Developmental Psychology

Longitudinal Associations Between Screen Time and Children's Language, Early Educational Skills, and Peer Social Functioning

Megan Gath, L. John Horwood, Gail Gillon, Brigid McNeill, and Lianne J. Woodward

Online First Publication, January 9, 2025. https://dx.doi.org/10.1037/dev0001907

CITATION

Gath, M., Horwood, L. J., Gillon, G., McNeill, B., & Woodward, L. J. (2025). Longitudinal associations between screen time and children's language, early educational skills, and peer social functioning. *Developmental Psychology*. Advance online publication. https://dx.doi.org/10.1037/dev0001907

AMERICAN PSYCHOLOGICAL ASSOCIATION

Developmental Psychology

ISSN: 0012-1649

https://doi.org/10.1037/dev0001907

Longitudinal Associations Between Screen Time and Children's Language, Early Educational Skills, and Peer Social Functioning

Megan Gath[1], L. John Horwood[2], Gail Gillon[1], Brigid McNeill[3], and Lianne J. Woodward[4]

[1] Child Well-being Research Institute, University of Canterbury
[2] Department of Psychological Medicine, University of Otago
[3] Faculty of Education, University of Canterbury
[4] Faculty of Health, University of Canterbury

Children's high and increasing levels of screen time are of growing concern to parents, health professionals, and researchers. With the growing availability and use of devices such as smartphones and tablets, it is important to understand the impact of children's screen use on development. Prospective longitudinal data from 6,281 children (48.3% female) in the Growing Up in New Zealand study were used to examine relations between the extent of screen exposure in early childhood (2–4.5 years) and later language development, early educational skills, and peer social functioning at ages 4.5 and 8 years. Higher levels of screen exposure were associated with lower levels of vocabulary, communication, writing, numeracy, and letter fluency and higher levels of peer problems. These associations were reduced after controlling for confounding family social background factors but remained significant. Results indicate that more than 1.5 hr of daily direct screen time at age 2 was associated with below average language and educational ability and above average levels of peer relationship problems at age 4.5. Exposure to more than 2.5 hr of daily direct screen time was associated with higher than average peer relationship problems at age 8. Findings indicate that high levels of screen exposure during early childhood are negatively associated with children's later language, educational, and social development. Such information is critical to help inform policy guidelines, health care, and parenting practices regarding the availability and children's use of screens in early childhood.

Public Significance Statement

This study indicates that even after controlling for social background characteristics, higher levels of screen time in early childhood are longitudinally associated with poorer developmental outcomes, including language, early educational skills, and forming positive friendships.

Keywords: screen time, language, peer problems, school readiness, Growing Up in New Zealand

Melissa M. Kibbe served as action editor.

Megan Gath https://orcid.org/0000-0002-8647-1262
Gail Gillon https://orcid.org/0000-0001-9501-8147
Brigid McNeill https://orcid.org/0000-0002-7298-880X
Lianne J. Woodward https://orcid.org/0000-0002-7790-1435

The data necessary to reproduce the analyses presented here are accessible through application to the Growing Up in New Zealand study (https://www.growingup.co.nz). The analytic code necessary to reproduce the analyses presented in this article is not publicly accessible. The materials necessary to attempt to replicate the findings presented here are publicly accessible by contacting the Growing Up in New Zealand research team.

The analyses presented here were not preregistered. The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the New Zealand Health and Disability Ethics Committee before every data collection wave. The authors have no conflicts of interest to disclose. This research was supported by a grant from the New Zealand Ministry of Social Development's Children and Families Research Fund (awarded to Megan Gath).

Megan Gath played a lead role in conceptualization, data curation, formal analysis, funding acquisition, and writing–original draft. L. John Horwood played a supporting role in data curation, formal analysis, and writing–review and editing. Gail Gillon played a supporting role in conceptualization and writing–review and editing and an equal role in supervision. Brigid McNeill played a supporting role in conceptualization and writing–review and editing and an equal role in supervision. Lianne J. Woodward played a lead role in writing–review and editing, a supporting role in conceptualization and formal analysis, and an equal role in supervision.

Correspondence concerning this article should be addressed to Megan Gath, Child Well-being Research Institute, University of Canterbury, Manawa Campus, 276 Antigua Street, Christchurch 8011, New Zealand. Email: megan.gath@canterbury.ac.nz

Early childhood is a time of rapid development and a critical period for establishing the foundations of children's lifelong trajectories of socioemotional well-being and educational attainment. For this reason, the World Health Organization has issued guidelines that promote children's health and development, which include recommendations on screen time for young children. Current guidelines recommend no screen time for children under age 2 years and less than 1 hr per day for children between the ages of 2 and 5 years (World Health Organization, 2019). These guidelines have been adopted by governments around the world (e.g., American Academy of Pediatrics Council on Communications and Media, 2016; Canadian Paediatric Society, 2022; New Zealand Ministry of Health, 2017). Yet research increasingly suggests that the screen use of many children currently exceeds these pediatric guidelines, with reports showing that up to 80% of 2-year-olds and 95% of 3-year-olds internationally are engaging with digital screens above recommended levels (Madigan et al., 2020). In New Zealand, the location of the present research, it is estimated that more than half of 2-year-olds and over 80% of 3- and 4-year-olds exceed recommended screen time use (Stewart et al., 2019).

High levels of screen time are of growing concern to parents, educators, and health professionals, given the increasing body of research demonstrating detrimental impacts of excessive screen use in young children (Eirich et al., 2022; Li et al., 2020). When children spend high levels of time engaged in sedentary screen time, their physical health suffers indicated by higher rates of obesity, illness, and more frequent doctors visits (Stewart et al., 2019). Further, time spent engaged with digital media decreases opportunities for optimal language, cognitive, and socioemotional development since it reduces time for other beneficial and enriching activities, such as reading, interacting with family members, and physical and creative play (Brushe et al., 2024; Madigan et al., 2020; Putnick et al., 2023). For example, Putnick et al. (2023) found that higher levels of screen time in 1- to 3-year-olds increased the likelihood of developmental delay indirectly through reduced time spent engaging in peer play time. Given the importance of social interaction to child development, if time spent on digital devices results in less time engaging with peers, parents, and siblings, there may be longer term effects on social functioning and well-being (e.g., Gath et al., 2023; Haidt, 2024; Skalická et al., 2019; Wilkinson et al., 2021).

In terms of the potential for media to provide a context for education and learning, research suggests that even very young children are able to engage and learn from onscreen content, particularly when the onscreen content provides contingent social interactivity, social relevance, and familiar characters (Hipp et al., 2017; Jing & Kirkorian, 2020; Kirkorian, 2018). However, meta-analytic evidence indicates that young children learn less well from information presented digitally compared to the same information presented in a face-to-face context (Strouse & Samson, 2021) and learn more from paper-based books than digitally based books (Furenes et al., 2021). Further, cumulative media use by young children contributes to problems with focused and sustained attention and the development of self-regulation skills (Corkin et al., 2021; Gueron-Sela & Gordon-Hacker, 2020) which may have flow-on effects for children's ability to learn.

Thus, while studies have demonstrated certain aspects of screen use that may be beneficial for children, such as social interactions over video conferencing (Capparini et al., 2023) or the use of screen media as a context for parent–child interaction (Ewin et al., 2021), overall the literature suggests that excessive screen use in early childhood is negatively associated with child developmental outcomes (e.g., Canadian Paediatric Society, 2022; Madigan et al., 2019, 2020).

To date, existing research has focused largely on the effects of screen time on children's behavioral regulation and early language development using cross-sectional methods. There is clearly a need to consider a wider array of developmental outcomes, ideally using longitudinal designs that allow for an assessment of screen use over time and its effects on a range of child outcomes over an extended period (Kaye et al., 2020). To address this gap, we examine relations between the extent of children's screen exposure in early childhood and a range of developmental outcomes assessed at age 4.5 (just prior to school entry) and again at age 8 years. Developmental outcomes spanned language development, early educational abilities, and peer social functioning.

Family Social Background Factors Associated With Screen Use

When examining associations between screen use and child developmental outcomes, it is important to consider other potential confounding factors. In particular, lower family socioeconomic status and maternal education tend to be associated with increased child screen exposure (Gebremariam et al., 2020; Konca, 2022). Additionally, children who regularly attend childcare tend to have lower levels of screen time than those who are at home during the day (Corkin et al., 2021). In New Zealand, heightened levels of screen use in young children have been noted among children of Māori, Pacific Island, and Asian ethnicity, relative to children of New Zealand European ethnicity (e.g., Stewart et al., 2019). This is consistent with international research showing higher screen use in ethnic minorities (e.g., S. E. Anderson et al., 2008; Nagata et al., 2022). Therefore, it is possible that any observed association between children's screen time and their language, early educational, and social skills could be explained, either in full or in part, by these confounding factors rather than the direct effects of screen time exposure. As such, it is critical to account for these factors in any analysis of children's screen use and outcomes. Unfortunately, only half of the 42 studies reviewed by Madigan et al. (2020) included any demographic or social background confounders. Thus, the present analysis includes a range of family social background characteristics correlated with screen use to determine the independent effect of screen exposure, after accounting for the effects of child and family social background factors correlated with screen use.

The Present Research

The overall goal of this article is to draw on prospective longitudinal data from a large birth cohort of New Zealand children studied from birth to age 8 years to examine associations between the extent of screen exposure during early childhood and later developmental outcomes during the early school years. While previous research using this data set has examined associations between screen time and children's physical health and behavioral self-regulation (e.g., Corkin et al., 2021; Stewart et al., 2019), in this research, we focus on additional outcomes of importance to child development: language, educational, abilities, and peer social functioning. Screen exposure was assessed using repeated

measures at ages 2, 4.5, and 8 years. Child language, educational, and social outcomes were assessed at ages 4.5 and 8 years. Children in New Zealand start school on (or as close as possible) to their 5th birthday. The 4.5-year assessments were completed prior to children turning five and entering formal schooling. Given evidence showing a negative association between background television and children's language development and social interactions (D. R. Anderson & Hanson, 2017; Christakis et al., 2009; Madigan et al., 2020), both direct and indirect (i.e., background television) screen exposure measures were included in our analysis. Specific research objectives were as follows:

1. To characterize the nature and extent of screen time use in a large cohort of New Zealand children assessed at ages 2, 4.5, and 8 years of age.
2. To examine associations between the extent of children's screen exposure prior to school entry and a range of measures of child language, educational, and peer social functioning at ages 4.5 and peer social functioning at age 8 years.
3. To assess the extent to which associations between child screen use and child outcomes could be explained by child and family social background factors correlated with screen use.
4. To examine dose-dependent associations between screen exposure and child language, educational, and peer social functioning at ages 4.5 and peer social functioning at 8 years.

Method

Participants

The study sample consisted of all participants in the Growing Up in New Zealand (GUINZ) study. A total of 6,822 pregnant women with an estimated delivery date between April 2009 and March 2010 were recruited from the Auckland, Counties Manukau, and Waikato District Health Board regions of New Zealand. See S. M. B. Morton et al. (2010, 2013, 2015) for a detailed description of the study's design, conceptual framework, and recruitment procedures. In these analyses, we use data collected across three study waves, corresponding to the following child ages: 2 years, 4.5 years, and 8 years. Data were collected using face-to-face interviews with parents and behavioral assessments and observations of children.

Retention to age 4.5 was high, with 90% of the baseline sample assessed. At age 8, however, 15% of the sample were lost to follow-up, with 5,556 children completing at least one component of the study. Of these, 559 had data available from only the mother/primary caregiver or the child (and not necessarily on all assessment measures). Figure 1 describes the data available at each assessment point and the sample included in analysis.

Measures

Daily Weekday Screen Exposure

At each age assessment, mothers or primary caregivers were questioned about the extent of their child's exposure to both direct and indirect screens. Daily screen time was measured in time per day (hours and minutes) on a usual weekday, with question wording differing as follows at each age, reflecting contextual changes in children's access and use of digital screens over time. At age 2, mothers were asked: *Thinking about the last weekday (i.e., yesterday/last Friday), how many hours did your child spend at home*:

1. Watching television (TV), DVDs, and videos?
2. Using a computer or laptop, including children's computer systems such as Leapfrog?
3. Playing with an electronic gaming system?
4. With the TV on in the same room as the child, whether or not he/she was watching it?

At age 4.5, the question was worded as follows: *Thinking about a usual weekday, approximately how many hours does your child spend at home*:

1. Watching television programming including free-to-air, online, and pay TV or DVDs either on TV or other media?
2. Using electronic media, for example, computer or laptop, including children's computer systems such as Leapfrog, iPad, tablets, smart phones, and any electronic gaming devices?
3. With the TV on in the same room as your child, whether or not he/she was watching it?

At age 8, the wording of the items was as follows:

1. Watching television programming including free-to-air, online, and pay TV or DVDs either on TV or other screen-based devices
2. Spending time with the TV on in the same room, whether they are watching it or not
3. Spending time doing activities and tasks, for example, homework, playing games, or sending messages, on any screen-based device including computers, laptops, tablets, smartphones, or gaming devices

Based on these measures, we calculated three measures of screen use/exposure at each age assessment: (a) direct screen use, which was the sum of television/video viewing and electronic media use; (b) indirect screen exposure, which consisted of the extent of background television exposure; and (c) total screen exposure, which was the sum of children's use and exposure to both direct and indirect screens.

A small subset of respondents reported implausible levels of daily screen hours, such as 20+ hours of screen exposure, when children were presumably sleeping for a period of time. Reported screen exposure of 20 or more hours per day occurred in 0.3% or less of the sample at ages 2, 4, and 5, and in 1.5% of the sample at age 8. These participants were removed from our analyses.

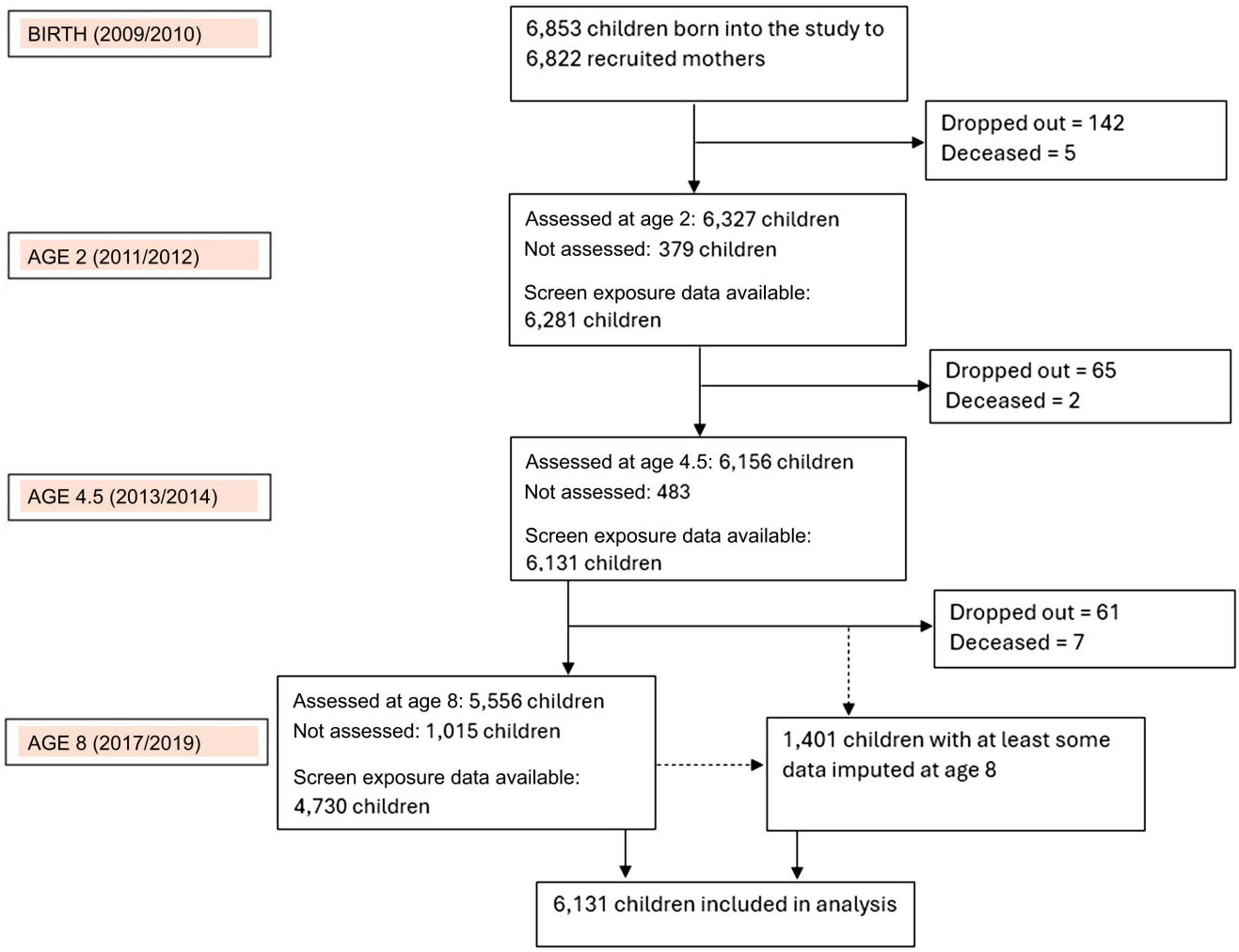
Child Outcomes at Ages 4.5 and 8 Years

Language.

Vocabulary: Age 4.5. The shortened version of the Peabody Picture Vocabulary Test (Dunn et al., 1997) provided a measure of

Figure 1

CONSORT Flow Diagram for Sample Retention and Data Availability



Note. CONSORT = consolidated standards of reporting trials. See the online article for the color version of this figure.

children's receptive vocabulary. The adapted version was based on work done in the United States for the Head Start Impact Study, which includes some word modifications for use in Australia (Rothman, 2005). Final scores on the task were the latent factor scores on the shortened Peabody Picture Vocabulary Test. The psychometric properties of the Peabody Picture Vocabulary Test have been well established, including test–retest reliability (0.61–0.89), alternate forms reliability (0.89–0.90), and convergent validity in a New Zealand sample (Reese & Read, 2000).

Communication Skills: Age 4.5. The five-item Parent Rating of Oral Language and Literacy was used to assess children's communication skills. The Parent Rating of Oral Language and Literacy was created as a modified version of the Teacher Rating of Oral Language and Literacy (Dickinson et al., 2001), designed for completion by parents. The first two items were rated on a 4-point scale ranging from *never* to *often*: *How often does your child try out new words?* and *How often is your child understandable when speaking to adults other than you or other family members?* The other three items were rated on similar 4-point scales appropriate to the question asked: *Which of the following best describes your child's pattern of asking questions?* ("never or rarely asks adults questions" to "often asks adults interesting or long questions"); *Which of the following best describes your child's ability to communicate personal experiences*

in a clear and logical way? ("very tentative, only offers a few words" to "tells experiences in a way that is nearly always complete, logical, and understandable"); *Which of the following best describes your child's ability to communicate when they are not first understood?* ("never continues trying" to "will work hard to be understood"). The mean of these five items was used to provide a measure of children's oral communication skills. Cronbach's α for the five items was .43.

Early Educational Ability.

Writing: Age 4.5. Two tasks from the "Who Am I"? Developmental Assessment used by the Longitudinal Study of American Children were used to assess children's early writing skills (de Lemos & Doig, 1999). Children were asked to first write their name and then write some numbers. Each writing task was scored on a scale from 0 to 4 according to the standard scoring manual (Rothman, 2005), with a total writing score calculated by summing the two task scores (correlation between tasks was r = .47). Reliability estimates for this measure range from 0.87 to 0.91 (de Lemos & Doig, 1999).

Numeracy: Age 4.5. Numeracy was also assessed using tasks from the "Who Am I"? Developmental Assessment (de Lemos & Doig, 1999). Interviewers asked children to first count from 1 to 10 and then to count down from 10 to 1. These counting tasks were scored according to the number of correct responses in the longest number sequence achieved by the child (i.e., without any interruptions or inclusion of other words/numbers). A total numeracy score was calculated by summing the two counting tasks (correlation between tasks was r = .38).

Letter Fluency: Age 4.5. The Letter Naming Fluency subtest from the Dynamic Indicators of Basic Early Literacy Skills was used to measure children's letter knowledge at age 4.5 years. This subtest assessed children's knowledge of letters, their ability to verbally name or say the letters, and letter naming speed. This scale has previously been validated with New Zealand children, with interrater reliability coefficients >0.90 (Schaughency & Suggate, 2008). An overall letter fluency score was formed using the total number of letters correctly named in a 1-min period.

Peer Social Functioning. Several aspects of children's *peer social functioning* were assessed at ages 4.5 and 8.

Peer Problems and Prosocial Behavior: Ages 4.5 and 8. Parental reports of child behavior were obtained using the peer relationship problems and prosocial behavior subscales of the Strengths and Difficulties Questionnaire (Goodman, 1997). The peer problems subscale included five items, such as "rather solitary, tends to play alone" and "generally liked by other children" (reverse-coded). The prosocial behavior subscale included five items, including "considerate of other people's feelings" and "shares readily with other children." All items were rated by parents as *not true* (0), *somewhat true* (1), or *certainly true* (2). After reverse-coding where appropriate, items were summed across each subscale, with higher scores indicating higher levels of peer problems or prosocial behaviors, respectively. Cronbach's α for peer problems and prosocial behavior was 0.55 and 0.69, respectively. The Strengths and Difficulties Questionnaire is a well-established parent-report measure that has been shown to be reliable and valid (Goodman, 2001).

Descriptive statistics for all dependent variables are provided in Table 1.

Table 1
Means, Standard Deviation, and Range for All Child Outcome Measures

Outcome measure	*N*	*M*	*SD*	Range
Language				
Vocabulary (age 4.5)	5,587	0	0.90	−4–3
Communication (age 4.5)	6,116	3.49	0.41	1–4
Educational ability				
Writing (age 4.5)	5,615	5.08	1.88	0–8
Numeracy (age 4.5)	5,615	12.68	5.89	0–20
Letter fluency (age 4.5)	5,464	8.39	10.53	0–69
Social functioning				
Peer problems (age 4.5)	6,131	1.60	1.58	0–9
Prosocial behavior (age 4.5)	6,130	7.75	1.81	0–10
Peer problems (age 8)	4,676	1.46	1.62	0–10
Prosocial behavior (age 8)	4,676	8.14	1.83	0–10

Note. Descriptive statistics are provided for the subset of children with screen exposure data available at each study wave.

Confounding Child and Family Social Background Factors

Six measures of child and family social background were identified from the GUINZ data set: child sex, ethnicity, maternal age, maternal education, extent of socioeconomic deprivation, and childcare attendance.

Child ethnicity was reported by the mother at the 9-month assessment and was categorized as NZ European, NZ Māori, Pacific Island, Asian, Middle Eastern, Latin American, or African, or Other. Multiple ethnic affiliations were allowed.

Maternal education was assessed at the antenatal study wave by asking mothers to select their highest completed qualification from no secondary school qualification, secondary school (National Certificate of Educational Achievement 1–4), diploma/trade certificate (National Certificate of Educational Achievement 5–6), bachelor's degree, or higher degree.

Socioeconomic deprivation was measured using the New Zealand Index of Deprivation (Atkinson et al., 2019) at each study wave. This measure is based on nine census variables and assigns levels of deprivation to small geographic areas, displayed as a decile system. A decile of 1 represents areas with the least deprivation, whereas a decile of 10 represents areas with the most deprivation.

Childcare attendance was measured at the 2-year study wave. Mothers were asked to report whether or not their child had been looked after by anyone other than their partner over the last 1 month.

Statistical Method

As indicated in Figure 1, data were included in the present analyses for the 6,131 children who were retained up the age 4.5 assessment point with missing data imputed at age 8 for the subset of children with data available at the 4.5-year study wave. We used multiple imputation with fully conditional specification (Huque et al., 2018) to impute missing values and adjust for nonresponse bias or differences in the groups of children that did and did not have data available at age 8. Predictors included in the imputation model were sex, ethnicity, socioeconomic deprivation, maternal education, and maternal age, and the final values used in

analysis were the mean of 5 iterations of imputation. Imputed values were used in all results presented using data from the 8-year assessment, with results cross checked by rerunning all analyses with the nonimputed data set.

Given the large sample size of the GUINZ data set, we focused on effect sizes where appropriate and used the threshold of effect sizes (e.g., Hedge's g) $\geq$0.2 as an indication of a significant effect. We considered bivariate correlations of $r \geq 0.1$ as representing a significant association. For all other analyses, the more stringent criterion of $p < .001$ was applied to indicate statistical significance.

Dimension Reduction

Due to the large number of child outcomes considered in our analyses, we used exploratory and confirmatory factor analyses to examine the extent to which outcome measures under each developmental domain might load on a common or smaller set of latent factors. Confirmatory factor analyses latent measurement models were conducted in Stata. Model fit was evaluated using the root-mean-square error of approximation, the comparative fit index, and the Tucker–Lewis index. Root-mean-square error of approximation values range from 0 to 1, with smaller values indicating better fit. Values below 0.08 are considered acceptable, with values below 0.06 considered a good fit (Hu & Bentler, 1999; Xia & Yang, 2019). Comparative fit index and Tucker–Lewis index values also range from 0 to 1, with higher values indicating better fit. Values above 0.90 were considered acceptable and above 0.95 indicative of a good fit (Bentler & Bonett, 1980; Hu & Bentler, 1999; Xia & Yang, 2019).

Longitudinal Associations of Screen Exposure With Language, Educational Ability, and Social Functioning

For ease of presentation and interpretation, all final outcome variables used in the main analyses (i.e., other than initial descriptive statistics) were standardized to a mean of 0 and standard deviation of 1.

To examine longitudinal associations between the extent of screen exposure and developmental outcomes, we first recoded the total screen exposure variables at age 2 and age 4.5 into quartiles, given the skewed distribution of these variables. The thresholds for classifying into quartiles can be found in Table 2, indicated by the 25th percentile, median, and 75th percentile. We next compared the mean levels of our dependent variables across these quartile groups using analyses of variance. Dependent variables examined in relation to the extent of screen exposure at age 2 were language factor score, educational ability factor score, peer problems, and prosocial behavior, all assessed at age 4.5. The dependent variables predicted from screen exposure quartiles at age 4.5 were peer problems and prosocial behavior, both assessed at age 8.

Adjustment for Confounding Factors. To examine the extent to which associations between screen time and later developmental outcomes could be explained by other child and family social background characteristics, the relationship between screen time and developmental outcomes was adjusted for the effects of potential confounding factors. Following the above analyses of variance, we next ran analyses of covariance to adjust our comparisons for our set of confounding factors (sex, ethnicity, socioeconomic deprivation, maternal education, and maternal age). Univariate analyses of covariance were run for each outcome with

Table 2
Duration of Different Types of Screen Use (Hours per Day) From Ages 2 Years to 8 Years

	Child age		
Screen use type	2 Years (n = 6,281)	4.5 Years (n = 6,131)	8 Years (n = 6,131)
Types of direct screen exposure			
Television/video viewing			
M hr (*SD*)	1.24 (1.35)	1.48 (1.19)	2.66 (2.02)
Mdn hr	1.0 (.25, 2.0)	1.0 (.75, 2.0)	2.1 (1.0, 3.4)
Electronic media			
M hr (*SD*)	0.12 (.44)	0.60 (0.76)	1.52 (1.46)
Mdn hr	0 (0, 0)	0.5 (.08, 1.0)	1.0 (0.5, 2.0)
Subtotal: direct screen exposure			
M hr (*SD*)	1.35 (1.48)	2.07 (1.67)	4.18 (2.92)
Mdn hr	1.0 (.25, 2.0)	2.0 (1, 2.75)	3.7 (2.1, 5.4)
Indirect screen exposure			
Background television			
M hr (*SD*)	2.47 (2.49)	2.15 (2.14)	1.97 (1.75)
Mdn hr	2.0 (.75, 3.5)	2.0 (0.5, 3.0)	1.8 (0.6, 2.8)
Total screen exposure			
Total[a] screen exposure			
M hr (*SD*)	3.73(3.38)	4.16 (3.18)	5.87 (3.36)
Mdn hr	3.0 (1.25, 5.0)	3.5 (2.0, 6.0)	5.7 (3.5, 7.8)

Note. Medians are presented as median (25th percentile, 75th percentile). *Mdn* = median; hr = hour.
[a] Total is less than the sum of the individual components due to removal of participants with 20+ hr reported and missing data.

the predictors of (a) extent of earlier screen time in quartiles and (b) family and social background characteristics.

Fixed Effects Regression Model. The assessment of peer problems at both ages 4.5 and 8 provided the opportunity to examine the extent to which variations in screen exposure were associated with changes in peer problems over this period. A fixed effects panel regression model fitted in a repeated measures framework was used to predict peer problems as a function of age and total screen exposure quartiles. In other words, this analysis predicted peer problems from total screen exposure quartiles (background television and direct screen time) and age (4.5 years and 8 years).

Dose-Dependent Association Between Screen Exposure and Outcomes. Finally, we examined the dose-dependent association between screen exposure and our dependent variables. For this analysis, continuous screen exposure variables were rounded to the nearest hour (e.g., 29 min or less would round down to 0 hr and 30 min or more would round up to 1 hr), with the highest category representing 6 or more hours (given the smaller sample sizes at these higher hourly increments). The outcome variables in this analysis were standardized factor scores on the latent language and educational factors at age 4.5 and standardized peer problems at age 4.5 and 8. Linear regressions were used to predict the standardized outcome measures (mean of 0, *SD* of 1) from all confounding variables (sex, ethnicity, socioeconomic deprivation, maternal education, and maternal age) and screen exposure, and covariate adjusted means for each outcome were calculated from the fitted models at hourly intervals of screen exposure. Given the standardization of outcome variables, mean differences between screen exposure intervals provide a measure of effect size. This analysis was run for both direct screen exposure and total screen exposure.

Transparency and Openness

All data and research materials are publicly available through a data access application at https://www.growingup.co.nz/. Analysis code is available on request from the corresponding author. This study was not preregistered.

Results

Nature and Extent of Children's Screen Time Exposure Between Ages 2 and 8

Table 2 describes the nature and duration (in hours and minutes) that parents reported that their study child spent on a typical weekday: (a) directly watching television and/or videos; (b) using electronic media; and (c) the amount of time that the television was on in the background (indirect screen exposure) at each age assessment from 2 to 8 years. Both mean and median durations of screen use are reported.

Results showed a tendency for children's direct screen use to increase with age across both TV/video viewing and electronic media use. In contrast, background television exposure decreased slightly with increasing child age.

Child and Family Factors Associated With Screen Exposure

To examine the extent to which children's screen exposure time might vary by child and family factors, Table 3 describes the extent of screen use at each age in relation to the following factors: child sex, child ethnicity, maternal age, maternal education, socioeconomic deprivation, and childcare attendance.

Child sex was not associated with screen exposure at any age (all Hedges' $g < 0.08$). Using binary indicator variables for each ethnic group, we found that European ethnicity predicted less screen exposure at all assessment points (all Hedges' $g > 0.40$). In contrast, Pacific Island ethnicity and Māori ethnicity were associated with more screen exposure at all ages (all Hedges' $g > 0.35$). Asian ethnicity predicted higher exposure at age 2 years (Hedges' $g = 0.26$).

Table 3
Means and Standard Deviations of Screen Exposure Across Levels of Child and Family Factors

Variable	Level	n[a]	Total screen exposure (hours per weekday) *M* (*SD*)		
			2 Years	4.5 Years	8 Years
Sex	Male	3,237	3.82 (3.42)	4.27 (3.20)	5.94 (3.40)
	Female	3,029	3.64 (3.35)	4.03 (3.15)	5.79 (3.32)
Ethnicity	European	4,274	3.15 (2.98)	3.80 (2.90)	5.45 (3.48)
	Māori	1,437	4.58 (3.69)	5.29 (3.51)	6.95 (3.35)
	Pacific Island	1,225	5.05 (3.93)	5.46 (3.69)	7.22 (2.78)
	Asian	977	4.44 (3.63)	3.98 (3.16)	5.74 (3.17)
Maternal age (assessed at child age 9 months)	30 and under	2,590	4.51 (3.70)	5.00 (3.53)	6.44 (3.31)
	Over 30	3,433	3.08 (2.95)	3.51 (2.71)	5.42 (3.44)
Maternal education	No secondary school qual	370	5.56 (4.01)	6.44 (3.83)	8.24 (2.64)
	Secondary school	1,375	4.33 (3.50)	4.87 (3.36)	6.76 (3.18)
	Diploma/trade certificate	1,829	4.17 (3.61)	4.64 (3.26)	6.29 (3.16)
	Bachelor's degree	1,429	2.93 (2.71)	3.126 (2.52)	5.04 (3.58)
	Higher degree	1,002	2.34 (2.44)	2.74 (2.26)	4.01 (3.07)
Socioeconomic deprivation[b]	High	3,321	4.36 (3.68)	4.78 (3.48)	6.44 (3.34)
	Low	2,706	2.88 (2.72)	3.39 (2.58)	5.15 (3.39)
Childcare attendance (age 2)	Yes	3,466	3.17 (2.95)	3.78 (2.89)	5.66 (3.52)
	No	2,732	4.39 (3.69)	4.55 (3.39)	6.01(3.34)

[a] Sample sizes are reported for 2-year assessment point. [b] High deprivation includes deciles 6 through 10, and low deprivation includes deciles 1 through 5. Cell values are presented as mean (standard deviation).

Maternal age and maternal education were both negatively correlated with screen exposure at all ages. In other words, children with older mothers and more educated mothers had less screen exposure (maternal age: $r = -.17$ to $-.25$; maternal education: $r = -.26$ to $-.33$). Higher socioeconomic deprivation was also associated with more screen exposure at all ages ($r = .22$–$.25$). Finally, children enrolled in early childhood education/care at age 2 engaged in lower levels of screen time at home than children not enrolled (Hedges' $g = .37$).

Dimension Reduction

As described in the Methods, due to the large number of dependent variables considered in this analysis, exploratory and then confirmatory factor analyses were used to reduce our child outcome measures to a smaller set of latent factors. With regard to language and educational outcomes at age 4.5, both single and two-factor solutions were considered, with the two-factor solution (with separate latent constructs of educational ability and language) found to have the best fit to the data (root-mean-square error of approximation = .08, comparative fit index = .97, Tucker–Lewis index = .91). The language factor included vocabulary and communication skills, and the educational ability factor included letter fluency, writing, and numeracy. Figure 2 summarizes the measurement model with standardized coefficients.

Table 4 provides the bivariable correlations between total screen exposure and dependent variables measured concurrently and subsequently. Correlations for all measures of language and educational ability, as well as the factor scores, are provided.

With regard to social outcomes, as seen in Table 4, we found differential associations between screen time and the two measures of social functioning. For this reason, these two social outcomes (peer problems and prosocial behavior) were examined separately in relation to early screen exposure.

Figure 2
Latent Measurement Model for Language and Educational Ability Outcomes at Age 4.5

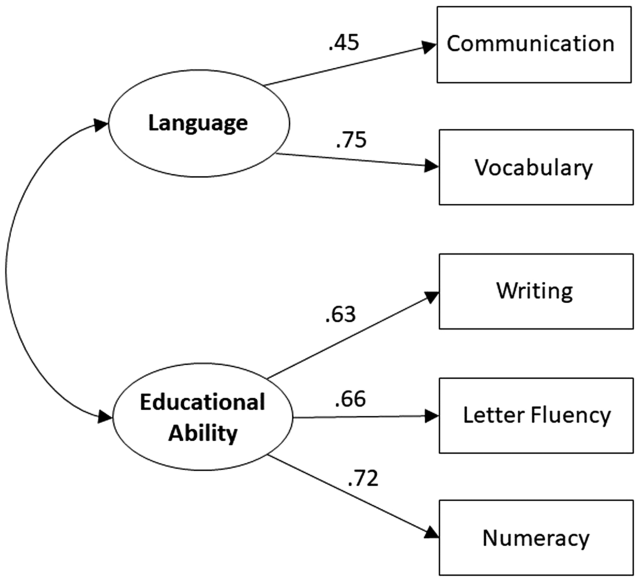


Table 4
Bivariate Correlations Between Screen Exposure and Dependent Variables Over Time

Outcome variable	Total screen exposure		
	2 Years	4.5 Years	8 Years
Language			
Vocabulary (age 4.5)	**−.23**	**−.21**	
Communication (age 4.5)	**−.14**	**−.14**	
Language factor score	**−.23**	**−.22**	
Educational ability			
Writing (age 4.5)	**−.11**	**−.18**	
Numeracy (age 4.5)	**−.15**	**−.15**	
Letter fluency (age 4.5)	−.09	**−.13**	
Educational ability factor score	**−.17**	**−.21**	
Social functioning			
Peer problems (age 4.5)	**.19**	**.21**	
Prosocial behavior (age 4.5)	−.04	−.04	
Peer problems (age 8)	**.18**	**.17**	**.18**
Prosocial behavior (age 8)	−.04	−.06	−.05

Note. Correlations above $r = .1$ are considered to be significant and are in bold (all $p < .01$).

Longitudinal Associations of Screen Exposure With Developmental Outcomes at Ages 4.5 and 8 Years

To examine associations between the extent of children's exposure to screen time during early childhood and their later outcomes, the sample was classified into four groups/quartiles (approximately equal groups) at age 2 and 4.5 years based on their total screen exposure. Groups ranged from the quarter of children with the lowest levels of screen time to the quartile of children with the highest levels of screen time. Table 5 describes the mean levels of developmental outcomes based on earlier screen time for each screen exposure quartile. Developmental outcomes at age 4.5 were examined in relation to the extent of screen time at age 2, and outcomes at age 8 were examined in relation to the extent of earlier screen time at age 4.5 years. One-way analyses of variance were used to examine associations between the extent of screen time and child outcome scores. For ease of interpretation, all developmental outcomes were standardized to a mean of 0, *SD* of 1 prior to analysis.

The results in Table 5 indicate that with increasing levels of screen time there were corresponding decreases in children's later language and literacy outcomes and increases in the extent of peer problems. While screen exposure at age 2 was only associated with later peer problems and not prosocial behavior at age 4.5 years, by age 8, higher levels of screen time at age 4.5 years were associated with both higher levels of peer relationship problems and lower levels of prosocial behavior.

Adjustment for Confounding Factors

Table 6 shows the associations between total screen exposure and later developmental outcomes after adjustment for a range of child and family factors correlated with children's screen time. Univariate analyses of covariance were run for each outcome including (a) the extent of screen exposure at the previous age assessment and (b) the range of child and family and social background characteristics shown in Table 3. The results of this analysis are provided in Table 6. Also shown are the covariate factors found to be significant in each model.

Results show that even after adjustment for confounding factors, the extent of children's prior screen exposure remained a significant

Table 5
Means and Standard Deviations for Developmental Outcomes by Earlier Screen Exposure Quartiles

	Screen exposure at age 2					
Outcome variable	Lowest use (bottom 25%) n = 1,642	Moderate–low use (25th–50th percentile) n = 1,869	Moderate–high use (50th–75th percentile) n = 1,199	Highest use (top 25%) n = 1,556	F	p
Language (age 4.5)	0.24 (0.95)	0.12 (0.98)	−0.08 (0.95)	−0.34 (1.02)	108.18	<.001
Educational ability (age 4.5)	0.18 (0.97)	0.09 (0.96)	−0.04 (1.02)	−0.26 (1.01)	57.90	<.001
Peer problems (age 4.5)	−0.16 (0.96)	−0.13 (0.95)	0.05 (0.99)	0.31 (1.04)	71.87	<.001
Prosocial behavior (age 4.5)	0.03 (1.00)	0.02 (1.00)	−0.01 (1.00)	−0.05 (0.99)	1.71	.16
	Screen exposure at age 4.5					
Outcome variable	Lowest use (bottom 25%) n = 1,845	Moderate–low use (25th–50th percentile) n = 1,443	Moderate–high use (50th–75th percentile) n = 1,534	Highest use (top 25%) n = 1,288	F	p
Peer problems (age 8)	−0.13 (0.98)	−0.16 (0.92)	0.05 (0.98)	0.30 (1.05)	64.73	<.001
Prosocial behavior (age 8)	0.04 (1.01)	0.07 (0.99)	−0.03 (0.99)	−0.10 (1.01)	8.31	<.001

predictor of subsequent developmental outcomes. The one exception was prosocial behavior (recall our more stringent criteria of $p < .001$ for identifying significant effects). These results suggest that associations between screen exposure and later developmental outcomes could not be fully explained by the confounding variables considered in this analysis.

Results were cross checked by rerunning all analyses with the nonimputed data set, and we found that the overall pattern of results was retained when using the nonimputed data set.

Repeated Measures Analysis of Peer Problems

To examine the extent to which changes in screen exposure with child age were associated with changes in outcome, a fixed effects panel regression model was fitted in a repeated measures framework to predict peer problems at both 4.5 and 8 as a function of age and total screen exposure quartiles. Results indicated a significant effect of time, whereby peer problems decreased from age 4.5 to age 8, $B = -0.25$ ($SE = 0.03$), $p < .001$. However, there was also a significant effect of total screen exposure, $B = 0.18$ ($SE = 0.01$), $p < .001$, with higher levels of screen exposure predicting increases in peer problems over time.

The key advantage of this fixed effects regression model is that it takes into account all sources of confounding from fixed factors, including the effects of the confounders in the regression models above plus other nonobserved fixed factors. Thus, it provides a more rigorous assessment of confounding and directionality than the simple regression models above.

Table 6
Mean Developmental Outcomes by Earlier Screen Exposure Quartiles After Adjustment for Confounders

	Screen exposure at age 2						
Outcome variable	Lowest use (bottom 25%) n = 1,642	Moderate–low use (25th–50th percentile) n = 1,869	Moderate–high use (50th–75th percentile) n = 1,199	Highest use (top 25%) n = 1,556	F	p	Significant covariate[a]
Language (age 4.5)	0.20 (0.39)	0.12 (0.40)	−0.05 (0.42)	−0.23 (0.41)	9.78	<.001	All
Educational ability (age 4.5)	0.14 (0.32)	0.09 (0.32)	−0.03 (0.34)	−0.16 (0.35)	6.18	<.001	1,2,3,4,5,7,8,9
Peer problems (age 4.5)	−0.15 (0.34)	−0.08 (0.35)	0.06 (0.38)	0.23 (0.37)	5.44	<.001	All
Prosocial behavior (age 4.5)	0.01 (0.18)	0.006 (0.18)	0.009 (0.18)	−0.003 (0.18)	1.33	.32	1,6,8,9
	Screen exposure at age 4.5						
Outcome variable	Lowest use (bottom 25%) n = 1,845	Moderate–low use (25th–50th percentile) n = 1,443	Moderate–high use (50th–75th percentile) n = 1,534	Highest use (top 25%) n = 1,288	F	p	Significant covariate[a]
Peer problems (age 4.5)	−0.13 (0.29)	−0.08 (0.30)	0.02 (0.32)	0.19 (0.32)	10.68	<.001	1,2,3,4,6,7,8
Prosocial behavior (age 4.5)	0.03 (0.22)	0.02 (0.22)	−0.01 (0.23)	−0.05 (0.23)	3.35	.02	1,5,8

[a] 1 = child sex, 2 = European ethnicity, 3 = Māori ethnicity, 4 = Pacific Island ethnicity, 5 = Asian ethnicity, 6 = maternal age, 7 = maternal education, 8 = socioeconomic deprivation, 9 = childcare attendance.

Dose-Dependent Association Between Screen Exposure and Outcomes

The above analyses indicate that even after adjustment for confounding factors, higher levels of antecedent screen time exposure were associated with later language and educational ability, as well as peer problems.

Given these findings, we next examined the dose-dependent association of screen exposure with outcomes, with a particular focus on evaluating whether or not results were in alignment with the current national and international screen time guidelines. For this analysis, we examined direct screen exposure independently from total screen exposure, as we have interpreted the national screen guidelines as referencing direct screen exposure (making direct screen exposure therefore the most relevant screen time variable for evaluating current guidelines).

In this analysis, continuous screen exposure variables were rounded to the nearest hour, with the highest category representing 6 or more hours, given the smaller sample sizes at these higher hourly increments. Outcome measures included in this analysis were the standardized factor scores for the latent language and educational factors at age 4.5 years and the standardized peer problems scores at age 4.5 and 8 years. Table 7 provides adjusted means for hourly increments of screen exposure after controlling for confounds. Analyses were run for total screen exposure as well as for the subtype of direct screen exposure (television viewing and electronic media use). To illustrate these adjusted effects, Figure 3 shows the adjusted means for developmental outcomes based on daily screen exposure at age 2 years, and Figure 4 shows the adjusted means for peer problems at 8-years-old based on daily screen exposure at 4.5-years-old.

As seen in Figure 3, the results of this analysis indicate a convergence at approximately 1.5 hr per day of daily direct screen time at age 2. More than 1.5 hr of daily direct screen time at age 2 is associated with dropping below the mean on later scores of language and educational ability and scoring above the mean on later scores of peer problems (with increasing levels associated with more detrimental outcomes). Consistent with this interpretation, examining mean differences in Table 7 as a measure of effect size, compared to 0 hr of direct screen exposure, an effect size of 0.2 was reached or approached after 2 hr of daily direct screen exposure. Effect sizes between those exposed to 0 hr per day of direct screen time and those engaging in 6 or more hours were moderate in size (0.32–0.55).

We have less evidence available for identifying a threshold of screen exposure at 4.5 years, given language and educational ability were not assessed at age 8. However, based on our analysis of peer problems at age 8, shown in Table 7 and Figure 4, when children are exposed to more than 2.5 hr of daily direct screen time at age 4.5, they score, on average, above the mean on peer problems at age 8. When examining effect sizes by hourly intervals, an effect size of 0.2 was reached at 3 hr of daily direct screen exposure (compared to 0 hr), and by 6 or more hours of daily direct screen time at age 4.5, the effect was moderate size (0.47).

Discussion

With the growing availability and use of devices such as smartphones and tablets, it is important to understand the associations between children's digital screen use and their development. In this study, we used data collected as part of the *GUINZ* study to assess relations between the extent of children's daily exposure to screen time during early childhood (2–4.5 years) and their language, early educational skills, and social functioning at ages 4.5 and 8. Study strengths included the large sample size and the availability of prospectively collected longitudinal measures of both screen time exposure and a range of developmentally important child outcomes over an 8-year period. Key study findings are discussed below.

Language and Educational Outcomes

Consistent with previous research, our results show a negative association between higher levels of screen use and children's language abilities. However, they also extend on other studies by demonstrating longer term associations with language, with screen exposure measured at 2 years of age predicting language abilities at age 4.5, and by extending these findings to early educational skills.

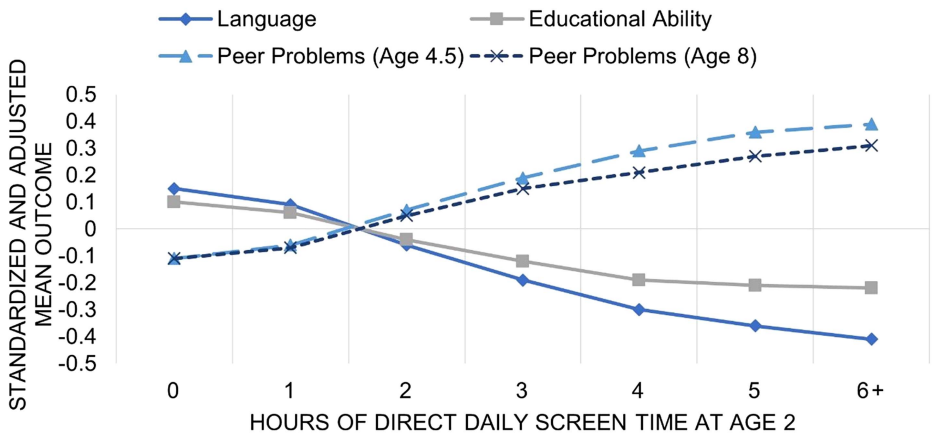
Table 7
Covariate Adjusted Means on Developmental Outcomes for Hourly Increments of Screen Exposure

Screen use type and age	Hours of daily screen exposure						
	0	1	2	3	4	5	6+
Outcome: language, *M* (*SD*)							
Age 2 direct	0.15 (0.40)	0.09 (0.40)	−0.06 (0.44)	−0.19 (0.40)	−0.30 (0.41)	−0.36 (0.37)	−0.41 (0.37)
Age 2 total	0.19 (0.40)	0.20 (0.38)	0.13 (0.40)	0.10 (0.39)	−0.03 (0.41)	−0.09 (0.43)	−0.24 (0.41)
Outcome: educational ability, *M* (*SD*)							
Age 2 direct	0.10 (0.33)	0.06 (0.34)	−0.04 (0.35)	−0.12 (0.34)	−0.19 (0.33)	−0.21 (0.37)	−0.22 (0.39)
Age 2 total	0.13 (0.32)	0.14 (0.32)	0.10 (0.32)	0.07 (0.32)	−0.02 (0.33)	−0.07 (0.34)	−0.16 (0.34)
Outcome: peer problems age 4.5, *M* (*SD*)							
Age 2 direct	−0.11 (0.35)	−0.06 (0.36)	0.07 (0.39)	0.19 (0.36)	0.29 (0.37)	0.36 (0.34)	0.39 (0.33)
Age 2 total	−0.14 (0.35)	−0.16 (0.33)	−0.09 (0.36)	−0.06 (0.35)	0.04 (0.38)	0.11 (0.36)	0.24 (0.39)
Outcome: peer problems age 8, *M* (*SD*)							
Age 2 direct	−0.11 (0.31)	−0.07 (0.30)	0.05 (0.34)	0.15 (0.31)	0.21 (0.31)	0.27 (0.30)	0.31 (0.30)
Age 2 total	−0.14 (0.30)	−0.16 (0.27)	−0.09 (0.30)	−0.06 (0.30)	0.02 (0.32)	0.08 (0.32)	0.18 (0.31)
Age 4.5 direct	−0.14 (0.30)	−0.12 (0.29)	−0.03 (0.31)	0.04 (0.33)	0.21 (0.31)	0.24 (0.30)	0.33 (0.31)
Age 4.5 total	−0.14 (0.30)	−0.17 (0.28)	−0.11 (0.29)	−0.06 (0.30)	−0.01 (0.32)	0.01 (0.32)	0.16 (0.33)

Note. "Direct" refers to direct screen exposure (television viewing and electronic media use). "Total" refers to total screen exposure (direct screen exposure and background television). Outcome variables have been standardized to a mean of 0, *SD* of 1.

Figure 3

Daily Direct Screen Time at 2-Years-Old in Relation to Later Developmental Outcomes



Note. See the online article for the color version of this figure.

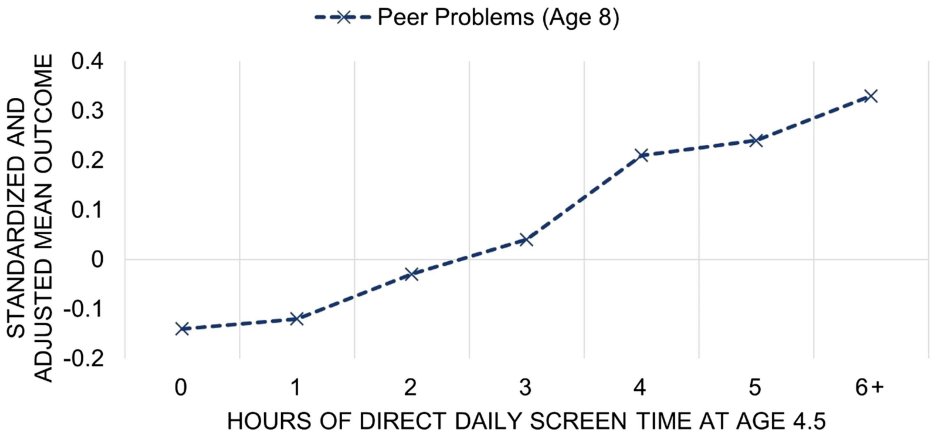
Our results indicate that heightened screen time in early childhood predicts lower scores on later language (vocabulary and communication) and educational skills (writing, numeracy, and letter fluency), even after controlling for confounding factors. The assessments of language and educational ability at the 4.5-year assessment were obtained prior to children starting formal schooling (which commences on or shortly after children's 5th birthday in New Zealand) and thus represented an indication of children's academic school readiness, in terms of their ability to write, count, and communicate prior to enrolment in elementary or primary school. Our results indicate that, consistent with Ribner et al. (2017), screen time during early childhood is predictive of the skills that children have on arrival to school, and the dramatic rise in screen use over recent years may partially explain why school readiness has been declining over recent years (Curriculum Associates, 2024). Understanding predictors of school readiness is important as the early skills that children have at school entry (including, e.g., letter fluency and language skills) set children up for success at school and are a strong predictor of later achievement and academic success (Brinkman et al., 2013; Feinstein & Duckworth, 2006).

Social Outcomes

We examined two aspects of social functioning: peer problems and prosocial behavior. Our results indicate a reliable association between heightened screen exposure and increased peer problems, but less so with prosocial behavior especially at younger ages. Previous research examining associations between screen time and children's social development is conflicting, with positive, negative, and null associations reported across studies (e.g., Conners-Burrow et al., 2011; Downey & Gibbs, 2020; Hinkley et al., 2018). Results from this study suggest that high levels of screen time may have an adverse effect on children's relationship with their peers, contributing to the development of peer problems. Our repeated measures analysis lends additional weight to this finding by showing that changes in peer problems

Figure 4

Direct Daily Screen Time at 4.5-Years-Old in Relation to Peer Problems at Age 8



Note. See the online article for the color version of this figure.

between ages 4.5 and 8 could be partially explained by changes in screen exposure over the same period. Spending a significant amount of time using digital media or watching television may lead to difficulties in forming positive peer relationships, whether due to underdeveloped social skills or fewer opportunities to develop friendships and connections with peers.

Given the inconsistent results between aspects of social functioning in this study, as well as the conflicting results of previous research in this area, it is clear that further research is needed to understand how screen media use influences children's social functioning. It may be that different types of screen media (e.g., video games vs. television viewing vs. social media) differentially relate to the development of social skills (Sanders et al., 2019), and these unique associations are obscured through examination of both screen usage and social functioning at a broad level. It will also be important for future research to include more detailed measures of peer functioning and friendships.

Child and Family Factors Associated With Screen Use

A strength of our research was the inclusion of child and family social background confounding factors in an attempt to elucidate the unique effect of screen exposure on child developmental outcomes above and beyond other contributing factors. Study results confirm previous international research linking excessive screen time exposure with higher socioeconomic deprivation (Gorely et al., 2004; Tandon et al., 2012) and lower maternal education (Cárdenas-Fuentes et al., 2021; Pons et al., 2020) and are also consistent with previous research indicating higher levels of screen exposure among Māori, Pacific Island, and Asian children in New Zealand (Stewart et al., 2019). Previous research is inconsistent regarding the association between maternal age and child screen time (Duch et al., 2013); however, the present findings indicate that children with older mothers had lower levels of screen exposure.

Further, our results suggest that social background characteristics were jointly the strongest predictors of later language, educational ability, and social functioning, explaining much of the association between screen exposure and outcomes. However, even after controlling for these factors, screen time remained an independent predictor of later child outcomes. These results add to the growing consensus that once accounting for other explanatory factors, including sociodemographic risk factors, the association between screen time and later outcomes is relatively modest (Kaye et al., 2020). This overall picture highlights the complexity of child development, with screen time representing only one of many potentially influencing factors. Madigan et al. (2020), however, emphasized that small effect sizes can have large public health implications, particularly when exposure (such as exposure to screen media) is pervasive and relatively easy to modify.

Screen Time Guidelines

Analyses examining dose-dependent association between screen exposure and child outcomes indicated that positive developmental outcomes dropped below the mean at 1.5 hr per day of direct screen time (encompassing television viewing and electronic media use) at age 2 and 2.5 hr per day of direct screen time at age 4.5. However, the results indicated a linear relationship, whereby the less screen exposure children had, the higher they scored on language and educational ability, and the lower they scored on peer problems. Effects were most apparent for children who spent the most time on screens (e.g., 4 or more hours per day of direct screen time). These findings are particularly strong given they include adjustment for confounding factors and thus only reflect the unique effect of screen exposure.

Limitations

Several study limitations should be noted. First, our analysis focused on screen exposure (i.e., amount of time) exclusively, without consideration of the content of that exposure or the context within which screen time occurred. Research has shown that effects may differ based on screen content (such as whether children are viewing high-quality educational content) and the context in which screen viewing occurs (such as whether parents are coviewing and verbally engaging with their child about the content; e.g., Madigan et al., 2020). Thus, it is important whenever possible to take a more nuanced view of screen time than simply the time that children are exposed to screen media. Unfortunately, the *GUINZ* study, given the timing of data collection and the changing range of devices available to children, made it difficult to obtain detailed information about qualitative aspects of children's screen time. Further, as daily screen time is correlated with the type of content children watch and the likelihood of coviewing (Barr et al., 2010; Jago et al., 2012, 2013), it is possible that both quantity and quality of screen exposure contributed to the associations found in the present research.

Many of the measures used in this research were reported by parents, including the screen exposure variables. The use of parent reports could introduce social desirability bias if parents are uncomfortable admitting the extent of their child's screen exposure. The assessment of communication skills at age 4.5 was also not ideal, given the low reliability of this measure. Finally, it is also important to note that there may be other confounding factors that were not included in this analysis, such as family structure and parental employment status, that may also help explain associations between child screen exposure and developmental outcomes.

One of the strengths of the GUINZ data set is its longitudinal nature. However, when analyzing data on a rapidly evolving aspect of society, it is important to note that the data collected are necessarily reflective of the context at the time of assessment. The data used in analysis were collected between 2011 and 2018 and may not be reflective of the types and extent of screen media that children are exposed to today. The digital landscape worldwide and within New Zealand changed dramatically over the time of the study, necessitating modifications in study questions to ensure adequate representation of the extent of children's screen use over time and with increasing child age. Some of these changes may impact the consistency of screen use data over time. Also, as suggested by our data, the nature and extent of children's screen use, particularly electronic media use, changed over that time likely due to a mix of child developmental and social contextual factors.

Finally, while retention rates were high across earlier study waves, there was a drop in the retention rate at the 8-year study wave. The characteristics of children and parents who remained in the study differed from those who did not participate in the 8-year wave, introducing sample selection bias. While we have employed statistical techniques to adjust for this missing data, there may still be impacts on our results.

Conclusions

This research was undertaken within the context of increases in children's exposure to digital media and devices such as smartphones and tablets. Although correlational in nature, our findings suggest that limiting screen time across early childhood may be beneficial for children's development, in terms of their language, early educational skills, and supporting healthy peer relationships. Even after controlling for child and family social background characteristics, there remained an independent effect of screen exposure.

Overall, the results suggest that screen time may be one of many factors influencing children's language, educational, and social development. However, given the ubiquity of screen media in children's daily lives and the fact that usage is easily modifiable, the public health impacts are likely to be significant even at modest effect sizes (e.g., Madigan et al., 2020). The findings of this research offer useful insight into the effects of increasing levels of screen exposure in early childhood on later language, educational, and social outcomes and are potentially helpful in informing parents, practitioners, and policymakers about the possible impacts of screen usage in early childhood.

References

American Academy of Pediatrics Council on Communications and Media. (2016). Media and young minds. *Pediatrics*, *138*(5), Article e20162591. https://doi.org/10.1542/peds.2016-2591

Anderson, D. R., & Hanson, K. G. (2017). Screen media and parent–child interactions. In R. Barr & D. N. Linebarger (Eds.), *Media exposure during infancy and early childhood: The effects of content and content on learning and development* (pp. 173–194). Springer International Publishing. https://doi.org/10.1007/978-3-319-45102-2_11

Anderson, S. E., Economos, C. D., & Must, A. (2008). Active play and screen time in US children aged 4 to 11 years in relation to sociodemographic and weight status characteristics: A nationally representative cross-sectional analysis. *BMC Public Health*, *8*(1), Article 366. https://doi.org/10.1186/1471-2458-8-366

Atkinson, J., Salmond, C., & Crampton, P. (2019). *NZDep2018 index of deprivation. Interim research report, December 2019*. Department of Public Health, University of Otago. https://www.otago.ac.nz/wellington/otago730394.pdf

Barr, R., Danziger, C., Hilliard, M., Andolina, C., & Ruskis, J. (2010). Amount, content and context of infant media exposure: A parental questionnaire and diary analysis. *International Journal of Early Years Education*, *18*(2), 107–122. https://doi.org/10.1080/09669760.2010.494431

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*(3), 588–606. https://doi.org/10.1037/0033-2909.88.3.588

Brinkman, S., Gregory, T., Harris, J., Hart, B., Blackmore, S., & Janus, M. (2013). Associations between the early development instrument at age 5, and reading and numeracy skills at ages 8, 10 and 12: A prospective linked data study. *Child Indicators Research*, *6*(1), 695–708. https://doi.org/10.1007/s12187-013-9189-3

Brushe, M. E., Haag, D. G., Melhuish, E. C., Reilly, S., & Gregory, T. (2024). Screen time and parent–child talk when children are aged 12 to 36 months. *JAMA Pediatrics*, *178*(4), 369–375. https://doi.org/10.1001/jamapediatrics.2023.6790

Canadian Paediatric Society. (2022). *Screen time and preschool children: Promoting health and development in a digital world*. https://cps.ca/en/documents/position/screen-time-and-preschool-children

Capparini, C., To, M. P. S., & Reid, V. M. (2023). Should I follow your virtual gaze? Infants' gaze following over video call. *Journal of Experimental Child Psychology*, *226*, Article 105554. https://doi.org/10.1016/j.jecp.2022.105554

Cárdenas-Fuentes, G., Homs, C., Ramírez-Contreras, C., Juton, C., Casas-Esteve, R., Grau, M., Aguilar-Palacio, I., Fitó, M., Gomez, S. F., & Schröder, H. (2021). Prospective association of maternal educational level with child's physical activity, screen time, and diet quality. *Nutrients*, *14*(1), Article 160. https://doi.org/10.3390/nu14010160

Christakis, D. A., Gilkerson, J., Richards, J. A., Zimmerman, F. J., Garrison, M. M., Xu, D., Gray, S., & Yapanel, U. (2009). Audible television and decreased adult words, infant vocalizations, and conversational turns: A population-based study. *Archives of Pediatrics & Adolescent Medicine*, *163*(6), 554–558. https://doi.org/10.1001/archpediatrics.2009.61

Conners-Burrow, N. A., McKelvey, L. M., & Fussell, J. J. (2011). Social outcomes associated with media viewing habits of low-income preschool children. *Early Education and Development*, *22*(2), 256–273. https://doi.org/10.1080/10409289.2011.550844

Corkin, M. T., Peterson, E. R., Henderson, A. M. E., Waldie, K. E., Reese, E., & Morton, S. M. B. (2021). Preschool screen media exposure, executive functions and symptoms of inattention/hyperactivity. *Journal of Applied Developmental Psychology*, *73*, Article 101237. https://doi.org/10.1016/j.appdev.2020.101237

Curriculum Associates. (2024). *School readiness for young children post-pandemic*. https://cdn.bfldr.com/LS6J0F7/at/p3ttt35vgq78fhvrqq8bwn2x/2170250_School_Readiness_for_Young_Students_Post-Pandemic.pdf

de Lemos, M., & Doig, B. (1999). *Who am I? Developmental assessment*. ACER.

Dickinson, D. K., McCabe, A., & Sprague, K. (2001). *Teacher rating of oral language and literacy (TROLL): A research-based tool* (Ciera Report #3-016). Centre for the Improvement of Early Reading Achievement (CIERA), University of Michigan. Retrieved December 11, 2014, from https://www.ryders-hayes.co.uk/images/LFDAy1/TROLL_full.pdf

Downey, D. B., & Gibbs, B. G. (2020). Kids these days: Are face-to-face social skills among American children declining? *American Journal of Sociology*, *125*(4), 1030–1083. https://doi.org/10.1086/707985

Duch, H., Fisher, E. M., Ensari, I., & Harrington, A. (2013). Screen time use in children under 3 years old: A systematic review of correlates. *The International Journal of Behavioral Nutrition and Physical Activity*, *10*(1), Article 102. https://doi.org/10.1186/1479-5868-10-102

Dunn, L. M., Dunn, L. M., & Williams, K. T. (1997). *Peabody picture vocabulary test–III*. American Guidance Service.

Eirich, R., McArthur, B. A., Anhorn, C., McGuinness, C., Christakis, D. A., & Madigan, S. (2022). Association of screen time with internalizing and externalizing behavior problems in children 12 years or younger: A systematic review and meta-analysis. *JAMA Psychiatry*, *79*(5), 393–405. https://doi.org/10.1001/jamapsychiatry.2022.0155

Ewin, C. A., Reupert, A. E., McLean, L. A., & Ewin, C. J. (2021). The impact of joint media engagement on parent–child interactions: A systematic review. *Human Behavior and Emerging Technologies*, *3*(2), 230–254. https://doi.org/10.1002/hbe2.203

Feinstein, L., & Duckworth, K. (2006). *Development in the early years: Its importance for school performance and adult outcomes*. Centre for Research in the Wider Benefits of Learning.

Furenes, M. I., Kucirkova, N., & Bus, A. G. (2021). A comparison of children's reading on paper versus screen: A meta-analysis. *Review of Educational Research*, *91*(4), 483–517. https://doi.org/10.3102/0034654321998074

Gath, M., McNeill, B., & Gillon, G. (2023). Preschoolers' screen time and reduced opportunities for quality interaction: Associations with language development and parent–child closeness. *Current Research in Behavioral Sciences*, *5*, Article 100140. https://doi.org/10.1016/j.crbeha.2023.100140

Gebremariam, M. K., Henjum, S., Terragni, L., & Torheim, L. E. (2020). Correlates of screen time and mediators of differences by parental education among adolescents. *BMC Pediatrics*, *20*(1), Article 279. https://doi.org/10.1186/s12887-020-02181-y

Goodman, R. (1997). The Strengths and Difficulties Questionnaire: A research note. *Journal of Child Psychology and Psychiatry*, *38*(5), 581–586. https://doi.org/10.1111/j.1469-7610.1997.tb01545.x

Goodman, R. (2001). Psychometric properties of the strengths and difficulties questionnaire. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*(11), 1337–1345. https://doi.org/10.1097/00004583-200111000-00015

Gorely, T., Marshall, S. J., & Biddle, S. J. (2004). Couch kids: Correlates of television viewing among youth. *International Journal of Behavioral Medicine*, *11*(3), 152–163. https://doi.org/10.1207/s15327558ijbm1103_4

Gueron-Sela, N., & Gordon-Hacker, A. (2020). Longitudinal links between media use and focused attention through toddlerhood: A cumulative risk approach. *Frontiers in Psychology*, *11*, Article 569222. https://doi.org/10.3389/fpsyg.2020.569222

Haidt, J. (2024). *The anxious generation: How the great rewiring of childhood is causing an epidemic of mental illness*. Random House.

Hinkley, T., Brown, H., Carson, V., & Teychenne, M. (2018). Cross sectional associations of screen time and outdoor play with social skills in preschool children. *PLOS ONE*, *13*(4), Article e0193700. https://doi.org/10.1371/journal.pone.0193700

Hipp, D., Gerhardstein, P., Zimmermann, L., Moser, A., Taylor, G., & Barr, R. (2017). The dimensional divide: Learning from TV and touchscreens during early childhood. In R. Barr & D. N. Linebarger (Eds.), *Media exposure during infancy and early childhood* (pp. 33–54). Springer. https://doi.org/10.1007/978-3-319-45102-2_3

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Huque, M. H., Carlin, J. B., Simpson, J. A., & Lee, K. J. (2018). A comparison of multiple imputation methods for missing data in longitudinal studies. *BMC Medical Research Methodology*, *18*(1), Article 168. https://doi.org/10.1186/s12874-018-0615-6

Jago, R., Edwards, M. J., Urbanski, C. R., & Sebire, S. J. (2013). General and specific approaches to media parenting: A systematic review of current measures, associations with screen-viewing, and measurement implications. *Childhood Obesity*, *9*(Suppl. 1), S51–S72. https://doi.org/10.1089/chi.2013.0031

Jago, R., Stamatakis, E., Gama, A., Carvalhal, I. M., Nogueira, H., Rosado, V., & Padez, C. (2012). Parent and child screen-viewing time and home media environment. *American Journal of Preventive Medicine*, *43*(2), 150–158. https://doi.org/10.1016/j.amepre.2012.04.012

Jing, M., & Kirkorian, H. L. (2020). Video deficit in children's early learning. In J. Van den Bulck, D. R. Ewoldsen, M. L. Mares, & E. Sharrer (Eds.), *The international encyclopedia of media psychology* (pp. 1–8). Wiley.

Kaye, L. K., Orben, A., Ellis, D. A., Hunter, S. C., & Houghton, S. (2020). The conceptual and methodological mayhem of "screen time." *International Journal of Environmental Research and Public Health*, *17*(10), Article 3661. https://doi.org/10.3390/ijerph17103661

Kirkorian, H. L. (2018). When and how do interactive digital media help children connect what they see on and off the screen? *Child Development Perspectives*, *12*(3), 210–214. https://doi.org/10.1111/cdep.12290

Konca, A. S. (2022). Digital technology usage of young children: Screen time and families. *Early Childhood Education Journal*, *50*(7), 1097–1108. https://doi.org/10.1007/s10643-021-01245-7

Li, C., Cheng, G., Sha, T., Cheng, W., & Yan, Y. (2020). The relationships between screen use and health indicators among infants, toddlers, and preschoolers: A meta-analysis and systematic review. *International Journal of Environmental Research and Public Health*, *17*(19), Article 7324. https://doi.org/10.3390/ijerph17197324

Madigan, S., Browne, D., Racine, N., Mori, C., & Tough, S. (2019). Association between screen time and children's performance on a developmental screening test. *JAMA Pediatrics*, *173*(3), 244–250. https://doi.org/10.1001/jamapediatrics.2018.5056

Madigan, S., McArthur, B. A., Anhorn, C., Eirich, R., & Christakis, D. A. (2020). Associations between screen use and child language skills: A systematic review and meta-analysis. *JAMA Pediatrics*, *174*(7), 665–675. https://doi.org/10.1001/jamapediatrics.2020.0327

Morton, S. M., Atatoa Carr, P. E., Grant, C. C., Robinson, E. M., Bandara, D. K., Bird, A., Ivory, V. C., Kingi, T. K., Liang, R., Marks, E. J., Perese, L. M., Peterson, E. R., Pryor, J. E., Reese, E., Schmidt, J. M., Waldie, K. E., & Wall, C. (2013). Cohort profile: Growing up in New Zealand. *International Journal of Epidemiology*, *42*(1), 65–75. https://doi.org/10.1093/ije/dyr206

Morton, S. M. B., Atatoa Carr, P. E., Bandara, D. K., Grant, C. C., Ivory, V. C., Kingi, T. R., Liang, R., Perese, L. M., Peterson, E. R., Pryor, J. E., Reese, E., Robinson, E. M., Schmidt, J., & Waldie, K. E. (2010). *Growing up in New Zealand: A longitudinal study of New Zealand children and their families. Report 1: Before we are born*. University of Auckland.

Morton, S. M. B., Ramke, J., Kinloch, J., Grant, C. C., Carr, P. A., Leeson, H., Lee, A. C., & Robinson, E. (2015). Growing up in New Zealand cohort alignment with all New Zealand births. *Australian and New Zealand Journal of Public Health*, *39*(1), 82–87. https://doi.org/10.1111/1753-6405.12220

Nagata, J. M., Ganson, K. T., Iyer, P., Chu, J., Baker, F. C., Pettee Gabriel, K., Garber, A. K., Murray, S. B., & Bibbins-Domingo, K. (2022). Sociodemographic correlates of contemporary screen time use among 9- and 10-year-old children. *The Journal of Pediatrics*, *240*, 213–220.e2. https://doi.org/10.1016/j.jpeds.2021.08.077

New Zealand Ministry of Health. (2017). *Sit less, move more, sleep well: Active play guidelines for under-fives*. Ministry of Health. https://www.health.govt.nz

Pons, M., Bennasar-Veny, M., & Yañez, A. M. (2020). Maternal education level and excessive recreational screen time in children: A mediation analysis. *International Journal of Environmental Research and Public Health*, *17*(23), Article 8930. https://doi.org/10.3390/ijerph17238930

Putnick, D. L., Trinh, M. H., Sundaram, R., Bell, E. M., Ghassabian, A., Robinson, S. L., & Yeung, E. (2023). Displacement of peer play by screen time: Associations with toddler development. *Pediatric Research*, *93*(5), 1425–1431. https://doi.org/10.1038/s41390-022-02261-y

Reese, E., & Read, S. (2000). Predictive validity of the New Zealand MacArthur Communicative Development Inventory: Words and sentences. *Journal of Child Language*, *27*(2), 255–266. https://doi.org/10.1017/S0305000900004098

Ribner, A., Fitzpatrick, C., & Blair, C. (2017). Family socioeconomic status moderates associations between television viewing and school readiness skills. *Journal of Developmental and Behavioral Pediatrics*, *38*(3), 233–239. https://doi.org/10.1097/DBP.0000000000000425

Rothman, S. (2005). *Report on adapted PPVT-III and who am I? Growing up in Australia: The Longitudinal Study of Australian Children*. Australian Department of Social Services.

Sanders, T., Parker, P. D., Del Pozo-Cruz, B., Noetel, M., & Lonsdale, C. (2019). Type of screen time moderates effects on outcomes in 4013 children: Evidence from the Longitudinal Study of Australian Children. *The International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), Article 117. https://doi.org/10.1186/s12966-019-0881-7

Schaughency, E., & Suggate, S. (2008). Measuring basic early literacy skills amongst year 1 students in New Zealand. *New Zealand Journal of Educational Studies*, *43*(1), 85–106. https://search.informit.org/doi/pdf/10.3316/informit.612541278756087

Skalická, V., Wold Hygen, B., Stenseng, F., Kårstad, S. B., & Wichstrøm, L. (2019). Screen time and the development of emotion understanding from age 4 to age 8: A community study. *British Journal of Developmental Psychology*, *37*(3), 427–443. https://doi.org/10.1111/bjdp.12283

Stewart, T., Duncan, S., Walker, C., Berry, S., & Schofield, G. (2019). *Effects of screen time on preschool health and development*. Ministry of Social Development. https://msd.govt.nz

Strouse, G. A., & Samson, J. E. (2021). Learning from video: A meta-analysis of the video deficit in children ages 0 to 6 years. *Child Development*, *92*(1), e20–e38. https://doi.org/10.1111/cdev.13429

Tandon, P. S., Zhou, C., Sallis, J. F., Cain, K. L., Frank, L. D., & Saelens, B. E. (2012). Home environment relationships with children's physical activity, sedentary time, and screen time by socioeconomic status. *The International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), Article 88. https://doi.org/10.1186/1479-5868-9-88

Wilkinson, C., Low, F., & Gluckman, P. (2021). *Screen time: The effects on children's emotional, social, and cognitive development*. The Centre for Informed Futures. https://informedfutures.org/screen-time/

World Health Organization. (2019). *Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age*. https://apps.who.int/iris/handle/10665/311664

Xia, Y., & Yang, Y. (2019). RMSEA, CFI, and TLI in structural equation modeling with ordered categorical data: The story they tell depends on the estimation methods. *Behavior Research Methods*, *51*(1), 409–428. https://doi.org/10.3758/s13428-018-1055-2

Received April 9, 2024
Revision received October 17, 2024
Accepted October 18, 2024 ■