Antrilli and Wang, 2018; Supanitayanon et al., 2020; Tomopoulos et al., 2010; Christakis et al., 2004; Tomopoulos et al., 2007; Zimmerman and Christakis, 2007; Barr et al., 2010a; Corkin et al., 2021), co-viewing (Richert et al., 2010; Corkin et al., 2021), verbal interaction during screen use (Supanitayanon et al., 2020), and the role of social interaction (Antrilli and Wang, 2018), as well as the mediating role of peer-play and the moderating role of gender (Putnick et al., 2023).

Summary of evidence on cognition

Studies on the link between screen time and cognition suggest either a weak undesirable link to cognitive development or no significant link, while very few desirable associations were reported (see Table 5). Studies were mostly cross-sectional or semi-longitudinal, which limits the causal inferences that can be drawn. Notably, studies mostly reported non-significant associations of screen time and various aspects of cognition, with a relevant proportion of studies showing undesirable associations. The type of content seems to play an important moderating role in this regard and needs to be studied in more experimental and longitudinal studies. No displacement effect through reduced peer play was found in a longitudinal study. Given the large amount of semi-longitudinal studies, longitudinal studies should assess the baseline of the outcome studied to examine bidirectional associations and to model the change in the outcome over time.

Learning efficiency

Experimental studies ($n = 28$) have examined young children's learning by imitation from screen media under a variety of conditions. In this review, the studies were categorized by topic and the sections are labeled accordingly. The presentation of the results in this section differs from other sections because this field is exclusively defined by experimental studies. We chose to separate learning efficiency from cognition based on a conceptual distinction: cognition refers to an individual's mental abilities and characteristics, while learning is an active process of acquiring new knowledge or skills.

Live vs. screen demonstration

Children as young as 12 to 21 (Barr et al., 2007b) and 24 months (Barr and Wyss, 2008; Nielsen et al., 2008) have been shown to be more able to imitate a target task when the task was demonstrated by a person live than when the demonstrator was videotaped, indicating a video deficit effect. Another experimental study found that children imitated the target action significantly better when their mothers performed the action live than via video. However, this was only true for children aged 13 to 20 months, not for children younger than 13 months of age or older children between 21 and 24 months (Krcmar, 2010). In an experimental study that adapted a real-world paradigm that showed children's ability to update their representation of an absent object's properties based on verbal information (Ganea et al., 2007), children were not able to show such an update to their representation based on an event shown on video, although they were able to remember which category the object belonged to Shinskey (2021).

Other studies focused on how well children would remember actions demonstrated by video. One study showed that 18-month-old children remembered actions from videos or books for 2 weeks and forgot them again after 4 weeks, while 24-month-old children remembered them for 4 weeks and forgot them again after 8 weeks, with no retention difference between books and videos for both ages (Brito et al., 2012). Another study found that video reminders helped toddlers remember actions they had learned from videos over 4 weeks, but picture book reminders did not help them remember book demonstrations. Cross-mode recall, e.g., from book to video, was not promoted (Barr et al., 2013). In a study examining deferred imitation (as an indicator of memory performance) for live events and for video presented events, watching video content, smartphone use, and tablet use were not found to be linked to memory for live presented events. As for video presented events, only time spent watching video had an undesirable association with memory performance (Koch et al., 2024). In contrast, children having seen a target action presented live showed better memory performance than those who saw the task on 2D video with and without support from their parents (Heimann et al., 2021).

Further studies examined whether children were able to learn puzzle tasks from video. It has been found that children showed better performance with 3D puzzles after a ghost demonstration in which virtual pieces moved to form the corresponding shape than with 2D puzzles on touchscreens, with no improvement from touchscreen practice beforehand. However, children's performance on 2D touchscreen puzzles improved more with live, social demonstrations than with ghost demonstrations (Zimmermann et al., 2016). Moreover, experiments showed that televised demonstrations were less effective than live ones, with meaningful context, such as the ocean, if the puzzle depicted a fish, enhancing puzzle assembly but not overcoming the video deficit (Zimmermann et al., 2015; Dickerson et al., 2013). Other studies conducted the same puzzle imitation task under different conditions. They found that young children imitated both video and live demonstrations similarly well on touchscreens (Moser et al., 2015), and children who were able to label the complete puzzle after the test phase could better imitate the target action, especially when a live demonstrator was present compared to absent (Moser et al., 2018). Furthermore, children struggled with translating 2D video demonstrations to 3D tasks but succeeded with 2D to 2D (Moser et al., 2015; Zack et al., 2009), with specific linguistic cues not enhancing children's imitation performance (Zack et al., 2013). However, children improved their learning transfer from 2D to 3D when instructed by their mothers, and higher-quality mother-child interactions further enhanced this learning (Zack and Barr, 2016).

Repeated viewing

The frequency with which video demonstrations are played may influence young children's learning transfer. They reported that children aged between 12 to 24 months, but not younger, experience a video deficit effect. This video deficit was mitigated, disappeared entirely, or even turned in the opposite direction, the more often children watched the same television content. This holds true even if there were no verbal labels provided by parents (Barr and Wyss, 2008). In contrast, another experimental study found that repeated demonstration of a target action on video did not enhance children's imitation performance (Krcmar, 2010).

Sound effects and language prompts

Children aged 18 to 24 months can imitate novel actions equally well from TV as from books, even without meaningful narration (Simcock et al., 2011). Similarly, it has been reported that 12- to 18-month-olds can learn just as effectively from both live and screen presentations when language and gaze cues are matched (Barr et al., 2009; Lauricella et al., 2016), whereas 6-months-olds imitated actions from videos regardless of sound effects (Barr et al., 2009). Additionally, instrumental soundtracks during video demonstrations may hinder imitation in young children, though action-related sound effects mitigate this effect without increasing the performance of the imitation task (Barr et al., 2010b). Furthermore, verbal labels presented either by parents co-viewing or on television via voice-over similarly facilitated an imitation task for 2-year-olds (Barr and Wyss, 2008).

Familiarity with presenting character

In addition, familiarity with the character presenting the task may enhance learning from videos in children under the age of two (Lauricella et al., 2011; Howard Gola et al., 2013). Conversely, no improvement in task performance with familiar characters were found in other studies (Nielsen et al., 2008; Seehagen and Herbert, 2010) through narratives based on mothers' descriptions helped children learning from videos (Seehagen and Herbert, 2010). Furthermore, another study reported that children's learning is enhanced when they are exposed to unfamiliar screen characters personalized to address them by name, in contrast to exposure to both familiar characters and non-personalized unfamiliar characters (Calvert et al., 2014).

Video chat

A study that focused on the effects of video chat found that 12- to 25-month-old children learned new actions and patterns better from adults in video chats than from prerecorded videos. The children who interacted with adults through video chat learned more novel patterns and preferred and recognized their adult partners a week later, while the children who watched the prerecorded video did not (Myers et al., 2017).

Interactivity

Further studies also indicate that children's learning from screens can be enhanced by interactive, contingent experiences with screen media. They reported that children aged 2 to 3 years performed significantly better on a given task when it was shown through an interactive computer game (Lauricella et al., 2010), or if they had the opportunity to interact with the person demonstrating the task via television (Nielsen et al., 2008), compared to seeing the demonstration on a screen without any interaction. Conversely, children aged 24 to 36 months were found to make increased perseverative errors in an object retrieval task (i.e., looking for an object in a spot where it did hide in a previous condition), particularly in a condition in which they did not interact with the screen or in which they interacted with the screen in a relevant way (Kirkorian et al., 2022). In the same study, children's media use at home was not found to be correlated to correct retrieval of objects (a bear) in a real-world task after observing on a screen where the bear did hide. There was also no correlation with the number of perseverative errors or with visual attention.

Methodological considerations

The outcome variables were determined by experimental behavioral observations in all studies. Screen time was generally assessed through standardized experimental conditions (Barr and

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TABLE 6 Summary of results pertaining to learning efficiency.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Learning efficiency	17	34	12	0	0	0	0	0	0	0	0	0	17	34	12

"−," undesirable association; "=," non-significant association; "+," desirable association.

Wyss, 2008; Nielsen et al., 2008; Krcmar, 2010; Brito et al., 2012; Barr et al., 2013; Heimann et al., 2021; Zimmermann et al., 2016, 2015; Dickerson et al., 2013; Moser et al., 2015, 2018; Zack et al., 2009, 2013; Barr et al., 2007b; Simcock et al., 2011; Barr et al., 2009; Lauricella et al., 2016; Barr et al., 2010b; Lauricella et al., 2011; Howard Gola et al., 2013; Seehagen and Herbert, 2010; Calvert et al., 2014; Myers et al., 2017; Lauricella et al., 2010), with few exceptions (Koch et al., 2024). The majority of studies only examined the effects of experimental televiewing or DVD watching (Barr and Wyss, 2008; Barr et al., 2007b; Krcmar, 2010; Brito et al., 2012; Barr et al., 2013; Heimann et al., 2021; Dickerson et al., 2013; Barr et al., 2007a; Simcock et al., 2011; Barr et al., 2009; Lauricella et al., 2016; Barr et al., 2010b; Lauricella et al., 2011; Howard Gola et al., 2013; Seehagen and Herbert, 2010; Calvert et al., 2014; Myers et al., 2017), other studies examined only touchscreen use (Zimmermann et al., 2016; Zack et al., 2009, 2013; Zack and Barr, 2016), and some examined multiple types of devices (Koch et al., 2024; Moser et al., 2015, 2018; Myers et al., 2017; Lauricella et al., 2010). All studies addressed the content of media, some the verbal interaction during screen use, the role of social interaction (Barr and Wyss, 2008; Moser et al., 2015, 2018; Zack and Barr, 2016; Simcock et al., 2011; Seehagen and Herbert, 2010), social demonstration (Zimmermann et al., 2016; Zack et al., 2013; Krcmar, 2010; Moser et al., 2018; Barr et al., 2007a,b; Brito et al., 2012; Myers et al., 2017; Zimmermann et al., 2015; Zack et al., 2009; Moser et al., 2015; Dickerson et al., 2013; Lauricella et al., 2016; Barr and Wyss, 2008), and interaction with the media (Nielsen et al., 2008; Myers et al., 2017; Lauricella et al., 2010; Kirkorian et al., 2022).

Summary of evidence on learning efficiency

Results related to learning efficiency are presented in Table 6. The terms *undesirable* and *desirable associations* carry slightly different meanings in the context of learning efficiency compared to the other outcomes discussed in this study. Specifically, we use the term *undesirable* associations for those associations where learning from screens is less efficient than learning from real-world presentations. Conversely, we use *desirable* associations for instances where learning from screens demonstrates greater efficiency. The review of associations between task presentation via screens and children's learning efficiency stem almost exclusively from experimental studies and mostly show non-significant associations. However, there was a similar amount of undesirable and desirable associations. Children learn better when a target task is demonstrated live than via video, suggesting the presence of a video deficit. However, aspects of media presentation, such as repetition, language prompts, and social contingency or familiarity with the character are significant contextual and content-related factors that can enhance young children's learning from videos and consequently reduce the video deficit effect.

Language

Results from studies ($n = 55$) that examined associations with overall language competencies, receptive and expressive language skills, and vocabulary are summarized here.

Language competence

One experimental study found an undesirable effect of intensive televiewing on language competence (Tanimura et al., 2007), whereas another study found no link from repeatedly watching a specific DVD (Richert et al., 2010), but noted that early watchers had poorer language scores. One longitudinal study found an undesirable association with televiewing over 2 h a day, especially for child-directed, but not adult-directed content (Duch et al., 2013), while another failed to find any longitudinal association (Zimmerman et al., 2009). Further, another study found that children with "low descending" televiewing patterns over time had the highest language achievement scores, whereas those with "high ascending" televiewing patterns had the lowest (Kim and Chung, 2021). Another longitudinal study found that children who had up to 2 h of screen time daily showed no increased risk for delayed language development. However, children exposed to three or more hours of screen time each day were significantly more likely to experience delays in language skills compared to all other groups (McArthur et al., 2022). A study involving children aged 12 to 36 months found no direct, but a small, undesirable indirect association between screen time and communication skills through peer play, with no moderation based on gender (Putnick et al., 2023). Mixed results were found in another longitudinal study that reported different models with different timepoints at which the outcomes and predictors were assessed (Slobodin et al., 2024). The authors also found indications of a moderation by socio-economic status that favored the group with a low status. The vast majority of results of semi-longitudinal studies supports the existence of undesirable associations (Aishworiya et al., 2019; Tomopoulos et al., 2010; Takahashi et al., 2023; Mendelsohn et al., 2010), whilst one study reported no association (Ruangdaraganon et al., 2009). However, an important note is that Mendelsohn et al. (2010) have shown that verbal interactions during screen time reduce the undesirable correlates, whereby undesirable correlates were only observed after more than 1 h of use without such interactions. As for the correlates of different content, undesirable correlates were found for consuming adult-oriented and older-child-oriented content but not for educational and non-educational young-child-oriented content (Tomopoulos et al., 2010). Language development was not systematically found to be linked to screen time in semi-longitudinal and cross-sectional models in another study (Kracht et al., 2023). Cross-sectional studies found no associations with increasing duration of screen time (Lin et al., 2020; Zimmerman et al., 2009; Bedford et al., 2016; van den Heuvel et al., 2019). However, undesirable links were reported for longer duration (Operto et al., 2020), more than 30 minutes (Plitponkarnpim et al., 2018), 2 h (Lin et al., 2015; Duch et al., 2013; Byeon and Hong, 2015), and 4 h (Perdana et al., 2017) of screen time. Co-viewing and media content as moderators did not influence this relationship (Operto et al., 2020). TV programs in two languages (Perdana et al., 2017) and child-directed content, but not adult-directed content (Duch et al., 2013), have been found to be undesirably related to language development. In this regard, a study found that children with delayed language skills and regular televiewing favored "realistic animations" or "baby education" content (Okuma and Tanimura, 2009). Furthermore, TV in the bedroom and first exposure to televiewing were not related to language development (Perdana et al., 2017).

Receptive language

Results of a short longitudinal experimental field study revealed that children are able to learn baby signs from video even in the absence of parental support during viewing (Dayanim and Namy, 2015). Another one reported greater gains in receptive vocabulary in children after watching a specific Baby DVD for 1 month (Vandewater, 2011). However, other such studies found no association (Richert et al., 2010; Robb et al., 2009). A longitudinal study that examined trajectory patterns in children's televiewing failed to find a link with receptive language scores (Kim and Chung, 2021). Semi-longitudinal studies reported that more fore- and background televiewing (Pagani et al., 2013; Bittman et al., 2011), a longer duration of media exposure (Tomopoulos et al., 2010), a television in the child's bedroom (Bittman et al., 2011), or more than 1 h daily of screen time (Mendelsohn et al., 2010) were undesirably associated with later receptive language. However, the latter study reported an undesirable link in the absence of media verbal interactions but not in their presence (Mendelsohn et al., 2010). Regarding the types of content, consuming adult-oriented and older child-oriented content was found to have undesirable links, whereas educational and non-educational content aimed at younger children was not (Tomopoulos et al., 2010). However, other semi-longitudinal studies failed to find a link for daily televiewing or media exposure and later receptive vocabulary (Evans Schmidt et al., 2009; Bittman et al., 2011; Dynia et al., 2021). A cross-sectional study showed that electronic sounds captured by the Language Environment Analysis system (LENA) were undesirably linked to receptive language development in children (Nyberg et al., 2020). Another study reported an undesirable association of longer duration of watching baby DVDs and videos, but other content such as educational shows, non-educational TV, and adult-directed TV show no associations (Zimmerman et al., 2007). However, the same data was reanalyzed a few years later with a different model specification regarding the inclusion/exclusion of covariates. The authors found that educational content led to improved receptive vocabulary in children aged 6 to 16 months, whereas other content remained non-significant (Ferguson and Donnellan, 2014). In a large-scale study among Danish children, mobile screen time was found to have an undesirable association with language comprehension, although the undesirable effect was moderated by frequent reading to the child but not by parental education or time spent with TV or PC (Rayce et al., 2024). A study focusing on the role of media quantity, context, and content found no association of any of these aspects with number of words understood across ages 12 to 16 months (Alroqi et al., 2023). Other cross-sectional studies on young children's televiewing and use of mobile touchscreen devices (Taylor et al., 2018), as well as on overall background television exposure and background television during dyadic toy play (Masur et al., 2016) found no significant associations.

Expressive language

Several short longitudinal experimental field studies yielded no association for children watching a specific DVD several times over a specific period in comparison to children who did not watch the target DVD (Richert et al., 2010; Vandewater, 2011; Robb et al., 2009). Longitudinal studies reported that greater exposure to background television during dyadic toy play has undesirable effects (Masur et al., 2016), and children with "high ascending" patterns of televiewing over time score lowest on later expressive language scores (Kim and Chung, 2021). Semi-longitudinal studies reported an undesirable link for longer duration of media exposure and later expressive language (Tomopoulos et al., 2010; Dynia et al., 2021), however one study found no significant link for more than 1 h of daily media exposure, regardless of the presence or absence of media verbal interactions (Mendelsohn et al., 2010). Further, undesirable longitudinal effects were found for consuming adult-oriented and older child-oriented content on expressive communication but not for educational and non-educational young child-oriented content (Tomopoulos et al., 2010). Several cross-sectional studies reported no associations between screen exposure (Taylor et al., 2018), more electronical sounds measured by LENA (Nyberg et al., 2020), or increasing duration of any content of screen time and expressive vocabulary in young children and expressive language outcomes (Zimmerman et al., 2007). A reanalysis of finding by Zimmerman et al. (2007) showed that educational contents led to improved expressive vocabulary in children aged 6 to 16 months, but not aged 17 to 27 months, while other content did not (Ferguson and Donnellan, 2014). Another study also reported no association between different forms of screen time and sentence use (Gago-Galvagno et al., 2023). A large-scale study found that mobile screen time was negatively associated with expressive language skills. This association was not influenced by factors such as frequent reading to the child, parental education level, or time spent with TV or PC (Rayce et al., 2024). Furthermore, two studies found that each additional 30-minute increase in media device use (van den Heuvel et al., 2019), and background television exposure during dyadic toy play (Masur et al., 2016) were undesirably linked to children's expressive language outcomes. A study found no link between media quantity, context, or content and word production in children aged 12 to 16 months. However, in children aged 17 to 36 months, higher media exposure was negatively associated with word production, and certain media contexts were linked to shorter utterances (Alroqi et al., 2023), although several non-significant findings were also reported for the remaining combinations of predictors and outcomes. Moreover, sentence use was found to be positively linked to PC time, but negatively to TV time and educational content use, while no link to verbal scaffolding and joint engagement was reported. Further, joint media engagement and verbal scaffolding were not found to act as moderators (Medawar et al., 2023). In addition, Masur et al. (2016) demonstrated that maternal speech acts as a mediator during toy play.

Vocabulary

Several experimental studies on the association between vocabulary and screen time were identified. It has been shown that children may learn novel words from screens, depending on their age and certain conditions. A study reported that children were able to learn novel words from video alone (Vandewater et al., 2010), whereas other studies only found associations in combination with social interactions. These studies stated that children seem to learn novel verbs from video or video chat only in combination with social interactions, either live or via video chat (Myers et al., 2017, 2018; Roseberry et al., 2009, 2014; Tsuji et al., 2021), and the older they are, the better their learning results are (Myers et al., 2017). Moreover, depending on their age, children were able to learn new verbs from contingent videos without reciprocal interactions with a live social partner, but only when the video content required specific responses (Kirkorian et al., 2016). However, there are also studies that showed that children were unable to learn new words from video chat or from a non-responsive video (Troseth et al., 2018), they seem to learn better in face-to-face contact than in contact with a virtual agent on screen (Krcmar, 2010; Tsuji et al., 2021). Another condition concerns the repeated viewing of content on screen. Depending on their age, children may learn novel words from screens if they are repeatedly exposed to particular screen content (Krcmar, 2010, 2014). However, other studies did not find such a desirable link between repeated viewing and learning new words, either co-viewing with a parent or alone (Richert et al., 2010; DeLoache et al., 2010). A cross-sectional study found that poor-quality televiewing, characterized by an earlier onset of televiewing, more background televiewing, exposure to TV content not intended for children, less co-viewing with a parent, was associated with lower overall vocabulary scores. Children's foreground but not background screen time was found to have an undesirable link to expressive vocabulary at age 12 and 24 months (Asikainen et al., 2021). Further, some studies revealed that the duration of televiewing (Hudon et al., 2013), or longer duration of any screen time (Ferguson and Donnellan, 2014) was not associated with vocabulary acquisition. Moreover, no association was found between different forms of screen time and child lexical density, except for child PC use, with an undesirable link (Gago-Galvagno et al., 2023). However, other studies found that the quantity of screen time is undesirably associated with a child's vocabulary and grammar (Operto et al., 2020; Sundqvist et al., 2021), while co-viewing and the content of the screen time did not moderate this relationship (Operto et al., 2020). In contrast, lexical density was found to be positively linked to joint media engagement, verbal scaffolding related to media use, and PC time, but negatively to TV time, app use and video gaming. Herein, joint media engagement and verbal scaffolding were not found to moderate the effects of TV and PC times (Medawar et al., 2023). Furthermore, smartphone and tablet use were not found to be linked to lower expressive and receptive vocabularies in children aged 12 months, but negatively to expressive vocabulary in those aged 24 months, with a small effect size. Additionally, the study showed that shared book reading buffered the effect of portable screen time on expressive vocabulary (Rosslund et al., 2024). Finally, one study found that co-viewing programs with the child is associated with better vocabulary at age 4 years (Bittman et al., 2011).

Methodological considerations

Outcomes were assessed with questionnaires and screenings (Richert et al., 2010; Lin et al., 2020; Plitponkarnpim et al., 2018; Putnick et al., 2023; Takahashi et al., 2023; Kim and Chung, 2021; McArthur et al., 2022; Slobodin et al., 2024; Bedford et al., 2016; van den Heuvel et al., 2019; Operto et al., 2020; Byeon and Hong, 2015; Perdana et al., 2017; Dayanim and Namy, 2015; Vandewater, 2011; Robb et al., 2009; Zimmerman et al., 2007; Ferguson and Donnellan, 2014; Rayce et al., 2024; Alroqi et al., 2023; Taylor et al., 2018; Masur et al., 2016; Medawar et al., 2023; Kirkorian et al., 2016; Krcmar, 2014; DeLoache et al., 2010; Asikainen et al., 2021; Hudon et al., 2013; Sundqvist et al., 2021; Rosslund et al., 2024; Duch et al., 2013), standardized tests (Kracht et al., 2023; Aishworiya et al., 2019; Tomopoulos et al., 2010; Lin et al., 2015; Pagani et al., 2013; Evans Schmidt et al., 2009; Myers et al., 2017; Zimmerman et al., 2009; Mendelsohn et al., 2010; Ruangdaraganon et al., 2009; Bittman et al., 2011; Dynia et al., 2021; Medawar et al., 2023; Myers et al., 2018; Roseberry et al., 2009, 2014; Tsuji et al., 2021; Troseth et al., 2018), and behavioral observations (Krcmar, 2010; Tanimura et al., 2007; Vandewater et al., 2010; Tsuji et al., 2021; Troseth et al., 2018). In one study, children were divided into delayed and non-delayed groups with respect to their language development based on the query of only one item, "speaking more than one meaningful word" (Okuma and Tanimura, 2009). One-time parent report was mostly used to measure screen time (Lin et al., 2020; Aishworiya et al., 2019; Lin et al., 2015; Takahashi et al., 2023; Pagani et al., 2013; Evans Schmidt et al., 2009; Kim and Chung, 2021; McArthur et al., 2022; Ruangdaraganon et al., 2009; Bedford et al., 2016; van den Heuvel et al., 2019; Operto et al., 2020; Byeon and Hong, 2015; Perdana et al., 2017; Okuma and Tanimura, 2009; Bittman et al., 2011; Dynia et al., 2021; Zimmerman et al., 2007; Ferguson and Donnellan, 2014; Rayce et al., 2024; Taylor et al., 2018; Medawar et al., 2023; Asikainen et al., 2021; Hudon et al., 2013; Sundqvist et al., 2021; Rosslund et al., 2024) or background screen time (Masur et al., 2016; Asikainen et al., 2021). However, a few studies applied 6 h-recall (Plitponkarnpim et al., 2018) or 24 h-recall diaries (Tomopoulos et al., 2010; Slobodin et al., 2024; Mendelsohn et al., 2010; Alroqi et al., 2023; Duch et al., 2013), an electronic diary using special hardware and software (e.g., LENA) (Zimmerman

TABLE 7 Summary of results pertaining to language.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Language competence	2	1	0	7	5	0	7	5	0	8	6	0	*24*	*17*	*0*
Receptive language	0	2	2	0	1	0	8	5	1	2	11	1	*10*	*19*	*4*
Expressive language	0	3	0	2	0	0	4	4	0	7	16	3	*13*	*23*	*3*
Vocabulary	1	11	10	0	0	0	0	1	0	12	10	3	*13*	*22*	*13*
Total	*3*	*17*	*12*	*9*	*6*	*0*	*19*	*15*	*1*	*29*	*43*	*7*	*60*	*81*	*20*

"−," undesirable association; "=," non-significant association; "+," desirable association.

et al., 2009; Nyberg et al., 2020), and viewing time diaries (Richert et al., 2010; Vandewater, 2011; Robb et al., 2009; Vandewater et al., 2010). Screen time was categorized in some studies with varying degrees of extreme-group comparisons (Kracht et al., 2023; Lin et al., 2015; Takahashi et al., 2023; Kim and Chung, 2021; McArthur et al., 2022; Mendelsohn et al., 2010; Ruangdaraganon et al., 2009; Byeon and Hong, 2015; Perdana et al., 2017; Okuma and Tanimura, 2009; Bittman et al., 2011; Asikainen et al., 2021; Sundqvist et al., 2021; Duch et al., 2013) or simply distinguished between TV on and off (Tanimura et al., 2007). One study used a specific type of categorization in quality and quantity of screen time, which resulted in a factor analysis (Hudon et al., 2013), and one study assessed trajectory patterns (Kim and Chung, 2021). A majority of the studies focused only on the effects of TV and DVD (Richert et al., 2010; Kracht et al., 2023; Pagani et al., 2013; Evans Schmidt et al., 2009; Krcmar, 2010; Tanimura et al., 2007; Zimmerman et al., 2009; Kim and Chung, 2021; Ruangdaraganon et al., 2009; Byeon and Hong, 2015; Perdana et al., 2017; Okuma and Tanimura, 2009; Dayanim and Namy, 2015; Vandewater, 2011; Robb et al., 2009; Bittman et al., 2011; Zimmerman et al., 2007; Ferguson and Donnellan, 2014; Masur et al., 2016; Vandewater et al., 2010; Roseberry et al., 2009; Krcmar, 2014; DeLoache et al., 2010; Hudon et al., 2013; Duch et al., 2013), while some studies considered video games in addition to televiewing (Putnick et al., 2023; McArthur et al., 2022; Mendelsohn et al., 2010; Dynia et al., 2021), a few experimental studies conducted the assessment by a computer (Myers et al., 2018; Roseberry et al., 2014) or on a monitor (Troseth et al., 2018), a few studies assessed the effect of tablet, handheld, and touchscreen devices (Lin et al., 2020; Myers et al., 2017; Bedford et al., 2016; van den Heuvel et al., 2019; Rayce et al., 2024; Kirkorian et al., 2016; Rosslund et al., 2024), and others considered multiple types of devices (Plitponkarnpim et al., 2018; Tomopoulos et al., 2010; Putnick et al., 2023; Takahashi et al., 2023; McArthur et al., 2022; Operto et al., 2020; Alroqi et al., 2023; Taylor et al., 2018; Gago-Galvagno et al., 2023; Medawar et al., 2023; Asikainen et al., 2021; Sundqvist et al., 2021; Duch et al., 2013). Some studies considered the content of screen time as a predictor (Tomopoulos et al., 2010; Okuma and Tanimura, 2009; Zimmerman et al., 2007; Ferguson and Donnellan, 2014; Alroqi et al., 2023; Hudon et al., 2013; Duch et al., 2013), others used specific content such as a specific DVD or videotape (Richert et al., 2010; Krcmar, 2010; Dayanim and Namy, 2015; Vandewater, 2011; Robb et al., 2009; Vandewater et al., 2010; Roseberry et al., 2009; Krcmar, 2014), one focused on the language of TV programs (Perdana et al., 2017), four experimental studies used specific videos made by the researchers (Krcmar, 2010; Myers et al., 2017; Roseberry et al., 2014; Kirkorian et al., 2016; Troseth et al., 2018), one used a virtual agent (Tsuji et al., 2021), and four studies performed live video chat (Myers et al., 2017, 2018; Roseberry et al., 2014; Tsuji et al., 2021; Troseth et al., 2018). It is worth mentioning that studies addressed the role of media verbal interactions and co-viewing (Mendelsohn et al., 2010; Operto et al., 2020), screen time content (Operto et al., 2020), and socio-economic status (Slobodin et al., 2024; Rayce et al., 2024), joint media engagement and verbal scaffolding (Medawar et al., 2023), or shared book reading (Rosslund et al., 2024) as moderators, and one study examined the quantity and quality of maternal speech in dyadic toy play as a mediator between background televiewing and vocabulary acquisition (Masur et al., 2016), while another study examined the mediating role of peer-play as well as the moderating role of gender (Putnick et al., 2023).

Summary of evidence on language

The findings across studies in this area were inconsistent, with some outcomes being more consistently and undesirably associated to screen time, such as language competence, and others being more consistently and desirably linked to screen time, such as vocabulary (see Table 7). Contextual and child-related factors, such as verbal interactions during screen time or co-viewing, screen content, frequency of children's exposure to screen media with the same content (Krcmar, 2010; Vandewater et al., 2010), shared book reading (Rosslund et al., 2024) and children's age (Krcmar, 2010), but not gender (Putnick et al., 2023) seem to be important moderators of the correlates of screen time on language development. In addition, there is still a lack of longitudinal studies, as well as studies focusing on various screen devices, especially modern ones.

Motor skills

Eight studies examined the link between screen time and motor skills among children under the age of three. One semi-longitudinal study reported that for each additional hour per day of parent-reported televiewing at age 29 months, a 9% decrease in locomotion (i.e., running, side shuffle) scores was observed at age 65 months (Pagani et al., 2013). In a cross-sectional study, children with more than 2 h of televiewing per day and children who had <2 h did

TABLE 8 Summary of results pertaining to motor skills.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Motor skills	0	0	0	2	5	0	0	3	0	1	2	1	3	*10*	*1*
Motor skills (age of attainment)	0	0	0	0	0	0	0	0	0	0	5	1	*0*	*5*	*1*
Locomotion	0	0	0	0	0	0	1	0	0	0	0	0	*1*	*0*	*0*
Total	*0*	*0*	*0*	*2*	*5*	*0*	*1*	*3*	*0*	*1*	*7*	*1*	*4*	*15*	*2*

"−," undesirable association; "=," non-significant association; "+," desirable association.

not differ in the odds of having delayed motor development, with children in the low-televiewing group having a higher percentage of delay. However, children aged 24 to 35 months with high televiewing were found to have 3.7 times higher odds of being delayed in their motor development (Lin et al., 2015). Bedford et al. (2016) reported no cross-sectional association between first touchscreen use and gross motor milestones attainment. Additionally, children with earlier first touchscreen use were found to attain the "stacking blocks" fine motor milestone earlier, with a small effect size. Importantly, this was only the case for scrolling, not for video watching on a touchscreen device. Motor development was not systematically found to be linked to screen time in semi-longitudinal and cross-sectional models in another study, although one undesirable cross-sectional association was found for girls at age 12 months (Kracht et al., 2023). A study focusing on children aged 12 to 36 months found no direct association, yet revealed a small, undesirable indirect link between screen time and both fine and gross motor skills through peer play, with no gender-based differences (Putnick et al., 2023). Another longitudinal study yielded mixed results, reporting various models with differing time points for assessing predictors and outcomes (Slobodin et al., 2024). Herein, no indications of a moderation by socio-economic status were found. In a semi-longitudinal study about multiple developmental outcomes, screen time at age 1 year was not systematically found to be linked with gross and fine motor development at age 2 and 4 years (Takahashi et al., 2023). Furthermore, no cross-sectional association was found between different forms of screen time and attainment of motor development milestones (Gago-Galvagno et al., 2023).

Methodological considerations

Motor-related outcomes were assessed with parent-reported data collected with questionnaires (Putnick et al., 2023; Takahashi et al., 2023; Slobodin et al., 2024; Bedford et al., 2016; Gago-Galvagno et al., 2023) or standardized test batteries (Kracht et al., 2023; Lin et al., 2015; Pagani et al., 2013). Most studies measured screen time by one-time parent report (Lin et al., 2015; Takahashi et al., 2023; Pagani et al., 2013; Bedford et al., 2016; Gago-Galvagno et al., 2023). Screen time was categorized in two studies (Kracht et al., 2023; Lin et al., 2015). Three studies examined only the effects of televiewing or DVD watching (Kracht et al., 2023; Lin et al., 2015; Pagani et al., 2013), and one assessed the effect of tablet, handheld, or touchscreen devices (Bedford et al., 2016), while another also encompassed gaming (Putnick et al., 2023). Some studies considered media content or contextual aspects such peer play as a mediator and gender as a moderator (Putnick et al., 2023) or socio-economic status as a moderator (Slobodin et al., 2024).

Summary of evidence on motor skills

The paucity of studies in this area and the inconsistent results render any conclusion about the effects of screens on motor development in the first 3 years of life difficult to draw (see Table 8). Overall, results indicating non-significant associations seem to prevail by a large margin. Results that were obtained so far in this field are limited by a complete absence of experimental and a limited number of longitudinal studies. However, a valuable aspect of some of these studies is the use of validated tests to assess outcomes studied, while a limitation of most studies is their reliance on one-time parent reports of screen time indicators.

Socio-emotional skills

Studies on the association between screen time and overall socio-emotional skills, internalizing and externalizing problems, social skills, and self-regulation ($n = 24$) are reported here.

Overall socio-emotional skills

A longitudinal study yielded a desirable association between televiewing and socio-emotional skills composite scores from age 1 year to age 3 years (Intusoma et al., 2013). The authors also reported that this desirable effect (Black et al., 2017) became an undesirable effect with an exposure of more than 2 h per day but (Britto et al., 2017) was more pronounced for educational content. However, the authors highlighted that cultural aspects might explain the link between televiewing and socio-emotional skills, as there was a positive link between televiewing and the socio-economic status of the family. Results from another longitudinal study suggest that screen media multitasking from age 18 months to 4 years might be linked to higher total problem scores on the Child-Behavior Check List (Achenbach, 1999) but not to parent-reported or teacher-reported total problem scores on the Strengths and Difficulties Questionnaire (Goodman, 1997) at age 6 years (Srisinghasongkram et al., 2020). A further study showed no link between children's screen time at age 18 months and negative emotionality at age 26 months (Gordon-Hacker and Gueron-Sela, 2020). Semi-longitudinal studies found that children showing "high-persistent" screen time from 24 to 60 months were found to have lower adaptive behavior scores, in contrast to children with "low to moderate" screen time (McArthur et al., 2020). A cross-sectional study with children aged 6 to 24 months of age found screen time to be undesirably related to socio-emotional skills, an association that was partly mediated by reduced parent–child play without screens (Wan et al., 2021). Another study reported a series of non-significant associations of different indicators of screen time with temperament (i.e., effortful control, surgency, and negative affect) as well as joint attention skills (Gago Galvagno, 2021). No experimental studies were found that examined overall socio-emotional skills.

Internalizing problems

A longitudinal study found that children exposed to more than 2 h of screen time (TV, PC, and video games) at age 36 months had a higher risk of internalizing problems at age 36 months controlling for internalizing problems at age 24 months (McArthur et al., 2022). One semi-longitudinal study supports the existence of an undesirable association of televiewing with anxiety and depression but not with affective problems, anxiety, somatic complaints, withdrawal, or internalizing behaviors at age 18 months (Chonchaiya et al., 2015). Adult TV programs were linked to more emotional-reactive problems (Chonchaiya et al., 2015). Another semi-longitudinal study found an undesirable link between early exposure to television and emotional reactiveness but not to anxious or depressive symptoms at age 55 months (Mistry et al., 2007). A third semi-longitudinal study found no association between televiewing and emotional symptoms at age 30 months (Cheng et al., 2010), and semi-longitudinal trajectories of screen time from 24 to 60 months were not found to be linked to internalizing problems at age 60 months (McArthur et al., 2020). Finally, a cross-sectional study reported an undesirable association between touch-screen use and emotional problems, social withdrawal, and anxious and depressive symptoms (Lin et al., 2020). No experimental studies were found that examined internalizing problems.

Externalizing problems

One longitudinal study found that high exposures of more than 1 h per day, but not low or moderate exposure, across 2 to 3 years of age was linked to the incidence and persistence of externalizing behaviors at age 3 years (Verlinden et al., 2012). Another longitudinal study found no significant link to externalizing problems from 2 to 8 years of age (Levelink et al., 2020). Further, children who spent two or more hours on screens (including TV, computers, and video games) at 36 months of age faced a higher risk of developing externalizing problems at that same age. This association was observed after accounting for externalizing problems present at 24 months (McArthur et al., 2022). One semi-longitudinal study found that trajectories of screen time from 24 to 60 months linked to externalizing problems at age 60 months: membership in the "high-persistent" class was linked to higher externalizing problems scores than the "low to moderate" class (McArthur et al., 2020). Another study found no association between televiewing and conduct problems at age 30 months (Cheng et al., 2010) and oppositional defiant behaviors at age 18 months (Chonchaiya et al., 2015), and undesirable associations with aggressive behavior and externalizing problems at ages 33 months (Tomopoulos et al., 2007) and 55 months (Mistry et al., 2007) were reported in other studies. Adult TV programs were linked to aggression and externalizing problems at age 18 months (Chonchaiya et al., 2015) and to aggression, oppositional defiant behavior, and externalizing problems at age 33 months (Tomopoulos et al., 2007). Furthermore, bedtime TV viewing at age 18 months was associated with more aggressive behavior and attention problems in Medicaid-eligible racial/ethnic minority children. This link was found to be mediated through worsened sleep (Miller et al., 2022). Results from cross-sectional studies support an undesirable association between touch-screen use and aggressive behavior in children aged 18 to 36 months (Lin et al., 2020) and between screen time and externalizing problems in children aged 6 to 24 months, and the latter connection was not found to be mediated by reduced parent–infant play without screens (Wan et al., 2021). No experimental studies were found that examined externalizing problems.

Social skills and peer problems

A longitudinal study of children aged 12 to 36 months found no direct association, but identified a small, undesirable indirect link between screen time and personal-social skills via peer play, with no gender-based moderation (Putnick et al., 2023). Semi-longitudinal studies found undesirable associations between televiewing at age 18 months and prosocial behavior at age 30 months (Cheng et al., 2010), between total screen, TV, gaming time, and social skills (Carson et al., 2019), and between televiewing in early childhood and victimization in fourth grade (Pagani et al., 2010, 2013). Another semi-longitudinal study investigating various developmental outcomes found that screen time at 1 year of age was partially associated with personal and social skills at ages two and four, especially when daily screen time exceeded 4 hours (Takahashi et al., 2023). One cross-sectional finding from a semi-longitudinal study was that no significant link was found for televiewing and prosocial behavior at age 30 months (Cheng et al., 2010). No experimental studies were found that examined social skills and peer problems.

Self-regulation

A longitudinal study by Cliff et al. (2018) reported that total media exposure at age 2 years was linked to slightly lower scores of self-regulation at age 4 years, which was in turn linked to higher media exposure at age 6, but not vice versa. Further, the effect of self-regulation on media use from age 4 years to 6 years was not moderated by gender or hostile parenting but by parental education: The link was only found in parents with a tertiary education. Separate analyses for TV, computer use, and gaming showed that these results were mainly driven by TV viewing. In another longitudinal study, screen time at the age of 12 months was linked to negative affect but not to effortful control. Further, screen time at age 12 months was related to lower increases in negative

TABLE 9 Summary of results pertaining to socio-emotional skills.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Overall socio-emotional skills	0	0	0	2	2	0	1	0	0	1	5	0	*4*	*7*	*0*
Internalizing behavior	0	0	0	1	0	0	3	8	0	3	0	0	*7*	*8*	*0*
Externalizing behavior	0	0	0	2	3	0	5	2	0	2	0	0	*9*	*5*	*0*
Social skills and peer problems	0	0	0	1	0	0	4	1	0	0	1	0	*5*	*2*	*0*
Self-regulation	0	0	0	3	2	0	1	0	0	0	0	0	*4*	*2*	*0*
Bonding	0	0	1	0	0	0	0	0	0	0	0	0	*0*	*0*	*1*
Total	*0*	*0*	*1*	*9*	*7*	*0*	*14*	*11*	*0*	*6*	*6*	*0*	*29*	*24*	*1*

"−," undesirable association; "=," non-significant association; "+," desirable association.

affect from 12 to 35 months of age but not to the development of effortful control. In addition, changes in screen time were unrelated to changes in negative affect and effortful control and no indications of effects of negative affect or effortful control at age 12 months on the development of screen time were found (Brauchli et al., 2024). A semi-longitudinal study was conducted to examine prospective associations and changes between self-regulation problems at 9 months and 2 years of age and tele- and video viewing at 2 years of age (Radesky et al., 2014). The results showed that children with persistent self-regulation problems were even more likely to watch television or videos at age 2 years, suggesting that this relationship is most likely bidirectional. No experimental or cross-sectional studies were found that examined self-regulation.

While not being specifically related to self-regulation, one experimental study that focused on mother-infant bonding will be placed here (Kaynak and Yilmaz, 2024). The study found that video calling as well as video calling combined with singing lullabies to preterm infants shortly after birth had desirable effects on mother-infant bonding scores as compared to a control group on the seventh and final day of the intervention.

Methodological considerations

Outcomes were assessed with questionnaires and screenings in all studies. Only few studies used a 24-h diary to assess screen time (Srisinghasongkram et al., 2020; Tomopoulos et al., 2007; Brauchli et al., 2024), and all others relied on one-time parent reports (Miller et al., 2022; Mistry et al., 2007; Chonchaiya et al., 2015; Lin et al., 2020; Pagani et al., 2010; Cheng et al., 2010; Takahashi et al., 2023; Pagani et al., 2013; Intusoma et al., 2013; Gordon-Hacker and Gueron-Sela, 2020; McArthur et al., 2020; Wan et al., 2021; Gago Galvagno, 2021; Verlinden et al., 2012; Levelink et al., 2020; Carson et al., 2019; Cliff et al., 2018; Radesky et al., 2014). Screen time was categorized in three studies (Mistry et al., 2007; Cheng et al., 2010; Takahashi et al., 2023; McArthur et al., 2022; Verlinden et al., 2012), and four studies categorized their outcomes to identify clinically relevant outcomes (Tomopoulos et al., 2007; Intusoma et al., 2013; Wan et al., 2021; Verlinden et al., 2012). Although the majority of studies only examined TV and DVD (Miller et al., 2022; Mistry et al., 2007; Chonchaiya et al., 2015; Pagani et al., 2010; Cheng et al., 2010; Tomopoulos et al., 2007; Pagani et al., 2013; Intusoma et al., 2013; Verlinden et al., 2012; Radesky et al., 2014), three studies also focused on handheld devices (Gordon-Hacker and Gueron-Sela, 2020), computers (Cliff et al., 2018), and playing games (Putnick et al., 2023; Gordon-Hacker and Gueron-Sela, 2020; Levelink et al., 2020; Cliff et al., 2018), one solely on touch screen use (Lin et al., 2020), another explored the effects of screen media multitasking (Srisinghasongkram et al., 2020), and others examined overall screen time (Takahashi et al., 2023; McArthur et al., 2022, 2020; Wan et al., 2021; Carson et al., 2019; Brauchli et al., 2024). One while one experimental study focused on the effects of mothers' video calls and singing lullabies with their preterm infants (Kaynak and Yilmaz, 2024), thus considering both the content and the context. Four studies examined the role of content (Chonchaiya et al., 2015; Tomopoulos et al., 2007; Intusoma et al., 2013; Verlinden et al., 2012), and others examined the moderating role of child gender (Levelink et al., 2020; Cliff et al., 2018), parental education (Cliff et al., 2018), and hostile parenting (Cliff et al., 2018). The mediating role of play without screens, parent–child play (Wan et al., 2021), and peer play were examined (Putnick et al., 2023). Finally, only one study considered co-viewing as a contextual variable (Wan et al., 2021).

Summary of evidence on socio-emotional skills

Associations between screen time and socio-emotional outcomes seem to be inconsistent across studies, with a tendency to more undesirable associations, independent of the study design (see Table 9). The most frequent study design was the semi-longitudinal one, which again calls for more longitudinal studies with more than two assessments that can model change and bidirectional associations. Regarding self-regulation, bidirectional links to screen time seem to be plausible. Additionally, few experimental studies were found in this field, and most studies focused on televiewing.

Social interaction

The results of the studies that examined associations with parent–child interaction, media–verbal interaction, attachment security, social closeness, and children's toy play ($n = 15$) are summarized below in one subcategory, social interaction.

Experimental and experimental field studies found an undesirable effect of background television on parent–child interactions (Pempek et al., 2011) as well as a number of aspects of social interactions on the side of children as well as parents. Regarding children's social interactions, undesirable associations were found with duration of play (Evans Schmidt et al., 2008), social interactions and responsiveness (Kirkorian et al., 2009), vocalizations and conversational turns (Brushe et al., 2023), and duration of attention to play (Evans Schmidt et al., 2008; Courage et al., 2010). On the parents' side, undesirable associations were found between background television and active involvement, responsiveness, and interaction in play (Kirkorian et al., 2009), vocalizations (Courage et al., 2010), quality and quantity of utterances (Tanimura et al., 2007), and duration of play interactions with children (Courage et al., 2010). In contrast, no associations was found with children's overall focused attention and maturity of play in one study (Evans Schmidt et al., 2008). Undesirable effects were also found regarding reaction to joint attention prompts when playing a tablet game about caring for animals, especially in older children, but not when watching a video of a child playing with a toy or when playing with a puzzle app on a tablet (Webb et al., 2024). Studies also showed that children approached strangers more easily when they watched a video with them than when the stranger was in the same room but could not see the video and was reading a book instead (Wolf and Tomasello, 2020). Furthermore, potential for an increase in parent–child interactions was found in videos that are designed to model parent behavior and support co-viewing while also offering a child-friendly narrative and storyline (Pempek et al., 2011). Finally, a comparison of interactions between young children and their parents when viewing tablet books and print books show that social control behaviors and less social reciprocity were more prevalent when viewing and reading tablet books than print books (Munzer et al., 2019a) but that verbal interaction and collaboration are lower with electronic books than with printed books (Munzer et al., 2019b).

A short-term longitudinal study showed that background television exposure at age 13 months was linked to poorer quantity and quality of maternal vocalizations, which was in turn linked to children's vocabulary acquisition (Masur et al., 2016). However, another study found that televiewing is not longitudinally associated with conversational turns (Zimmerman et al., 2009). A semi-longitudinal study among low-income families found that media verbal interactions compensated for the undesirable associations of televiewing with language development and even had positive associations with language development when only educational videos were viewed (Mendelsohn et al., 2010). One cross-sectional study found the frequency of parent-child interactions during background and foreground televiewing to be lower than 25% of exposures and to be highest for educational child content and for content that was co-viewed (Mendelsohn et al., 2008). However, there were no indications of more co-viewing for educational content than for non-educational content for young children, school-aged children, teenagers, or adults. Cross-sectional findings from a longitudinal study found that an hour's more televiewing is associated with fewer conversational turns (Zimmerman et al., 2009). Further, neither screen time nor co-viewing was found to be linked to attachment insecurity, and parental absorption in media was found to have an undesirable link to attachment security (Linder et al., 2021). Moreover, the authors reported that active parental mediation was found to buffer against the potential negative effects of child televiewing.

Methodological considerations

Outcome variables were measured with screenings or questionnaires (Mendelsohn et al., 2010; Masur et al., 2016; Mendelsohn et al., 2008; Linder et al., 2021), observation of videotaped interaction situations (Tanimura et al., 2007; Masur et al., 2016; Pempek et al., 2011; Evans Schmidt et al., 2008; Kirkorian et al., 2009; Courage et al., 2010; Webb et al., 2024; Wolf and Tomasello, 2020; Munzer et al., 2019a,b), and electronic diaries using special hardware and software (e.g., LENA) (Zimmerman et al., 2009; Brushe et al., 2023). Screen time was measured through one-time parent reports (Masur et al., 2016; Linder et al., 2021), diaries (Mendelsohn et al., 2010; Pempek et al., 2011; Mendelsohn et al., 2008), hardware and software-based diaries (Zimmerman et al., 2009), and the LENA software (Brushe et al., 2023). A majority of the studies focused solely on televiewing and DVD watching (Masur et al., 2016; Pempek et al., 2011; Evans Schmidt et al., 2008; Kirkorian et al., 2009; Courage et al., 2010; Wolf and Tomasello, 2020), some on games (Mendelsohn et al., 2010; Webb et al., 2024; Mendelsohn et al., 2008), and other studies on modern portable screen devices (Tanimura et al., 2007; Munzer et al., 2019a,b; Linder et al., 2021). Some studies addressed the role of content (Mendelsohn et al., 2010; Okuma and Tanimura, 2009; Pempek et al., 2011; Evans Schmidt et al., 2008; Kirkorian et al., 2009; Mendelsohn et al., 2008), two studies examined electronic books (Munzer et al., 2019a,b), and two studies addressed the protective role of active parental mediation (Linder et al., 2021) and media verbal interactions (Mendelsohn et al., 2010).

Summary of evidence on social interaction

The pattern of results regarding the association between screen time and social interactions quite clearly shows undesirable links to various aspects of social interaction (see Table 10). Strong evidence from several experimental studies suggests that televiewing reduces the quantity and quality of parent–child interaction and might also negatively affect children's attention to play and its duration. However, other results indicate the role of content and context of screen time, an area that needs to be examined in more depth. Notably, that these results mostly pertain to televiewing, and the role of modern screen devices has yet to be explored in this age range.

Overall development

Although most studies examining association between screen time and child development focused on one or more specific outcomes, some studies ($n = 8$) elucidated links with overall

TABLE 10 Summary of results pertaining to social interactions.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Play duration (child)	1	0	0	0	0	0	0	0	0	0	0	0	*1*	*0*	*0*
Responsiveness (child)	1	0	0	0	0	0	0	0	0	0	0	0	*1*	*0*	*0*
Parent's vocalizations	1	0	0	2	1	0	0	0	0	0	0	0	*3*	*1*	*0*
Child vocalization	0	0	0	1	0	0	0	0	0	0	0	0	*1*	*0*	*0*
Parents' active involvement	1	0	0	0	0	0	0	0	0	0	0	0	*1*	*0*	*0*
Parents' responsiveness	1	0	0	0	0	0	0	0	0	0	0	0	*1*	*0*	*0*
Social interactions	7	0	2	1	0	0	1	0	0	2	1	0	*11*	*1*	*2*
Duration of attention to play	2	1	0	0	0	0	0	0	0	0	0	0	*2*	*1*	*0*
Response to joint attention	1	2	0	0	0	0	0	0	0	0	0	0	*1*	*2*	*0*
Parental utterances	2	0	1	0	0	0	0	0	0	0	0	0	*2*	*0*	*1*
Attachment insecurity	0	0	0	0	0	0	0	0	0	1	1	0	*1*	*1*	*0*
Total	*17*	*2*	*3*	*4*	*1*	*0*	*1*	*0*	*0*	*3*	*2*	*0*	*25*	*6*	*3*

"–," undesirable association; "=," non-significant association; "+," desirable association.

development, mostly in composite scores from developmental screenings or test batteries. These studies are reviewed below.

In a longitudinal study from 6 months to 8 years of age, children with different patterns of televiewing were not found to differ in their developmental status at age 6 months, but children who exhibited a "extremely high descending" pattern (i.e., children starting with more than 3 h of screen time per day at age 2.2 years and dropping to <2 h at age 7.3) were found to have the highest incidence of delayed development, while children in the "low descending" group had the lowest incidence at age 2 years (Kim and Chung, 2021). However, differences in changes in developmental scores were not examined among the various groups. One of the few longitudinal studies found that children's overall screen time at age 2 years had an undesirable association with their composite development score at age 3 years (Madigan et al., 2019). The same undesirable link was also found from screen time at age 3 years to composite development score at age 5 years. Notably, the reverse association was not statistically significant, although the link between development at age 3 years and screen time at age five had the largest effect size. Another publication that used the same dataset showed that two latent classes of screen use could be identified from age 24 months to 60 months: a "low to moderate" class and a "high-persistent" class (McArthur et al., 2020). The authors were able to show that children in the "high-persistent" class had lower total scores at age 60 months than children from the "low to moderate" class. However, analyses were not performed with latent class growth curve models for composite developmental scores. Another longitudinal study indicated that children who engaged in two or more hours of screen time (TV, computer, or video games) at 36 months had an increased likelihood of delayed achievement of developmental milestones at that age, even when controlling for developmental milestones at 24 months (McArthur et al., 2022). Another longitudinal study identified not direct but a small undesirable indirect negative association between screen time (including watching shows, movies, and gaming) and developmental delays via peer play from ages 12 to 36 months. This association showed no gender-based moderation (Putnick et al., 2023). One semi-longitudinal study identified an undesirable impact of televiewing and adult TV programs over time from 6 months to 18 months on children's pervasive developmental problems at age 18 months (Chonchaiya et al., 2015). Similarly, boys but not girls with higher, and in particular those with more than 1 h but <2 h per day of TV and/or DVD screen time at age 12 months were found to have an increased risk of having received an autism spectrum disorder diagnosis (ASD) by the age of 36 months, controlling for their development at age 12 months (Kushima et al., 2022). However, <1 h was not strongly related to ASD and was even associated with a lower risk in girls. In a cross-sectional study among a representative sample of French 2-year olds, weekly and daily TV, PC, tablet, and smartphone use was linked to slightly higher odds of an intermediate risk of autism, but with reduced odds of a high risk. A similar pattern was observed for number of hours on different devices (Melchior et al., 2022). No experimental studies were found that examined overall development.

Methodological considerations

All studies assessed developmental outcomes with questionnaires and screenings reported by parents. Only one study used a 24-h media diary instead of a one-time report from parents (Chonchaiya et al., 2015). Some studies examined the unique associations with televiewing or DVD watching (Chonchaiya et al., 2015; Kim and Chung, 2021; Kushima et al., 2022; Melchior et al., 2022), and others assessed the links to modern portable screen device use (McArthur et al., 2020; Madigan et al., 2019; Melchior et al., 2022). One study also addressed the role of content (Chonchaiya et al., 2015), but none of the studies considered aspects of media context such as co-viewing. Furthermore, two studies addressed the role of trajectories of media use (Kim and Chung, 2021; McArthur et al., 2020) and its link to the outcome

TABLE 11 Summary of results pertaining to overall development.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Overall development	0	0	0	6	1	0	2	1	0	1	1	1	9	3	1

"−," undesirable association; "=," non-significant association; "+," desirable association.

studied. One study examined the mediating role of peer-play and the moderating role of gender (Putnick et al., 2023). Two studies adopted a gold-standard technique for the modeling of change (Putnick et al., 2023; Madigan et al., 2019).

Summary of evidence on overall development

Conclusions about the role of screen time for children's overall development are tentative given that only a handful of studies examined this link (see Table 11). Nonetheless, results that were obtained so far point to undesirable correlates across early and middle childhood.

Discussion

This comprehensive review presents a systematic scoping analysis of 158 studies that explored the relationships between screen time and a broad spectrum of developmental outcomes, including sleep, physical health, cognition, learning efficiency, language, motor skills, socio-emotional skills, social interaction, and overall development in children aged zero to 36 months. A general overview and interpretation of the evidence summarized in the results section are presented below.

Overall summary of evidence

Results across all developmental aspects are summarized in Table 12. A total of 225 findings within the 158 studies indicated undesirable associations between screen time and child development. Another 268 findings showed that screen time was not significantly linked to child development. Finally, 46 findings described desirable associations between screen time and child development. Thus, the number of results that indicate undesirable and non-significant associations is comparatively high, whereas the number indicating desirable ones is low. In the following, this pattern of results is referred to as the *overall pattern* and is described with three numbers in parentheses (undesirable/non-significant/desirable). Thus, the overall pattern can be represented as (225/268/46). Regarding the overall pattern for the four types of design separately, results suggest that experimental studies mostly reported non-significant results but also yielded a meaningful number of undesirable associations as well as desirable ones. In contrast, longitudinal studies, semi-longitudinal studies as well as cross-sectional studies all reported both undesirable and non-significant associations, with comparable proportions, but virtually no desirable ones. In the following, we discuss how this pattern applies to the various developmental outcomes and what other patterns deviate from this overall pattern. Further, we discuss whether the overall pattern can be found in studies with different study designs and whether the pattern aligns with results from other systematic reviews and meta-analyses.

The overall pattern of mostly undesirable and non-significant results and a smaller number of desirable results was found for sleep (39/47/0), physical health (17/18/5), cognition (25/40/2), and socio-emotional skills (29/24/1). Cross-sectional and semi-longitudinal designs were most prominent in these fields, with a higher prevalence of cross-sectional studies on sleep and physical health and a higher occurrence of semi-longitudinal studies on cognition and socio-emotional skills. The overall pattern of undesirable and non-significant associations also predominated among all longitudinal studies in these areas, while experimental studies were rare. Thus, the evidence appears to be ambiguous. However, the number of undesirable associations is much higher than the number of desirable ones. This might indicate a tendency toward undesirable associations between screen time and sleep, physical health, cognition, and socio-emotional skills.

Results about sleep and physical health align with those from other reviews and meta-analyses in that there are comparable proportions of undesirable and non-significant associations (Guellai et al., 2022; Lund et al., 2021; Eirich et al., 2022). The tendency to undesirable associations might be interpreted as partial evidence for the displacement hypothesis (Mutz et al., 1993; Roberts et al., 1993). For instance, increased screen time might lead to less opportunities to interact with peers and to learn socio-emotional skills, or to less physical activity, which might lead to worse physical health and less healthy sleep. The video deficit hypothesis (Barr, 2008; Anderson and Pempek, 2005) and the mental-effort hypothesis (Valkenburg and van der Voort, 1994) might additionally explain undesirable associations of screen time on cognition, especially regarding television, as children might tend to habituate to being stimulated without any need for effort. In a recent review and meta-analysis, Mallawaarachchi et al. (2022) reported that mobile device use is associated with poorer sleep, but not with psychological and cognitive outcomes, which suggest that the content and the modality of use might warrant further investigation.

Several deviations from the overall pattern described above were identified: (1) a deviation toward a presence of desirable associations, (2) a deviation in the direction of dominant undesirable associations, and (3) an absence of a sufficient number of results. A noticeable presence of desirable associations was given for learning efficiency (17/34/12) and language (60/81/20). The presence of desirable associations in the context of dominantly undesirable associations aligns with other reviews on language development (Massaroni et al., 2024). Further, the balance between undesirable and desirable associations regarding learning

TABLE 12 Grand summary of all results.

Development area/subcategories	Experimental			Longitudinal			Semi-longitudinal			Cross-sectional			*Total*		
	−	=	+	−	=	+	−	=	+	−	=	+	−	=	+
Total sleep	0	5	0	7	9	0	1	0	0	31	34	0	*39*	*47*	*0*
Total physical health	1	0	4	3	4	0	5	3	0	8	11	1	*17*	*18*	*5*
Total cognition	0	4	0	4	3	0	15	20	2	6	13	0	*25*	*40*	*2*
Total learning efficiency	17	34	12	0	0	0	0	0	0	0	0	0	*17*	*34*	*12*
Total language	3	17	12	9	6	0	19	15	1	29	43	7	*60*	*81*	*20*
Total motor skills	0	0	0	2	5	0	1	3	0	1	7	2	*4*	*15*	*2*
Total socio-emotional skills	0	0	1	9	7	0	14	11	0	6	6	0	*29*	*24*	*1*
Total social interaction	17	3	3	4	1	0	1	0	0	3	2	0	*25*	*6*	*3*
Total overall development	0	0	0	6	1	0	2	1	0	1	1	1	*9*	*3*	*1*
Overall total	*38*	*63*	*32*	*44*	*36*	*0*	*58*	*53*	*3*	*85*	*117*	*11*	*225*	*268*	*46*

"−," undesirable association; "=," non-significant association; "+," desirable association.

underscores that while learning is possible through screen based media in experimental conditions, the context and content of the respective materials might be central to the learning effect (Guellai et al., 2022; Massaroni et al., 2024; Kostyrka-Allchorne et al., 2017). The dominance of undesirable associations that was obtained for social interaction (25/6/3) seems to be the most robust finding, especially given the high amount of experimental and longitudinal studies. These results show how attractive screens are for both children and adults and align with research on the phenomenon of technoference (Krogh et al., 2021), thus highlighting the importance of parental awareness of the potential for disruption of adult-child interactions through screen media.

On a methodological note, studies on learning efficiency and on social interaction were almost exclusively experimental in design. The studies on language also included a comparatively high proportion of experimental studies, although cross-sectional and semi-longitudinal studies still prevailed. Cross-sectional, semi-longitudinal, and longitudinal studies examining links to language tended to find more undesirable associations. In contrast, studies using an experimental approach tended to find more desirable associations. This was not the case for studies on social interaction, where experimental studies clearly report undesirable results, which is in line with results from previous reviews (Kostyrka-Allchorne et al., 2017). This pattern suggests that controlled experimental studies can shed light on both desirable correlates of screen time on isolated processes such as word learning as well as on undesirable correlates of social interaction. Conversely, field studies examining the same associations within a real-world context yield less clear results. An explanation for this finding might be that cause-effect relationships in this field are very complex and hard to capture in real-world settings due to a high number of potential moderating and confounding variables. While experimental studies can address this complexity by isolating specific components of interest, correlational field studies may find it more challenging to isolate the unique effects of children's screen time on development, particularly when cross-sectional designs are employed. Further, ethical issues and general concerns about the exposure of infants and toddlers to screens pose an additional challenge in this field of research. Besides experimental designs, longitudinal designs with more than two assessments and state-of-the-art modeling of change (i.e., random intercept cross-lagged models, latent growth models), ideally accompanied by methods that allow the inspection of intraindividual processes, such as experience sampling studies might also be valuable to strengthen our understanding of this complex field. Such methods might also tackle social desirability and memory distortions.

Finally, two outcomes that are comparatively understudied are motor skills (4/15/2) and overall development (9/3/1). Results about the associations between screen time and motor skills mostly stem from cross-sectional studies, but those about associations to overall development almost exclusively stem from longitudinal studies. Accordingly, the knowledge base about the associations between screen time and motor skills must be strengthened before any stable conclusions can be drawn. However, there is some evidence that screen time might have undesirable links to overall development, although we believe that the results of studies on specific development outcomes are more informative.

Several specific methodological and conceptual factors may have influenced the outcomes of the various studies. In the following section, we will elaborate on these aspects to discuss the results from a more theoretical perspective.

Does screen time displace learning opportunities and/or is screen time an inferior learning opportunity?

The present study demonstrates a heterogeneous pattern of associations between screen time and developmental outcomes across different domains. The most dominant tendency observed is toward undesirable associations between screen time and developmental outcomes. From the perspective of the displacement hypothesis (Mutz et al., 1993; Roberts et al., 1993), the tendency for screen time to act as a risk factor for child development can be explained by its displacement of other activities that are essential for development. In this view, screen time leads to a displacement of activities that would have otherwise positively influenced developmental outcomes. For instance, reductions in physical activity and social interaction (Rayce et al., 2024), both critical for healthy development, illustrate how screen time may indirectly contribute to undesirable developmental outcomes. While there are only few studies on the associations between screen time and motor development from ages zero to three, there is evidence that physical activity is linked to motor skills, language as well as cognition, and academic achievement (Zeng et al., 2017). Further, there is some evidence, although mixed, that physical activity is associated with poorer sleep (Antczak et al., 2020; Pesonen et al., 2011; Pano-Rodriguez et al., 2023). Assuming that screen time is mostly (although not exclusively) a sedentary activity (World Health Organization, 2019), the displacement of essential developmental outcomes seems plausible. Higher screen time may reduce physical activity, leading to undesirable effects on various developmental areas. The frequent association between screen time and reduced social interactions also supports the idea of a displacement process. When a screen is visible, it may divert attention from meaningful social interactions for both the child and others, potentially displacing opportunities for exchanges. This reduction in social interaction could indirectly affect language acquisition and socio-emotional development. For instance, as Masur et al. (2016) found, maternal speech declines when a screen is activated during parent-child play, which could mediate reductions in children's expressive vocabularies (Ferjan Ramírez et al., 2022). Similarly, screen time was found to have an undesirable indirect association with child development because it displaces peer play time, which would in turn be positively associated with child development (Rayce et al., 2024).

Thus, physical activity and social interaction may serve as central mediators in explaining the displacement effects of screen time, impacting not only motor development but also physical health, sleep, learning efficiency, and socio-emotional and cognitive skills. A longitudinal extension of the displacement hypothesis would suggest that as screen time increases with age (Brauchli et al., 2024; Anderson et al., 2008), the risk of developmental disruption grows, forming a bidirectional cycle (Cliff et al., 2018; Magee et al., 2014; Neville et al., 2021). This conceptual mechanism, displayed in Figure 2, could be expanded to include additional mediators and complex mechanisms beyond those addressed in this study. For example, sleep was found to mediate the link between bedtime TV viewing and aggressive behavior and attention problems, which also indicates a possible displacement mechanism (Miller et al., 2022). In this sense, Figure 2 offers a simplified representation of the displacement hypothesis.

The video deficit hypothesis (Barr, 2008; Anderson and Pempek, 2005) further supports the tendency toward undesirable outcomes, as the quality of stimulation and learning efficiency from screen media may reduce the likelihood of positive developmental results. When combined with the displacement hypothesis, a compounded risk emerges. Not only are important learning opportunities missed due to time spent on screens, but the learning opportunities presented via screens often lack the quality that other, non-screen activities provide. Incorporating the mental-effort hypothesis (Koolstra and van der Voort, 1996) and the passivity hypothesis (Valkenburg and van der Voort, 1994) into this framework suggests that, beyond missing key learning experiences (displacement hypothesis) and encountering lower-quality learning (video deficit hypothesis), children may adopt a passive stance. Together, these hypotheses highlight the layered risks of excessive screen time for young children's development.

This combination of hypotheses presents a rather pessimistic view of screen time's impact on child development. Given the complexity of developmental processes, however, the displacement hypothesis may require refinement to account for different mechanisms of change across various developmental outcomes. For instance, the way screen time affects motor development could differ significantly from its effects on socio-emotional development. This idea is echoed in the Dimensional Model of Adversity (McLaughlin and Sheridan, 2016; McLaughlin et al., 2019), which posits two key environmental dimensions: deprivation (e.g., low levels of social and cognitive stimulation) and threat (e.g., exposure to violence). The model suggests that these environmental factors influence physiological and psychological outcomes in specific ways, rather than having broad, generalizable (and merely cumulative) effects. In the context of screen time, the deprivation dimension may align with the displacement hypothesis for *excessive* screen time, while the threat dimension could relate to exposure to highly inappropriate content. Within this framework, the type of stimulation a child is deprived of due to digital media use must be examined in relation to specific outcomes. For example, a child who is encouraged to be physically active during screen time might not experience motor deprivation, or a child who takes a video call with a grandmother might still benefit from interaction and language exposure. Missing stimuli necessary for experience expectant plasticity (Greenough et al., 1987) taking place during early childhood might play a crucial role in the mechanisms of how digital media use affects early childhood development. This model could help explain differential effects on developmental outcomes, depending on the specific ways in which digital media is used and underlines once more early childhood as a critical period, also for digital media use. Hence, the effects of screen time on different aspects of child development likely vary to such an extent that broad generalizations about its impact are untenable. This limitation highlights the need for more nuanced guidelines that emphasize empowering parents as competent caregivers, rather than imposing strict screen time limits (Lerner and Barr, 2015). Moreover, the significant number of studies that do not report negative associations, both in early childhood (as shown in this review) and at later developmental stages (Ferguson et al., 2024), suggests that existing hypotheses and models do not fully capture the complexity of this phenomenon. This calls for additional frameworks to better explain the range of outcomes related to screen media use.

Differential susceptibility and resilience as additional perspectives

Interindividual differences in how screen time is linked to development can be explained by theories that address the complex interaction of individual and contextual factors. Two such theories

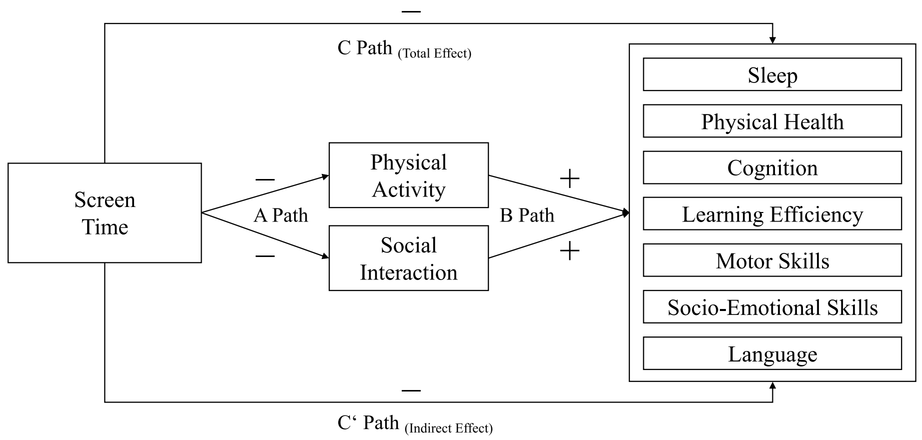

FIGURE 2
Conceptual model of the displacement hypothesis as a mediation mechanisms in the link between screen time and development. −, Negative association; +, Positive association; A, Direct effect of screen time on mediators; B, direct effect of mediators on development; C, Total effect of screen time on development; C′, Indirect effect of screen time on development.

or models are the theory of resilience (Masten and Barnes, 2018; Werner, 1993) and the Differential Susceptibility to Media Effects Model (Valkenburg and Peter, 2013).

Resilience is a concept from developmental systems theory (Ford and Lerner, 1992) that describes a system's ability to maintain healthy functioning in adversity (Masten, 2011). It emerges as a multi-layered process involving interactions among risk, promotive, and protective factors (Chmitorz et al., 2018). Risk factors increase the likelihood of adverse outcomes, promotive factors have positive effects regardless of risk, and protective factors mitigate risk-dependent effects (Masten and Barnes, 2018). Factors can be either promotive (Burke et al., 2017), protective (Wustmann Seiler et al., 2017), or both (Masten and Barnes, 2018). To understand the causal mechanisms of resilience, methodological approaches like longitudinal studies with multiple measurements are crucial (Hamaker et al., 2015). Promotive effects can be tested through main effects, while protective effects require modeling interactions or moderating effects (Burke et al., 2017; Sticca et al., 2017, 2020).

Regarding screen time as a risk factor, there is significant variability in how children engage with screen media, which complicates efforts to link screen time with early childhood development. As highlighted in our results section, many studies focus on more passive forms of screen use, such as televiewing or DVD watching, while others examine newer devices like smartphones and tablets. Even within these categories, the range of activities is vast, differing in interactivity (Kirkorian, 2018), educational content (Cerniglia and Cimino, 2020), or cognitive load (Zack et al., 2013), among other factors. This variability makes it difficult to draw definitive conclusions about the impact of screen time on child development. Additionally, the diversity of screen-based activities creates challenges in defining what constitutes "high" or "excessive" screen time, particularly when considering differences in children's age and developmental stage. For example, 30 min of watching Sesame Street might have a vastly different effect on a three-year-old's vocabulary development compared to 30 min of watching the news. Further, low doses of screen time might not have an impact on child development (Dynia et al., 2021; Ferguson, 2017), while very high exposure might carry a high level of risk (Takahashi et al., 2023). This underscores the need for more nuanced approaches when studying screen time's effects.

In addition to the diversity of screen devices, children can also participate in a wide range of digital activities. These activities include watching TV shows or movies, taking photos, playing interactive games, making video calls, and background televiewing. Some studies therefore focused on the duration that children spent engaged with screens in the foreground or background, while others examined the type of content being viewed, such as child-directed or adult-directed content, and educational or entertainment content. Furthermore, some studies analyzed the context in which screens were used, such as co-viewing (Kim et al., 2020), media verbal interactions (Mendelsohn et al., 2010), and usage during the week or weekend (Sigmundova and Sigmund, 2021). Some studies considered a combination of these aspects. In line with current discussions (Barr et al., 2018), our findings suggest that future research on screen time effects should go beyond merely quantifying screen time. Contemporary frameworks like the DREAMER model have synthesized these concepts and provide valuable theoretical and methodological guidance for organizing research efforts to address the complex challenges associated with screen time's impact on development (Barr et al., 2024). These frameworks encourage a more nuanced approach, considering not just the amount of screen time, but also the quality, context, and content of screen-based activities.

Regarding the role of promotive and especially protective factors, only a limited number of studies examined psychological mechanisms that could have moderated the association of children's screen time and child development. These moderators include factors such as the child's age, the type of screen content, and contextual factors such as co-viewing and engagement in non-digital activities (Barr et al., 2018). One example of how moderators can impact the relationship between children's screen time and developmental outcomes is demonstrated in the study conducted by Mendelsohn et al. (2010), who found that the negative associations between children's screen time and developmental outcomes were only significant in the absence of verbal interactions during the child's screen time. This review highlights that more research on the mechanisms of change is needed. For example, individual factors such as children's working memory (Choi et al., 2021), gender (Padmapriya et al., 2019; Levelink et al., 2020), and age (Hu et al., 2019), type of content (Operto et al., 2020), particularly educational child-directed content (Corkin et al., 2021; Chonchaiya et al., 2015), frequency of viewing the same content (Barr and Wyss, 2008; Barr et al., 2007b), matching sound effects or language prompts (Barr et al., 2009; Lauricella et al., 2016), familiarity with the character displayed on the screen (Lauricella et al., 2016; Howard Gola et al., 2013), interactivity with the screen (Nielsen et al., 2008; Lauricella et al., 2010), and contextual factors such as verbal interactions, co-viewing (Porter et al., 2022; Mendelsohn et al., 2010; Corkin et al., 2021; Richert et al., 2010), active parental mediation (Linder et al., 2021), social interaction (Antrilli and Wang, 2018), and less parenting factors (Cliff et al., 2018) need to be studied in more detail. Further, considering that only few studies have examined the 1st and the 2nd year of life, the moderating role of child attributes such as age and temperament have not been intensively studied in this area and needs more attention in future research to examine the differential susceptibility among children.

Another relevant theoretical model that addresses individual differences in how screen time affects development is the *Differential Susceptibility to Media Effects Model* (Valkenburg and Peter, 2013). This model, akin to resilience theory, posits that the impact of screen time on development is moderated by various factors, including dispositional, developmental, and social susceptibility. It highlights the complex interplay between individual characteristics and contextual factors, suggesting that these variables may have longitudinal, self-reinforcing effects over time. By considering these moderating influences, the model provides a more nuanced understanding of how screen time can affect development differently across individuals. By not taking complex interplay into account, many studies may have missed potential desirable associations with children's screen time, or they may have overemphasized the negative associations. Figure 3 shows how the displacement hypothesis (as a mediation) could be translated into a buffering hypothesis (as a moderation).

The role of cultural context

Supplementary Table S.1 shows the countries in which the studies were carried out. The most prevalent studies were conducted in North America, with a total of 67 studies, largely due to the high number of studies from the USA and Canada. In contrast, only 3 studies were carried out in South America. In Asia, there were 32 studies, contributed by countries such as Thailand, Japan, and Singapore. Europe saw 33 studies, with significant contributions from the UK, Sweden, and Italy. Meanwhile, Oceania had 6 studies, mostly from Australia and New Zealand. Additionally, there were 2 studies that spanned multiple continents, and 3 studies where the countries were not reported or specified.

Building on the geographical distribution of the studies outlined in Supplementary Table S.1, it is important to address the cultural context in which these studies were conducted, as this can significantly influence the results and their generalizability. Most of the studies were conducted in North America, particularly the United States of America. A substantial portion of the reviewed studies likely comes from WEIRD (Western, Educated, Industrialized, Rich, and Democratic) populations, which raises concerns about the applicability of these findings to non-Western, non-industrialized societies. The results of the present study do not reveal a consistent pattern suggesting significant differences between continents, as mixed findings were reported across all regions and even within countries on the same continent. While it is well-established that screen time varies by geographical region (LeBlanc et al., 2015), it is crucial to examine whether the associations between screen time and developmental outcomes are moderated by cultural factors. Additionally, it is important to explore whether the effects of contextual variables are better examined within or across cultures. To our knowledge, no studies have directly investigated how cultural context might influence these associations, making this an important area for future research. Nonetheless, Barr et al. (2024) provide an overview of socio-contextual factors that may influence differential susceptibility, such as ethnicity/race and socio-economic status. They propose a new theoretical framework, DREAMER, which integrates many of the theories and models discussed above and emphasizes the role of family media ecology and mechanisms of change that unfold over time across various contextual levels (Barr et al., 2024).

Methodological considerations

It is also important to consider the impact of study design on the results, as this plays a crucial role in the quality and reliability of the findings. Along with differences in sample size and participant demographics, more than 60% of the results included in the review stem from cross-sectional or semi-longitudinal designs. These study designs can only measure correlations between variables at a single point in time or over a short period and thus are unable to assess causality. Another important consideration in interpreting the findings of these studies is the issue of reverse causality. Reverse causality is the possibility that developmental problems may lead to increased screen time, rather than screen time causing developmental problems (Radesky et al., 2014). This issue has been relatively understudied in the literature. Longitudinal studies that assess children's screen time and developmental outcomes at multiple time points and that use state-of-the-art multivariate longitudinal models (Hamaker et al., 2015) can help address this issue by providing a more comprehensive understanding of the relationship between children's screen time and children's developmental outcomes over time while also taking contextual moderators into account. Such studies might contribute to our understanding of whether screen time is a cause, a consequence, or an epiphenomenon of child development and/or of the context in which children live.

Differences in assessment and statistical modeling could also contribute to the heterogeneity of findings observed. Most of the studies reviewed here relied on single-time parental reports, which,

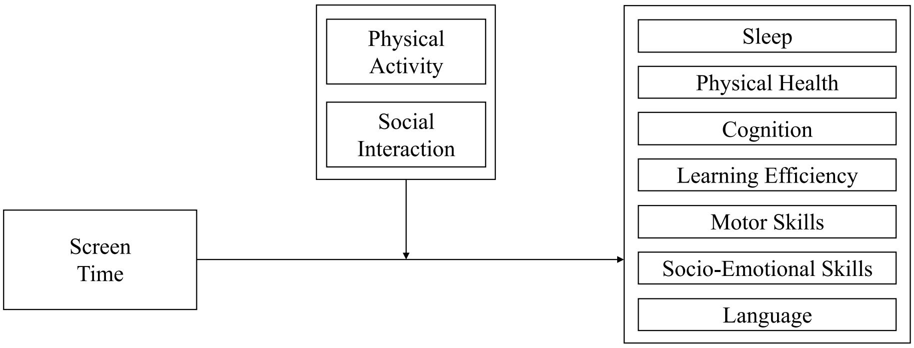

FIGURE 3
Conceptual model of the buffering hypothesis as a moderation mechanisms in the link between screen time and development.

while cost-effective and suitable for large-scale assessments, have several limitations. These include the potential for high social desirability biases, the possibility of recall and cognitive distortions affecting accurate reporting, and the lack of clarity around what constitutes "screen time" for participants. In this regard, Barr et al. (2020) recommend combining parental reports, activity diaries, and passive sensing apps to obtain a more comprehensive and precise picture of children's screen time. While this approach would certainly provide more accurate data, its feasibility may be limited, particularly in longitudinal studies where participant burden is high and obtaining representative samples can be challenging. Regarding statistical modeling, some studies used extreme-group modeling, which focuses on comparing children with high and low levels of screen time. Such a comparison of extreme groups is more likely to yield significant differences between groups than approaches that operationalize children's screen time as a continuous measure. Very high levels of screen time have been found to be related to a number of undesirable outcomes such as sleep (Chindamo et al., 2019; Cespedes et al., 2014; Mistry et al., 2007), physical health (Hu et al., 2019; Saldanha-Gomes et al., 2017; Collings et al., 2018; Manios et al., 2009), cognition (Mistry et al., 2007; Supanitayanon et al., 2020; Lin et al., 2015; Cheng et al., 2010; Barr et al., 2010a), language (Lin et al., 2015; Duch et al., 2013; Kim and Chung, 2021; Mendelsohn et al., 2010; Ruangdaraganon et al., 2009; Byeon and Hong, 2015; Perdana et al., 2017; Okuma and Tanimura, 2009; Bittman et al., 2011; Sundqvist et al., 2021), and socio-emotional skills (Mistry et al., 2007; Cheng et al., 2010; Verlinden et al., 2012). While this strategy might shed light on non-linear relation with screen time, questions about the reasons as to why such high levels arise in the first place. In particular, there might be other risk factors that lead to both a very high screen time and undesirable developmental outcomes (Duch et al., 2013). In line with the DREAMER framework (Barr et al., 2024), the present results suggest, that more complex methods of the assessment and modeling of screen time need to be pursued in future research.

Strengths and limitations

This study exhibits several strengths worth mentioning. First, results were summarized from 158 studies that examined the associations of children's screen time in early childhood with a variety of developmental outcomes to offer a broad picture of the correlates of screen time. Furthermore, the PRISMA-ScR checklist for reporting scoping reviews (Tricco et al., 2018) was followed throughout the review process (see Supplementary Table S.2) to ensure its replicability. In addition, as early childhood has been shown to be a sensitive time for experiences that influence development (Black et al., 2017; Britto et al., 2017), the age focus of this study, from birth to 36 months, is of particular importance. Finally, the study includes both traditional and modern screen media devices, which underlines how scarce research on modern screen media remains.

The study also has limitations. Studies were selected by two study co-authors without consideration of interrater reliability. We assume that the systematic comparison of studies included in hindsight and the snowball principle applied compensated for this. However, some studies might have been missed. Furthermore, the studies were not systematically assessed for potential bias and the role of covariates that were considered in the various studies could not be systematically addressed due to the very large amount of information; therefore, the findings of this review should be interpreted and compared with caution. Additionally, we opted not to include gray literature as the number of studies that were found was already very large and the amount of published non-significant results was quite large. This could be interpreted as a comparably low level of selective reporting of results (Kostyrka-Allchorne et al., 2017). Although some of the developmental outcomes included in the present review have been extensively studied, no meta-analysis was performed in the context of the present study.

Conclusion and future directions

While some theoretical approaches have been outlined in the introduction of this review, we believe that more research is needed to address why and under which conditions children's screen time can have undesirable or desirable associations with their development. For instance, such undesirable associations may be explained by the displacement hypothesis (Mutz et al., 1993). However, to demonstrate the existence of displacement, a holistic and longitudinal examination of young children's digital and non-digital activities is necessary. In more technical terms, future studies need to focus on mediator and moderator variables that help us understand the associations between children's screen time and early childhood development. Barr et al. (2018) have proposed that the associations between screen time and development depend on three C's: the *child*, including their age, development level, and temperament; the *context*, such as screen co-viewing with a parent, non-digital activities, family, and environment; and the *content* for instance whether it is suitable for children or permits interactivity. This will allow an examination of whether children's screen time is the cause of an impairment in early childhood development or whether it is rather a symptom of another unfavorable condition in the child's close environment that might impair early childhood development. Findings from this review support the consideration of these three C's as essential for future research on the effects of screen time on early childhood development.

Overall, the complex pattern of findings in the literature on the correlates of children's screen time and early childhood development is shaped by a combination of factors, including differences in screen time patterns, variability in digital activities, variations in the operationalization of constructs of interest, lack of consideration of potential moderators or mediators, and differences in study design. The present study shows that the effects of screen time on child development in early childhood are highly complex. This complexity arises from the interaction of multiple sources of variability and raises the question of whether any general conclusions can be drawn about the effects of screen time on child development. Based on the results of the present study, we argue that such conclusions can only be made at a very general level, and that specific conclusions can only be drawn with respect to a specific outcome of a specific type of activity, in a specific context, and for a specific target population. This complexity has been progressively recognized over the past decades, and both research and practice are addressing this complex topic in a more differentiated way, thus supporting children, parents, teachers, practitioners, and policymakers in making informed decisions about how to integrate screens into children's daily lives.

Author contributions

FS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. VB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing, Project administration. PL: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

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During the preparation of this work the authors used ChatGPT to correct selected text elements as well as Elicit to search for literature. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdpys.2024.1439040/full#supplementary-material

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