Original Article

Early-Life Digital Exposure Patterns and their Association with Language Delay Severity and Developmental Outcomes in Children with Normal Hearing: A Cohort-Based Analytical Study

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ABSTRACT

Objective: To evaluate the relationship between digital device exposure patterns and language delay severity, while examining their association with developmental outcomes in a carefully filtered pediatric cohort

Study Design: Retrospective cohort-based analytical study

Place and Duration of Study: This study was conducted at the College of Medicine, Al-Qadisiyah University, Iraq, from 1st December 2025 to 31st March 2026.

Methodology: 500 pediatric records were initially assessed. After applying strict inclusion criteria, 95 cases were retained for final analysis.

Results: A highly significant increase in daily screen time was observed with increasing language delay severity ($P \leq 0.001$), with strong pair-wise differences between mild vs. moderate and mild vs. severe groups ($P \leq 0.001$). Screen time showed a strong positive correlation with severity scores ($r \approx 0.70$, $P \leq 0.001$). Conversely, sleep duration significantly decreased with increasing severity ($P \leq 0.001$), demonstrating a negative correlation ($r \approx -0.45$, $P \leq 0.001$). Early initiation of device use was significantly associated with poorer developmental outcomes ($P \leq 0.001$). The significant association between high screen exposure (>4 hours/day) and increased severity of language delay ($P \leq 0.001$). Additionally, developmental assessment outcomes were significantly influenced by device exposure patterns and age of initiation ($P \leq 0.01$). No significant differences were observed with respect to gender distribution.

Conclusion: Excessive screen exposure and early initiation of device use were strongly associated with increased language delay severity and poorer developmental outcomes in children. Reduced sleep duration further amplified these effects.

Key Words: Behavioral modulation, Developmental phenotype, Pediatric cognition, Screen exposure.

doi:http://doi.org/10.60110/medforum.37.10.10

Citation of article: Abdulhassan SD, Abdulhassan SD. Early-Life Digital Exposure Patterns and their Association with Language Delay Severity and Developmental Outcomes in Children with Normal Hearing: A Cohort-Based Analytical Study. Med Forum 2026;37(10):53-58. doi:http://doi.org/10.60110/medforum.37.10.10.

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INTRODUCTION

It is widely accepted that early childhood is the critical period for acquiring language and stimulating cognitive development. During this window of development, the environment plays the most significant role in determining the level of neural development and the extent of communication skills development. Children are being exposed to digital media more at younger ages than has ever been the case. This trend is worrying because of the many unknowns that might accompany the rapid digital media exposure in early childhood development. Previous studies indicated that increased screen time negatively impacts rapid media exposure and can be improved by increased interactive verbal communication between a parent and a child.[1]

The increased screen time is negatively correlated with language development. The use of media at infants predicted the ability to express oneself. Furthermore, even when media was viewed without a parent present, early exposure to media was correlated with a delay in

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Received: June, 2026
Reviewed: July-August, 2026
Accepted: September, 2026

language development.[2] More recently, when screen exposure was measured at 1 years of age, there was decreased communication ability in children at 2 and 4 years of age.[3]

The extent, to which the digital pattern of exposure was influential, apart from duration, was remarkable. Age of first exposure, device type, and parental supervision level impacted developmental outcomes. In the absence of supervision, children faced a significantly greater risk of developmental delays from unstructured device use than those with limited media-guided use.[4] There was global evidence indicating that children exceeding the recommended screen time guidelines were at an even greater risk, as most children fell within this cohort.[5]

Most researches to date has been focused on developmental delay without examining aftermath of the situation that most research is focused on without splitting out the aftermath. In addition, few studies included frustration hearing as a control, but few studies looked at hearing, which is a key element of language. The lack of these recommendations generally leads to an unbalanced view of the association. Inequitable opportunities in early life, parental involvement, and early childhood condition inequitable, and these gap.[6]

Within these gaps, the current study was formulated to assess the relationship between the severity of language delay and the digital exposure patterns among children with verified normal hearing. An additional purpose was to investigate the relationship between the exposure parameters and the developmental assessment results. This methodology facilitates a greater degree of clarity as to whether screen exposure is a principal cause of severity or a modifying factor within a more expansive developmental framework.

METHODOLOGY

This retrospective cohort-based analytical study was conducted at College of Medicine, Al-Qadisiyah University, Iraq from 1st December 2025 to 31st March 2026 vide letter No. 276 dated November 5, 2025. The study population 500 cases were further refined by applying more inclusion and exclusion criteria. Only children with results from hearing tests that showed normal hearing were included in the final analyses. All cases were excluded that showed even a mildly moderate degree of hearing loss. In addition, children presenting any form of behavioral problem (hyperactivity, tantrums, poor eye contact, etc.) were also excluded to reach 95 cases. This was done in order to avoid possible confounding effects on language and developmental outcomes. Based on these criteria, a subset of eligible participants was selected for final statistical analyses.

Participants were divided into three groups: mild, moderate, and severe language delays. The assessment criteria to classify participants into clinical and developmental assessments were standardized and recorded in the files of the participants. To ease statistical modeling and correlation analysis, severity was encoded to a certain number for the sake of the analysis. Systematic extraction of records, using a structured format, included demographic data such as age (in months), sex, daily screen time (hours/day), age at which the child began using the assigned device (months), device type (mobile, tablet, both), and whether the device was used with parental supervision (yes/no). Furthermore, behavioral traits, such as tantrums, hyperactivity, and reduced eye contact, were noted.

Exposure to screening was classified into three categories: ≤2 hours/day, 2-4 hours/day, and >4 hours/day. First use age of device was categorized into ≤12 months, 13-24 months, and >24 months aiming to capture and reflect developmental milestones. Device type and parental supervision were treated as categorical variables. Standardized developmental assessment records were used to assess developmental status. Outcomes were classified into three groups: normal development, borderline delay, and confirmed developmental delay. Statistical analysis was performed using SPSS-25. One-way analysis of variance (ANOVA) was used to compare mean scores between three or more groups. The Welch t-test was used for pairwise comparisons. The Chi-square test was used to test the association of categorical variables. A p-value of less than 0.05 was considered statistically significant. One quantitative variable was assessed by Spearman rank correlation to determine correlation between them.

RESULTS

The age distribution covered a broad pediatric span, reflecting the wide range of developmental stages. The cases were grouped into language delay levels of mild, moderate, and severe to create a clear basis for the planned analyses. There were statistically no significant ($P>0.05$) differences in sex distribution by severity categories (Table 1).

The shift of the distribution pattern indicated higher exposure durations, especially amongst the older children. This demonstrates more time spent engaging with the digital devices. The starting age of children being exposed to digital devices indicated a tendency for children to start using the devices earlier, with most of the children starting the usage of digital devices during the age of critical neurodevelopment. Exclusive use of tablets was less common, as well as use of mobile phones. Part of the children used the devices without any supervision at all, and the use of devices without supervision was more common than use of devices with supervision. These findings provide the widespread context for the relationship between developmental outcomes and the digital exposure

(Table 2). Panel A breaks down the range of daily screen exposure and shows that most subjects have long screen exposure. Panel B breaks down the age that subjects first began using screens. Most subjects showed early screen exposure as children. Panel C breaks down the type of screens/technology used and shows that most subjects used a mobile device. Panel D shows the extent of parental supervision of screen use, and most subjects experienced unsupervised screen exposure. Language delay severity ($P \leq 0.001$) was significantly and comparably correlated to higher screen exposure. Device type and parental supervision were significantly and comparably correlated, but the correlation was weak ($P > 0.05$).

It was found a clear relationship between time spent with screens and severity of language delay. Participants were categorized 'severe language delay' had more mean screen times than the moderate language delay participants, and the moderate language delay participants had more mean screen time than the mild language delay participants. One-way ANOVA shows us how different three groups ($P < 0.001$). If the difference between the three groups is clear, it makes sense to measure the difference between the two language delay groups in a pair, and of course, using Welch's t-test to measure the difference between the language delay groups mild-moderate, mild-severe, and moderate-severe. Age of screen time use also gives us a sense of how language delay severity is correlated: earlier screens meant language delay severer. This is a good example of early screen time of greater average developmental delay ($P \leq 0.01$) and less sleep in ($P \leq 0.001$) severest language delay. It is a fair interpretation about screen time, sleep, and language delay severity, and they sleep less and have more screen time than children in the mild and moderate groups (Fig. 1). In panel A, daily screen time shows a significant increase in exposure with greater severity in the mild, moderate, and severe groups ($P \leq 0.001$). Significant pairwise differences were confirmed between mild vs. moderate ($P \leq 0.001$), mild vs. severe ($P \leq 0.001$), and moderate vs. severe ($P \leq 0.05$). In panel B, early onset of device use was significantly correlated with higher severity levels ($P \leq 0.01$). In panel C, as severity increased, sleep duration decreased significantly ($P \leq 0.001$), with the most significant pairwise differences observed between mild and severe groups ($P \leq 0.001$).

The mild language delays were more often associated with either normal or borderline outcomes of developmental achievement. This gradient pattern demonstrates a relationship in the imbalance of linguistic function and the imbalance of developmental function, reinforcing the idea that cognitive and linguistic development is interdependent. The lack of supervision by parents, the high screen time, and the early initiation of screen time were always aligned subsumed the adverse developmental outcomes. The more dominant the supervised low screen time, the more favorable the developmental outcome. The relationships among multiple variables emphasize the interdependence of the development and the environment in the overall progress of development. This is especially true in the case of impaired pediatric development overall (Fig. 2). The provided heatmap reveals the correlation between levels of language delays and delays in the developmental assessment, duration of device usage, and patterns of supervision. The most evident is language delays and negative outcomes in developmental assessments. High screen time and early initiation of the device were constantly linked to negative developmental outcomes, whereas low screen time and good parental supervision were linked to normal or borderline developmental outcomes. The correlation between the delays in language development and the delays in the assessment of developmental milestones is substantial and has statistical significance ($P \leq 0.001$). The correlation of the type of device and supervision, is mixed, some correlations are significant ($P \leq 0.05$) and some are not significant ($P > 0.05$).

The daily time spent with screens showed a high positive correlation to the language delay severity of ($r \approx 0.70$, $P \leq 0.001$), thus the more severe the language delay, the more time spent on screens, and the more screen time. The relationship that is consistent and strong screen time and language delay. Additionally, the sleep duration showed a moderate negative correlation to the language delay severity ($r \approx -0.45$, $P \leq 0.001$), that is the lesser the sleep, the more severe the language delay. The correlation found for the age of children using digital devices for the first time and developmental outcomes being significant and negative means the earlier the age of first use, the poorer the developmental outcomes ($P \leq 0.01$). A negative correlation between developmental health and the amount of time a child spends using digital devices. Lack of sleep, on the other hand, appears to have a positive influence on developmental health. The correlation matrix shows how integrated and inter-related the variables are to each other, as well as how good analytical framework of the study (Fig. 3). Daily screen time and severity of language delays had a strong positive correlation ($r \approx 0.70$, $P \leq 0.001$). The greater the severity of the language delays the less sleep, with a moderate negative correlation of sleep duration with severity ($r \approx -0.45$, $P \leq 0.001$). The age at which screen time was first introduced had a negative correlation with development, such that earlier screen time was associated with poorer developmental outcomes ($P \leq 0.01$). Other correlations between the variables were weaker and not significant ($P > 0.05$). The matrix is an aggregate look at the correlations of the variables.

Table No. 1; Comparison of genders

Gender	Mean±SD	P value
Male	43.25±7.39	0.3049 (NS)
Female	58.26±5.28	

Table No. 2: Comparison of age groups

Age (months)	Mean±SD	P value
<24	18.25±11.16	0.0451 (S)
24-35	27.28±21.30	
36-47	33.31±28.35	0.5225 (NS)
49-49	22.23±18.22	

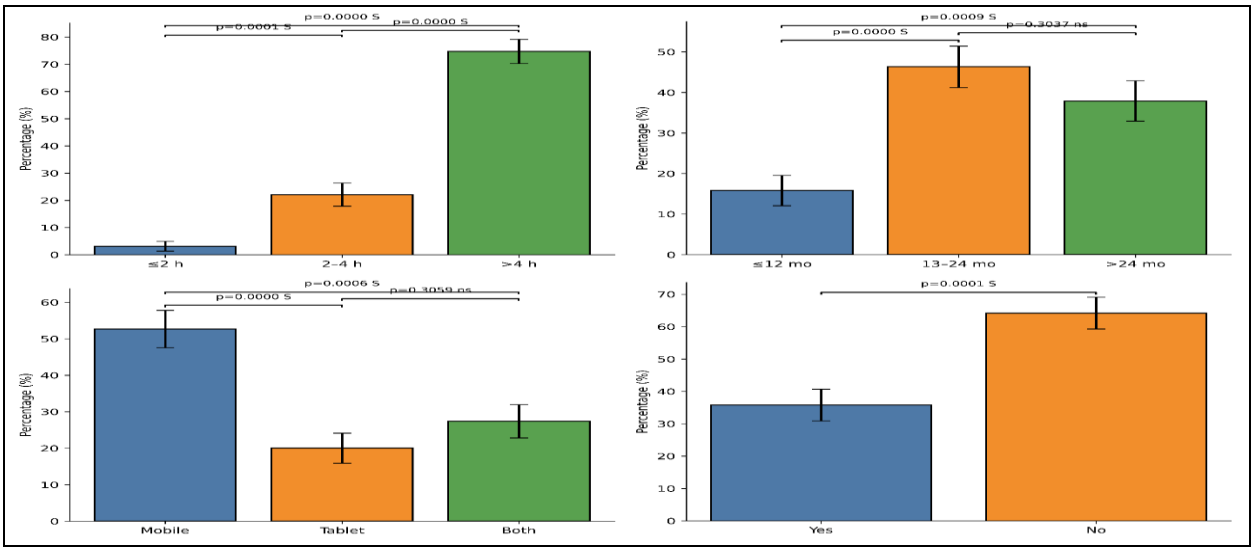


Figure No. 1: Multi-panel descriptive exposure profile

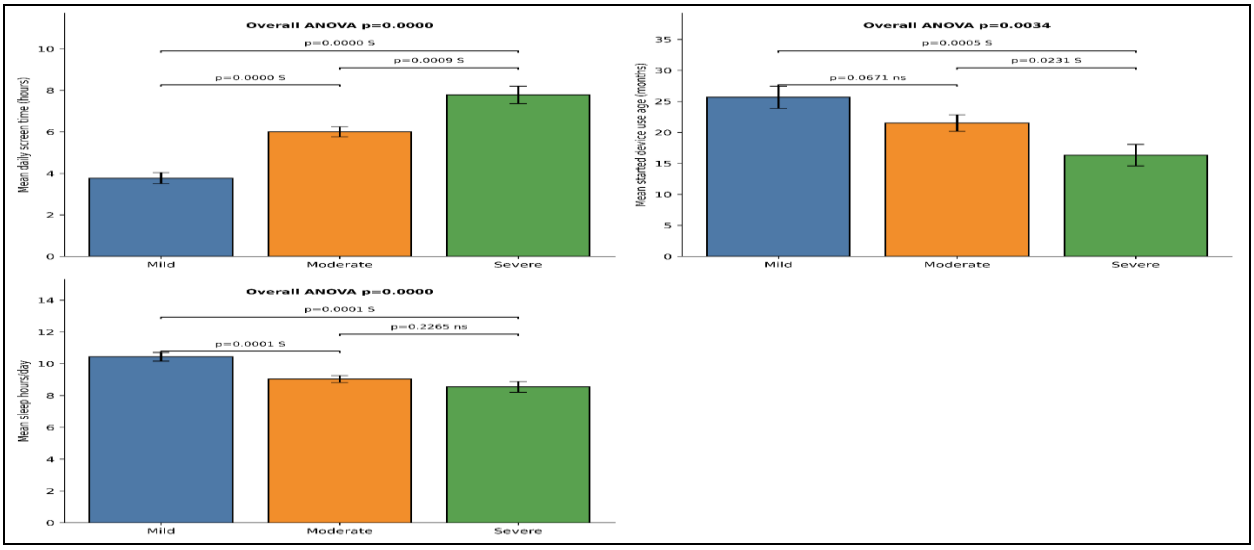


Figure No. 2: Severity of language delay versus exposure variables

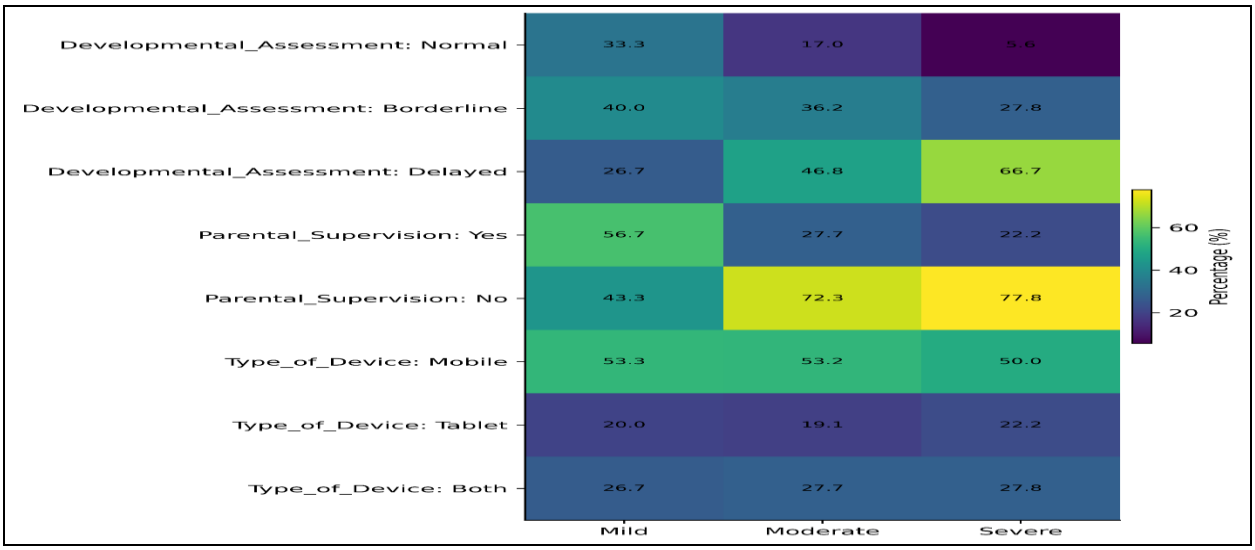


Figure No. 3: Developmental phenotype heat map

DISCUSSION

This study showed a considerable number of children were observed to have prolonged daily screen use, with a significant number exceeding four hours. A number of recent report has documented the continued out of the target screen time recommendations of children globally.[5]

Most of the reports digital screen exposure to children has focused on the use of a mobile device. This in itself, demonstrates the continued evolution of digital media where, in most cases, collapsible and portable media have replaced traditional forms of viewing media (e.g. television viewing). The difference in levels of parental involvement during screen use suggests not only the extensive screen use but also the unmonitored use of screen time. The absence of adult moderation during media use has been recognized by researchers as one of the most important aspects of media use that can influence positive or negative developmental outcomes.[7,8] The findings of this study suggest that the screen exposure profiles of children in this study were not only determined by the total screen exposure time but also by the contexts, quality of exposure and the nature of the screen time activities at the time of exposure, all of which contributed in varying degrees to increased developmental risk.

This study showed that there is a strong and statistically relevant correlation between daily screen time and language delay severity. Compared to children with mild and moderate language delays, children with severe language delays spend significantly more time, and the differences are significant across all groups. This finding supports the research, and states that screen time may inhibit language development because children are not interacting and receiving the proper verbal stimulation because they are too busy staring at a screen.[9]

The more severe the delays, less children sleep. Developmentally, this sleep deprivation may create further delays. The Prior study has focused on sleep as an indirect mediator, whereas the present study shows that sleep reduction is directly and more strongly correlated to an increase in the severity levels.[10] The early onset screen time use was also significantly correlated to severity. This supports the theory that when young children are in the developmentally sensitive period with neural plasticity, the screen time will have a greater negative impact on the child's development.[11] This study shows that total divisor (screen time and sleep) and the time frame (early screen time use) is crucial in regard to the language development.

The most evident association was made between the outcomes of the developmental assessment and patterns of parental supervision. Children who used digital media while supervised by parents, showing some level of parental control, experienced more positive developmental outcomes than children who used digital media without supervision. This is consistent with the evidence that parents watching media with children and actively talking to children while watching media can reduce some of the negative effects of the media and even improve their thinking and language skills.[12]

Many studies have pointed out that the amount of time children spend using screens and their exposure to other environmental and social factors are not unrelated.[13,14] This study showing, particularly, the nature of supervision and how the media is used are important factors in the development of the children.

Correlation analysis shows a systematic structure for the main quantitative variables, given the daily screen time and language delays, whereby the greater the exposure the greater the language delay and vice versa. Additionally, sleep duration is negatively correlated with delay severity, meaning the less sleep the greater the delay. While a strong individual correlation is apparent, the language delay results seem to arise, fundamentally, from a multitude of interacting variables rather than one dominant variable. Integrated flow analysis shows that children with the same levels of exposure did not always follow the same developmental pathways, which suggests the presence of controlling variables like the level of supervision and the timing of the exposure. This multidimensional structure is consistent with the developmental models of Kucker and Schneider[15], which posit that cognitive outcomes develop from the interaction of environmental, biological and behavioral exposures.

CONCLUSION

The level of language delay and the age in which children begin using devices is correlated with the amount of time children spend using devices and the amount of time children spend using devices and the amount of time children spend using devices. The level of language delay is also affected by the amount of sleep children get. Children be given less time using devices and improve children s sleep time, and better use of devices, and the amount of time children spend using devices and the amount of time children spend using devices.

Author's Contribution:

Concept & Design or acquisition of analysis or interpretation of data:	Shaima'A Dakhel Abdulhassan, Safa'A Dakhel Abdulhassan
Drafting or Revising Critically:	Shaima'A Dakhel Abdulhassan, Safa'A Dakhel Abdulhassan
Final Approval of version:	All the above authors
Agreement to accountable for all aspects of work:	All the above authors

Conflict of Interest: The study has no conflict of interest to declare by any author.

Source of Funding: None

Ethical Approval: No.276 Dated 05.11.2025

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