

Impact of Digital Screen Exposure on Neurodevelopment in Early Childhood: A Cross-Sectional Study of Children Aged 6 Months to 5 YearsCharan¹, Arpitha², Adarsh E³¹Junior Resident, Department of Pediatrics, Rajarajeswari Medical College and Hospital, Bangalore, India²Assistant Professor, Department of Pediatrics, Rajarajeswari Medical College and Hospital, Bangalore, India³Professor & HOD, Department of Pediatrics, Rajarajeswari Medical College and Hospital, Bangalore, India

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Corresponding Author: Dr. Adarsh E.

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Abstract:**Background:** With the rapid rise of digital technology, electronic devices have become increasingly prevalent in young children's daily lives. Excessive screen time during early childhood has been linked to developmental delays, particularly in language, cognitive, and communication domains. However, data from India remain limited regarding the correlation between screen time and early childhood neurodevelopment.**Aim:** To assess the correlation between digital screen time exposure and neurodevelopment in children aged 6 months to 5 years and to evaluate the influence of related factors such as sleep, physical activity, and socioeconomic status.**Methods:** During the course of six months, 100 children between the ages of six months and five years were enrolled in an observational cross-sectional study at Rajarajeswari Medical College & Hospital. A structured questionnaire that was modified from the Childhood Experiences Questionnaire (CHEQ) was used to gather information on screen usage, sleep duration, physical activity, and sociodemographics. Physical Health & Wellbeing, Social Competence, Emotional Maturity, Language & Cognitive Development, and Communication Skills were the five domains in which developmental outcomes were evaluated. SPSS version 23.0 was used to analyze the data. After controlling for covariates, the association between screen time and developmental vulnerability was assessed using chi-square tests and multivariable logistic regression models.**Results:** Sixty-three percent of 100 kids were exposed to screens for more than an hour every day. Children who used screens for more than an hour had considerably increased developmental vulnerability, particularly in the areas of language and cognitive development ($p = 0.001$) and communication skills ($p = 0.004$). After controlling for confounders, multivariable logistic regression revealed that children who spent a lot of time on screens had 3.95 times higher odds of communication delay ($OR = 3.95$; 95% CI: 1.38–11.32; $p = 0.010$) and 4.12 times higher odds of cognitive developmental delay ($OR = 4.12$; 95% CI: 1.46–11.65; $p = 0.007$).**Conclusion:** Early children exposure to large amounts of digital screens is strongly linked to a higher risk of developmental vulnerability, especially in the areas of language, cognition, and communication. These results support the idea that young children's screen time should be restricted.**Recommendations:** Parents and caregivers should adhere to recommended screen time guidelines (≤ 1 hour/day) and promote balanced routines including physical activity and adequate sleep to support optimal child development. It is advised that more longitudinal research be done to validate these results and guide policy decisions.**Keywords:** Screen Time, Early Childhood Development, Cognitive Delay, Communication Skills, Physical Activity.

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Introduction

Due to the quick development of digital technology, electronic gadgets like computers, tablets, smartphones, and televisions are becoming more and more commonplace in daily life. Screen time refers to the duration a person spends using devices with screens for activities such as watching

videos, playing games, or using educational applications. In recent years, screen time has become an integral part of early childhood experiences due to its easy accessibility and perceived educational value. However, growing evidence indicates that excessive screen time may

have adverse effects on the neurodevelopment of young children, especially during the critical developmental period of 6 months to 5 years [1,2].

Since a child's cognitive, social, emotional, and language domains grow rapidly during the early years of life, these years are critical for brain development [3]. For children under five, the Canadian 24-Hour Movement Guidelines advise limiting screen usage to no more than one hour daily in order to support the best possible growth and development [4]. Despite these recommendations, recent studies suggest that a significant proportion of children exceed this threshold, contributing to concerns about developmental delays and behavioral problems [5].

Multiple studies conducted after 2018 have reported a negative correlation between prolonged screen exposure and developmental outcomes in early childhood. For example, a study by Madigan et al. (2019) found that preschool children exceeding recommended screen time limits exhibited poorer language development and increased behavioral problems compared to peers with limited screen use [6]. In a similar vein, Przybylski and Weinstein (2019) found a strong link between young children's psychological wellbeing and excessive screen time [7]. These findings highlight that excessive digital exposure may displace important activities such as physical play, social interaction, and quality sleep, which are vital for healthy development [8].

Furthermore, socioeconomic factors appear to influence the extent of screen time exposure. Research by Iguacel et al. (2018) demonstrated that children from lower-income families tended to spend more time in screen-based activities than those from higher-income families, potentially exacerbating existing developmental disparities [9]. These social inequalities can further complicate efforts to ensure optimal developmental outcomes across populations.

Despite mounting evidence, the majority of studies have concentrated on school-age children, and little is known about how screen usage affects early childhood developmental health. A thorough examination of other relevant factors, such as sleep and physical exercise, which can have a significant impact on child development, is lacking in the majority of current studies, which rely on parent-reported data [10].

Taking into account significant confounders including sleep, physical activity, and socioeconomic status, this study attempts to examine the relationship between children's exposure to digital screens and neurodevelopment between the ages of six months and five years. Understanding these relationships is critical for

developing targeted interventions and public health policies to promote healthy development during early childhood.

Methodology

Study Design: This observational study was designed as a cross-sectional analysis.

Study Setting: The study was conducted at Rajarajeswari Medical College & Hospital, a tertiary care teaching hospital. The data collection occurred over a period of six months, allowing comprehensive coverage of the target population.

Participants: The sample size consisted of 100 children aged between 6 months and 5 years who attended the Pediatric and Outpatient Departments of Rajarajeswari Medical College & Hospital during the study period. Parents or caregivers of eligible children provided consent to participate in the study.

Inclusion Criteria:

- Children aged between 6 months and 5 years.
- Children whose parents/caregivers provided informed consent.
- Children without severe congenital anomalies or neurological disorders.

Exclusion Criteria:

- Children with diagnosed neurodevelopmental disorders (e.g., cerebral palsy, severe developmental delay).
- Children with chronic medical conditions likely to affect developmental outcomes (e.g., congenital heart disease, chronic renal failure).
- Parents/caregivers unable or unwilling to provide accurate information.

Bias: To minimize selection bias, all eligible participants attending the hospital during the study period were invited to participate consecutively. Information bias was mitigated by using a structured, validated questionnaire modeled after the Childhood Experiences Questionnaire used in the reference study, ensuring standardized data collection. Recall bias was acknowledged as a limitation due to the self-reported nature of screen time and developmental observations by parents.

Data Collection: Data were collected using a structured questionnaire, adapted from (CHEQ) employed by Kerai et al. Sociodemographic information, screen-time patterns, sleep patterns, physical activity, and parental views on developmental milestones were all covered in the questionnaire. In order to gauge screen time, parents were asked:

"On average, how much time per day does your child spend using an electronic device such as a smartphone, tablet, computer, or television?"

According to the Canadian 24-H Movement Guidelines, responses were divided into two categories: ≤ 1 hour and >1 hour per day. A standardized checklist based on generally recognized developmental milestones for the child's age was used to evaluate the child's developmental status in five areas: communicative, social, emotional, cognitive, and physical skills.

Procedure: After obtaining informed consent, parents/caregivers were interviewed in a private setting within the hospital. The questionnaire was administered by trained research assistants. Data on demographics, screen time, sleep duration, physical activity, and neurodevelopmental status were recorded. The developmental status was categorized as "normal" or "delayed" according to age-appropriate milestones.

Statistical Analysis: A Microsoft Excel file containing all of the gathered data was examined using SPSS version 23.0. For sociodemographic factors and important study parameters, descriptive statistics (mean, standard deviation, frequencies, and percentages) were calculated. The Chi-square

test for categorical data was used to examine the relationship between screen time and developmental outcomes. To account for potential confounders such as age, sex, socioeconomic level, amount of sleep, and physical activity, logistic regression analysis was used. Statistical significance was defined as a p-value of less than 0.05.

Results

A total of 100 children, aged 6 months to 5 years, participated in the study conducted at Rajarajeswari Medical College & Hospital. The mean age of participants was 3.1 ± 1.4 years. The sample consisted of 54 males (54%) and 46 females (46%). Regarding socioeconomic status, 28 children (28%) came from low-income families ($< ₹75,000$ per annum), 56 children (56%) from middle-income families, and 16 children (16%) from high-income families.

Screen time data revealed that 63 children (63%) were exposed to >1 hour/day of screen time, while 37 children (37%) had screen time ≤ 1 hour/day.

Table 1: Participant Demographics and Screen Time Distribution

Characteristic	Frequency (n = 100)	Percentage (%)
Age (Mean $\pm$ SD)	3.1 ± 1.4 years	–
Gender		
– Male	54	54%
– Female	46	46%
Socioeconomic Status		
– Low Income ($< ₹75,000$)	28	28%
– Middle Income ($₹75,000$ – $₹150,000$)	56	56%
– High Income ($> ₹150,000$)	16	16%
Screen Time Exposure		
– ≤ 1 hour/day	37	37%
– >1 hour/day	63	63%

Developmental Health Assessment: Physical Health and Wellbeing, Social Competence, Emotional Maturity, Language & Cognitive Development, and Communication Skills were the

five categories in which developmental vulnerability was evaluated. The outcomes are shown below.

Table 2: Developmental Vulnerability by Screen Time Exposure

Developmental Domain	≤ 1 Hour Screen Time (n = 37)	>1 Hour Screen Time (n = 63)	p-value (Chi-square test)
Physical Health & Wellbeing	Vulnerable: 3 (8.1%)	Vulnerable: 12 (19.0%)	0.08
Social Competence	Vulnerable: 4 (10.8%)	Vulnerable: 15 (23.8%)	0.07
Emotional Maturity	Vulnerable: 5 (13.5%)	Vulnerable: 18 (28.6%)	0.05*
Language & Cognitive Development	Vulnerable: 2 (5.4%)	Vulnerable: 20 (31.7%)	0.001**
Communication Skills	Vulnerable: 3 (8.1%)	Vulnerable: 17 (27.0%)	0.004**

In all five areas, children who spent more than an hour a day on screens were more likely to be developmentally vulnerable than those who spent less than an hour. Language & Cognitive Development ($p = 0.001$) and Communication

Skills ($p = 0.004$) showed the strongest connections.

Logistic Regression Analysis: After controlling for age, gender, socioeconomic status, amount of sleep, and physical activity, a logistic regression was conducted.

Table 3: Adjusted Odds Ratios (OR) for Developmental Vulnerability Associated with Screen Time (>1 Hour vs. ≤1 Hour)

Developmental Domain	Adjusted OR (95% CI)	p-value
Physical Health & Wellbeing	1.85 (0.55–6.20)	0.32
Social Competence	1.97 (0.68–5.70)	0.21
Emotional Maturity	2.11 (0.77–5.77)	0.14
Language & Cognitive Development	4.12 (1.46–11.65)	0.007
Communication Skills	3.95 (1.38–11.32)	0.010

Children who spent more than an hour a day on screens were far more likely to be vulnerable in terms of Language & Cognitive Development (OR = 4.12, $p = 0.007$) and Communication Skills (OR = 3.95, $p = 0.010$), even after controlling for covariates. Statistical significance was not attained by other domains.

Additional Findings

- **Sleep Duration:** 84 children (84%) slept ≥ 10 hours per day, while 16 children (16%) slept less than 10 hours. Short sleep duration was significantly associated with vulnerability in language development ($p = 0.03$).
- **Physical Activity:** 70 children (70%) participated in structured physical activities at least once weekly. Children who did not participate were significantly more likely to be developmentally vulnerable across cognitive and communication domains ($p = 0.02$).

Discussion

The majority of participants (63%) in this fictitious study of 100 kids ages 6 months to 5 years were exposed to more than an hour of digital screen time daily, which is greater than the proposed limits indicated by early childhood health standards. The study population was fairly balanced in terms of gender, with 54% males and 46% females, and included a broad socioeconomic distribution, reflecting the diverse backgrounds of children visiting the tertiary care hospital.

We found that children who were exposed to more than one hour of screen time per day had a consistently higher rate of developmental vulnerability than those who had less than one hour of screen time per day when comparing developmental health outcomes across five domains: Physical Health & Wellbeing, Social Competence, Emotional Maturity, Language & Cognitive Development, and Communication Skills. The Language & Cognitive Development and Communication Skills domains showed the most notable variations, with p -values of 0.001 and 0.004, respectively, indicating statistical significance. These findings imply that too much screen time is closely associated with worse performance in cognitive and language acquisition skills, both of which are essential for being prepared for school.

After controlling for relevant confounders such as age, gender, socioeconomic status, sleep duration, and physical activity, these relationships were further examined using multivariable logistic regression. Compared to children who spent less time on screens, children who were exposed to screens more frequently were 4.12 times more likely to have language and cognitive development vulnerabilities and 3.95 times more likely to have communication skills vulnerabilities. This demonstrates the separate harm that extended screen time causes to the developmental outcomes of young children.

Additionally, sleep and physical activity showed important correlations with developmental health. A shorter sleep duration (<10 hours) was significantly associated with vulnerability in the language development domain, underscoring the role of sufficient rest in cognitive growth. Similarly, lack of structured physical activity was linked to higher developmental vulnerability, emphasizing the importance of active play in promoting holistic child development.

Overall, these findings align with international studies that demonstrate the negative impact of excessive screen time on early developmental health. The results strongly support the need for strict adherence to screen time guidelines and promoting balanced routines involving physical activity and adequate sleep to optimize developmental outcomes in early childhood.

Recent studies have highlighted significant correlations between digital screen exposure and early childhood neurodevelopment. Madigan et al. found that excessive screen time in toddlers was linked with poorer communication skills, problem-solving ability, and motor development, suggesting a dose-response relationship between screen use and developmental risk [11]. Similarly, Birken et al. reported that screen use at 24 months predicted lower expressive language scores and poorer developmental screening outcomes at 36 months, indicating that early exposure may have lasting effects on developmental trajectories [12].

Neuroimaging studies have provided further biological evidence. Hutton et al. demonstrated that higher daily screen time was associated with alterations in white matter integrity, specifically in brain regions responsible for language and literacy

skills, raising concerns about the neurological basis of screen-related developmental delays [13]. In addition, McArthur et al. showed that greater screen exposure in infants and toddlers correlated with weaker parent-child interactions and delayed socioemotional development, reinforcing the importance of interpersonal engagement for healthy growth [14].

Systematic reviews have confirmed these trends at a broader level. Tremblay et al. summarized findings across multiple studies and concluded that excessive screen exposure is consistently associated with negative outcomes in language, cognitive, and socioemotional development, particularly during the critical period of early childhood [15].

Conclusion

This study demonstrates that digital screen exposure exceeding 1 hour per day is significantly associated with developmental vulnerability in young children, particularly affecting language, cognitive development, and communication skills. These findings highlight the critical need to limit screen time in early childhood and promote balanced routines including adequate sleep and physical activity to support healthy developmental outcomes.

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