Associations of Smartphone and Tablet Use in Early Childhood with Psychosocial, Cognitive and Sleep Factors: A Systematic Review and Meta-Analysis

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Abstract: The current study provides the first systematic review and meta-analysis of the associations of smartphone and tablet use with psychosocial, cognitive, and sleep-related factors in early childhood development. The meta-analysis aimed to provide an overall assessment of the evidence while the systematic review offered a rich overview of the methodological approaches adopted to assess these associations. Studies were included in the review if they examined the association of smartphone or tablet use with a measure of psychosocial development, cognitive development, or sleep in toddlers or preschoolers. Out of 1050 articles that were initially identified, 26 studies were included in the final sample of the systematic review, of which 19 were included in the meta-analysis. Data were screened, extracted, and synthesized according to PRISMA guidelines. A random-effects meta-analysis of correlations found a significant yet weak association of increased smartphone and tablet use with poorer overall child developmental factors. Additionally, a similar but stronger association was found between parental perceptions of problematic device use and poorer overall child factors. Meta-correlations with device use were significant for sleep, but not for psychosocial and cognitive factors. Overall, the results suggest that longitudinal cohort and experimental investigations would elucidate more causal relationships of child factors with smartphone and tablet use. Employing multiple methods of screen-use assessment, and considering the multiple levels of proximal and distal influences on child smartphone and tablet use, would also be useful. Adopting more rigorous research practices in the future, will facilitate deeper insights into the potential developmental implications of smartphone and tablet use in early childhood.

Keywords: screen media, mobile devices, early childhood, child development, child behavior

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Introduction

Since the debut of the iPhone in 2007, smartphones and tablets have gained immense popularity among children of increasingly younger ages (Barr et al., 2018; Rhodes, 2017; Smith & Page, 2015; Wartella et al., 2013). In 2019, at least one-third of US preschool children by the age of three years had access to a dedicated mobile device which they used, on average, approximately two hours per day (Radesky et al., 2020). The increase of smartphone and tablet use during early childhood years has raised concern about potential problematic use, yet the rapid pace of technology uptake currently outstrips research examining the potential benefits and harms associated with childhood use of screens (Radesky et al., 2015). The toddler (age 1 to 3 years) and preschool years (age 3 to 5 years) are important periods of psychosocial and cognitive development, typically characterized by large amounts of brain plasticity (Fox et al., 2010; Jimenez et al., 2016; Shonkoff, 2010). Early childhood years may also influence life-long screen habits, similar to other health-related behaviors such as diet and physical activity (Radesky & Christakis, 2016). To better understand the potential harms and benefits of smartphone and tablet use in young children, the present study provides a systematic review and meta-analysis of research examining the relationships of smartphone and tablet use with psychosocial, cognitive and sleep-related factors in young children.

Child Development in Toddlers and Preschool Children

Child development during the early years is a dynamic sequence of maturation that is influenced by family and social environments, and individual characteristics of the child. Aspects of psychosocial and cognitive development, such as maturation in thinking, regulating emotions and behavior, reasoning, problem-solving and communication (Sigelman & Rider, 2014) are key areas of early childhood development that are crucial for effective integration into the social world. For example, gaining the ability to understand and follow simple instructions by 12-18 months, having a spoken vocabulary of about 20 to 300 words by 18-24 months, turn taking and sharing by 3 years, and perspective taking by 4 years are examples of typical cognitive and psychosocial milestones achieved during early childhood (Petty, 2016). Milestone achievement

is promoted through various stimulating behaviors such as physical activity (Hinkley et al., 2014; LeBlanc et al., 2012), active exploration of natural environments (Sigelman & Rider, 2014), social interactions with caregivers (McCabe & Altamura, 2011), and child-led creative, unstructured or pretend play (Burdette & Whitaker, 2005; Ginsburg, 2007; Lillard et al., 2013).

Children who have an inadequate opportunity to interact with their environment can fail to meet developmental milestones, and this may cause further challenges in acquiring other necessary cognitive, social, and emotional skills (Sigelman & Rider, 2014; Trawick-Smith, 2013). In extreme cases, children suffering severe neglect can fail to develop language, motor, and socio-emotional skills necessary for normal functioning (e.g., Carr et al., 2020); however, in less extreme cases, interference to healthy development may result in adverse outcomes such as self-regulation difficulties (Phillips & Shonkoff, 2000), social withdrawal (Rubin et al., 2009), poor literacy and communication abilities (Horwitz et al., 2003; Paul et al., 1991), and physical health problems such as obesity (Suglia et al., 2012, 2013). Although some difficulties may not be severe enough to receive clinical attention, they are likely to reduce the benefit that children derive from education (Janus & Offord, 2007).

Role of Smartphones and Tablets in Child Development

Child development research has long sought to identify factors that interfere with healthy development. Screen time has received considerable attention (Madigan et al., 2019; Radesky & Christakis, 2016), with most screen time research focused on the effect of traditional screen media (e.g., television, video gaming consoles) on young children's well-being and development (e.g., Hinkley et al., 2014; Madigan et al., 2019; Madigan et al., 2020; Radesky & Christakis, 2016; Thompson & Christakis, 2005; Zimmerman & Christakis, 2005; Zimmerman et al., 2007). However, the potential for smartphone and tablet use to adversely affect development in early childhood has been given relatively less attention. Smartphones and tablets have become very appealing to young children (Kabali et al., 2015; Paudel et al., 2017), possibly due to their unique features such as portability, interactivity, internet access, and multi-functionality (Wartella et al., 2013). Their smaller size and hand-held nature also permit more solitary use, making parental supervision and monitoring more difficult (Radesky & Christakis, 2016). However, it is not clear whether the influence of smartphone and tablet use on children's well-being and development is more pronounced and persistent than that of traditional screen media (Haughton et al., 2015).

Several studies have found that use of interactive smartphone or tablets apps in early childhood can have developmental benefits such as improved development of fine-motor skills (Bedford et al., 2016; Vatavu et al., 2015), executive functioning (Huber et al., 2018), and science/mathematics learning and problem solving (see Herodotou, 2018; Xie et al., 2018 for reviews). Chiong and Shuler (2010) further suggested that when used in moderation, the benefits for young children can be optimized through well-designed, developmentally appropriate educational apps. The positive learning effects were found to be content-dependent however, and limited to mainly interactive educational apps (i.e., not passive viewing; Huber et al., 2016). However, as these studies have been predominantly conducted with smartphone or tablet use as an experimental condition (Lawrence & Choe, 2021), the extent of the positive effects and the point at which naturalistic or habitual use may become problematic (i.e., when harms outweigh the benefits), is yet to be investigated.

Domoff et al. (2020) have proposed a theoretical framework that outlines multiple levels of influence on children's problematic screen use. The model identifies proximal influences (e.g., child behavior and skills, parent beliefs and practices) and distal influences (e.g., demographics, parent use of technology, technological features) that are theorized to interactively influence early childhood screen use. The framework, adapted from Bronfenbrenner and Morris' (2007) bio-ecological model, proposes that smartphone and tablet use can be bi-directionally associated with child- and parent-related factors. For example, the child-specific skill of self-regulation (proximal factor) could be considered a predictor of screen time when considered in concert with the enticing technological features and portability of smartphones and tablets (distal factors). Together, poor self-regulation and attractive technological features may make it difficult for young children to naturally limit their own screen time, and potentially increase resistance to parental attempts to limit screen time. Conversely, screen time could, in theory, impair development of self-regulation. This could be possible if screen time displaces developmentally necessary and productive language-rich social interactions or opportunities for outdoor play (Radesky et al., 2015). Similarly, parents may in some cases rely on screens to soothe a distressed child. Effectively using a smartphone or tablet to regulate behavior could result in more frequent and prolonged episodes of childhood screen use as parental beliefs about the convenience of device use strengthen (Haughton et al., 2015; Radesky et al., 2015; Radesky et al., 2014). Past studies have found that using smartphones or tablets as "electronic pacifiers",

"electronic babysitters" or "shut-up toys" (Radesky et al., 2015) is associated with the development of self-regulatory mechanisms. Parents may also control their child's free/outdoor play in response to their own anxiety about child safety. Studies that have examined the ideas of 'cotton wool' children and 'helicopter parenting' illustrate this pattern of hyper-cautious parental thinking (e.g., Lee et al., 2010), which may influence parents' decision-making about when and how often to substitute outdoor play with digital play on smartphones and tablets.

Although there is now an emerging body of research on young children's smartphone and tablet use in early childhood, there is value in an evaluative synthesis of the current literature. For instance, the early childhood smartphone and tablet use literature concerning psychosocial or cognitive factors have reported positive associations (e.g., Huber et al., 2016; Neumann & Neumann, 2017), negative associations (e.g., Cheung et al., 2017; Lin et al., 2020), and no association (e.g., McNeill et al., 2019; Taylor et al., 2017). To develop clear directions for ongoing research in this area, it is important to assess the collective findings so as to draw inferences about the associations that may exist between young children's smartphone and tablet use and their psychosocial and cognitive factors. Additionally, sleep-related factors such as onset and duration should be included in any review of the literature, given the important role of sleep in childhood psychosocial (Anders, 2004; Sadeh, 2003; Zhao et al., 2018) and cognitive (Hoyniak et al., 2020; Kocevska et al., 2017) development.

Past systematic reviews of the early childhood years have not focused on relationships between smartphone or tablet use and child-specific factors in psychosocial, cognitive and sleep domains. Instead, some have focused on other aspects of screen use such as sedentary screen time (Carson et al., 2016; Hinkley et al., 2014; LeBlanc et al., 2012), television viewing (Kostyrka-Allchorne et al., 2017; Thakkar et al., 2006), and combined traditional and modern screen media use (Duch et al., 2013; Kaur et al., 2019) in relation to the same domains. Despite a growing body of evidence concerning smartphone and tablet use in young children (e.g., Kabali et al., 2015; Levine et al., 2019; Radesky et al., 2015), to date only one review by Paudel et al. (2017) has examined correlates associated with smartphone and tablet use in early childhood. They focused on demographic and environmental correlates of smartphone and tablet use, which are considered distal factors within the Domoff et al. (2020) interactional framework.

The Current Study

To our knowledge, no review or meta-analysis has examined or synthesized the empirical

literature on the associations of smartphone and tablet use with proximal child-specific factors in the psychosocial, cognitive, and sleep domains of early childhood development. Further, a systematic review offers both an in-depth understanding of the methodological approaches within studies, and a timely opportunity to highlight existing gaps and methodological shortcomings in this emerging area to present future research recommendations.

Therefore, we posed the following research question; what associations exist between smartphone and/or tablet use and psychosocial, cognitive and sleep-related factors, in toddlers and preschoolers? In addressing this research question, first, the systematic review sought to provide a rich overview of methodological approaches used in this literature to help generate insights into factors that might explain variations in study findings. Second, the meta-analysis sought to provide an overall synthesis of the current estimates of the strength of association between study variables.

Method

Protocol

The protocol of the review was registered with PROSPERO Prospective International Register for Systematic Reviews (Registration number: CRD42020185907; URL: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020185907). The PRISMA guidelines for reporting of systematic reviews were followed in preparation of this manuscript (see supplement S9; Moher et al., 2011).

Eligibility Criteria

For a study to be included in the review, it needed to satisfy the following five criteria (see Table S1 for further details). First, the study needed to be published after January 2007 and before November 2020, when the final search was conducted. The 2007 cutoff corresponds to the debut of iPhones and the beginning of widespread use of smartphones (Sarwar & Soomro, 2013). Second, the study needed to focus on non-clinical populations of children aged between 1 and 6 years and prior to primary school entry. Third, it needed to include a dedicated measure of children's smartphone use, tablet use, or combined mobile device use with a predominant focus on smartphones/ tablets. Fourth, it needed to include a measure of child psychosocial, cognitive, or sleep characteristics. Finally, it needed to provide quantitative measures of association in a naturalistic setting. Smartphone-related interventions and experimental studies, which included smartphone or tablet use as an experimental group, were excluded.

Search and Information Sources

Systematic searches using PsycINFO, Medline Complete, EMBASE and CINAHL were conducted for original research articles published between January 2007 and November 2020. Medline Complete and EMBASE were chosen as they have been recommended as essential health databases (as two of the largest) by the Cochrane guidelines (Higgins et al., 2020). PsycINFO and CINAHL were selected as the subject-specific databases due to the direct relevance of psychology and nursing (allied health), respectively, to the research topic. For completeness, we also piloted the search on the ERIC database but found that it identified no additional articles. Searches were performed on title, abstract, and subject headings for articles containing at least one match in the following three categories: (a) smartphone or tablet use, (b) child psychosocial or cognitive or wellbeing or development or sleep, and (c) toddler or preschool children. Example search terms were (smartphone* OR "mobile device*" OR ipad*") AND (e.g., "child behavi*" OR social OR emotion* OR cogniti*) AND (e.g., preschool* OR toddler* OR "young child*"). The full search strategy used in PsycINFO is provided in Table S2. Additional articles were identified by examining the reference lists and subsequent citations of key articles.

Study Selection

Articles identified by the search process were imported into Endnote X9 and duplicates were deleted. Remaining articles were imported into Covidence systematic review software (Veritas Health Innovation, available at www.covidence.org) and titles and abstracts were screened by the first and second authors to identify articles for full-text screening. Full-text screening of the eligible articles was conducted by both the first and second authors to determine final eligibility for inclusion in the review synthesis. Conflicts over study inclusion were resolved through critical discussion, cross-checking with criteria in the protocol, and consultation with the third and fourth authors. Inter-rater agreement rates for the screening processes are provided in the ‘Study Selection’ section of the Results.

Methodological Assessment

Methodological quality and risk of bias was assessed using the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies (National Heart, Lung and Blood Institute, 2014). This tool was used to assess the relevance to the review question, methodological rigor, and risk of bias at the study and variable level following guidelines set out by the National Heart,

Lung, and Blood Institute (NHLBI; See Table S3). This assessment was conducted independently by the first and second authors, with consensus reached for any inconsistencies in scoring directed by the NHLBI guidelines, following the approach adopted by meta-analyses in the area of screen time (e.g., Adelantado-Renau et al., 2019; Madigan et al., 2020). The tool comprised 10 criteria including clarity of research question, appropriateness of study design, clarity of sample, appropriateness of measurements and analyses that were rated as either low or high-risk of bias. Examples of items that have been assigned a rating of 'high' or 'low' risk of bias for each criterion are provided in Table S3. Each study was classified as (a) low risk of bias [0 or 1 bias markers], (b) moderate risk of bias [2 or 3 bias markers], (c) high risk of bias [4 or more bias markers].

Data Extraction and Narrative Synthesis

Following quality assessment, data extraction was independently undertaken by the first and second authors using a piloted data extraction template (see Table S4). The following data were extracted: (a) study design, (b) sample size, (c) other sample characteristics, (d) measure of use of smartphones, tablets or both, (d) measure of child-specific factors (i.e., psychosocial, cognitive, or sleep-related), (e) main findings regarding the association of smartphone and tablet use with child factors, and (e) what, if any, covariates were examined. For the narrative synthesis, the child-specific factors were conceptualized into the three domains: psychosocial, cognitive, and sleep. Psychosocial factors related to the development of child's socio-emotional competence and ability to maintain relationships. Cognitive factors involved thinking, reasoning, language, and literacy-related variables. Sleep factors included variables related to the quantity and quality of sleep.

Data Analysis for Meta-Analysis

As the final sample of studies largely included linear relationships which were cross-sectional in nature and given the heterogeneity in covariates used in adjusted analyses, meta-analysis of correlations was deemed the most appropriate summary statistic. Where available, correlation coefficients were extracted for each study. The direction of the coefficient was reversed for negative variables such as speech delay, internalizing/ externalizing behavior, and sleep problems so that all variables were positively aligned with wellbeing or development. Sixteen corresponding authors were contacted via email for additional information on correlations between relevant variables, of which seven provided this information. If

standardized regression coefficients were reported instead of correlation coefficients, they were converted to correlation coefficients using formula described by Peterson and Brown (2005). When multiple groups were drawn from the same dataset, the data were analyzed as independent samples. If multiple effect sizes for comparable factors within the same domain were available for the same study, they were aggregated by averaging (Borenstein et al., 2009) to only include one effect size from each study. If there were multiple effect sizes from the same study belonging to different domains in the high-level meta-analysis of associations between amount of use and overall child-specific factors, the robust variance estimation approach (RVE; Hedges et al., 2010) was used to account for any within-study dependencies.

A random-effects meta-analysis was conducted given that correlations were expected to vary based on sample, measurement, design, and other characteristics (Borenstein et al., 2009). The meta-analysis was conducted in R using the "metafor" package (Viechtbauer, 2010), with alpha levels of .05 (i.e., $p < .05$), considered to be statistically significant. The "robumeta" package (Fisher & Tipton, 2015) was further used to carry out the high-level RVE analysis of association between amount of use and overall child-specific factors, accounting for multiple effect sizes from same study and small number of studies available. The moderating effects of the variables (a) time period (year range) of publication (given the rapid adoption of mobile technology across the years) and (b) quality of study (given the variation in risk of bias and quality among studies) were tested using supplementary moderation analyses also conducted in R using the "metafor" package. These supplementary moderation analyses were conducted to determine how much each of these variables may contribute to the observed variability of effect sizes between studies (Quintana, 2015). Heterogeneity across studies was assessed using tau (τ; the estimated standard deviation of underlying effects across studies) and I^2 statistics (I^2 values of 25%, 50% and 75% considered as low, moderate and high, respectively) (Borenstein et al., 2009). Egger regression asymmetry test, funnel plots and rank tests were conducted to assess publication bias, with $p < .05$, considered to be statistically significant (Quintana, 2015). All scripts and data for the meta-analyses are available on the OSF: https://osf.io/5zka6/?view_only=9773162de4de48c398b6df0f00579d0c

Results

Study Selection

Figure 1 provides the PRISMA flow diagram for study inclusion. Following removal of

duplicates, 1,050 unique articles were identified for title and abstract screening. An inter-rater agreement rate of .90 (Cohen's κ = .44) was established during the abstract screening process. Abstract screening identified 83 articles that potentially met the inclusion criteria and were progressed to full-text screening. An inter-rater agreement rate of .82 (Cohen's κ = .62) was maintained during the full-text screening process. Following full-text screening, assessment of quality, methodological relevance and risk of bias, a final sample of 26 articles were included in the narrative synthesis. Of the final eligible articles, published and unpublished data from 19 articles were included in the meta-analysis (See Tables 1, 2 and 3).

Study Characteristics

Methodological Assessment

A detailed risk of bias assessment is presented in the online supplement (see Table S3 and Table S5). Of the 26 articles reviewed, risk of bias ratings were as follows: low (*N* = 4; 15%); moderate (*N* = 19; 73%); and high (*N* = 3; 12%). Most studies were cross-sectional with only three studies (McDaniel & Radesky, 2020; McNeill et al., 2019; Poulain et al., 2018) using longitudinal designs. In terms of exclusively measuring use of smartphones and tablets, one article (Borajy et al., 2019) did not include detailed reporting of screen time, another study (McNeill et al., 2019) assessed type of use (i.e. app use) rather than amount of overall use in relation to smartphone and tablet use, while three studies (Lan et al., 2020; Levine et al., 2019; Poulain et al., 2018) aggregated portable media such as iPods or hand-held videogames with smartphones and tablets. Only ten studies reported pre-determined eligibility criteria prior to recruitment, taking into account various developmental variances and other clinical conditions in young children that may differentially influence their development and potentially influence their smartphone and tablet use. Nine studies did not adjust for potential covariates (e.g., demographics). Further, one study (Cannoni et al., 2018) was dropped from the review because it did not use a validated or standardized instrument for measurement of child-specific factors and included limited statistical analyses (chi-squared analysis only).

Sample Characteristics

Details on the sample, measures used, key findings and the covariates examined in each article in the psychosocial, cognitive, and sleep domains respectively are shown in Table 1, Table 2 and Table 3. Altogether, there were 24 samples with a combined sample size of 11,515. Most articles (*N* = 19; 73%) were published since 2018 with the remainder published from 2014

to 2017. In terms of study design, most were cross-sectional (*N* = 23; 89%) while only 3 (11%) were longitudinal. The most common countries for conducting studies were the United States (*N* = 7; 27%), South Korea (*N* = 5; 19%), Australia (*N* = 2; 8%), and the United Kingdom (*N* = 2; 8%). In terms of child factors examined in articles, noting that some articles examined more than one, 13 examined psychosocial factors, 10 examined cognitive factors, and 7 examined sleep. Of these, four articles which examined psychosocial factors also examined cognitive factors (Lin et al., 2020; McNeill et al., 2019; Moon et al., 2019) and sleep (Nathanson & Beyens, 2018b).

The mean ages of the included samples ranged from 1.43 years (17.14 months) to 5.42 years (with only one sample of preschool children in Turkey with a mean age > 5 years; Gülay Ogelman et al., 2016). Most articles (*N* = 17; 62%) consisted of samples of only preschool children (defined as above 3 years and prior to primary school entry), but some articles (*N* = 7; 27%) examined only toddlers (defined as aged 1 to 3 years), or combined toddlers and preschoolers (*N* = 2; 8%). Sample sizes ranged from 56 (Lawrence et al., 2020) to 2,903 (Lan et al., 2020). Among the final sample of included studies, three articles (i.e., Beyens & Nathanson, 2019; Nathanson & Beyens, 2018a, 2018b) included the same dataset and sample. All three articles were included in the narrative review as three different exposure-outcome relationships were examined, i.e., smartphone and tablet use in relation to (a) sleep quantity, bedtime resistance and daytime sleepiness (Nathanson & Beyens, 2018a), (b) sleep and effortful control (Nathanson & Beyens, 2018b), and (c) napping behavior and sleep consolidation (Beyens & Nathanson, 2019). However, only one effect size was used for the meta-analysis from the dataset.

Smartphone, Tablet, and Child-Factor Measurement

All studies measured smartphone and tablet use in children using reports by parents or primary caregivers. Smartphone and tablet use was primarily operationalized as frequency (e.g., number of times the device is used per week; *N* = 4; 15%) or duration of use (e.g., time spent on device in hours per day; *N* = 17; 65%). The timing of device use (e.g., whether they were used around bedtime) was measured in one sample (Beyens & Nathanson, 2019; Nathanson & Beyens, 2018a, 2018b). Five studies measured parental perceptions of excessive or problematic use by young children, using various terminology including smartphone addiction proneness (Cho & Lee, 2017), addiction tendency (Lee et al., 2015), over-dependency (Lee & Park, 2018), and immersion tendency (Kim & Hwang, 2017). One study (Hutton et al., 2020) only reported

whether a child had access to their own mobile device. Most studies (N = 20; 77%) reported use of both smartphones and tablets, while four included only smartphones (Cho & Lee, 2017; Kim & Hwang, 2017; Lee et al., 2015; Lee & Park, 2018), and two included only tablets (Nathanson & Beyens, 2018b; Neumann, 2014).

Only six studies (23%) examined the nature of a child's smartphone or tablet use (Cho & Lee, 2017; Kotrla Topić et al., 2020; Levine et al., 2019; Lin et al., 2020; Neumann, 2014; Taylor et al., 2017). These studies generally found that smartphones and tablets were most commonly used for non-educational purposes including watching videos (Cho & Lee, 2017; Levine et al., 2019), entertainment (Kotrla Topić et al., 2020; Taylor et al., 2017) and gaming (Neumann, 2014). Sixty percent of primary caregivers surveyed in Lin et al. (2020) reported providing devices to young children to sooth them, while 40% of parents in Cho and Lee (2017) reported providing the device to amuse the child. In contrast, approximately 22% (Lin et al., 2020), 23% (Levine et al., 2019) and 55% (Neumann, 2014) of the respective samples in these studies reported that smartphones and tablets were used for educational purposes.

Psychosocial factors were generally measured through validated parent-reported instruments (N = 13), with the additional behavioral assessment of self-regulation in Lawrence et al. (2020) and a preschool teacher-reported assessment of child social skills in Gülay Ogelman et al. (2016). Child behavior-based questionnaires such as the Child Behavior Checklist (Achenbach & Rescorla, 2000) and the Strengths and Difficulties Questionnaire (Goodman, 1997) were commonly used. Seven studies measuring cognitive and language factors used measures administered directly to the child by clinicians or researchers (Borajy et al., 2019; Hutton et al., 2020; Jusienė et al., 2020; Kotrla Topić et al., 2020; McNeill et al., 2019; Moon et al., 2019; Neumann, 2014). Child sleep-related factors were all reported by parents, with five studies employing validated questionnaires (Beyens & Nathanson, 2019; Cheung et al., 2017; Nathanson & Beyens, 2018a, 2018b; Zhu et al., 2020).

Meta-Analysis and Research Synthesis

Summaries of key findings for each study are presented for psychosocial factors (Table 1), cognitive factors (Table 2) and sleep (Table 3). The overall patterns of findings for each factor are presented in Figure 2, and a high-level summary of evidence is presented in Table 4.

Upon inspection of the available data, a meta-analysis was conducted on various subsets of factors, based on three levels of aggregation. This included associations of young children's

amount of device use (i.e., duration or frequency of use, excluding parental perceptions of problematic use) with (a) all child factors aggregated, (b) psychosocial, cognitive, and sleep domains separately, and (c) more nuanced factors (i.e., self-regulation, language, executive functioning) within the domains where there were 3 or more studies available, as per recommendations by Borenstein et al. (2009). Table 5 presents the results of the meta-analysis (see Supplement S6 for forest plots). Overall, there was a weak negative correlation (16 studies, 26 effect sizes, r = -.08, p = .001, 95% CI [-.13, -.03], see Figure 3) between amount of use of smartphones and tablets and overall child-specific factors. Supplementary moderation analyses demonstrated that study quality and time period of publication were not significant moderators of this association (see Table S8 for further information). When an additional RVE model was run on the association between amount of smartphone and tablet use and overall child-specific factors, the pooled estimate remained statistically significant (r = -.08, p = .017, 95% CI [-.15, -.02]). Finally, we conducted a separate meta-analysis focusing on parental perceptions of problematic smartphone or tablet use by young children, which showed a much stronger negative correlation with overall child-specific factors (k = 10, r = -.31, p = .001, 95% CI [-.49, -.12], see Figure 4).

Examination of the heterogeneity of effect sizes suggest that most relationships showed moderate heterogeneity (see Table 5). An exception was seen for the association between overall child factors and parental perceptions of problematic use (τ = 0.26; I^2 = 86.26%; p < .0001) and the association with self-regulation (τ = 0.15; I^2 = 86.44%; p < .0001) which showed more substantial variation. Funnel plots and Egger regression test for asymmetry indicated statistically significant publication bias only for the analysis of association between parental perceptions of problematic use and overall factors (z = 3.42, p < .001; see Supplement S7 for further information). A description of meta-analytic findings with illustrative study methodological details are presented below.

Psychosocial Factors

The meta-analytic correlation between psychosocial factors and device use was non-significant (k = 12, r = -.07, p = .115, 95%CI [-.15, .02]). In relation to amount of use (e.g., average duration) and problematic (e.g., addiction proneness) smartphone and tablet use in young children, self-regulation, externalizing, and internalizing behavior were the most commonly studied psychosocial factors, while interpersonal social skills (or prosocial behaviors)

received limited attention. Most studies (9/12) analyzing the association of device use and psychosocial factors adjusted for other variables including child age, parental occupation, parental education, and family income. Collectively, children tended to spend more time on smartphones and tablets when they were older (Lawrence et al., 2020; Levine et al., 2019; McDaniel & Radesky, 2020) and had parents who were less educated and used devices more (Levine et al., 2019). Studies that examined gender as a covariate found no differences between boys and girls in their amount of use of smartphones and tablets (McDaniel & Radesky, 2020; Poulain et al., 2018).

Of the more nuanced psychosocial factors, only self-regulation had sufficient studies to conduct a meta-analysis. Externalizing and internalizing behavior, emotional factors, and social skills did not contain sufficient comparable effect sizes (less than three relevant effect sizes available for each variable in relation to amount of use) to conduct a meta-analysis. Specifically, the variation in measures of device use (i.e., amount of use vs. perceptions of problematic use), study designs and analyses (correlations and linear regressions vs. mean differences vs. logistic regressions) prevented the use of a meta-analysis for these psychosocial factors. Nevertheless, we present a summary of the systematic review findings of methodological details including study designs, covariates, and types of analyses used for these factors.

Self-regulation

The meta-analytic correlation between self-regulation and amount of device use (i.e., excluding parental perceptions of problematic device use) was close to zero and non-significant ($k = 5$, $r = -.03$, $p = .65$, 95% CI [-.18, .11]). Five studies examined device use and self-regulation. In two studies, regression analyses were used to model device use as a predictor of self-regulation (Lawrence et al., 2020; Nathanson & Beyens, 2018b), while the remaining three studies reversed the direction, modelling self-regulation as a predictor of device use (Kim & Hwang, 2017; Lee & Park, 2018; Levine et al., 2019). Additionally, self-regulation assessed as a facet of child temperament was included as a covariate in van den Heuvel et al. (2019) when examining the association between amount of device use and expressive language.

Externalizing behavior

Smartphone and tablet use was tested as a predictor of externalizing behavior (e.g., aggression or hyperactivity) cross-sectionally in two of six studies that examined the association between device use and child behavior (Cho & Lee, 2017; Lin et al., 2020). In two longitudinal

studies, externalizing behavior at baseline (McDaniel & Radesky, 2020; Poulain et al., 2018), 6-months follow-up (McDaniel & Radesky, 2020), and 12-months follow-up (Poulain et al., 2018) were studied as both a predictor and outcome of device use to examine a possible reciprocal relationship between smartphone and/or tablet use and child behavior. A variety of analyses were used among the studies that assessed associations between device use and child behavior. Odds ratios of increased risk of behavioral problems between users and non-users of smartphones (Poulain et al., 2018), mean differences in behavioral problems between non-, low dose- and high-dose users of apps (McNeill et al., 2019) were reported in addition to linear relationships of continuous variables of device use and behavior scores (Cho & Lee, 2017; Lee et al., 2015; Lin et al., 2020; McDaniel & Radesky, 2020). Of the various covariates studied, significant mediating effects of parenting stress on the longitudinal association of externalizing behavior predicting tablet use at 6 months follow-up in young children is noteworthy (McDaniel & Radesky, 2020). Interestingly, use of traditional devices (i.e., television), especially for program viewing, was found to be associated with increased externalizing behavior whereas use of smartphone and tablet-based media was not (McNeill et al., 2019).

Emotional factors

Of the five studies that investigated child emotional factors, three measured amount of device usage (Lin et al., 2020; McNeill et al., 2019; Poulain et al., 2018) while the other two measured parental perceptions of problematic use (Cho & Lee, 2017; Lee et al., 2015). Two of the five studies were longitudinal (McNeill et al., 2019; Poulain et al., 2018). Similar to externalizing behavior, a variety of covariates were adjusted for in the regressions to assess associations between device use and emotional factors. Child and parent demographic characteristics such as age and gender were common covariates used across the studies (Cho & Lee, 2017; Lin et al., 2020; McDaniel & Radesky, 2020; McNeill et al., 2019; Poulain et al., 2018), while more specific factors such as parent education (Lin et al., 2020; McDaniel & Radesky, 2020), socio-economic status (SES; McNeill et al., 2019; Poulain et al., 2018) and only child status (Lin et al., 2020) were also adjusted for. While studies including McNeill et al. (2019) and Poulain et al. (2018) attempted to use a more representative sampling approach through pre-school clustering and/or adjusting for SES, they note that, overall, participants were typically of higher SES.

Social development

Cross-sectional associations between smartphone and tablet use and interpersonal social skills were explored in only two of the reviewed studies, both in preschool children (Gülay Ogelman et al., 2016; Moon et al., 2019). Neither of the studies adjusted their analyses for any covariates, however, Moon et al. (2019) performed separate correlational analyses for each age category (3 years vs. 4 years vs. 5 years) to account for the dynamic developmental differences across these young ages.

Cognitive Factors

There was no significant meta-analytic correlation between device use and cognitive factors (k = 10, r = -.07, p = .14, 95%CI [-.16, .02]). Overall, half (5/10) of the studies in the cognitive domain reported correlations as well as regression analyses statistically controlling for other factors including child and parent characteristics (Jusienė et al., 2020; Kotrla Topić et al., 2020; Lin et al., 2020; Taylor et al., 2017; van den Heuvel et al., 2019). Language and speech development were the most commonly examined variables in relation to smartphone and tablet use in these populations. Cognitive and language outcomes such as emergent literacy and executive functioning in relation to smartphone and tablet use were only studied in preschool children.

Language and speech development

The meta-analytic correlation between device use and language development was non-significant, r = -.09, p = .09 (k = 9, 95%CI [-.20, .01]). Two cross-sectional studies investigated smartphone and tablet use in relation to expressive and receptive language development (Lin et al., 2020) and expressive speech delay (van den Heuvel et al., 2019) in toddlers and preschool children (Moon et al., 2019). Three studies with relatively small samples of 69 (Hutton et al., 2020), 97 (Kotrla Topić et al., 2020) and 109 (Neumann, 2014) preschool children explored smartphone and tablet use with regards to emergent literacy. Interestingly, relationships of device use with literacy measures were no longer significant in two studies, once quality of home literacy environment (Kotrla Topić et al., 2020), and child's age (Neumann, 2014) were included as covariates. Unsurprisingly, children who were older (Neumann, 2014), were not the only child (Lin et al., 2020), who had more educated parents, and who spent more time engaged in interactive home reading (Kotrla Topić et al., 2020; Taylor et al., 2017) had more developed language and literacy levels.

Executive function and other cognitive factors

The meta-analytic correlation between device use and executive function was non-significant ($k = 5$, $r = -.09$, $p = .14$, 95% CI [-.22, .05]). The device use variables varied across four studies that explored the association with executive functioning related cognitive skills. While amount of overall smartphone and tablet usage was the more common approach (Jusienė et al., 2020; Moon et al., 2019), McNeill et al. (2019) focused on app usage specifically, and Hutton et al. (2020) studied the association with respect to child access to own device. Given the developmental sensitivity of cognitive skills during the preschool period, child age was considered an important factor to be accounted for in a majority (3/4) of these studies (Jusienė et al., 2020; McNeill et al., 2019; Moon et al., 2019). Correlational analyses was the most common statistical approach (Hutton et al., 2020; Jusienė et al., 2020; Moon et al., 2019), however, Jusienė et al. (2020) and McNeill et al. (2019) conducted multiple regression analyses predicting executive functioning related cognitive factors (e.g., working memory, inhibitory control) from device use, controlling for various demographic characteristics such as parent education.

Sleep

Overall, the meta-analysis of four studies found a significant negative correlation of $r = -.15$, $p < .001$ [95%CI = -.22, -.08] between amount of device use and measures of child sleep outcomes. In addition to sleep duration (Cheung et al., 2017; Chindamo et al., 2019; Lan et al., 2020; Nathanson & Beyens, 2018a, 2018b), a range of sleep quality indicators were studied in relation to daily and evening smartphone and tablet use, including bedtime resistance (Nathanson & Beyens, 2018a, 2018b), night-time awakenings (Cheung et al., 2017), sleep onset latency (Cheung et al., 2017; Chindamo et al., 2019), sleep consolidation (i.e., less organization of sleep patterns due to less accrual of sleep over night; Beyens & Nathanson, 2019), and risk of sleep disorder (Zhu et al., 2020). Notably, relatively large samples of 715 (Cheung et al., 2017) and 1117 (Chindamo et al., 2019) toddlers, as well as 2278 (Zhu et al., 2020) and 2903 (Lan et al., 2020) preschoolers, were studied to explore these associations cross-sectionally. Child demographic characteristics (i.e., age, gender), parental education levels, and SES-related variables were commonly studied covariates for the relationships between smartphone/ tablet use and sleep (Cheung et al., 2017; Chindamo et al., 2019; Lan et al., 2020; Nathanson & Beyens, 2018a, 2018b; Zhu et al., 2020). Bedtime routine (Chindamo et al., 2019) and child's levels of daily activities (e.g., physical activity; Lan et al., 2020) were less commonly considered.

Traditional device use, especially television exposure was accounted for in all studies that examined sleep in relation to device use. Interestingly, Zhu et al. (2020) found a stronger negative association between TV time and sleep compared to mobile screens, which is contrary to findings of Lan et al. (2020).

Discussion

The current study provides the first systematic review and meta-analysis of the associations of smartphone and tablet use with psychosocial, cognitive, and sleep-related factors in young children. While the meta-analysis provided an overall synthesis of the evidence of associations, the systematic review enabled an in-depth understanding of the methodology, potential covariates, and other noteworthy aspects of the included studies which helped to understand variations in study findings. Notably, the review shows that the study of early childhood smartphone and tablet use is an emerging area of empirical interest with the numbers of articles published each year increasing since 2014. Several important findings emerged. First, increased early childhood smartphone and tablet use was correlated, albeit weakly, with poorer overall child-specific developmental factors (i.e., aggregate of psychosocial, cognitive and sleep domains). Second, less conclusive evidence was present for the associations of smartphone and tablet use with psychosocial and cognitive factors in young children. Finally, greater use of smartphones and tablets was associated with poorer sleep outcomes in young children.

Overall Child-Specific Factors

The meta-analytic results provided initial evidence that greater smartphone and tablet use was associated with poorer aggregated child-specific proximal factors in early childhood. Nonetheless, the correlations were quite small, and these modest associations were significant for only the overall aggregate and the sleep domain. Additionally, the meta-analysis was based on cross-sectional correlations, limiting the ability to draw inferences about causal relationships. As theorized by Domoff et al. (2020), simplistic correlational studies do not adequately capture the risk factors (e.g., distal influences through home environment and digital environment design; proximal influence from parents and peers) that may cause problematic media use in a child, in addition to child-specific factors. Thus, while the findings are consistent with the contention that smartphone and tablet use may displace developmentally healthy traditional activities such as play, reading, sleep, and physical activity in young children (AAP Council on Communications and Media, 2016), they are also consistent with other causal explanations. It would be helpful to

see study designs, such as randomized controlled trials, used more frequently to facilitate rigorous investigation of potential causality between distal and proximal influences on early childhood screen use and development.

Furthermore, meta-analytic evidence showed that parental perceptions of problematic childhood screen use were more strongly associated with poorer overall child-specific factors than with the general amount of child device use. This is not particularly surprising as parents who perceive their child's use to be problematic may be more likely to also perceive problems with their child's behavior and well-being.

Despite the inclusion of parental observations as usage measures in the early childhood–screen use literature, the inclusion of parenting practices surrounding childhood smartphone and tablet use is far less common. Only 4 (15%) of the included studies accounted for parenting related variables in their statistical models. The Domoff et al. (2020) framework incorporates parenting practices and beliefs as variables that exert important proximal influences on childhood device use. Parental factors, such as attitudes towards technology, parenting styles, and parenting efficacy, are also likely to guide parental practices in managing children's screen use (Sanders et al., 2016). Accordingly, parents vary in their reasons for providing devices to their children. Reasons can include education, amusement, or convenience (Radesky et al., 2015), and parenting styles and attitudes are likely to inform the technology-related screen-time management strategies used by parents (e.g., level of intervention, level of facilitated exposure and time-setting). Having information about parental beliefs and attitudes, along with their use of management strategies, can add clarity to the context of screen use by young children. That is, to what extent does a child engage with a device based on their own initiative versus a parent facilitating use of the device. Given a young child's limited autonomy, incorporating parental perceptions, practices, and challenges in future research on associations of young children's use of smartphones and tablets, is of primary importance.

Psychosocial and Cognitive Factors

The meta-analytic results in the psychosocial and cognitive domains were not significant, aligning with the high variation in findings as evident through the systematic review. This differs from past reviews of overall screen time (combination of traditional and contemporary devices) (e.g., Duch et al., 2013; Radesky & Christakis, 2016) which found negative relationships for amount of screen time with psychosocial and cognitive development in early childhood. There

are two plausible explanations for the non-significant results. First, the variation is likely to be partially attributable to the heterogeneity in study designs, and varying measurements of screen use and child psychosocial or cognitive factors (see the forthcoming section 'Recommendations for Future Research' for further details). Second, the non-significant association with smartphones and tablets compared to traditional television usage may be due to the inherent differences in the amount and types of usage each device offers. Past research has typically relied on generic, free-to-air television programming where the amount of high-quality educational content is limited. In contrast, smartphone and tablet content is typically curated for the individual child and is unlimited in terms of access to interactive, educational, and social applications. This warrants more in-depth understanding of the nature of use of smartphones and tablets when examining its relationships with psychosocial or cognitive factors, based on how the child uses the device.

Despite the many other variables that were examined in studies in this review (as covariates), relevant information on the multiple levels of influence which drive child media use as proposed by the Domoff et al. (2020) model were rarely provided. Specifically, proximal influences such as parenting stress and practices, along with parents' own use, and distal influences including household dynamics, socio-economic status, and digital environmental design were often overlooked. These influences may further clarify the varying conditions under which use of mobile screens may be beneficial or detrimental to child's well-being and development. While it may not be feasible to consider all of these factors in a single study, it is important to acknowledge their potential interactions and to assess their influence through longitudinal cohort studies. The early childhood screen time literature would benefit from longitudinal studies assessing the interactional influences these factors may have, while assessing the continuous changes which occur within these factors over time (e.g., changing technology, child's developmental changes).

Psychosocial factors

Of the psychosocial factors, self-regulation received the most attention and was the only psychosocial factor with enough relevant primary studies for a meta-analysis. The meta-analytic evidence did not demonstrate a significant association between amount of use and self-regulation. The pooled effect size does not reflect the negative associations between problematic use of smartphones and self-regulation in adolescents and adults (Berger et al., 2018; Kim et al.,

2016; Yang et al., 2019). The non-significant result may be understood in terms of the way that child screen usage is conceptualized within studies of child self-regulation. The present meta-analysis utilized only data that represented actual amount of child smartphone/ tablet usage in early childhood, whereas past self-regulation literature in relation to screen use in older populations predominantly relies on measures of parental or self-evaluations of problematic smartphone or tablet use. Thus, there is a clear need to delineate raw amount of use from perceptions of problematic use in future research, to more clearly to understand any differential effects on child well-being and development.

Cognitive factors

The sub-group analysis of executive functioning-related cognitive factors with use of smartphones and tablets in young children yielded similar non-significant results. The non-significant relationship could suggest a more pronounced contribution of environmental influences (e.g., the home literacy environment), biological influences (e.g., genetics), or parental factors (e.g., level of education and literacy beliefs) to young children's early cognitive and language development (Burgess et al., 2002; Weigel et al., 2006). However, the paucity of longitudinal research and the limited number of cognitive factors tested in the very few existing studies, limits drawing any definitive conclusions about the effects of mobile screens on executive function and cognitive development in young children.

The meta-analysis obtained a small negative association between device use and language-related variables, but this was non-significant, consistent with the mix of significant and non-significant associations in the primary studies that examined language, literacy, and speech development. More insight into types of use (i.e., passive vs. interactive use) of smartphones and tablets would be required to fully elucidate this relationship. Theory and the broader screen time literature suggests that high levels of solo passive device use, as opposed to co-use with parents or siblings, may be more problematic for language development where it displaces social interactions and other activities that foster language skills. For instance, Madigan et al. (2020) found in their review that language skills were negatively associated with overall screen time (i.e., a combination of traditional and new media), but positively associated with co-viewing and viewing higher quality educational programs. Given that language and literacy apps are now highly prevalent among families of preschoolers to promote emergent literacy in the digital world (Neumann & Neumann, 2017), testing for associations of language skills with

higher quality apps and content is warranted. Thus, longitudinal studies should aim to include more experimental investigations of the use of language and literacy apps to examine their short- and long-term effects on language and literacy-related outcomes in young children. The distal influence of digital environmental design (Domoff et al., 2020) is also of relevance in this context, given that persuasive design features (e.g., continuous rewards, auto-play, reduced mental effort) may divert a child's attention away from language or literacy learning content (Barr et al., 2018; Hirsh-Pasek et al., 2015; Meyer et al., 2021). In addition to experimental studies, intervention studies which implement additional parental controls and minimize the persuasive features of child-focused apps could aim to evaluate their effects on children's cognitive and language outcomes.

Sleep-Related Factors

Overall, the systematic review and meta-analysis indicated that smartphone and tablet use had a significant but weak relationship with less sleep and poorer sleep quality (i.e., increased bedtime resistance and delayed sleep onset) in young children. It is also important to acknowledge that the amount of sleep that most children need is much less at the end of early childhood (i.e., age 6) than at the beginning (i.e., age 1). Given that device use increases with age, it is particularly important for studies to control for age-related changes. Accounting for socio-cultural factors with regards to timing of evening activities (e.g., dinner time) and bedtime routines or practices (e.g., co-sleeping, reading before sleep, liquids before sleep) is of further importance, given their potential moderating effect on the relationship between screen use and sleep in young children.

Nonetheless, the present study findings are consistent with previous reviews conducted in early childhood populations, which have reported negative associations between sedentary screen media use (i.e., television viewing and computer use) and sleep duration or healthy sleeping routines (Janssen et al., 2020; Zhang et al., 2021). The blue light emissions from smartphones and tablets, which are typically held much closer to the face than traditional media (Twenge et al., 2019), may help to explain the association. Blue light is known to interfere with circadian rhythms and sleep cycles, and disrupted circadian rhythms can lead to bedtime resistance, delayed sleep onset, and reduced sleep in children and adolescents (see Cain & Gradisar, 2010 for a review). Compared to traditional media such as television, the portability of smartphones and tablets means that they can be used in bed, thereby increasing the likelihood of

disrupted or displaced sleep routines (Twenge et al., 2019). Previous research in older child and adolescent populations has found that inadequate sleep quantity and poorer sleep quality is associated with greater smartphone use (see Carter et al., 2016 for a review). Accordingly, greater smartphone and tablet use, especially at night-time, may have adverse implications for sleep in toddlers and preschool children due to one or more of these reasons.

Adequate and good-quality sleep is also a well-established factor in healthy child development, especially in key psychosocial and cognitive domains (see El-Sheikh & Sadeh, 2015 for a review). Parent et al. (2016) and Wu et al. (2017) found that compromised sleep quality that resulted from smartphone or tablet use may contribute to increased irritability and externalizing behavior in young children. Similarly, sleep quality was a mediator in Nathanson and Beyens (2018b), where evening tablet use was related to delayed sleep onset, greater bedtime resistance, and overall, poorer sleep quality, which in turn predicted poorer effortful control. This highlights the need to further investigate the extent to which sleep mediates any effect of early childhood device use on behavioral regulation, especially over time.

Recommendations for Future Research

We identify several methodological issues and gaps in the literature, specifically in relation to (a) conceptualization and measurement of smartphone and tablet use, (b) measurement of children's development, and (c) consistency in age brackets of early childhood samples. Addressing these issues in future research would allow for better synthesis of research findings.

Conceptualization and Measurement of Smartphone and Tablet Use in Early Childhood

First, smartphone and tablet use should be conceptualized as a multifaceted variable. In addition to the amount of time and frequency of device use, researchers should also seek to measure; (a) type of use (e.g. whether it is passive or interactive, whether it is solitary or involves co-use), (b) the content (e.g., educational, social, or recreational), (c) the timing of the use (e.g., around bedtime or during the day), and (d) the reasons for use (e.g., entertainment, boredom, distress, learning). It is also important to consider the child's overall history of device use (i.e., age at first regular device use and time from child's first regular use). Further, it is important to understand the degree to which smartphone and tablet use is supplanting other forms of screen time, such as watching television, and how multi-screen use is related to developmental factors.

Second, future research should seek to supplement parent reports of smartphone and

tablet use with objective measures (e.g., Radesky et al., 2020). Despite the popularity and convenience of parent reports, they are imperfect and subject to problems with recall and socially desirable responding. For instance, a recent meta-analysis of mostly young adults suggests that people are only moderately accurate at estimating their own smartphone use (Parry et al., 2021). That said, the meta-analysis did pool measures of problematic usage and estimates of amount of use; a more recent large sample study of the general adult population with greater variance in objective usage suggested that self-rated estimates were somewhat more accurate (Horwood et al., 2021). In summary, people appear to be able to provide rough estimates of use, but they are imprecise. Obtaining objective measures of device use would also enable more fine-grained analyses of the multifaceted nature of smartphone use.

Third, considerable care is required when interpreting findings based on measures of perceived problematic device use. While most studies have focused on amount of use, other studies have formulated various definitions of excessive or problematic use. Heterogeneity of operationalizations makes comparison of problematic device use in early childhood difficult. Furthermore, the use of the word 'addiction' implies a clinically diagnosable level of any behavior and seems to over-reach for the purposes of assessing excessive screen use in young children. We propose a more consistent and tempered term, 'problematic mobile screen use', in young children to better understand the phenomenon. But considerable empirical work is required to operationalize 'problematic use'.

Measurement of Children's Development

Another challenge for research synthesis is the variation in type of measures used for the same or similar child developmental factors. Similar to measurement of smartphone/ tablet use, the sole reliance on parent and/or teacher reports for assessment of child development poses the risk of various inherent biases, which potentially may be compounded in instances where there is a common rater for both child's smartphone/ tablet use and child factors. On the other hand, several studies in the review employed validated or clinically administered measures for measurement of developmental constructs. Accordingly, this variation in the type of measure used is also a plausible factor which may have contributed to some of the heterogeneity observed in study findings in our review. To overcome this limitation in future research, we propose the consistent use of norm-referenced standardized measures which may better tap into the underlying developmental constructs of primary interest. In part, this may also resolve any issues

with inconsistency in terminology and definitions of developmental constructs (e.g., 'externalizing behavior' also termed 'aggressive behavior', 'behavioral problems or difficulties' and 'externalizing symptoms') that are used across research in the screen time field.

Determination of Age Groups for Study Samples

While the review attempted to discretely outline findings for the two different developmental groups of toddler and preschool children, there was substantial variation in how researchers defined toddler and preschooler age ranges. The inconsistency could be a function of the differing global educational systems. For example, in Australia and the UK, pre-school age typically ends at 5 years old when primary (elementary) school commences, however children typically start primary school later at age 6 (e.g., US, China, India) or 7 (e.g., Sweden, South Africa) in other parts of the world. Future research should aim to account for the importance of developmental stages when determining prospective samples and analyses in future studies. Increasing levels of data sharing in future publications is an open science practice that would enable researchers to conduct appropriate statistical analyses by filtering or accounting for age.

Practical Recommendations

Despite the wealth of evidence which suggests that harms of longer and more frequent use of smartphones and tablets may outweigh the benefits of such use, there is a general lack of reporting of specific dose-response relationships that can determine a threshold for use which may pose negative implications. Therefore, at this stage, it may be useful to be guided by the American Academy of Pediatrics 2016 statement (AAP Council on Communications and Media, 2016). The AAP recommendations state that children under 18 to 24 months of age should not engage in any screen time (with the exception of parent-mediated video chatting) while those aged 2 to 5 years should ideally consume only high-quality screen time for a maximum of an hour per day. These AAP recommendations are illustrative of the international guidelines targeted for worldwide screen use in early childhood, as they align with the physical activity, sedentary screen time, and sleep guidelines (World Health Organization, 2019) which also recommend that children aged less than 2 years have no sedentary screen time and those aged 2 to 5 years have no more than one hour per day.

While the evidence base is only just emerging, we offer the following initial recommendations for early childhood educators and clinicians. First, the potential negative associations between smartphone and tablet use and child-specific factors outline the importance

of assisting and guiding parents to identify alternative non-screen-based strategies to use in instances where device use may otherwise impede development of a child's natural regulatory mechanisms (e.g., to soothe or occupy a child). Second, the AAP screen time recommendations (AAP Council on Communications and Media, 2016) around avoiding device use within one hour of bedtime should be emphasized to families, to highlight the importance of the timing of device use and potential implications on young children's sleep. Third, it is important to help parents consider the content and context of smartphone and tablet use in addition to time spent on these devices, i.e., is the content developmentally appropriate and easy to switch off? As outlined in the Zero to Three's recent research report (Barr et al., 2018), the 3C's: Child (i.e., unique, individual child characteristics), Content (i.e., the quality and meaningfulness of the media content) and Context (i.e., the setting in which child uses device; alone or with parents/ siblings) can be useful as a simple rule-of-thumb for parents when choosing appropriate screen media on mobile devices for their child. Finally, families should be advised to be cognizant of the unique features of smartphones and tablets compared to traditional media (such as television), which includes increased tendency for solitary use, enticing touch-screen interface (Haughton et al., 2015) and exposure to high amounts of advertising via internet connectivity (Domoff et al., 2020). Thus, a note of caution is warranted for decisions surrounding provision of these devices at increasingly younger ages in early childhood. Families could be advised to avoid introducing technology early, as children are very capable of grasping the necessary skills as they engage in use of these devices in learning contexts (AAP Council on Communications and Media, 2016).

Strengths and Limitations

There are several strengths and limitations of the review that should be acknowledged. A major strength of the review was the protocol which employed a broad and verified search strategy to incorporate a widespread range of child-specific proximal factors in psychosocial, cognitive, and language domains, and further including sleep-related factors which have a central influence on young children's development. Screening, data extraction and quality assessment were carried out independently by two reviewers maintaining a high inter-rater reliability. The PRISMA checklist was followed throughout the review and in the reporting (see Supplement S9). Nevertheless, several limitations should be noted. First, the main limitation is that the research literature is only just emerging. As such, more research is needed for more definitive

and nuanced conclusions. Relatedly, the high degree of heterogeneity in measures combined with the relatively small number of studies, limited the ability to meta-analytically examine more specific measures. Finally, as predominantly published findings were included in both the meta-analysis and systematic review, the possibility of publication bias could not be completely ruled out.

Conclusion

It is promising to see a growing number of research studies investigating intra- and inter-personal child-specific psychosocial, cognitive, and sleep factors in early childhood smartphone and tablet use. Although it is difficult to draw robust inferences about the directionality or dosage effects, there was some evidence that increased amount of smartphone and tablet use was associated with slightly poorer measures of child-specific factors, particularly in relation to sleep. Self-regulation, internalizing and externalizing behavior, social skills, cognitive, and language development remain areas to be further investigated. Future research should aim to conduct methodologically rigorous studies examining longitudinal associations between smartphone and tablet use and psychosocial, cognitive, and sleep domains of child development. The meta-analytic associations that were investigated in this review were correlational, however, in reality, early childhood screen use is likely to be far more nuanced. Therefore, future research should also seek to model the effect of additional factors including parenting practices and beliefs, the household environment, and the digital environment design on young children's smartphone and tablet use. The multiple aspects of smartphone and tablet use, i.e., duration, frequency, content, context, and history of use, are important to be considered individually as well as in combination, to further understand the developmental implications. Consequently, this would better inform policy-making and general recommendations for parents, educators, clinicians, and stakeholders in the digital media industry. Deeper insights into manifestation of problematic mobile screen use in early childhood would also enable effective early intervention of such problematic use.

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Table 1

Findings for Association between Smartphone and Tablet Use and Psychosocial Factors in Young Children

Author/s (Year): Country	Sample characteristics	Type of screen use	Developmental factor and measure	Key findings of association	Covariates accounted/ controlled for	Overall quality (Risk of bias)
Young children (toddlers and preschool children)						
*McDaniel and Radesky (2020): USA	183 heterosexual couples with young children aged 1 to 5 years (M = 3, SD =1.2 years, 45% male)	Smartphone and tablet: Average use duration per day (hours/day)	Externalizing behavior: Child Behavior Checklist (CBCL)	Greater child externalizing behavior significantly predicted greater tablet use (not phone use) at follow-up via parenting stress (based on structural equation modeling). However, greater smartphone and tablet use did not significantly predict later externalizing behavior.	Child age, parents' gender, education, and depression levels	Strong (Low)
#Cho and Lee (2017): South Korea	303 parents of young children aged 1-6 years (prior to elementary school entry, 51% male)	Smartphone addiction proneness reported by parents	Problematic behavior: Korea Personality Inventory for Children (K-PIC) and Preschooler Behavior Questionnaire (PBQ); Emotional intelligence: reported by parents	All smartphone addiction tendencies were significantly positively associated with problematic behavior, and all addiction tendencies except 'Interference with daily life' were significantly negatively associated with emotional intelligence, even after controlling for confounding variables.	Parental age, level of education, and occupation, children's age and daily smartphone usage	Acceptable (Moderate)
Toddlers						
*Lin et al. (2020): Taiwan	161 primary caregivers of toddlers (M = 2.14, SD = 0.45 years, 53% male)	Smartphone and tablet: Average use duration per day (hours/day)	Internalizing and externalizing behavioral problems: CBCL 1⅟2–5	Children who spent more time on smartphone and tablets were more likely to have more emotional problems, anxious/ depressive symptoms, social withdrawal and aggressive behavior, even after controlling for confounding variables.	Child's sex and age, prematurity, only child status, primary caregiver, and parents' education	Strong (Low)
*Levine et al. (2019): USA	326 parents of toddlers (M = 1.43, SD = 0.83 years, 58% male)	Smartphone and tablet: Frequency of use alone and with parents (six-point scale anchored by "Never" = 0 and "Very Frequently" = 5)	Self-regulation: Infant-Toddler Symptom Checklist (ITSC)	Greater frequency of use of smartphone and tablets alone by child was significantly predicted by greater child self-dysregulation.	Educational or non-educational motives of parents for children's media use; age and sex of child; parent's education and relationship status	Acceptable (Moderate)
Preschool children						

#Lee and Park (2018): South Korea	171 mothers of preschool children (M = 4.63, SD = 1.06 years, 53% male)	Smartphones over-dependence tendency: The smartphone over-immersion evaluation scale; Average duration of use (min or hours/day)	Self-regulation: Parent reported self-adjustment tool	Children's smartphone over-dependence tendency was significantly associated with poorer self-regulation, even after controlling for confounding variables.	Mother's occupation, child's age, smartphone usage frequency, mother's average daily smartphone usage time, parental efficacy and maternal interactions	Acceptable (Moderate)
*Nathanson and Beyens (2018b): USA	402 mothers of preschool children (M = 4.0, SD = 0.80 years, 52% male)	Tablets only: Average daily duration of use (min /day) and evening use (min)	Temperament i.e., effortful control (EC): Early Childhood Behavior Questionnaire (ECB)	Tablet use was significantly negatively associated with effortful control. However, this relationship was moderated by total sleep time (i.e., this association was significant only when the child received less sleep) and was mediated by quality of sleep (i.e., the association was significant via quality indicators of sleep).	Child's age, the child's sex, mother's employment status, number of days the child attends childcare, mother's education, household income, TV viewing	Acceptable (Moderate)
Poulain et al. (2018): Germany	527 preschool children (M = 3.81, SD = 0.89 years, 52% male) and their parents	Mobile phones only: Duration of use per day formed into categories of users vs non-users	Emotional, conduct, hyperactivity/inattention and peer problems: Strengths and Difficulties Questionnaire (SDQ)	Baseline use of mobile phones was significantly associated with more conduct problems and hyperactivity or inattention at follow-up. Further, peer relationship problems at baseline was significantly associated with greater mobile phone use at follow-up. No significant associations were present between mobile phone use and emotional problems at baseline/ follow-up.	Age, gender, socio-economic status (SES), year of data acquisition, other baseline predictors and the outcomes	Acceptable (Moderate)
*Lawrence et al. (2020): USA	56 preschool children (M = 3.12, SD = 0.38 years, 54% male) and their parents	Smartphone and tablet: Average weekly duration of use (hours/week)	Self-regulation: Children's Behavior Questionnaire or ECBQ reported by parents and 11-task behavioral self-regulation battery administered to children	Children's mean weekly use of smartphone and tablets was significantly associated with lower behaviorally assessed self-regulation. However, there was no significant association with parent-reported self-regulation.	Use of traditional media like TV, age of first use of any screen based media, parent education, family income, child age and sex.	Acceptable (Moderate)
#Lee et al. (2015): South Korea	83 mothers of preschool children aged 4 and 5 years (47% male)	Smartphone addiction tendency: Korean children's internet addiction observer diagnosis scale (modified for smartphones)	Problem behavior: Preschool behavior questionnaire	Smartphone addiction tendency was significantly positively correlated with hyperactive-distractible behavior. However, there was no significant correlation between smartphone addiction tendency and hostile-aggressive or anxious-fearful behavior.	NA	Acceptable (Moderate)
#Kim and Hwang (2017): South Korea	263 preschool children (4 year old, 53% male)	Smart device (mainly smartphones) immersion tendency: Modified 'Internet and child	Self-regulation: Modified Kendall and Willcox's Self-Control Rating scale; Prosocial	Children's smart device immersion tendency was significantly negatively correlated with self-regulation and prosocial behavior. Further, self-regulation significantly predicted smart device	NA	Weak (High)

		addiction diagnosis scale' developed by the Korea Information Society Agency	behavior: Prosocial Behavior Questionnaire (PBQ)	immersion tendency. Self-regulation also significantly mediated the relationship between prosocial behavior and smart device immersion tendency.		
McNeill et al. (2019): Australia	185 preschool children (M = 4.2, SD = 0.6 years, 61% male) and their parents	Smartphone and tablet app use only: Categories of non-users (0 min/d); low-dose users (1−29 min/d); or high-dose users (≥30 min/d)	Externalizing and internalizing behavior, total difficulties, prosocial behavior: SDQ	App use on smartphone and tablets at baseline did not significantly predict scores on the psychosocial domains of development at follow-up.	Age, sex, suburb-level SES, parental education, participation in sports, physical activity duration, home learning environment, sleep duration, total program viewing, and childcare-level clustering	Acceptable (Moderate)
*[#]Moon et al. (2019): South Korea	117 preschool children (M = 4.5, SD = 0.9 years, 54% male) and their parents	Smartphone and tablet: Average frequency of use per week and duration of use (hours/day)	Social development: The parent reported Korean-developmental screening test	Greater average use of smartphone and tablets was not significantly correlated with social developmental levels.	NA	Acceptable (Moderate)
*Gülay Ogelman et al. (2016): Turkey	162 preschool children (M = 5.42, SD = 0.45 years, 56% male)	Smartphone and tablet: Duration of use on weekdays and weekends	Social skills: Social Skills Evaluation scale (SSES); Social status, i.e., social preference and social impact: Picture sociometry scale	Children's smartphone and tablet use was not significantly associated with social skills. Tablet use was not significantly associated with social status. However, smartphone use was significantly associated with lower social preferences in children.	Duration of TV, and portable computers use and duration of overall media use	Acceptable (Moderate)

Note: *included in the meta-analysis relating to amount of use; [#] included in the meta-analysis relating to perceptions of problematic use

Table 2

Findings for Association between Smartphone and Tablet Use, Cognitive and Language Factors in Young Children

Author/s (Year): Country	Sample characteristics	Type of screen use	Developmental factor and measure	Key findings of association	Covariates accounted/ controlled for	Overall quality (Risk of bias)
Toddlers						
*Lin et al. (2020): Taiwan	161 primary caregivers of toddlers (M = 2.14, SD = 0.45 years, 53% male)	Smartphone and tablet: Average use duration per day (hours/day)	Language development/ delay: Communication and Language Screening Test for Birth to Three Chinese-Speaking Infant-Toddlers (CLST)	Smartphone and tablet use was significantly correlated with language development. However, when confounding variables were controlled for, the association was no longer significant, i.e., children who spent more time on smartphone and tablets were not more likely to have language delay.	Child's sex, age, prematurity, only child status, primary caregiver, and parents' education	Strong (Low)
*Taylor et al. (2017): UK	131 toddlers (M = 1.67, SD = 0.69 years, 47% male) and their parents	Smartphone and tablet: Duration of use on a typical day (min or hours/day)	Vocabulary production and comprehension: Lincoln UK-Communicative Development Inventory (CDI) for Toddlers	Time spent engaging with smartphone and tablets was not significantly associated with vocabulary comprehension or production scores.	Child's age	Acceptable (Moderate)
*van den Heuvel et al. (2019): Canada	893 parents of toddlers (M = 1.56 years, 54% males)	Smartphone and tablet : Average daily duration of use (min/day)	Expressive speech delay and other communication delays: Infant toddler checklist (ITC)	For children who used a smartphone and tablet, each additional 30-minute increase in daily smartphone and tablet use was significantly associated with increased odds of parent-reported expressive speech delay. However, use was not significantly associated with other parent-reported communication delays.	Child sex, household income, maternal education, the 3 temperament domains, and participation year, non–smartphone and tablet use, and parent smartphone and tablet use	Strong (Low)
Borajy et al. (2019): Saudi Arabia	74 toddlers (aged 18 to 36 months) and their parents	Smartphone and tablet: Duration of use (hours/day)	Speech delay: Speech and language screening guidelines assessed by pediatric residents	Child's smartphone and tablet use did not significantly influence the odds of having speech delay.	NA	Weak (High)
Preschool children						
*[#]Moon et al. (2019): South Korea	117 preschool children (M = 4.5, SD = 0.9 years, 54% males) and their parents	Smartphone and tablet: Average frequency of use per week and duration of use (hours/day)	Language development i.e., receptive and expressive language: Preschool receptive-expressive language scale; Cognitive developmental levels: Korean Developmental Screening	Child's smartphone and tablet use time was significantly negatively correlated with expressive language development in three-year old children. However, there were no such relations in four or five year old children. There were no significant relations between use and cognitive developmental levels across	NA	Acceptable (Moderate)

			Test	all ages		
*Neumann (2014): Australia	109 pre-school children (M = 4.22, SD = 0.52 years, 52% male) and their parents	Tablets only: Access (number of tablets at home) and average duration of use (min/day)	Emergent literacy skills: Early literacy measures for letter name and sound knowledge, numeral identification, name writing, print concepts and word reading	Time spent on tablets was not significantly associated with emergent literacy skills of children. However, children with greater access to tablets were found to have higher letter sound and name writing skills.	Child's age	Weak (High)
*Kotrla Topić et al. (2020): Croatia	97 pre-school children aged 6-7 years (56% male) and their parents	Smartphone and tablet: Duration of use on a typical day for entertainment purposes (hours/day)	Literacy skills: Letter recognition test	Time spent on smartphone and tablets for entertainment purposes was significantly negatively correlated with letter recognition. However, this association was no longer significant, when other variables were also included in the regression model.	Maternal education level, home literacy environment (HLE)	Acceptable (Moderate)
*Hutton et al. (2020): USA	69 pre-school children (M = 4.33, SD = 0.67 years, 49% male) and their parents	Smartphone and tablet: Access to child's own device assessed using the ScreenQ novel survey	Cognitive abilities; Emerging literacy skills: Get Ready to Read (GRTR) and The Reading House (TRH); Expressive vocabulary test (EVT-2); Preschool & Primary Inventory of Phonological Awareness, rhyming subscale (PIPA); Comprehensive Test of Phonological Processing (CTOPP), Rapid Object Naming subtest)	Access to child's own smartphone and tablet was significantly negatively correlated with TRH score of emergent literacy and CTOPP score of processing speed. Access to child's own smartphone and tablet was only marginally significantly (negatively) correlated with the other language and literacy measures.	NA	Acceptable (Moderate)
*Jusienė et al. (2020): Lithuania	190 pre-school children (M = 4.90, SD = 0.61 years, 56% male) and their parents	MTSD: Average daily duration of use per day (min/day)	Executive functioning; Mental set shifting: Shape School Task; Working memory: Missing Scan Task; Inhibitory control: Head and Feet Task	Executive functioning measures were not significantly predicted by MTSD use.	Age, parental education	Acceptable (Moderate)
McNeill et al. (2019): Australia	185 preschool children (M = 4.2, SD = 0.6 years, 61% males) and their parents	Smartphone and tablet app use only: Categories of non-users (0 min/d); low-dose users (1−29 min/d); or high-dose users (≥30 min/d)	Executive functioning: Visual-spatial working memory: "Mr. Ant" task; Phonological working memory: "Not This" task, inhibition: Go/No-Go task; shifting: Dimensional Change Card Sort Task	High-dose app users at baseline had a significantly lower inhibition score at follow-up than low-dose app users; App use did not significantly predict other cognitive outcomes at follow-up.	Age, sex, suburb-level SES, parental education, participation in sports, physical activity duration, home learning environment, sleep duration, total program viewing, and childcare-level clustering	Acceptable (Moderate)

Note: *included in the meta-analysis relating to amount of use; [#] included in the meta-analysis relating to perceptions of problematic use

Table 3

Findings for Associations between Smartphone and Tablet Use and Sleep Factors in Young Children

Author/s (Year): Country	Sample characteristics	Type of screen use	Developmental factor and measure	Key findings of association	Covariates accounted/ controlled for	Overall quality (Risk of bias)
Toddlers						
*Cheung et al. (2017): UK	715 toddlers (M = 1.63, SD = 0.69 years, 53% male) and their parents	Tablets only: Average daily duration of use on a typical day (min /day)	Night-time and daytime sleep duration, night time awakenings, sleep onset: The Brief Screening Questionnaire for Infant Sleep Problems (BISQ38)	Tablet use was significantly associated with reduced overall amount of sleep and delayed sleep onset. However, tablet use was not significantly associated with frequency of night awakenings.	Average duration of daily TV exposure, child's age and sex, mother's education	Acceptable (Moderate)
Chindamo et al. (2019): Italy	1117 parents of toddlers (M = 2.11, SD = 0.03 years, 51% male)	Smartphone and tablet: Frequency of habitual use (times used/ week)	Night-time sleep, daytime sleep and mean sleep onset latency: reported by parents	Everyday use of smartphone and tablets was significantly associated with shorter total sleep time and longer sleep onset latency, i.e., everyday use of smartphone and tablets significantly raised the odds of a shorter total sleep time, and their frequent (3–5 times a week) or everyday use raised the odds of a longer sleep onset latency irrespective of other confounding factors.	Gender, having siblings, attending kindergarten, breastfeeding, age and parents' formal education, children's habitual bedtime routines recreational activities (e.g., TV viewing) and behavioral characteristics (e.g., temperament)	Acceptable (Moderate)
Preschool children						
*Nathanson and Beyens (2018b): USA	†402 mothers of preschool children (M = 4.0, SD = 0.80 years, 52% male)	Tablets only: Average daily duration of use (min /day) and evening use (min)	Sleep quality (bedtime resistance and daytime sleepiness): Children's Sleep Habits Questionnaire (CSHQ); Sleep quantity: Total sleep duration reported by parents	The relation between tablet use and effortful control was moderated by children's sleep time, i.e., Tablet use was significantly negatively related to effortful control only among children who received less sleep. Also, the relation between evening tablet use and effortful control was mediated by sleep quality, i.e., evening tablet use was significantly related to later bedtimes, more bedtime resistance, and worse sleep duration, and these indicators of poor sleep quality, in turn, significantly predicted weaker effortful control.	Child's age, the child's sex, mother's employment status, number of days the child attends childcare, mother's education, household income, TV viewing	Acceptable (Moderate)
Nathanson and Beyens (2018a): USA	†402 mothers of preschool children (M = 4.0, SD = 0.80	Smartphone and tablet: Average daily duration of use on typical weekday and weekend	Sleep quality (bedtime resistance and daytime sleepiness): Children's Sleep Habits Questionnaire (CSHQ); Sleep quantity:	Daily and evening tablet use was significantly associated with greater bedtime resistance and compromised sleep duration, after controlling for confounding factors. Daily or evening smartphone and tablet use was not significantly associated with daytime sleepiness. Smartphone use was not significantly related	Child's age, number of days the child attends preschool, mother's education, mother's income, and mother's employment status. TV viewing	Acceptable (Moderate)

	years, 52% male)	(hours/day)	Total sleep duration reported by parents	to sleep duration nor bedtime resistance. However, evening smartphone use was significantly associated with bedtime resistance.		
Beyens and Nathanson (2019): USA	†402 mothers of preschool children (M = 4.0, SD = 0.80 years, 52% male)	Smartphone and tablet: Average daily duration of use on typical weekday and weekend (hours/day)	Bedtime, wake time, napping behavior and sleep consolidation: Reported by parents	Heavier evening and daily tablet use were associated with later bedtimes and later wake times, but not lower amount of sleep. Smartphone use was not significantly associated with bedtimes nor wake times. However, evening smartphone use was significantly associated with increased naptime sleep. Evening tablet use, and both daily and evening smartphone use were significantly associated with poorer sleep consolidation.	TV and other electronic devices time, child's age and daycare attendance, mother's education, employment and household income	Acceptable (Moderate)
*Lan et al. (2020): Hong Kong	2903 parents of preschool children (M = 3.9, SD = 1.0 years, 44% male)	Smartphone and tablet use (and other portable devices): Average daily duration of use on typical weekday and weekend (min/day)	Sleep duration: Reported by parents	Each additional hour spent on smartphone and tablets was independently associated with a reduction in daily sleep duration of 11 and 6 minutes in boys and girls, respectively. Compared to non-portable devices, use of portable ones was more closely associated with short sleep duration.	Age, gender, parental education level, parental work status, housing area, family income, parental age, parental sleep duration and children outdoor physical activity	Acceptable (Moderate)
Zhu et al. (2020): China	2278 parents of preschool children (aged 3 to 6 years, 51% male)	Smartphone and tablet use: Average daily duration of use on typical weekday and weekend (hours and min/day)	Sleep disorder: CSHQ	More time spent on phone or tablet was not significantly associated with increased risk of sleep disorder. However, the groups of sleep disorder and non-sleep disorder significantly differed in their phone use.	Child's age, gender, recent history of disease (i.e., asthma, eczema, rhinitis and conjunctivitis), parents' smoking and education and residential distance to the main road.	Acceptable (Moderate)

Note: †Same sample and data; *included in the meta-analysis relating to amount of use; # included in the meta-analysis relating to perceptions of problematic use

Table 4

High-level Summary of Evidence of Associations between Smartphone and Tablet Use and Child-Specific Factors in Young Children

Domain	Factors	Significant negative association	Significant positive association	No association
Self-regulation	Self-regulation	Levine et al. (2019); Lee and Park (2018); Kim and Hwang (2017); Nathanson and Beyens (2018b); smartphone and tablet use as predictor: Lawrence et al. (2020)		Smartphone and tablet use as outcome: Lawrence et al. (2020)
Emotional factors	Internalizing behavior		Anxiety, depression and social withdrawal: Lin et al. (2020)	Smartphone and tablet use as both predictor and outcome: Poulain et al. (2018); McNeill et al. (2019); Lee et al. (2015) [Anxious sub-type of behavior]
	Emotional intelligence	Cho and Lee (2017)		
Externalizing behavior	Hyperactivity/ Inattention		Lee et al. (2015); smartphone and tablet use as predictor: Poulain et al. (2018)	Smartphone and tablet use as outcome: Poulain et al. (2018)
	Conduct problems		Cho and Lee (2017) [problematic behaviour]; Smartphone and tablet use as predictor: Poulain et al. (2018)	Smartphone and tablet use as outcome: Poulain et al. (2018)
	Aggression		Smartphone and tablet use as outcome: McDaniel and Radesky (2020); Lin et al. (2020)	Smartphone and tablet use as predictor: McNeill et al. (2019); McDaniel and Radesky (2020)
Social development	Social skills	Social preferences: Gülay Ogelman et al. (2016)		Moon et al. (2019); Gülay Ogelman et al. (2016)
	Peer problems		Smartphone and tablet use as outcome: Poulain et al. (2018)	Smartphone and tablet use as predictor: Poulain et al. (2018)
	Prosocial behavior	Kim and Hwang (2017)		
Cognitive	Executive functioning	Inhibitory control: McNeill et al. (2019)		Working memory: McNeill et al. (2019);

development				Jusienė et al. (2020); set shifting: Jusienė et al. (2020)
(Executive functioning)	Cognitive development	Processing speed: Hutton et al. (2020)		Moon et al. (2019)
Language and speech development	Language development (expressive or receptive)	Only in 3 year olds: Moon et al. (2019)		Lin et al. (2020); In 4 and 5 year olds: Moon et al. (2019)
	Speech development	Expressive speech delay: van den Heuvel et al. (2019)		Borajy et al. (2019); Other communications delays: van den Heuvel et al. (2019)
	Vocabulary production and comprehension			Taylor et al. (2017)
Literacy	Emergent literacy	Access to own smartphone and tablet: Hutton et al. (2020)	Access to tablet: Neumann (2014)	Time spent on tablet: Neumann (2014)
Sleep duration	Night-time sleep duration	Cheung et al. (2017); Chindamo et al. (2019); Lan et al. (2020); Tablet use: (Nathanson & Beyens, 2018a, 2018b)		Smartphone use: Nathanson and Beyens (2018a); Beyens and Nathanson (2019)
Sleep quality	Bedtime resistance	(Nathanson & Beyens, 2018a, 2018b)		
	Sleep onset	Cheung et al. (2017); Chindamo et al. (2019);		
	Other factors	Sleep consolidation: Beyens and Nathanson (2019)		Night awakenings: Cheung et al. (2017); daytime sleepiness: Nathanson and Beyens (2018a); sleep disorder: Zhu et al. (2020)

Table 5

Meta-analytic Correlations of Amount of Smartphone and/or Tablet Use with Psychosocial, Cognitive and Sleep-Related Factors in Young Children

Child Factor	*k*	*n*	$\bar{r}$	*p*	[95% CI]	τ	I^2
All child-specific factors	16	7,566	-.08*	.001	[-.13, -.03]	.10	73.98%
Psychosocial factors	12	2,629	-.07	.115	[-.15, .02]	.11	72.45%
Self-regulation	5	1,621	-.03	.648	[-.18, .11]	.15	86.44%
Cognitive factors	10	1,589	-.07	.143	[-.16, .02]	.10	56.54%
Executive functioning	5	368	-.09	.196	[-.22, .05]	.09	30.30%
Language-related factors	9	1,399	-.09	.090	[-.20, .01]	.11	58.04%
Sleep-related factors	4	4,181	-.15*	<.001	[-.21, -.08]	.06	67.75%

Note. *k* = number of samples; *n* = total sample size; $\bar{r}$ = combined effect size. All child-specific factors represent an overall aggregate.
* $p < .05$

Figure 1

PRISMA flow diagram of study selection

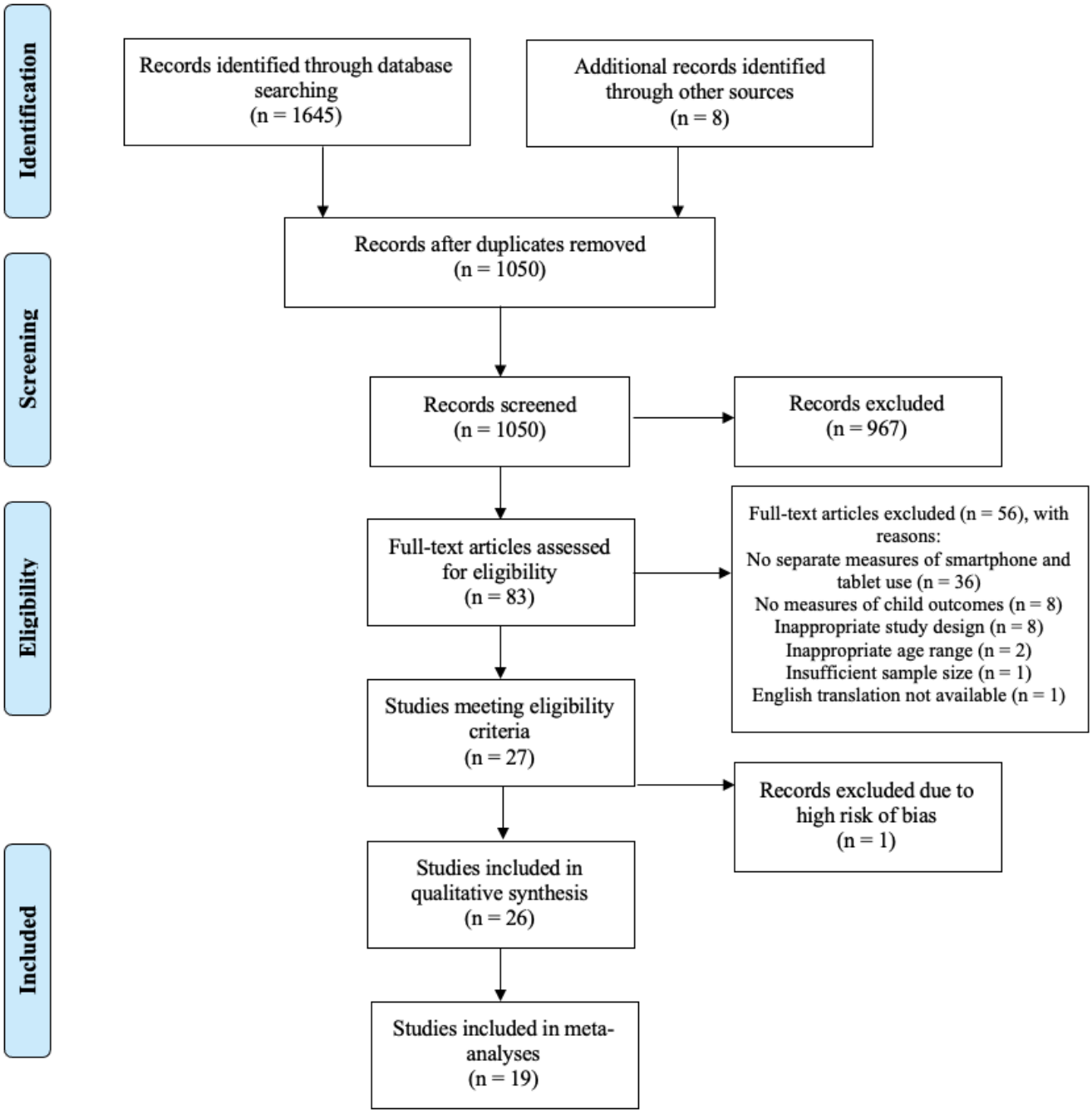
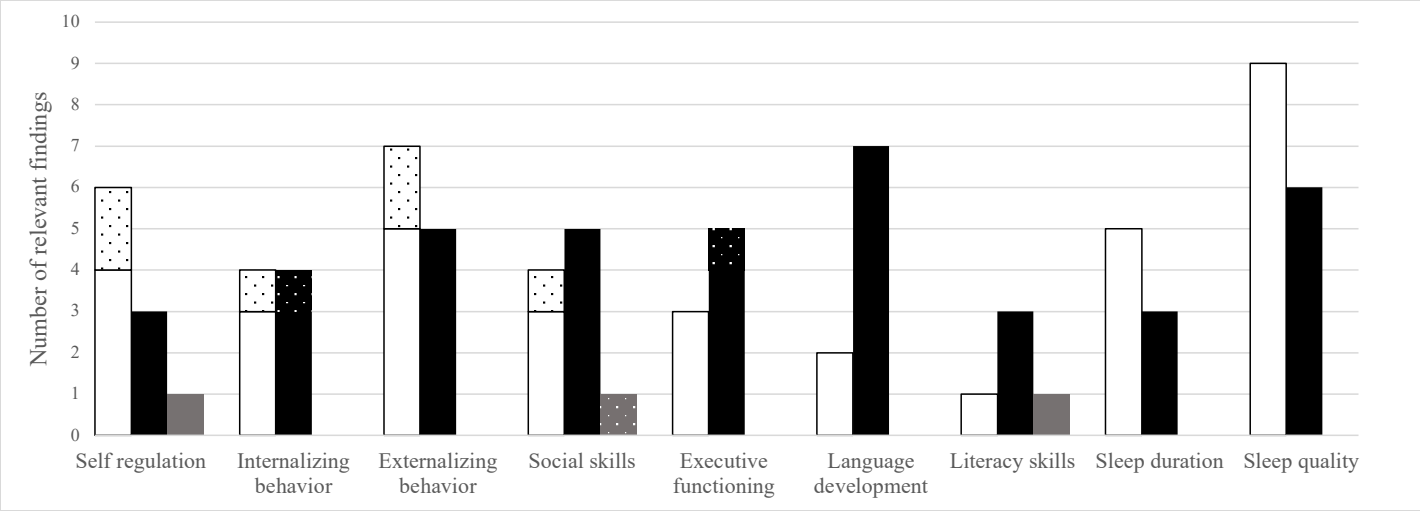


Figure 2

Summary of findings relating to smartphone and tablet use with psychosocial, cognitive and sleep-related factors in young children



Note. White = adverse association; black = null association; grey = beneficial association; dots denote studies that reported parental perceptions of problematic use by children rather than a measure of amount of use.

Figure 3

Forest plot of correlations between amount of smartphone or tablet use and overall aggregated child-specific factors in young children

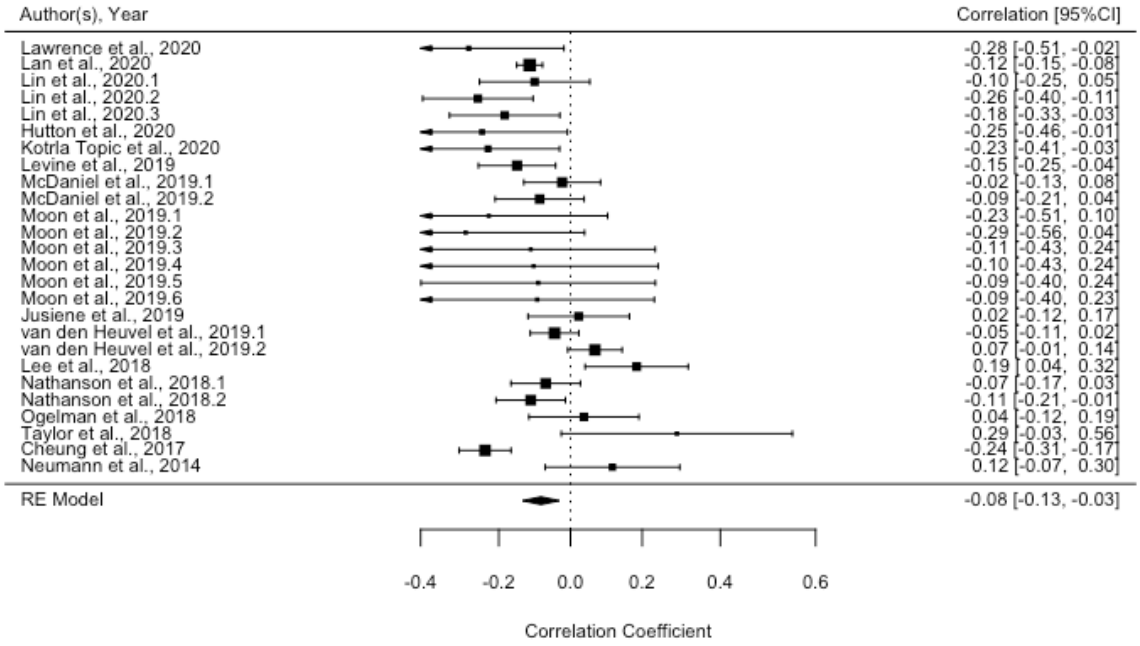


Figure 4

Forest plot of correlations between parental perceptions of problematic smartphone and tablet use and overall child-specific factors in young children