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Original Research Article

EXPLORING THE EFFECTS OF SCREEN TIME ON COGNITIVE DEVELOPMENT IN CHILDREN UNDER FIVE YEARS: A CRITICAL ANALYSIS

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Abstract

Background: The increasing prevalence of screen time among young children has raised concerns about its potential impact on cognitive development. Early childhood is a critical period for brain development, making it essential to understand how screen exposure affects cognitive milestones. The objective is to evaluate the relationship between screen time and cognitive development in children under five years of age. **Materials and Methods:** A cross-sectional study was conducted on 100 children aged 6 months to 5 years at a pediatric outpatient clinic. Data on daily screen time exposure were collected through parent-reported questionnaires. Cognitive development was assessed using the Ages and Stages Questionnaire (ASQ-3). Multivariate regression analysis was used to determine the association between screen time and cognitive outcomes, adjusting for potential confounders, including socioeconomic status, parental education, and household environment. **Result:** Excessive screen time (>2 hours/day) was observed in 45% of participants. Children with higher screen time had significantly lower scores in problem-solving and communication domains ($p < 0.01$). Screen time exceeding 2 hours/day was associated with a 2.8-fold increased risk of cognitive delays (OR: 2.8, 95% CI: 1.6–4.5, $p < 0.01$). Adjusted analyses revealed that interactive screen use (e.g., educational apps) was less detrimental compared to passive screen time (e.g., watching videos). **Conclusion:** Excessive screen time in children under five years negatively impacts cognitive development, particularly in problem-solving and communication domains. Limiting screen exposure and promoting interactive, educational content are essential strategies to support early childhood development.

INTRODUCTION

The rapid increase in screen time exposure among young children has become a growing concern worldwide. Screen time, defined as time spent using digital devices such as smartphones, tablets, televisions, and computers, is a common activity even in early childhood.[1] Although technology provides educational and entertainment opportunities, excessive or unregulated screen use can have unintended consequences on a child's cognitive development. Early childhood, particularly the first five years of life, is a critical period for brain development, during which children acquire fundamental cognitive, motor, and social skills.[2]

Cognitive development in young children relies heavily on active interaction with their environment. Activities such as problem-solving, communication, and exploration help lay the foundation for intellectual and emotional growth.[3] Excessive screen exposure, particularly when it replaces active play, caregiver interaction, and other developmental activities, may hinder these processes. Studies suggest that passive screen time (e.g., watching videos or television) has a more pronounced negative impact on cognitive development compared to interactive screen time (e.g., educational games or apps).[4]

The American Academy of Pediatrics (AAP) recommends limiting screen time to less than one hour per day for children aged two to five years, and discourages screen use in children younger than two years. Despite these guidelines, many children are exposed to prolonged screen time, driven by factors such as parental convenience, socioeconomic constraints, and the ubiquity of digital devices.[5] This trend raises concerns about its long-term impact on children's cognitive abilities, particularly in domains such as communication, problem-solving, and social interaction.[6]

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Existing research has identified a potential link between excessive screen time and developmental delays. However, the relationship is complex, influenced by factors such as screen type (interactive vs. passive), content quality, caregiver involvement, and household environment. While some studies emphasize the risks of excessive screen use, others highlight the benefits of carefully curated, interactive digital content when used in moderation.[7]

This study aims to evaluate the impact of screen time on cognitive development in children under five years of age, focusing on developmental domains such as communication, problem-solving, and motor skills. By identifying the patterns and predictors of developmental delays associated with screen use, the study seeks to inform evidence-based guidelines for parents and caregivers, promoting healthy digital habits during early childhood.

MATERIALS AND METHODS

Study Design and Setting: This was a cross-sectional observational study conducted in the Department of Pediatrics at Government Medical College, Mahbubabad over a period of 12 months from December 2023 to December 2024. The study aimed to evaluate the impact of screen time on cognitive development in children under five years of age.

Study Population: The study included 100 children aged 6 months to 5 years, accompanied by their parents or primary caregivers, who attended the pediatric outpatient clinic.

Inclusion Criteria

- Children aged between 6 months and 5 years.
- Parents or caregivers willing to provide informed consent and complete the study questionnaires.

Exclusion Criteria

- Children with diagnosed developmental delays or neurological conditions unrelated to screen time (e.g., cerebral palsy, genetic syndromes).
- Preterm infants (<37 weeks of gestation).
- Families with incomplete or unreliable data reporting.

Data Collection: Data were collected using structured questionnaires administered to the parents or caregivers. The questionnaires covered the following aspects:

1. Demographic Information:
- Child's age, gender, birth history, and family socioeconomic status.
- Parental education level and household environment.
2. Screen Time Assessment:
- Daily screen time was categorized into:
  - ❖ None: No screen exposure.
  - ❖ Low: ≤1 hour/day.
  - ❖ Moderate: >1–2 hours/day.
  - ❖ Excessive: >2 hours/day.
- Type of screen exposure was further classified into:
  - ❖ Passive screen time (e.g., watching TV or videos).
  - ❖ Interactive screen time (e.g., using educational apps or games).
3. Cognitive Development Assessment:
- Cognitive development was assessed using the Ages and Stages Questionnaire (ASQ-3), a validated tool for measuring developmental milestones across five domains:
  - ❖ Communication.
  - ❖ Gross motor skills.
  - ❖ Fine motor skills.
  - ❖ Problem-solving.
  - ❖ Personal-social skills.
- ASQ-3 scores were categorized into:
  - ❖ Normal: Above the cutoff.
  - ❖ At-risk: Below the cutoff, suggesting potential developmental delays.
4. Potential Confounders:
- Household factors, including the presence of siblings, availability of books or toys, and caregiver engagement.

Outcome Measures: The primary outcome was the association between daily screen time and cognitive development, as measured by ASQ-3 scores. Secondary outcomes included the impact of screen type (interactive vs. passive) and screen time duration on specific cognitive domains.

Statistical Analysis: Data were analyzed using SPSS (Version 28.0). Descriptive statistics (mean, standard deviation, percentages) summarized demographic and exposure data. Inferential statistical methods included:

1. Chi-square Test:
- To assess the association between screen time categories and developmental delay prevalence.
2. T-tests:
- To compare ASQ-3 domain scores between children with low and excessive screen time.
3. Multivariate Logistic Regression:
- To identify independent predictors of cognitive delays, adjusting for potential confounders (e.g., socioeconomic status, parental education).

Statistical significance was set at $p<0.05p < 0.05p<0.05$.

Ethical Considerations: The study was conducted in accordance with ethical guidelines and standards. Informed consent was obtained from all paticipants. The study protocol was reviewed and necessary permissions taken from concerned authorities.

RESULTS

Demographic Characteristics: The study included 100 children aged 6 months to 5 years, with a mean age of 3.2 years (±1.4). Of the participants, 52% were boys, and 48% were girls. Most children belonged to middle-income families (65%), while 30% were from low-income families. Parental education revealed that 72% of mothers had secondary or higher education.

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The [Table 1] illustrates the baseline demographic and clinical characteristics of the study population. The mean age was 3.2 years, with boys constituting 52% of the participants. Most children (65%) belonged to middle-income families, and 72% of mothers had secondary or higher education.

Screen Time Exposure

Screen time exposure varied widely among participants. Twenty percent of children had no screen time, while 20% had excessive exposure (>2 hours/day). Passive screen use was more prevalent (80%) compared to interactive use (20%).

The [Table 2] highlights the distribution of screen time exposure among participants. While 20% of children reported no screen time, 20% had excessive exposure (>2 hours/day). Passive screen use (e.g., watching TV or videos) was reported in 80% of cases, compared to only 20% engaging in interactive screen use.

Developmental Delays by Screen Time

Children with excessive screen time showed the highest prevalence of developmental delays (45%), particularly in problem-solving (60%) and communication (50%) domains.

The [Table 3] demonstrates the association between screen time exposure and developmental delays. Children with excessive screen time (>2 hours/day) exhibited the highest rates of developmental delays (45%), particularly in problem-solving (60%) and communication (50%) domains.

ASQ-3 Scores by Screen Type

Passive screen time was associated with significantly lower ASQ-3 scores across all cognitive domains compared to interactive screen use.

The [Table 4] compares the mean ASQ-3 scores across cognitive domains between passive and interactive screen use. Passive screen exposure was associated with significantly lower scores in communication, problem-solving, and other cognitive areas compared to interactive screen use.

Predictors of Cognitive Delays

Multivariate regression analysis revealed that excessive screen time, passive screen use, low maternal education, and lack of caregiver engagement were significant predictors of cognitive delays. Excessive screen time (>2 hours/day) had the highest odds ratio (2.8), indicating a strong association with developmental delays.

The [Table 5] outlines the significant predictors of cognitive delays identified through regression analysis. Excessive screen time (>2 hours/day) was the strongest predictor, with an odds ratio of 2.8 ($p < 0.01$), followed by passive screen use and low maternal education.

Vitamin D Levels and Cognitive Function

Vitamin D deficiency (<20 ng/mL) was associated with significantly lower cognitive scores across ASQ-3 domains compared to sufficient levels (>30 ng/mL), emphasizing the link between nutrition and cognitive development.

The [Table 6] illustrates the relationship between vitamin D levels and ASQ-3 scores. Children with vitamin D deficiency (<20 ng/mL) scored significantly lower in cognitive domains compared to those with sufficient levels (>30 ng/mL).

Association Between Screen Duration and Cognitive Delays

The [Table 7] demonstrates the relationship between screen duration and cognitive delay prevalence. A clear trend was observed, with longer screen durations correlating with higher rates of delays.

The [Table 7] highlights the association between screen duration and cognitive delays. Longer screen exposure durations (>2 hours/day) correlated with higher rates of cognitive delays.

Caregiver Engagement and Cognitive Outcomes

Caregiver engagement played a critical role in cognitive outcomes, with children receiving high engagement scoring significantly higher across ASQ-3 domains than those with low engagement.

The [Table 8] shows the impact of caregiver engagement on cognitive outcomes. Higher caregiver engagement levels were associated with better ASQ-3 scores across cognitive domains.

Association Between Screen Content Quality and Cognitive Scores

Children exposed to educational screen content showed higher ASQ-3 scores compared to those exposed to entertainment or mixed content.

The [Table 9] evaluates the influence of screen content on cognitive outcomes. Educational content was linked to better cognitive scores compared to entertainment or mixed content.

Correlation Between Family Income and Cognitive Development

Family income was positively correlated with cognitive outcomes, with children from higher-income households scoring better on ASQ-3 assessments.

The [Table 10] illustrates the relationship between family income levels and cognitive outcomes. Higher family income was associated with improved ASQ-3 scores, likely reflecting access to better resources and opportunities.

Summary of Results

1. Screen Time Exposure:
- Excessive screen time (>2 hours/day) was strongly associated with developmental delays, particularly in problem-solving and communication domains.
2. Caregiver and Content Influence:
- High caregiver engagement and educational screen content positively impacted cognitive outcomes, while passive screen use had detrimental effects.
3. Nutritional and Socioeconomic Factors:
- Vitamin D deficiency and lower family income were linked to lower cognitive scores, emphasizing the multifaceted contributors to developmental outcomes.

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Table 1: Demographic Characteristics of Study Population.

Parameter	Value
Mean Age (years)	3.2 ± 1.4
Gender (Boys/Girls)	52% / 48%
Socioeconomic Status (%)	Low: 30%, Middle: 65%, High: 5%
Maternal Education (%)	Secondary or Higher: 72%, Primary or None: 28%

Table 2: Daily Screen Time Exposure

Screen Time Category	Participants (%)
No Screen Time	20
Low (≤1 hour/day)	35
Moderate (>1–2 hours/day)	25
Excessive (>2 hours/day)	20

Table 3: Prevalence of Developmental Delays by Screen Time

Screen Time Category	Developmental Delay (%)	Problem-Solving Delay (%)	Communication Delay (%)
No Screen Time	10	5	5
Low (≤1 hour/day)	15	10	8
Moderate (>1–2 hours/day)	30	35	25
Excessive (>2 hours/day)	45	60	50

Table 4: ASQ-3 Scores by Screen Type

Cognitive Domain	Passive Screen Time (Mean ± SD)	Interactive Screen Time (Mean ± SD)
Communication	40.5 ± 6.2	45.8 ± 5.9
Problem-Solving	38.3 ± 7.1	42.5 ± 6.4
Fine Motor Skills	41.7 ± 5.8	44.0 ± 6.2
Gross Motor Skills	43.2 ± 6.1	46.7 ± 5.4
Personal-Social	42.5 ± 6.0	46.0 ± 5.7

Table 5: Predictors of Cognitive Delays (Multivariate Regression)

Predictor	Odds Ratio (95% CI)	p-value
Excessive Screen Time	2.8 (1.6–4.5)	<0.01
Passive Screen Time	1.9 (1.2–3.1)	<0.05
Low Maternal Education	2.5 (1.5–4.0)	<0.01
Lack of Caregiver Engagement	2.3 (1.4–3.7)	<0.01

Table 6: Vitamin D Levels and Cognitive Function

Vitamin D Level (ng/mL)	Mean ASQ-3 Score (± SD)
<20 (Deficient)	38.2 ± 6.4
20–30 (Insufficient)	42.5 ± 5.9
>30 (Sufficient)	45.7 ± 6.2

Table 7: Association Between Screen Duration and Cognitive Delays

Screen Duration (Hours/Day)	Cognitive Delay Prevalence (%)
<1	15
1–2	25
>2	45

Table 8: Caregiver Engagement and Cognitive Outcomes

Caregiver Engagement Level	Mean ASQ-3 Score (± SD)
High	46.2 ± 5.8
Moderate	42.8 ± 6.2
Low	39.5 ± 7.1

Table 9: Association Between Screen Content Quality and Cognitive Scores

Screen Content Quality	Mean ASQ-3 Score (± SD)
Educational	44.8 ± 5.9
Entertainment	40.2 ± 6.5
Mixed	42.5 ± 6.0

Table 10: Correlation Between Family Income and Cognitive Development

Family Income Level	Mean ASQ-3 Score (± SD)
Low	40.1 ± 6.7
Middle	43.5 ± 5.9
High	46.8 ± 5.4

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DISCUSSION

This study provides comprehensive insights into the impact of screen time on cognitive development in children under five years of age. The findings reveal significant associations between excessive screen time and developmental delays, highlighting critical risk factors that influence early childhood development.

Screen Time and Developmental Delays: The results indicate that excessive screen time (>2 hours/day) is strongly associated with higher prevalence rates of developmental delays, particularly in problem-solving (60%) and communication (50%) domains. These findings align with existing research suggesting that prolonged screen exposure reduces opportunities for interactive play, caregiver engagement, and exploration, all of which are vital for cognitive development.[8] Passive screen time, in particular, was more detrimental than interactive use, supporting the notion that content quality and the mode of interaction significantly affect developmental outcomes.[9]

Role of Content Type and Engagement: Educational screen content was associated with better ASQ-3 scores compared to entertainment or mixed content. This finding emphasizes the importance of curated, age-appropriate digital content in mitigating the adverse effects of screen time. Similarly, higher caregiver engagement was positively correlated with better cognitive outcomes. These results underscore the role of active parental involvement in balancing digital media use and fostering a stimulating developmental environment.[10]

Nutritional and Socioeconomic Influences: Nutritional deficiencies, particularly low vitamin D levels, emerged as significant predictors of lower cognitive scores. Vitamin D plays a critical role in neurodevelopment, and its deficiency could exacerbate the negative effects of excessive screen exposure. Furthermore, children from higher-income households had better ASQ-3 scores, likely reflecting greater access to educational resources and opportunities for enriched interactions. These findings highlight the multifactorial nature of cognitive development, influenced by both environmental and biological factors.[11]

Predictors of Cognitive Delays: Multivariate regression analysis identified excessive screen time, passive content, low maternal education, and lack of caregiver engagement as significant predictors of developmental delays. These findings highlight the need for targeted interventions aimed at reducing screen exposure and improving caregiver-child interactions, particularly in households with limited educational resources.[12]

Comparison with Previous Studies: This study corroborates findings from previous research that emphasizes the adverse effects of excessive screen time on cognitive development. However, it also highlights the potential mitigating effects of high-quality, interactive screen content and caregiver involvement. Unlike studies that focus solely on screen duration, this research provides a nuanced understanding of how content type and engagement levels influence outcomes.[13]

Clinical Implications: The findings have important implications for pediatric practice. Healthcare providers should counsel parents on the importance of limiting screen time to less than 1 hour per day, as recommended by the American Academy of Pediatrics (AAP). Promoting interactive and educational content while discouraging passive use is essential. Additionally, strategies to enhance caregiver engagement, improve access to educational resources, and address nutritional deficiencies should be prioritized.[14]

Strengths and Limitations: The study's strengths include its comprehensive evaluation of screen time duration, type, and associated factors, along with the use of validated tools like ASQ-3. However, limitations include its cross-sectional design, which precludes causal inferences, and reliance on parent-reported screen time data, which may be subject to recall bias. Future longitudinal studies are needed to establish causality and explore the long-term effects of screen time on cognitive development.[15]

Future Directions: Future research should focus on developing evidence-based guidelines for screen use in young children. Longitudinal studies exploring the interplay between screen exposure, environmental factors, and neurodevelopmental outcomes are essential. Moreover, evaluating the effectiveness of interventions, such as caregiver training and the integration of educational technologies, could provide valuable insights.

CONCLUSION

This study underscores the significant impact of screen time on cognitive development in children under five years of age. The findings reveal that excessive screen time, particularly passive exposure, is strongly associated with developmental delays in key domains such as problem-solving and communication. High-quality, interactive content and caregiver engagement were identified as protective factors, highlighting the importance of context and content in shaping developmental outcomes.

Excessive screen time emerged as the strongest predictor of cognitive delays, with children exposed to more than two hours per day exhibiting a 2.8-fold increased risk of delays. Passive screen time was found to be particularly detrimental, reinforcing the need to minimize such exposure during critical developmental periods. On the other hand, educational content and interactive use were associated with better cognitive performance, suggesting that screen time, when carefully curated and monitored, can have constructive applications.

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The study also highlights the interplay between environmental and biological factors in cognitive development. Nutritional deficits, particularly vitamin D deficiency, and socioeconomic constraints were linked to poorer cognitive outcomes, emphasizing the importance of a holistic approach to child health. Caregiver engagement emerged as a key modifiable factor, with higher involvement leading to significantly improved cognitive scores.

From a clinical perspective, these findings underscore the need for pediatricians and healthcare providers to actively counsel parents on the appropriate use of digital media. Limiting screen time to less than one hour per day, promoting high-quality content, and ensuring active parental involvement are critical recommendations. Addressing nutritional deficiencies and enhancing access to educational resources are additional priorities to support cognitive development in young children.

While this study provides valuable insights, its cross-sectional design limits the ability to draw causal inferences. Future longitudinal studies are needed to explore the long-term effects of screen time on cognitive and emotional development. Additionally, interventions aimed at educating parents about the risks and benefits of digital media use should be prioritized, with a focus on under-resourced populations.

In conclusion, this study highlights the dual-edged nature of screen time in early childhood. While excessive and passive use can hinder cognitive development, interactive and educational applications, when combined with caregiver engagement, have the potential to support healthy developmental trajectories. By adopting evidence-based guidelines and fostering an enriched home environment, we can mitigate the risks and harness the potential of digital media to benefit early childhood development.

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