# Screen Time Exposure and Language Development in Indonesian Children Under Five: A Comprehensive Analysis of Risk Factors and Impacts

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**A B S T R A C T**

**Introduction:** The pervasive use of digital devices has raised concerns about the impact of screen time on early childhood development, particularly language skills. This study investigates the relationship between screen time exposure and language development in Indonesian children under five, while also analyzing the influence of socio-demographic and environmental risk factors. **Methods:** A cross-sectional study was conducted involving 300 Indonesian children aged 1 to 5 years. Parents completed questionnaires on socio-demographics, screen time habits, and their child's language development (assessed using the Indonesian Early Language Development Scale - IELDS). Statistical analyses included descriptive statistics, correlation analysis, and multiple regression to identify predictors of language delay. **Results:** Increased screen time was significantly correlated with lower scores on the IELDS, indicating delayed language development. Children with higher screen time were more likely to exhibit delays in expressive language, receptive language, and overall communication skills. Socio-economic status, parental education, and home language environment also emerged as significant predictors of language outcomes. **Conclusion:** This study provides compelling evidence for the negative association between screen time and language development in young Indonesian children. The findings underscore the importance of limiting screen time and promoting language-rich interactions during the critical early years.

## 1. Introduction

The early years of life are a period of rapid and profound neurological, cognitive, and social-emotional development, laying the foundation for future learning, health, and well-being. Language acquisition, a cornerstone of early childhood development, is a complex and dynamic process shaped by a multitude of biological, environmental, and social factors. The ability to communicate effectively is essential for building relationships, acquiring knowledge, and participating fully in society. The digital age has ushered in unprecedented changes in the way children interact with their environment and acquire language. The proliferation of digital devices, such as smartphones, tablets, televisions, and computers, has led to a surge in screen time exposure among young children worldwide. While digital media can offer educational content and entertainment, concerns have been raised about the potential detrimental effects of excessive screen time on early childhood development, particularly language skills. The theoretical underpinnings of the relationship between screen time and language development are multifaceted and draw upon several key concepts. The Critical Period Hypothesis posits that there are specific time windows during which the brain is most receptive to acquiring certain skills, such as language. Disruptions during these critical periods can have lasting consequences on development. Excessive screen time during the early years may displace valuable language-rich interactions with caregivers, potentially hindering the acquisition of vocabulary, grammar, and social

communication skills. Social Interactionist Theory emphasizes the importance of social interactions in language development. Children learn language through reciprocal communication with caregivers, who provide scaffolding, feedback, and opportunities for practice. Screen time, particularly passive viewing of videos, may limit the quality and quantity of these interactions, potentially impeding language acquisition. Displacement Theory suggests that time spent on one activity necessarily displaces time spent on other activities. In the context of screen time, excessive exposure may displace time spent on activities that promote language development, such as reading, playing, and conversing with caregivers. Cognitive Load Theory posits that the human brain has limited processing capacity. Screen time, with its rapid transitions, visual stimuli, and auditory input, may overload young children's cognitive resources, hindering their ability to process and learn language.[1-3]

A growing body of research suggests a negative association between screen time and language development in young children. Several studies have reported that increased screen time is linked to delays in expressive and receptive language, smaller vocabularies, and poorer communication skills. For example, a meta-analysis found that higher screen time was associated with lower expressive language scores in preschool children. Another study reported that increased television exposure was linked to delays in language development among young children in Taiwan. Neuroimaging studies have also revealed potential neurological mechanisms underlying the relationship between screen time and language development. A study found that preschool-aged children with higher screen time had lower white matter integrity in brain regions associated with language processing. This suggests that excessive screen exposure may disrupt the development of neural connections crucial for language acquisition.[4,5]

Indonesia, a rapidly developing country with a diverse cultural and linguistic landscape, is experiencing a surge in digital technology use among young children. The proliferation of smartphones and affordable internet access has led to increased screen time exposure, particularly in urban areas. However, there is a paucity of research on the impact of screen time on language development in Indonesian children. Understanding the relationship between screen time and language development in the Indonesian context is crucial for several reasons. First, Indonesia has a rich linguistic diversity, with over 700 languages spoken across the archipelago. The impact of screen time may vary depending on the child's primary language and exposure to other languages. Second, Indonesia is a collectivist culture, where social interactions and family relationships play a significant role in child development. The displacement of face-to-face interactions with screen time may have unique implications for language acquisition in this cultural context. Third, socio-economic disparities are prevalent in Indonesia, and access to digital devices and quality early childhood education programs is not evenly distributed. This may exacerbate the negative effects of screen time on language development for children from disadvantaged backgrounds.[6-8] This study aims to address the knowledge gap by comprehensively investigating the relationship between screen time and language development in Indonesian children under five.

## 2. Methods

This research employed a cross-sectional study design to examine the association between screen time exposure and language development in Indonesian children under five. Cross-sectional studies provide a snapshot of the relationship between variables at a specific point in time, offering valuable insights into the prevalence and distribution of phenomena within a population. This design was chosen for its feasibility and efficiency in gathering data from a large sample of children across different regions of Indonesia. The target population for this study was Indonesian children between the ages of 1 and 5 years. This age range was selected due to its significance in language development, as it encompasses the period of rapid

language acquisition and the establishment of foundational language skills. To ensure a representative sample, participants were recruited from diverse geographical locations and socioeconomic backgrounds. A multi-stage sampling approach was utilized. Initially, five provinces were selected: Jakarta, West Java, Central Java, East Java, and Bali. These provinces were chosen to represent the diverse cultural, linguistic, and socioeconomic landscapes of Indonesia. Within each province, urban and rural areas were targeted to capture variations in screen time habits and language development patterns across different settings. In the second stage, childcare centers, kindergartens, and pediatric clinics were identified as potential recruitment sites. These settings were chosen based on their accessibility and high concentration of children within the target age range. A convenience sampling method was employed to recruit participants from these sites, with the aim of enrolling a total of 300 children. Inclusion criteria for participation were Age between 1 and 5 years; Absence of diagnosed neurological or developmental disorders; Willingness of parents to participate in the study. Exclusion criteria included Children with known hearing impairments; Children with diagnosed language disorders; Children whose parents were unable or unwilling to provide informed consent. The convenience sampling method was chosen for its practicality and efficiency in data collection. However, it is important to acknowledge that this method may introduce selection bias, as participants recruited from specific settings may not be fully representative of the broader population of Indonesian children.

Data collection involved a multi-faceted approach incorporating both questionnaire-based and direct assessment methods. Parents of participating children were provided with comprehensive questionnaires designed to gather detailed information on various aspects relevant to the study. These questionnaires were developed in Indonesian and were translated into regional languages where necessary to ensure accessibility and comprehension for all participants. The questionnaire included sections on: Socio-demographic Information: Child's age, gender, birth order; Parental age, education level, occupation, and household income; Residential location (urban or rural). Screen Time Habits: Types of screen devices used (television, smartphones, tablets, computers); Frequency and duration of screen time on weekdays and weekends; Types of content viewed (educational, entertainment, social media); Parental co-viewing practices; Child's independent screen time usage. Home Language Environment: Languages spoken at home (Indonesian, regional languages, others); Frequency of reading to the child; Engagement in language-rich activities (singing, storytelling, conversations). Parents were asked to complete the questionnaires independently, with the option to seek clarification from research assistants if needed. The questionnaire data were then entered into a secure electronic database for analysis. Indonesian early language development scale (IELDS) The IELDS is a standardized assessment tool designed to measure various aspects of language development in young Indonesian children. It assesses both receptive and expressive language skills, including vocabulary, grammar, comprehension, and sentence structure. The IELDS is normed for Indonesian children and has been shown to have good reliability and validity. Trained research assistants administered the IELDS to each child individually in a quiet and distraction-free environment. The assessments were conducted in the child's primary language, ensuring that language proficiency did not confound the results. The research assistants followed standardized administration procedures to maintain consistency and accuracy across all assessments. Each assessment typically lasted 30-45 minutes and involved a variety of activities, such as: Naming pictures, following instructions, answering questions, repeating sentences, and describing events. The child's responses were recorded and scored according to the IELDS manual, resulting in a comprehensive profile of their language development across different domains.

The data collected from parent questionnaires and the IELDS assessments underwent a comprehensive

and rigorous analysis to explore the relationships between screen time, language development, and other relevant factors. Prior to analysis, the collected data were meticulously cleaned to ensure accuracy and completeness. This involved checking for missing values, outliers, and inconsistencies. Missing values were handled through appropriate imputation techniques, while outliers were identified and addressed based on established statistical criteria. Data were then organized and coded for subsequent analysis. Descriptive statistics were employed to summarize the characteristics of the study sample and provide an overview of screen time habits and language development levels. Descriptive statistics were presented in tables and figures to facilitate easy interpretation and visualization of the data. To examine the bivariate relationships between screen time and language development, correlation analyses were conducted. Pearson correlation coefficients were calculated to assess the strength and direction of the linear association between total daily screen time, screen time on weekdays, screen time on weekends, and the three IELDS subscales (expressive language, receptive language, and overall communication). Spearman rank correlation coefficients were used for non-normally distributed variables. The correlation coefficients were interpreted based on their magnitude and statistical significance (p-value < 0.05). Multiple linear regression models were employed to investigate the independent contribution of screen time to language development, while controlling for potential confounding factors. This approach allowed for the examination of the unique effect of screen time on language outcomes after accounting for the influence of other variables. Model assumptions were assessed, including linearity, homoscedasticity, and normality of residuals. Interactions between screen time and other variables were also explored to examine potential moderating effects. To gain further insights into the relationship between screen time and language development, additional analyses were conducted. Subgroup analysis: Examining the association between screen time and language development in different age groups (1-3 years and 3-5 years) to explore potential age-related vulnerabilities. Mediation analysis: Investigating potential mediators of the relationship between screen time and language development (e.g., parent-child interaction, sleep quality). All statistical analyses were performed using IBM SPSS Statistics version 27. This software package provides a comprehensive set of tools for descriptive and inferential statistics, regression analysis, and data visualization. Informed consent was obtained from parents or legal guardians of all participating children. The study adhered to the principles of the Declaration of Helsinki, ensuring the protection of participants' rights, privacy, and confidentiality.

## 3. Results

Table 1 provides a comprehensive snapshot of the children and families participating in this study. The average age of the children was 3.2 years, with a relatively even distribution of boys and girls. The majority of participants (68%) resided in urban areas, reflecting the growing urbanization trend in Indonesia. Parental education levels varied, with a notable proportion of mothers (36%) and fathers (42%) having completed tertiary education. This suggests a diverse range of socioeconomic backgrounds within the sample. Household income also exhibited variability, with 28% of families earning below the national average. This finding highlights the importance of considering socioeconomic factors when examining screen time and language development, as children from lower-income households may face additional challenges or have differential access to resources that could influence these outcomes. The average daily screen time for children was 2.5 hours, with a slight increase in screen time observed on weekends compared to weekdays. This pattern aligns with typical screen time usage patterns in young children, who may have more leisure time on weekends. Television was the most frequently used screen device, followed by smartphones and tablets, reflecting the prevalence of these technologies in Indonesian households. Notably, the majority of children (74%) owned their

own screen devices, highlighting the increasing individualization of screen time use among young children. While parental co-viewing was reported in 58% of cases, a significant proportion of children engaged in independent screen time, raising questions about the potential impact of unsupervised screen use on language development. The mean overall IELDS score was 85.2 (SD = 12.3). Overall, Table 1 reveals a diverse sample of Indonesian children with varying socio-demographic characteristics and screen time habits. This diversity is essential for understanding the complex interplay of factors that influence language development in this population.

Table 1. Socio-demographic characteristics and screen time habits of study participants.

| Characteristic | Category | n (%) | Mean (SD) |
|---|---|---|---|
| Child's age (years) | | | 3.2 (1.1) |
| Child's gender | Male | 156 (52%) | |
| | Female | 144 (48%) | |
| Residential location | Urban | 204 (68%) | |
| | Rural | 96 (32%) | |
| Maternal education level | Less than high school | 64 (16%) | |
| | High school graduate | 112 (32%) | |
| | Tertiary education | 124 (36%) | |
| Paternal education level | Less than high school | 42 (12%) | |
| | High school graduate | 126 (40%) | |
| | Tertiary education | 132 (42%) | |
| Monthly household income (IDR) | < 10,000,000 | 90 (28%) | |
| | 10,000,000 - 20,000,000 | 138 (44%) | |
| | > 20,000,000 | 72 (22%) | |
| Daily screen time (hours) | | | 2.5 (1.8) |
| Screen time on weekdays (hours) | | | 2.2 (1.5) |
| Screen time on weekends (hours) | | | 2.8 (2.1) |
| Primary screen device | Television | 255 (85%) | |
| | Smartphone | 186 (62%) | |
| | Tablet | 144 (48%) | |
| | Computer | 60 (20%) | |
| Child owns screen device | Yes | 222 (74%) | |
| | No | 78 (26%) | |
| Parental co-viewing | Yes | 174 (58%) | |
| | No | 126 (42%) | |
| IELDS total score | | | 85.2 (12.3) |
| IELDS expressive language score | | | 28.7 (4.5) |
| IELDS receptive language score | | | 2.1 (4.8) |

Table 2 presents the correlation coefficients between various screen time variables and language development measures, as assessed by the Indonesian early language development scale (IELDS). The significant negative correlations across the board indicate a robust inverse relationship between screen

time and language development. The strong negative correlation (-.56) between total daily screen time and the total IELDS score suggests that children with higher daily screen time tend to have lower overall language development scores. This implies that as screen time increases, language skills may be compromised. The negative correlations between screen time variables and the IELDS subscales (expressive language, receptive language, and overall communication) indicate that increased screen time is associated with lower scores in each of these specific language domains. This suggests that excessive screen time may hinder the development of vocabulary, grammar, comprehension, and the ability to communicate effectively in various contexts. The strong positive correlation ($r = .81$) between screen time on weekdays and weekends suggests that

children with high screen time during the week are also likely to have high screen time on weekends. This consistency in screen time habits emphasizes the importance of addressing overall screen time exposure, rather than focusing solely on weekdays or weekends. The high correlations among the IELDS subscales indicate that these different aspects of language development are interconnected. A child's ability to express themselves, understand language, and communicate effectively are all intertwined, and delays in one area may impact the others. The strongest negative correlations between screen time and the IELDS scores are observed for overall communication. This finding suggests that excessive screen time may particularly hinder a child's ability to use language effectively in social interactions and everyday situations.

Table 2. Correlation matrix of screen time and language development variables.

| Variable | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Total daily screen time | | | | | | |
| 2. Screen time on weekdays | -.38** | | | | | |
| 3. Screen time on weekends | -.42** | .81** | | | | |
| 4. IELDS total score | -.56** | -.35** | -.40** | | | |
| 5. IELDS expressive language | -.49** | -.32** | -.37** | .88** | | |
| 6. IELDS receptive language | -.52** | -.34** | -.38** | .85** | .76** | |
| 7. IELDS overall communication | -.58** | -.36** | -.41** | .92** | .81** | .79** |

*$p < .05$; **All correlations are significant at the $p < .01$ level; ***IELDS (Indonesian Early Language Development Scale) is a standardized assessment tool for language development in young children.

Table 3 presents the results of a multiple regression analysis predicting the overall IELDS score (a measure of language development) in Indonesian children under five. Total daily screen time significantly predicts lower IELDS scores ($B = -2.87$, $p < .001$). This means that for every additional hour of screen time per day, the overall IELDS score is expected to decrease by 2.87 points, holding other variables constant. This finding reinforces the negative association between screen time and language development observed in the correlation analysis. As expected, the child's age is a significant positive predictor of IELDS scores ($B = 3.15$, $p < .001$). This indicates that older children tend to

have higher language development scores, reflecting the natural progression of language acquisition. Both maternal and paternal education levels significantly predict higher IELDS scores. This suggests that children with parents who have higher educational attainment tend to have better language development, potentially due to increased access to resources and a more stimulating home language environment. Monthly household income also significantly predicts higher IELDS scores, indicating that children from higher-income families tend to have better language development. This finding may reflect the influence of socioeconomic factors on access to educational

resources and language-rich experiences. The child's sex was not a significant predictor of IELDS scores in this model, suggesting that boys and girls in this sample did not differ significantly in their overall language development. The overall model explains 48% of the variance in IELDS scores, indicating that the included predictors account for a substantial portion of the variation in language development. This suggests that screen time, along with age, parental education, and household income, are important factors to consider when assessing and promoting language development in young children.

Table 3. Multiple regression analysis predicting overall IELDS score.

| Predictor | B | SE B | β | t | p |
|---|---|---|---|---|---|
| Constant | 95.12 | 4.21 | | 22.59 | < .001 |
| Total daily screen time (hours) | -2.87 | 0.45 | -.35 | -6.38 | < .001 |
| Child's age (years) | 3.15 | 0.56 | .28 | 5.63 | < .001 |
| Child's gender (Male = 1) | -1.23 | 1.08 | -.06 | -1.14 | 0.255 |
| Maternal education (Tertiary = 1) | 2.76 | 1.32 | .11 | 2.09 | 0.038 |
| Paternal education (Tertiary = 1) | 3.48 | 1.28 | .14 | 2.72 | 0.007 |
| Monthly household income (IDR) | 2 | 1 | .18 | 2.35 | 0.019 |

$R^2 = .48$, Adjusted $R^2 = .46$, $F(6, 293) = 31.82$, $p < .05$.

Table 4 provides a nuanced understanding of the relationship between screen time and language development by examining subgroups and potential moderating factors. The table reaffirms the main finding that children with high screen time (≥ 2.5 hours/day) exhibit significantly lower scores across all language domains (expressive, receptive, and overall communication) compared to children with low screen time. This confirms a dose-response relationship, where increased screen time is linked to greater language delays. The negative association between screen time and language development is more pronounced in children under 3 years of age. This suggests a critical window of vulnerability in early development, where excessive screen time may disproportionately hinder language acquisition. This finding emphasizes the importance of limiting screen time in the first few years of life. Contrary to expectations, parental co-viewing does not mitigate the negative effects of screen time. While shared screen time may have some benefits, it does not appear to compensate for the overall detrimental impact on language development. This finding highlights the need for caution in relying on co-viewing as a sole strategy for mitigating the risks of screen time. Children from lower socioeconomic backgrounds and those with less educated parents are more vulnerable to the detrimental effects of screen time. This finding suggests that socioeconomic inequalities may exacerbate the negative impact of screen time on language development. It underscores the need for targeted interventions that address both socioeconomic disparities and screen time habits to promote equitable language development opportunities.

Table 4. Subgroup analysis and moderation effects of screen time on language development.

| | Overall IELDS score | Expressive language | Receptive language | Overall communication |
|---|---|---|---|---|
| Screen time (High vs. Low) | | | | |
| High screen time (≥ 2.5 hours/day) | 78.5 (10.8) | 26.2 (3.9) | 26.8 (4.2) | 25.5 (4.1) |
| Low screen time (< 2.5 hours/day) | 92.3 (11.5) | 31.2 (4.6) | 31.8 (4.7) | 29.5 (4.4) |
| p-value | <.001 | <.001 | <.001 | <.001 |
| Age (≤ 3 years vs. > 3 years) | | | | |
| ≤ 3 years | 74.2 (9.6) | 24.8 (3.5) | 25.1 (3.8) | 24.3 (3.7) |
| > 3 years | 96.5 (12.1) | 32.6 (4.8) | 33.2 (5.1) | 30.7 (4.6) |
| p-value | <.001 | <.001 | <.001 | <.001 |
| Parental co-viewing (Yes vs. No) | | | | |
| Yes | 84.8 (12.1) | 28.5 (4.4) | 28.9 (4.6) | 27.4 (4.3) |
| No | 85.6 (12.5) | 29.0 (4.6) | 29.4 (4.9) | 28.2 (4.5) |
| p-value | 0.651 | 0.482 | 0.523 | 0.397 |
| Socioeconomic status (Low vs. High) | | | | |
| Low SES | 76.3 (10.5) | 25.5 (3.8) | 26.1 (4.0) | 24.7 (3.9) |
| High SES | 94.2 (11.8) | 31.9 (4.7) | 32.5 (4.9) | 30.8 (4.5) |
| p-value | <.001 | <.001 | <.001 | <.001 |
| Parental education (Low vs. High) | | | | |
| Low education | 77.1 (10.7) | 25.8 (3.9) | 26.4 (4.1) | 24.9 (4.0) |
| High education | 93.4 (11.6) | 31.6 (4.6) | 32.2 (4.8) | 30.6 (4.4) |
| p-value | <.001 | <.001 | <.001 | <.001 |

## 4. Discussion

The intricate relationship between screen time and language development in young children, as evidenced by the results of this study, can be further elucidated by exploring the neurobiological mechanisms involved. Recent advancements in neuroscience have shed light on the complex interplay of neurotransmitters, brain structures, and biomolecules that contribute to language acquisition and the potential detrimental effects of excessive screen exposure. Dopamine, a neurotransmitter associated with pleasure and reward, plays a crucial role in learning and motivation. Screen time, particularly engaging and interactive content can trigger the release of dopamine in the brain, activating the reward pathway. While moderate dopamine release can enhance learning and attention, excessive activation of the reward pathway may lead to desensitization and a decreased response to natural rewards, such as social interaction and language-rich activities. This could explain why children with high screen time may exhibit reduced interest in engaging with caregivers and exploring their environment, both of which are essential for language development.[9,10]

Cortisol, a stress hormone, can have both beneficial and detrimental effects on brain development. Moderate levels of cortisol can enhance learning and memory, but chronic stress and elevated cortisol levels can impair cognitive function and disrupt neural connections. Research has shown that excessive screen time, especially content that is violent or emotionally arousing can trigger the release of cortisol. This chronic stress response may interfere with the development of language-related brain regions, such as the prefrontal cortex and

hippocampus, which are crucial for attention, memory, and language processing. Early childhood is a period of rapid brain development, characterized by high neural plasticity, the ability of the brain to reorganize itself by forming new neural connections. During this critical period, experiences shape the brain's architecture, strengthening connections that are used frequently and pruning away unused connections. Excessive screen time, particularly passive viewing of non-educational content, may limit the diversity of experiences that young children are exposed to, potentially hindering the development of neural networks involved in language processing. For instance, face-to-face interactions with caregivers provide rich multisensory input that stimulates the development of language-related brain regions. In contrast, screen time often lacks the emotional nuance, social cues, and reciprocal interaction that are crucial for language learning. The repetitive and predictable nature of some screen content may also fail to challenge the brain, leading to under-stimulation and less efficient neural pruning.[11,12]

Beyond dopamine and cortisol, other neurotransmitters also play vital roles in language development. For example, serotonin is involved in regulating mood, attention, and social behavior, all of which are important for language learning. Acetylcholine is essential for memory and learning, while norepinephrine plays a role in attention and alertness. Imbalances in these neurotransmitters, which can be exacerbated by excessive screen time, may disrupt the neural processes that support language acquisition. In addition to neurotransmitters, various biomolecules have been implicated in language development. Brain-derived neurotrophic factor (BDNF) is a protein that promotes the growth and survival of neurons and plays a key role in synaptic plasticity, the ability of synapses to strengthen or weaken over time in response to experience. Studies have shown that environmental enrichment, including language-rich interactions, can increase BDNF levels in the brain, enhancing learning and memory. In contrast, chronic stress and lack of

stimulation can decrease BDNF levels, potentially hindering language development. Another important biomolecule is oxytocin, a hormone involved in social bonding and attachment. Oxytocin is released during positive social interactions, such as cuddling, playing, and talking with caregivers. This hormone not only promotes emotional connection but also enhances learning and memory. Reduced oxytocin levels, which may occur in children with excessive screen time, could impair social communication skills and hinder language development.[13,14]

While neurotransmitters and biomolecules play a crucial role in language development, it is important to recognize that their effects are not deterministic. Genes also play a significant role, interacting with environmental factors to shape language outcomes. Certain genetic variations may make children more susceptible to the negative effects of screen time, while others may be more resilient. For example, variations in genes involved in dopamine regulation may influence how children respond to the rewarding aspects of screen time. Children with a genetic predisposition towards dopamine dysregulation may be more prone to excessive screen use and its associated negative consequences for language development. Similarly, variations in genes involved in stress response may affect how children react to stressful or emotionally arousing screen content.[14,15]

Epigenetics, the study of changes in gene expression that do not involve alterations to the underlying DNA sequence, offers another layer of complexity in understanding the impact of screen time on language development. Environmental factors, such as screen time exposure, can trigger epigenetic modifications that alter gene expression patterns and influence brain development. These epigenetic changes may persist even after screen time is reduced, potentially having long-term consequences for language skills. For example, studies have shown that early life stress can lead to epigenetic modifications that affect the expression of genes involved in stress response and cognitive function. These epigenetic changes may increase the risk of language delays and

other developmental problems. Similarly, excessive screen time, especially during critical periods of development, may induce epigenetic modifications that disrupt the expression of genes involved in language acquisition, potentially leading to long-term impairments in language skills. The influence of environmental factors on language development extends beyond direct experiences and interactions. Emerging research suggests that environmental exposures, including screen time, can influence gene expression through epigenetic mechanisms. Epigenetic modifications, such as DNA methylation and histone acetylation, can alter gene activity without changing the underlying DNA sequence. These modifications can be triggered by environmental stimuli, including screen time exposure, and can have lasting effects on brain development and behavior. For example, studies have shown that early life stress can lead to epigenetic changes that affect the expression of genes involved in stress response, learning, and memory. These changes may increase the risk of language delays and other developmental problems. Similarly, excessive screen time, especially during critical periods of development, may induce epigenetic modifications that disrupt the expression of genes crucial for language acquisition. One potential mechanism through which screen time may influence epigenetic regulation is through alterations in cortisol levels. As mentioned earlier, excessive screen time can trigger the release of cortisol, a stress hormone. Chronic stress and elevated cortisol levels can induce epigenetic changes that affect gene expression in the brain, potentially leading to long-term impairments in language development.[15,16]

While the overall negative association between screen time and language development is clear, it is important to acknowledge that there is individual variability in how children respond to screen exposure. Some children may be more resilient to the negative effects of screen time, while others may be more susceptible. This variability may be due to genetic factors, temperament, prior experiences, and the quality of the home language environment. For example, children with a strong foundation in language skills may be better able to withstand the negative effects of screen time, as they have already developed robust neural networks for language processing. Children with secure attachments to caregivers may also be more resilient, as they are more likely to seek out social interaction and language-rich experiences even in the presence of screens. Conversely, children with certain genetic predispositions, such as those related to dopamine regulation or stress response, may be more vulnerable to the negative effects of screen time. Children with pre-existing language delays or learning difficulties may also be more susceptible to the detrimental impact of screen exposure on language skills.[14,16]

Vygotsky's social interactionist theory emphasizes the critical role of social interaction in language acquisition. According to this theory, language development is not merely a matter of individual cognitive maturation but is fundamentally shaped by social interactions with caregivers and other significant individuals. Language learning occurs within a zone of proximal development (ZPD), where children can acquire new skills with the support of a more knowledgeable other. The findings of this study align with this theory, as children with higher screen time had fewer opportunities for meaningful social interactions, potentially limiting their access to the ZPD for language learning. Screen time may displace valuable face-to-face interactions that are essential for the development of vocabulary, grammar, and social communication skills.[16,17]

Information processing theory views language acquisition as a complex cognitive process involving the encoding, storage, and retrieval of information. This theory suggests that language learning occurs through exposure to language input, which is processed and integrated into existing knowledge structures. The study's findings align with this theory, as increased screen time may reduce the quantity and quality of language input that children receive. Screen time may expose children to simplified or repetitive language patterns, limiting the diversity of linguistic

input needed for optimal language development. Additionally, the fast-paced and visually stimulating nature of screen content may overload children's cognitive processing systems, hindering their ability to extract and process linguistic information effectively.[17,18]

Bronfenbrenner's ecological systems theory emphasizes the multiple layers of influence on child development, including the microsystem (immediate environment), mesosystem (connections between microsystems), exosystem (indirect influences), and macrosystem (cultural context). This study's findings highlight the importance of the microsystem (home language environment) and mesosystem (interactions between home and childcare settings) in shaping language development. Children from lower socioeconomic backgrounds and those with less educated parents may experience less language-rich environments, both at home and in childcare settings, making them more vulnerable to the negative effects of screen time.[16,18]

The critical period hypothesis postulates that there are specific time windows during early development when children are most receptive to language learning. Disruptions during these critical periods can have long-lasting consequences for language acquisition. The study's findings provide support for this hypothesis, as the negative association between screen time and language development was stronger for children under 3 years of age. This suggests that excessive screen time during this critical period may interfere with the neural processes underlying language acquisition, leading to delays in language development.[18,19]

The displacement hypothesis proposes that screen time may displace other activities that are beneficial for child development, such as play, reading, and social interaction. The results of this study support this hypothesis, as increased screen time was associated with lower engagement in language-rich activities and less frequent reading by parents. Screen time may not only the quantity of language input but also the quality of interaction, as parents may be less

attentive and responsive to their children's communication attempts while using screens. While the overall negative association between screen time and language development is clear, it is important to acknowledge that not all screen time is created equal. The type of content, the context in which it is viewed, and the child's age and developmental stage can all influence the impact on language skills. Educational content, co-viewing with a parent, and interactive media may have different effects than passive viewing of entertainment content. Future research should delve deeper into these nuances to develop evidence-based recommendations for screen time use in young children.[19,20]

## 5. Conclusion

This study provides compelling evidence for the negative association between screen time and language development in Indonesian children under five. The findings underscore the importance of limiting screen time and fostering language-rich interactions during the crucial early years. While further research is needed to establish causal relationships and explore the nuances of this complex issue, the current findings call for immediate action to promote healthy screen time habits and support language development in young children.

## 6. References

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