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Objectively measured infant and toddler screen time: Findings from a prospective study

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ABSTRACT

Objective: Screen time guidelines recommend no screens under two years due to the potential negative impacts on development. While current reports suggest many children exceed this, research relies on parent reports of their children's screen exposure. We objectively assess screen exposure during the first two years and how it differs by maternal education and gender.

Methods: This Australian prospective cohort study used speech recognition technology to understand young children's screen exposure over an average day. Data collection occurred every six months when children were 6, 12, 18 and, 24 months old (n = 207). The technology provided automated counts of children's exposure to electronic noise. Audio segments were then coded as screen exposure. Prevalence of screen exposure was quantified, and differences between demographics examined.

Results: At six months, children were exposed to an average of 1hr, 16 min (SD = 1hr, 36 min) of screens per day, increasing to an average of 2 h, 28 min (SD = 2 h, 4 min) by 24-months. Some children at six months were exposed to more than 3 h of screen time per day. Inequalities in exposure were evident as early as six months. Children from higher educated families were exposed to 1hr,43 min fewer screens per day, 95%CI (-2hr, 13 min, -1hr, 11 min) compared to lower educated households, with this difference remaining consistent as children age. Girls were exposed to an additional 12 min of screens 95%CI (−20 min, 44 min) per day compared to boys at six months, but this difference reduced to only 5 min by 24-months.

Conclusion: Using an objective measure of screen exposure, many families exceed screen time guidelines, the extent increasing with child's age. Furthermore, substantial differences between maternal education groups emerge as young as six months old. This highlights the need for education and supports for parents around screen use in the early years, balanced within the realities of modern life.

Recent recommendations from the World Health Organization (WHO) state that children under two years old should not be exposed to any screen time (World Health Organization, 2019), given the mounting evidence of potential negative relationships with children's physical, language and socioemotional development (Heller, 2021; Stiglic & Viner, 2019). The Australian government has followed the WHO's advice, providing guidelines stating no screen time for infants up to 24 months (Australian Government, 2017). Despite these recommendations, over the last decade, the introduction of mobile technology has seen screen-based devices (such as tablets and touch screen mobile phones) become ubiquitous in the home environment of children and families (Rideout & Robb, 2020).

A recent systematic review and meta-analysis pooled data from 95 international samples (n = 89,163 children) to demonstrate only 24.7% (95%CI, 19.0%, 31.5%) of children aged 0–2 years were meeting the recommendations outlined by the WHO (McArthur et al., 2022).

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Interestingly, this finding was moderated by several factors, suggesting children under 2 years were more likely to meet current guidelines if: (1) the published data was collected more recently, (2) screen use was measured using questionnaires compared to interviews, and (3) when a variety of screen time activities were measured, compared to TV/movies only. The authors argue that the current literature is limited by methodological challenges, related to a lack of valid and reliable survey tools and no objective measures of screen time. The review highlights that prohibiting screen use in this age group is a challenge for many families, however, the magnitude of screen exposure in young children remains unclear.

The Common Sense Census, one of the most comprehensive reports from the US (n = 5700), has been monitoring children's media use since 2011, with their most recent data collected in 2020, just before "stay-at-home" orders were in place for the COVID-19 pandemic (Rideout & Robb, 2020). Since the first census, there has been some variability in the average amount of screen exposure for 0–2-year-olds. In 2011, parent-reports indicated children were exposed to an average of 53 min per day, this increased to 58 min in 2013, declined to 42 min in 2017, and then increased again in 2020 to 49 min. Most of the screen exposure was due to watching television or videos, but over the monitoring period, patterns of screen exposure have changed, with children sampled from more recent years watching less television and more streaming services or online videos (e.g., YouTube). One of few prospective cohort studies within this age group, began following UK children (n = 1558) from 6 months of age between 2008 and 2013 (Barber et al., 2017). Their estimates suggested average screen exposure per day was 55 min (95%CI 53.4 min, 57 min) at 6 months, 56 min (95% CI 54.6 min, 58.2 min) at 12 months, increasing to 1hr, 17 min (95%CI 1hr, 15 min, 1hr, 18 min) at 18 months, and 1hr, 43 min (95%CI 1hr, 40 min, 1hr, 45 min) at 24 months. This evidence, however, was focused solely on television viewing, therefore updated longitudinal data is required to understand young children's screen use, including mobile technology.

Understanding the magnitude of the current issue is crucial in highlighting to governments and policy makers that support is needed to address the growing problem of screen exposure in very young children. Furthermore, identifying key demographic factors that predispose a child or family to engage in excessive screen time is a critical step to help tailor and target these supports. A systematic review has described numerous correlates of screen time among 0–3 year olds at the individual, family and sociocultural level (Duch et al., 2013). This included factors like older child age, minority ethnic status, maternal depression, and cognitive stimulation of the home environment. Interestingly, associations with variables related to socioeconomic status (e.g., family income and maternal education) revealed inconsistent findings and child gender was not associated with screen time. These findings are in contradiction to reports from the 2020 Common Sense Census that highlighted differences in screen exposure between both socioeconomic groups and child gender, with evidence that socioeconomic inequalities were growing substantially over time. Specifically, children aged 0–8 years from lower-educated households saw an increase in average screen use from 2 h, 39 min to 3 h, 12 min from 2011 to 2020. Comparatively, screen use for children of similar age from higher-educated households remained consistent, at an average of roughly 1hr, 30 min over the same period. Gender differences were also identified within the 2020 data for the 0–8 age range, with boys using screens for an average of 2 h, 40 min compared to only 2 h, 5 min for girls. Contradictory findings may be due to differences in the period of data collection, for instance the systematic review only included studies published up until 2013 (Duch et al., 2013). It could also be due to the Common Sense Census only reporting socioeconomic and gender differences across a wider 0–8 years age range (Rideout & Robb, 2020). Given we know screen use increases with age, these findings may not be evident among infants and toddlers. Collectively, it remains unclear if these demographic differences exist for very young children and if so, how early do these inequalities in screen exposure emerge.

As mentioned earlier, the current body of research aiming to quantify the magnitude of children's screen exposure relies on subjective parent-reported estimates. This assumes that parents are consistently monitoring their child's screen time; however, when parents of 0–2 year old's were asked to report the time they spend co-viewing screens with their child, 24% of parents said only 'some of the time' and 13% stated 'hardly ever/never', with these percentages increasing for older age groups (Rideout & Robb, 2020). Qualitative research has also highlighted parents' feelings of guilt around their child's screen use and judgement towards other families' behaviour (Blum-Ross & Livingstone, 2018). This sentiment may lead parents to provide socially desirable responses to their child's screen time for fear of being judged as a 'bad parent'. A recent systematic review of screen time measurement among children aged 0–6 years argued for improved measurement of children's screen time (Byrne et al., 2021). The rapid evolution of technology requires innovative tools to move the literature from focusing on TV or gaming console use only, to including newer screen-based devices like tablets and mobile phones.

The Electronic Use in Little Ones (EUiLO) study provides an objective, contemporary, and longitudinal understanding of the screen habits of infants and toddlers in Australian homes. Leveraging data from an existing prospective study, Language in Little Ones (LiLO), which began in 2017, it uses advanced speech recognition technology to capture the audio in a child's home environment over a 16-h day. Through automatic quantification of the audio, the technology flags when children are exposed to TV or Electronic Noise. Researchers then listen to these audio segments to determine whether the child is being exposed to a screen or other electronic noise (e.g., music from the radio). Participant consent to analyse the segments of electronic noise audio was provided by parents retrospectively after data collection had been completed. Therefore, parents were unaware during the audio recordings that screen time would be a focus of study, providing a unique insight into parents' natural screen habits with their children. Informed by descriptive epidemiology frameworks (Fox et al., 2022), the present study aims to:

1. Quantify the amount of time Australian children were exposed to screens in their home environment at 6, 12, 18, and 24 months old.
2. Determine whether disparities between two key demographic factors (maternal education and child gender) exist in relation to screen exposure and whether any differences change over the first two years of life.

1. Methods

1.1. Study design

EUiLO is a prospective study that follows children from 6 months old, once every six months until they begin school. Families participating in EUiLO were initially recruited into the LiLO study (Brushe et al., 2020; Brushe et al., 2021) that was focused on understanding inequalities in the early home language environment. LiLO utilised advanced speech recognition technology called Language Environment Analysis (LENA), which quantifies the amount of talk occurring in the home and the amount of electronic noise the child was exposed to. The design of the LiLO study included purposive stratification by two levels of maternal education (only completed secondary school education or less and completed a bachelor's degree or higher) to maximize, and adequately power contrasts across socioeconomic groups. Families were compensated with a $10 supermarket voucher after completing each wave of data collection. Following community and stakeholder interest, the EUiLO study was established to explore the electronic noise data that had already been collected during the first three years of LiLO. Ethics approval was granted by the University of Western Australia Human Research Ethics Committee, and all participants provided written

informed consent.

1.2. Participants

Recruitment methods for the LiLO study have been previously reported (Brushe et al., 2020; Brushe et al., 2021). Briefly, families were recruited antenatally and postnatally across South Australia, Western Australia, and Queensland. Children born between January 1, 2017, and December 31, 2017, were eligible provided: (1) English was predominantly spoken in the family home due to the validity of the LENA technology, (2) the child was born full-term (37+ weeks), (3) did not belong to a multiple birth, and (4) did not have any diagnosed causes of language impairment. Families were also categorised into either the high education group (mothers with a bachelor's degree or above) or the low education group (secondary/high school-only education). If the mother's highest level of education did not fall into one of those two groups, they were also excluded from the study.

Families still participating in the LiLO study in 2020 (n = 277) were invited to participate in the EUiLO study during their regular home visit by the researcher (see Supplementary Materials for a flow chart of recruitment). 222 families (80.14%) consented to participate in EUiLO, including 88 families from the low educated group and 134 families from the high educated group. Participants were able to withdraw at any time however, as there was no additional burden placed on families, researchers were simply retrospectively coding already collected data, no participants withdrew from the EUiLO study.

1.3. Measures

Electronic noise was captured via the LENA technology, which included a specially designed age-appropriate vest or t-shirt worn by the child that held a digital language processor (DLP) in the front pocket and accompanying LENA software (Gilkerson & Richards, 2009). The child wore the clothing and DLP for one day every six months. Parents were instructed to choose an 'average home day' where the child was not sick, attending day care or loud public events. After the recording day, researchers would collect the DLP from the family, and through algorithmic analysis of the speech signal, the LENA software analysed the audio recording and reported the number of adult words, child vocalisations, conversational turns and the amount of time children were exposed to TV or electronic noise over a 16-hr recording day. Previous research has demonstrated good reliability of the LENA technology, with high consistency between scores computed by LENA and those generated by human transcribers (Xu et al., 2009). However, the level of agreement is reportedly lower for the electronic noise data (71%) compared to the counts of adult words (82%). Along with providing automated counts, LENA allows audio recordings to be exported in 5-min segments.

1.4. Procedure

Families completed one LENA recording day every 6 months as part of the LiLO study (see Supplementary Appendix for further details). Participants did not complete additional data collection for EUiLO. Researchers exported all audio where the LENA technology flagged 'electronic noise' over the 16-hr recording day. Given that LENA provides no information on the type of electronic noise the child is exposed to (e.g., electronic noise may have included things such as screen-based devices, car noises, music on a radio, microwave beeping etc.), researchers recoded the 5-min segments as either "Screen Media", "Music", "Noise" or "Sleeping". The categorisation was based on audio cues such as identification of common noises (e.g., microwave, car starting), media content theme songs or character voices, contextual conversations around the electronic noise (e.g., the child asks for an iPad, parent mentions child's asleep) and reports within activity diaries (e.g., parent states child is watching TV or sleeping). When multiple researchers could not identify the source of the electronic noise, it was categorised as "Unknown". Research staff were trained by a master coder and were required to achieve 90% accuracy as compared to the master coder before coding independently. The category 'Screen Media' was used as the primary measure of screen time and included any time the child was exposed to a screen, excluding when the child was asleep. To reduce potential coding bias, the coders were blinded to all information about the participants when listening to the audio segments. This method of categorisation was consistently applied across all waves of data collection.

1.5. Statistical approach

Descriptive statistics were calculated for average screen exposure at each time point and presented in violin plots. Random effects longitudinal models for screen exposure were modelled using the *xtmixed* command in Stata to understand differences across maternal education groups and gender when children were 6, 12, 18 and, 24 months. Separate models were run for maternal education and gender. In each model, the interaction between either maternal education or gender and wave of data collection was included as the fixed effect in the model and Participant ID as the random effect to identify changes over time between high and low educated groups, and male and female gender. The parameters were computed using the expectation maximisation algorithm, and the *margins* command in Stata to calculate the predicted means at each time point which were then plotted. All analyses were conducted using Stata 17 (StataCorp. Stata Statistical Software, 2021).

2. Results

Data collection for the first four waves occurred between August 1, 2017, and January 31, 2020. EUiLO audio segments were coded between June 1, 2020, and November 30, 2021. Of the families who had consented to participate in the EUiLO study, data were available for 177 families at the 6-month data collection, 189 at 12 months, 198 at 18 months and 207 at 24 months. Due to recruitment difficulties within the LiLO study, as described previously (Brushe et al., 2020; Brushe et al., 2021), timelines for recruitment were extended, and families could join the study even if they had missed earlier waves of data collection. This reflects the increases in the sample size as the study progressed (an additional 32 families between the 6- and 24-month collection), with additional recruitment efforts focusing on families from low-educated backgrounds. Missing data were therefore due to either families joining the study at subsequent waves or being unable to complete the home visit due to personal reasons, which included six families at 6 months, one family at 12 months, five families at 18 months and three families at 24 months.

Table 1 describes sample characteristics across each wave. At the final wave of data collection, the analysis sample consisted of 207 families; 64.25% were categorised as high educated, and 53.62% were of female gender. The average age of the mother at childbirth was 31.51 years; roughly half the sample was first born, and 87.44% of mothers were employed before their pregnancy. Due to the focused recruitment effort of low educated families after wave one, the sample proportion of low to high educated mothers changed over time. All other demographic characteristics remained relatively consistent across waves within the sample. Table 1 also reports the average amount of screen exposure at each wave and the percentage of children meeting current screen time recommendations of no screens under 24 months old. At six months old, children were exposed to an average of 76.05 (SD = 95.96) minutes (1hr, 16 min) of screen time, with only 11.3% of children meeting recommendations. By 24 months, average screen exposure had increased to 148.31 (SD = 124.43) minutes (2hr, 28 min), with only 2.4% meeting the recommended screen time for this age group. Fig. 1 shows the distribution of screen exposure across ages. The violin plots demonstrate most of the sample were exposed to less than 100 min (1hr, 40 min) of

Table 1
Sociodemographic characteristics of the sample.

	6 month Data Collection (N = 177)	12 month Data Collection (N = 189)	18 month Data Collection (N = 198)	24 month Data Collection (N = 207)
Child				
Age, mo, mean (SD)	5.78 (0.58)	11.94 (0.49)	17.97 (0.47)	24.13 (0.58)
Girls, n (%)	96 (54.24)	103 (54.50)	108 (54.55)	111 (53.62)
Gestation, wk, mean (SD)	39.23 (1.59)	39.22 (1.57)	39.24 (1.56)	39.23 (1.53)
Firstborn, n (%)	95 (53.67)	96 (50.79)	101 (51.01)	104 (50.49)
Screen exposure in minutes, mean (SD)	76.05 (95.96)	88.41 (107.04)	117.64 (110.78)	148.31 (124.43)
Meeting screen time guidelines, n (%)	20 (11.30)	23 (12.17)	13 (6.57)	5 (2.42)
Mother				
Highest level of completed education, University, n (%)	131 (74.01)	133 (70.37)	132 (66.67)	133 (64.25)
Age at childbirth, y, mean (SD)	31.25 (4.30)	31.33 (4.44)	31.50 (4.57)	31.51 (4.69)
Working up until pregnancy, yes, n (%)	156 (88.14)	166 (87.83)	174 (87.88)	181 (87.44)

Note. Children were deemed meeting screen time guidelines if they did not receive any screen exposure on their recording day.

screen time per day across each age group. A small number of children as young as six months old however, were exposed to more than 200 min (3 h, 20 min) of screen time. The distribution widened as age increased, with a larger number of children being exposed to over 200 min on average. Concerningly, there were children who were exposed to more than 400 min (6 h, 40 min) at all four age groups.

Table 2 shows the results from the random effects models, including the interaction between mother's education and wave of data collection, and gender and wave of data collection on children's screen exposure. The coefficient demonstrates the changes in screen exposure for each group, at each time point in comparison to a specified reference category. In Model 1, both the low- and high-educated groups are compared to the 6-month baseline for the low-educated group. In Model 2, boys and girls at each wave are compared to the 6-month baseline for boys. These estimates were used to plot the predicted means across each time point to determine differences between groups and highlight any changes over time. For mothers' education, results demonstrate large differences in the amount of screen exposure between lower and higher educated groups. At six months old, children from higher educated families were exposed to 102.70 fewer minutes (1hr, 42 min) per day, 95%CI (−133.89, −71.50) compared to lower educated households. While the amount of screen exposure increased for both groups with child age, by 24 months old, children from higher educated backgrounds were still exposed to 44.59 fewer minutes per day, 95%CI (−75.75,

Table 2
Random effects model estimates for screen exposure (minutes) by maternal education and child gender.

	Coef.	*p-value*	95% CI	
Model 1: Maternal Education x Wave of Data Collection				
Amount of screen exposure at 6 months *among low educated = 151.02 min (ref)*				
Low Educated at 12 months	23.04	0.092	−3.78,	49.87
Low Educated at 18 months	40.58	0.002	14.27,	66.88
Low Educated at 24 months	73.40	0.000	47.36,	99.43
High Educated at 6 months	−102.70	0.000	−133.89,	−71.50
High Educated at 12 months	−99.25	0.000	−130.40,	−68.09
High Educated at 18 months	−70.98	0.000	−102.16,	−39.81
High Educated at 24 months	−44.59	0.005	−75.75,	−13.44
Model 2: Child Gender x Wave of Data Collection				
Amount of screen exposure at 6 months *among boys = 77.08 min (ref)*				
Boys at 12 months	9.30	0.378	−11.38,	30.00
Boys at 18 months	38.76	0.000	18.08,	59.44
Boys at 24 months	68.97	0.000	48.56,	89.38
Girls at 6 months	12.18	0.455	−19.81	44.17
Girls at 12 months	21.76	0.179	−9.97,	53.49
Girls at 18 months	44.80	0.005	13.24,	76.36
Girls at 24 months	73.99	0.000	42.56,	105.42

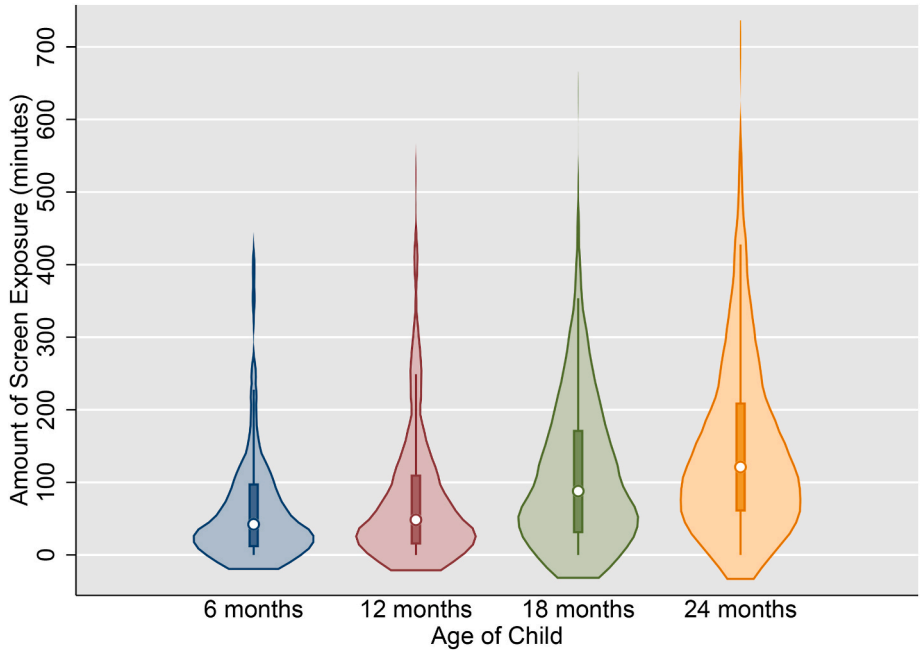

Fig. 1. Violin plots of the distribution of screen exposure in minutes at 6-, 12-, 18- and 24-month wave of data collection within a 16 h recording period.

−13.44) compared to what the children from lower educated backgrounds were exposed to at six months. Conversely, by 24 months, children from lower educated backgrounds had increased their screen exposure by 73 min (1hr, 13 min), 95% CI (47.36, 99.43), compared to their screen exposure at six months. This reflected an average difference of 48.32 min between groups at 6 months, increasing to 117.99 min (1hr, 57 min) at 24 months, with children from lower educated backgrounds being exposed to more screen time (See Fig. 2).

The results for the child's gender show smaller differences between boys and girls. At six months old, girls were exposed to an additional 12.18 min of screen time, 95%CI (−19.80, 44.17) on average, compared to boys of the same age. While girls were continually exposed to slightly more screens at 12, 18 and 24 months, the gap between genders reduced as the children aged and were exposed to more screens, with a difference of only 5 min in screen exposure by the time they were 24 months (see Fig. 3).

3. Discussion

The study investigated the screen exposure of Australian infants and toddlers aged 6–24 months on an average day, using objectively collected prospective data. The findings add contemporary and objective evidence that the majority of young Australian children exceed current government and WHO recommendations of no screen time under the age of two (Australian Government, 2017; World Health Organization, 2019). Within the current sample, children as young as six months old were exposed to almost an hour and a half of screens per day, and only 11% of families met the current guidelines. By the time children were 24 months, screen exposure had increased to over two and a half hours on average, and only 2% of children were exposed to no screens. The results also indicate substantial variability across families, with infants at the most extreme end being exposed to screens in excess of 6 h in all four age groups. Recent parent-reported data from the US suggested children aged 0–2 years were exposed to an average of 49 min per day (Rideout & Robb, 2020). The objective estimates exceed this, even for the youngest children.

Previous reports have also highlighted differences between socioeconomic groups in terms of maternal education on young children's screen exposure (Rideout & Robb, 2020). Before the current findings, what was unclear was how early these inequalities emerged. Our estimates suggest that even as young as six months old, children from lower educated families were exposed to an additional 1.71 h of screens per day. This gap between education groups remained relatively stable from 6 to 24 months. While the uneven sample size across the education groups may be a limitation of the study, these early differences in maternal education are evident and highlight the need for clearer information and supports around managing screen time, particularly for families with lower education levels. In support of this claim, previous qualitative investigations aiming to understand parents interpretations of the Australian government's screen time guidelines for children younger than 2 years, demonstrated disparities in the awareness of guidelines and large diversity in the understanding of them (Brown & Smolenaers, 2018). Clearer guidance is needed for parents to understand the potential harms associated with excessive screen time early in life.

The current findings also suggest small gender differences in this very young age group, with girls aged six months exposed to an additional 12 min of screens, on average, compared to boys. This is contrary to previous reports of boys being exposed to 35 additional minutes of screen time compared to girls (Rideout & Robb, 2020). These previous estimates, however, were inclusive of a broader age range (i.e., 0–8 years). One explanation for the findings might be that larger gender differences emerge later in childhood when boys increase screen time. Future research will need to continue monitoring screen use by gender groups as children grow, to determine when and if differences emerge. Given that both genders, on average, are exceeding current recommendations, it is also necessary to determine whether small differences of 10 min of screen time for very young children warrant gender-specific targeted strategies.

Screens are now a ubiquitous part of everyday life, and it is crucial that researchers and policymakers collaborate with parents to better manage screen time during the early years. Having quantified exposure to screens at early ages, future research will need to examine both the potentially positive and negative effects of exposure. Examining the quality of screen time will also be a necessary future direction of research, to better understand whether children under 2 years can benefit from certain types of educational content. The body of literature on potential positive and negative impacts of screen time could also be refined in future studies by employing causal inference methodology,

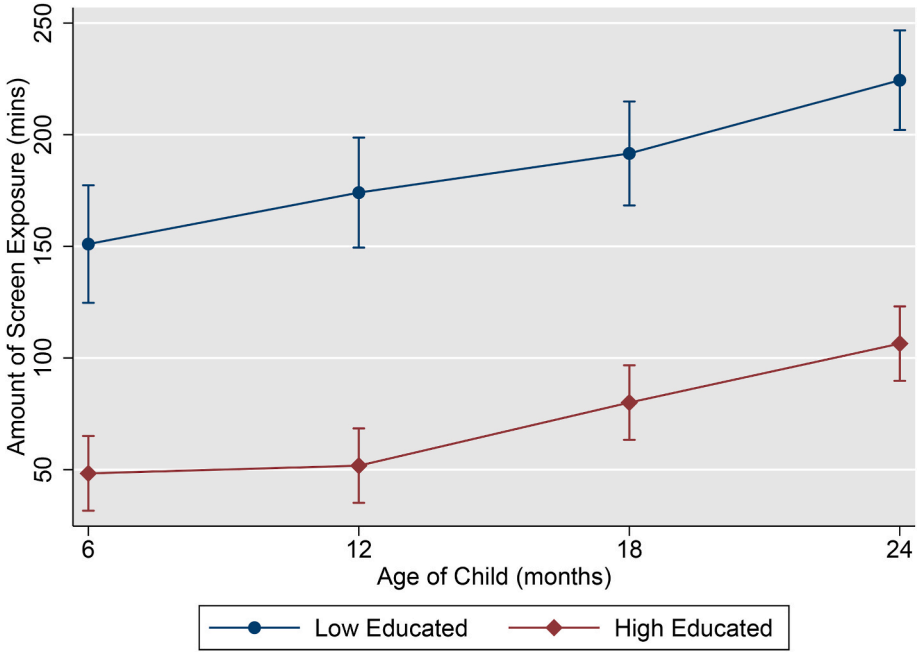

Fig. 2. Predicted mean screen exposure and 95% CI by maternal education across 6-, 12-, 18- and 24-month wave of data collection.

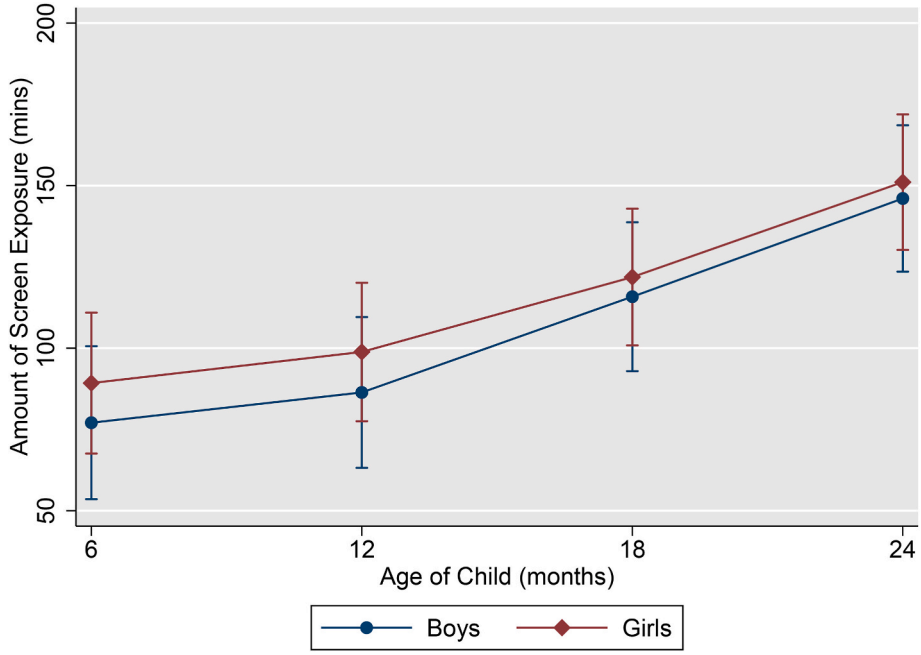

Fig. 3. Predicted mean screen exposure and 95% CI by child gender across 6-, 12-, 18- and 24-month wave of data collection.

which is becoming popular in epidemiological observational studies (Hernan et al., 2019) to better understand the causal impact of screen time during the early years on later development. Establishing a more robust evidence base on both the benefits and disadvantages of screen exposure may allow early childhood professionals to provide education to new parents on 'healthy screen behaviours' rather than a blanket zero-screen time approach (Blum-Ross & Livingstone, 2018; Heller, 2021). Finally, the study was purposely limited to children of English-speaking backgrounds and families with the extremes of high and low maternal education background. Therefore, research investigating screen use in culturally and linguistically diverse backgrounds will be valuable future research.

One potential limitation of the current study is that given our classification of screen exposure is based on audio recordings extracted from the LENA software, without access to accompanying video, there is a chance that non-screen-based electronic devices may have been miscoded as screen exposure. To mitigate this, each researcher was provided extensive training, and any uncertainty was checked by another researcher. A conservative approach was also taken when coding, which, if anything, may have led to underreporting of screen exposure if the researcher could not confidently tell whether a screen-based device was present. While this is a potential limitation, it cannot explain the clear socioeconomic differences. The aim of this study was to understand the magnitude of screen exposure for very young children, therefore we did not explore the quality of screen time. Nonetheless, we acknowledge this is an important consideration within the field and will be examining important elements of quality such as type of content (e.g., educational vs entertainment), level of engagement with the screen (e.g., passive vs interactive), and type of device used within future investigations of the EUiLO data.

4. Conclusion

This is the first study to objectively quantify infant and toddler screen exposure in an era of ubiquitous mobile technology. Results emphasise that most families do not meet current screen time guidelines, with many dramatically exceeding zero hours during the first two years of life and total screen time increasing with age. Furthermore, substantial differences in screen exposure between maternal education groups began as young as six months old. This may help explain one of the potential mechanisms driving inequalities in early childhood development (Collier et al., 2020) that could be targeted through improved parent education and supports around screen use.

Ethical statement

Ethics approval was granted by the University of Western Australia's Human Research Ethics Committee (2022/ET000028; Supersedes RA/4/18825), and all participants provided written informed consent.

Author contributors' statement

Mary Brushe: Conceptualization, Methodology, Data Curation, Project Administration, Funding Acquisition, Writing – Original Draft. John Lynch: Conceptualization, Methodology, Funding Acquisition, Writing – Review & Editing. Edward Melhuish: Conceptualization, Methodology, Funding Acquisition, Writing – Review & Editing. Sheena Reilly: Conceptualization, Methodology, Funding Acquisition, Writing – Review & Editing. Murthy Mittinty: Methodology, Data Curation, Writing – Review & Editing. Sally Brinkman: Conceptualization, Methodology, Funding Acquisition, Writing – Review & Editing.

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The authors have no financial relationships relevant to this article to disclose.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101395.

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