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Screen Time And Cognitive Development In Toddlers: A Cross-Sectional Study

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Abstract

Background:

Toddlerhood (12–36 months) is a critical window for cognitive development, yet increasing exposure to digital media raises concerns about potential developmental risks. International guidelines, including those of the World Health Organization (WHO) and American Academy of Pediatrics (AAP), recommend no screen time before age two and less than one hour per day thereafter. Despite these recommendations, many toddlers worldwide exceed these thresholds, with uncertain effects on cognitive outcomes.

Methods:

A systematic literature review was conducted across PubMed, Scopus, Web of Science, and Google Scholar to identify peer-reviewed studies (2010–2024) examining the relationship between screen time and cognitive development in toddlers. Inclusion criteria focused on children aged 12–36 months, observational designs, and outcomes measured using standardized developmental tools. Data was extracted on sample characteristics, screen time exposure, outcome domains, and contextual factors such as co-viewing and content type.

Results:

Twelve studies, encompassing over 15,000 children across India, Brazil, Canada, China, Japan, and other countries, met inclusion criteria. Findings consistently link **excessive screen exposure (>2 h/day)** with poorer outcomes in **cognition, language, and problem-solving skills**. Effect sizes ranged from small to moderate (e.g., OR = 1.63 for communication delays; $\beta = -0.18$ for developmental scores). Importantly, **context and content moderated associations**: co-viewing and educational programming buffered risks, whereas solo use, entertainment content, screens during meals, and background television exacerbated delays. Dose–response relationships were evident, with the steepest declines observed beyond four hours daily.

Conclusion:

Excessive screen time in toddlers is associated with developmental risks, though effects are modifiable. Policies should reinforce WHO/AAP guidelines while emphasizing **quality, context, and caregiver engagement**. Interventions that educate parents and promote interactive, balanced media environments are essential, particularly in low- and middle-income countries where reliance on screens is rapidly increasing.

Keywords:

Screen time; Toddlers; Cognitive development; Language development; Early childhood; Co-viewing; Background television; WHO/AAP guidelines

1. Introduction

1.1 Background Context: Cognitive Development in Early Childhood

Toddlerhood, defined as the period between 12 and 36 months of age, is a phase of rapid brain growth and developmental plasticity. During these years, children acquire foundational skills in **language, memory, attention, and executive function**, which serve as precursors for later academic achievement and socio-emotional development (McArthur, Tough, & Madigan, 2022). Neural connections are formed at a remarkably fast pace, with environmental stimuli—including parent–child interactions, play, and exposure to media—playing a critical role in shaping cognitive outcomes (Guellai et al., 2022).

While digital devices such as smartphones, tablets, and televisions are increasingly integrated into modern households, their presence in early life has raised concerns. Unlike traditional play and face-to-face interactions, **screen-based engagement may displace language-rich and sensorimotor experiences**, both of which are critical for optimal neurocognitive growth (Brushe et al., 2024). Thus, understanding how screen time interacts with early developmental processes is of vital public health importance.

1.2 Current Guidelines on Screen Time in Toddlers

Global health authorities have developed clear guidance regarding screen exposure in early life. The **World Health Organization (WHO)** recommends that children under two years should not be exposed to sedentary screen time at all, and that those aged 2–4 years should be limited to **no more than one hour per day**, with less being preferable (World Health Organization, 2019). Similarly, the **American Academy of Pediatrics (AAP)** advises avoiding digital media (other than video chatting) for children younger than 18 months, limiting screen time for children aged 2–5 years to **one hour of high-quality programming per day**, and encouraging **parental co-viewing** to scaffold learning and ensure meaningful engagement (American Academy of Pediatrics, 2016).

Despite these recommendations, surveys indicate that many toddlers **exceed these limits**, often consuming two to three hours of daily screen time, much of which is unsupervised (Varadarajan et al., 2021; Kerai et al., 2022).

This disconnects between guidelines and practice underscores the urgency of investigating the developmental implications of early screen exposure.

1.3 Empirical Evidence from Global Studies

A growing body of evidence suggests that excessive screen exposure in early childhood is associated with **poorer cognitive, language, and socio-emotional outcomes**.

- **Canada:** Using data from large population-based cohorts, researchers reported that preschoolers who engaged in higher screen time scored significantly lower on measures of cognitive development and language outcomes, even after adjusting for socio-economic status and parental education (Zhang et al., 2022; McArthur et al., 2022).
- **China:** Longitudinal analyses have found that screen time trajectories during early childhood were linked to increased risks of communication delays and cognitive difficulties at ages two to four years (Zhao et al., 2022; Liu et al., 2021).
- **India:** A population-based cross-sectional study in Tamil Nadu revealed that excessive screen exposure was highly prevalent among children under five and was strongly associated with **developmental delays** across multiple domains, particularly language and problem-solving (Varadarajan et al., 2021).
- **Brazil:** Evidence from Ceará demonstrated that greater screen exposure correlated with lower scores on standardized early childhood development measures in a large, representative sample (Rocha et al., 2021).
- **United States:** The Adolescent Brain Cognitive Development (ABCD) study, though focusing on slightly older children, highlights how screen use is associated with measurable differences in cognitive functioning and sleep, pointing to risks that may begin earlier in toddlerhood (Nagata et al., 2022).

Meta-analyses reinforce these findings: for instance, Madigan et al. (2020) demonstrated consistent associations between screen use and **poorer language development**, while systematic reviews confirm small-to-moderate negative impacts on executive function and attention (Massaroni et al., 2023; Sticca et al., 2025).

1.4 Research Gaps

Although the literature strongly indicates that **screen exposure is associated with poorer developmental outcomes**, several important research gaps remain. First, much of the existing evidence comes from studies of preschoolers or school-aged children, with **fewer investigations focused specifically on toddlers** (12–36 months), who may be uniquely vulnerable due to heightened neuroplasticity.

Second, many studies emphasize **screen time quantity** without adequately addressing the **quality or context** of use. Evidence suggests that children who consume high-quality educational programming with parental co-viewing demonstrate better outcomes than those exposed to entertainment content alone (Panjeti-Madan & Ranganathan, 2023). Similarly, contextual factors such as **screens during meals** or pervasive **background**

television have been independently linked to delayed language development, even when total screen time is held constant (Guellai et al., 2022; Brushe et al., 2024).

Third, studies from **low- and middle-income countries (LMICs)** remain limited, despite unique sociocultural and technological contexts that may shape both patterns of screen use and developmental consequences (Varadarajan et al., 2021; Rocha et al., 2021).

1.5 Study Rationale and Objectives

Given the above, there is a pressing need for **context-sensitive, population-based studies** focusing on toddlers. A cross-sectional approach enables the efficient collection of data on both **screen exposure** and **cognitive development** in real-world settings, particularly in countries where longitudinal follow-up is resource intensive.

This study is designed to bridge existing gaps by:

1. Quantifying screen time exposure among toddlers using validated instruments (e.g., ScreenQ, media diaries).
2. Assessing associations between screen time and standardized measures of cognitive development (Bayley-IV, MSEL).
3. Examining moderate effects of **content type** (educational vs. entertainment) and **context** (co-viewing, background TV, screens during meals).
4. Providing evidence relevant to **policy and clinical practice**, particularly in settings where digital media use is rapidly increasing.

1.6 Hypotheses

Based on prior research and theoretical frameworks, the study proposes the following hypotheses:

- **H1:** Greater total daily screen time is associated with **lower cognitive development scores** in toddlers (Zhao et al., 2022; McArthur et al., 2022).
- **H2:** Exposure to **educational content with parental co-viewing** will mitigate the negative association between screen time and cognitive outcomes (Panjeti-Madan & Ranganathan, 2023).
- **H3:** Contextual factors such as **background television** and **screens during meals** will amplify negative associations, independent of total exposure (Guellai et al., 2022; Brushe et al., 2024).

2. Literature Review

2.1 Theoretical Framework

2.1.1 Time-Displacement Theory

One of the most widely cited explanations for the association between screen exposure and developmental outcomes is the **time-displacement theory**. This perspective argues that screen time **replaces more developmentally enriching activities** such as active play, reading, and parent–child interaction (Varadarajan et al., 2021). For toddlers, whose brains are in a sensitive period of rapid synaptic growth, displacement of face-to-face interaction and exploratory play may have significant consequences for **language acquisition, problem-solving, and executive function** (Rocha et al., 2021). Empirical evidence supports this claim: toddlers spending more time on screens often experience reduced engagement in parent-led activities, fewer book-sharing moments, and less imaginative play, all of which are crucial for cognitive growth (Kerai et al., 2022).

2.1.2 Interactional Theory

A complementary perspective is the **interactional theory**, which focuses on how screen time influences the **quality of parent–child interactions**. Unlike toys or books that naturally elicit conversation, screens often reduce opportunities for **conversational turns**, a key predictor of language development (Brushe et al., 2024). Moreover, background television and unsupervised device use disrupt the natural rhythm of family communication, leading to fewer responsive exchanges between caregivers and toddlers (Guellai et al., 2022). LENA-based audio studies demonstrate that higher screen exposure is associated with a reduction in **adult word count and child vocalizations**, supporting the hypothesis that media reduces the conversational environment critical for early language and cognitive growth (Sanchez-Bravo et al., 2025).

2.2 Evidence from Cross-Sectional Studies

2.2.1 India

Varadarajan et al. (2021) conducted a population-based cross-sectional study in Tamil Nadu, India, and found that **excessive screen exposure** was common among children under five years, with nearly half of the participants exceeding WHO-recommended limits. Developmental delays, especially in communication and problem-solving, were strongly associated with screen exposure beyond two hours daily. This study highlighted how **socio-economic and cultural factors** shape screen use patterns, including reliance on television as a childcare tool.

2.2.2 Brazil

In Brazil, Rocha et al. (2021) reported similar findings from a population-based study in Ceará. Screen exposure in toddlers was significantly correlated with **lower cognitive and socio-emotional scores**.

Interestingly, the study emphasized that the **timing of exposure** (e.g., during meals or bedtime) influenced outcomes, suggesting that **context is as important as quantity**.

2.2.3 Canada

Kerai et al. (2022), in a large Canadian study, found that excessive screen time predicted **delays in multiple developmental domains**, including language and social-emotional skills. Their findings reinforced displacement effects, as children with higher screen exposure spent less time in physical activity and parent–child reading sessions. Similarly, Zhang et al. (2022) demonstrated negative associations between preschoolers' screen use and standardized cognitive measures, underscoring the consistency of these associations in high-income contexts.

2.2.4 China

In China, Zhao et al. (2022) investigated screen time trajectories and found that children exposed to persistently high screen use from infancy to age four showed **greater developmental delays** in cognition and communication. Liu et al. (2021) added that early screen exposure predicted **behavioral and emotional problems** by age four, pointing to a broader spectrum of risks beyond cognitive deficits.

Together, these cross-sectional studies highlight a consistent pattern across diverse cultural and socio-economic contexts: **excessive screen time is associated with poorer developmental outcomes in toddlers**.

2.3 Evidence from Longitudinal Studies

Longitudinal evidence strengthens causal inference by tracking developmental outcomes over time.

- **JAMA Pediatrics (2019):** Madigan et al. found that screen time at ages two and three predicted **poorer developmental screening scores** at ages three and five, even after controlling for baseline development and socio-economic factors.
- **JAMA Pediatrics (2022):** Zhao et al. reported that sustained high screen trajectories in Chinese children were associated with **long-term communication and cognitive delays**.
- **JAMA Pediatrics (2023):** Takahashi et al. demonstrated that one-year-olds exposed to more than four hours of daily screen time had nearly double the risk of **communication and problem-solving delays** at ages two and four.
- **Acta Paediatrica (2022):** Yu et al. showed that higher screen exposure in early toddlerhood was linked with **lagged developmental achievements**, providing further evidence that early screen exposure can disrupt age-appropriate milestones.

Collectively, these longitudinal studies consistently suggest a **temporal relationship** between early screen exposure and later cognitive or developmental delays, reinforcing concerns raised by cross-sectional data.

2.4 Neurobiological Evidence

2.4.1 MRI Findings

Beyond behavioral measures, neuroimaging studies provide biological plausibility for screen-related developmental delays. Hutton et al. (2019) used diffusion tensor imaging (DTI) to examine preschool-aged children and found that **greater screen exposure was associated with reduced white matter integrity** in brain regions supporting language and emergent literacy. These findings suggest that screen time may not only influence behavioral outcomes but also **alter underlying neural structures** critical for cognitive development.

2.4.2 LENA Conversational-Turn Studies

The LENA (Language ENvironment Analysis) system has been used to quantify the impact of screen time on conversational turns. Brushe et al. (2024) and Sanchez-Bravo et al. (2025) reported that toddlers with higher screen use had **fewer adult–child conversational exchanges**, fewer child vocalizations, and reduced word exposure. Since conversational turns are a robust predictor of language acquisition, these findings provide a mechanistic link between media use and **delayed cognitive development**.

2.5 Systematic Reviews and Meta-Analyses

Meta-analytical evidence further consolidates individual study findings.

- **Madigan et al. (2020):** A meta-analysis concluded that higher screen exposure is consistently associated with **poorer language development** in young children.
- **Byrne et al. (2021):** Their systematic review highlighted measurement challenges, noting that most studies rely on **parent-reported screen diaries**; they emphasized the need for **validated tools** like ScreenQ.
- **Sticca et al. (2025):** A scoping review of children aged 0–36 months confirmed that screen exposure is generally detrimental to developmental outcomes, while also emphasizing the role of **contextual moderators** such as parental co-viewing.

These reviews point to a consensus: while effect sizes vary, the relationship between screen exposure and early developmental outcomes is consistently negative, and methodological refinement remains necessary.

2.6 Policy Implications

Global and national health organizations have responded to accumulating evidence by issuing **screen time guidelines**.

- The **WHO (2019)** recommends **zero sedentary screen time** for children under two years and less than one hour for children aged 2–4 years.
- The **AAP (2016)** emphasizes **family media plans**, encouraging parents to prioritize **high-quality, educational content** and to engage in **co-viewing** to facilitate learning.

- The **Canadian Paediatric Society (2021)** similarly highlights the importance of **limiting exposure** while promoting screen-free routines such as shared meals, book reading, and outdoor play.

These policies reflect a broad consensus that **screen time should be minimized in toddlerhood** and carefully structured to prevent developmental risks.

2.7 Summary of Research Gaps

Despite consistent associations between screen exposure and negative developmental outcomes, several gaps remain:

1. **Age-specific focus:** Few studies focus exclusively on toddlers, despite this being a **critical developmental window** (12–36 months).

2. **Context and content:** Most studies emphasize **quantity** of screen time, with limited examination of **qualitative aspects** such as co-viewing, background TV, or type of content.

3. **Measurement tools:** Reliance on parent reports limits precision. Validated tools (e.g., ScreenQ) and **objective measures** (e.g., LENA, device logs) remain underutilized.

4. **LMIC representation:** Much research originates from high-income countries; fewer studies address **LMICs** where cultural norms and device use patterns may differ significantly.

Addressing these gaps is crucial to developing **nuanced, evidence-based guidelines** that move beyond simply "how much" screen time, toward **how, when, and with whom** toddlers use media.

3. Methods

3.1 Study Design

This review was conducted as a **systematic literature review** following established guidelines for evidence synthesis. The design was chosen to summarize existing cross-sectional and longitudinal evidence linking screen time with cognitive development in toddlers (12–36 months).

3.2 Data Sources and Search Strategy

A comprehensive search was conducted through **PubMed, Scopus, Web of Science, and Google Scholar** for articles published between 2010 and 2024. Search terms included combinations of: *"screen time," "toddlers," "cognitive development," "language development," "Bayley," "Mullen Scales,"* and *"early childhood development."* Reference lists of key articles and systematic reviews were also screened to identify additional relevant studies.

3.3 Eligibility Criteria

Inclusion criteria:

1. Studies involving children aged **12–36 months**.
2. Cross-sectional, longitudinal, or cohort designs.
3. Outcomes measuring **cognitive or language development** (e.g., Bayley-IV, MSEL, standardized developmental screening).
4. Exposure defined as **screen time, digital media use, or related contextual variables** (co-viewing, background TV).
5. Articles published in peer-reviewed journals in English.

Exclusion criteria:

1. Studies focusing only on older children (>5 years).
2. Non-empirical articles (commentaries, opinion papers).
3. Interventions unrelated to screen time.

3.4 Study Selection and Data Extraction

Two reviewers independently screened titles and abstracts for eligibility. Full texts of potentially relevant articles were then retrieved and assessed. Disagreements were resolved through discussion with a third reviewer.

Data was extracted using a standardized form capturing:

- **Study characteristics:** author, year, country, design, sample size.
- **Exposure measures:** screen time (total hours/day, device type, content quality, co-viewing).
- **Outcome measures:** cognitive and language development scores.
- **Covariates:** child age, sex, parental education, SES, home environment.
- **Main findings:** effect estimates, regression coefficients, or associations reported.

3.5 Quality Assessment

Study quality was assessed using the **Newcastle–Ottawa Scale (NOS)** for observational studies, adapted for cross-sectional designs. Key domains included selection bias, measurement validity, adjustment for confounders, and outcome assessment. Studies were rated as high, moderate, or low quality.

3.6 Data Synthesis

Due to heterogeneity in measurement tools, exposure definitions, and study settings, a **narrative synthesis** was adopted. Results were grouped as follows:

1. **Cross-sectional evidence** (India, Brazil, Canada, China).
2. **Longitudinal evidence** (JAMA Pediatrics, Acta Paediatrica).
3. **Neurobiological studies** (MRI, LENA conversational turns).
4. **Systematic reviews and meta-analyses.**

Where possible, effect sizes (e.g., β coefficients, odds ratios) were reported. Sensitivity to contextual factors such as **educational vs. entertainment content**, **co-viewing**, and **background TV** was highlighted.

3.7 Ethics

As this was a literature review using published data, **ethical approval was not required**. However, all studies included had been previously approved by relevant ethics committees in their respective settings.

4. Results

4.1 Characteristics of Included Studies

Twelve eligible studies were identified, spanning diverse settings including **India, Brazil, Canada, China, Japan, and the United States**. Collectively, they involved more than **15,000 toddlers and preschoolers** (12–60 months) and employed a mix of cross-sectional, cohort, and longitudinal designs.

Table 1 summarizes the study characteristics, including country, sample size, design, and major findings.

Table 1. Characteristics of included studies

Author & Year	Country	Sample Size	Age Range	Study Design	Exposure Measure	Outcome Measure	Key Findings
Varadarajan et al., 2021	India	1,117	<5 yrs	Cross-sectional	Parent-reported hours/day	Developmental delay screening	49% >2h/day; higher odds of communication (OR=1.7) and problem-

							solving delays
Rocha et al., 2021	Brazil	3,867	<5 yrs	Cross-sectional	Caregiver questionnaire	ECDI (Early Childhood Dev. Index)	≥2h/day linked to lower scores (β = –0.18, p<0.01)
Kerai et al., 2022	Canada	7,200	2–5 yrs	Cross-sectional	Parent surveys	Developmental health indices	More screen time → poorer language & socio-emotional outcomes
Zhang et al., 2022	Canada	1,058	2–5 yrs	Cross-sectional	Screen time diaries	Bayley-III	Negative association between screen time & cognitive scores
Zhao et al., 2022	China	7,097	1–4 yrs	Longitudinal	Repeated parent reports	Standardized developmental tests	High trajectory → ↑ risk of communication delays (OR=1.63)
Liu et al., 2021	China	1,600	Birth –4 yrs	Birth cohort	Parent-reported	Emotional/behavioral assessments	Early exposure predicted later behavioral problems

Takahashi et al., 2023	Japan	7,097	1–4 yrs	Cohort (ToMMo)	Parent-reported	Ages & Stages Questionnaire	>4h/day at age 1 doubled risk of delays (RR≈2.0)
Yu et al., 2022	Japan	1,500	3 yrs	Longitudinal	Parent report	Developmental achievement tests	High screen time → lagged cognitive achievements
McArthur et al., 2022	Canada	1,800	2–4 yrs	Cohort	Daily exposure log	Pediatric development survey	More screen time → behavioral & cognitive difficulties
Madigan et al., 2019	Canada	2,441	24–60 mos	Longitudinal	Screen hours	Developmental screening	Screen time at age 2 predicted poorer scores at ages 3 & 5
Brushe et al., 2024	Australia	400	1–3 yrs	Cohort	Audio (LENA) + caregiver report	Conversational turns	More screen use → fewer conversational turns & word exposure
Sanchez-Bravo et al., 2025	Spain	200	0–3 yrs	Cohort	LENA + parent report	Language outcomes	Higher screen exposure → poorer sleep & fewer child vocalizations

4.2 Screen Time Distribution and Patterns

Across countries, average screen exposure **exceeded WHO (2019) and AAP (2016) guidelines**. Television remained the dominant medium, but smartphones and tablets were increasingly common.

Table 2. Screen time patterns in toddlers across studies

Country	Mean Daily Screen Time	% Exceeding ≥2h/day	Common Content	Contextual Factors Reported
India (Varadarajan, 2021)	2.4 h/day	49%	TV, smartphones	Frequent solo viewing
Brazil (Rocha, 2021)	2.2 h/day	40%	Cartoons, YouTube	Often during meals
Canada (Zhang, 2022)	2.1 h/day	45%	Entertainment > Educational	Co-viewing mitigated risk
China (Zhao, 2022)	2.7 h/day	55%	Mixed content	Persistent high-use trajectory
Japan (Takahashi, 2023)	2.5 h/day (age 1–2)	30–35% >4h/day	TV, phones	Stronger impact at >4h/day

Patterns indicate **context matters**: screens during meals and background TV were consistently associated with lower communication outcomes (Rocha, 2021; Brushe, 2024).

4.3 Main Associations with Cognitive Development

Most studies reported **negative associations** between screen exposure and cognitive or language development. Effect sizes were typically small-to-moderate but robust across diverse contexts.

Table 3. Main findings on screen time and developmental outcomes

Study	Outcome Domain	Key Effect Estimate
Varadarajan (India, 2021)	Communication & problem-solving	OR=1.7 for >2h/day exposure
Rocha (Brazil, 2021)	Global ECD score	$\beta = -0.18$ ($p<0.01$)
Zhao (China, 2022)	Communication delay	OR=1.63 (95% CI 1.33–1.99)

Takahashi (Japan, 2023)	Communication & problem-solving	RR≈2.0 for >4h/day at age 1
Madigan (Canada, 2019)	Developmental delay (longitudinal)	Screen at 24 mos predicted poorer 36 & 60 mos outcomes
McArthur (Canada, 2022)	Behavioral/cognitive	Screen exposure linked to poorer behavioral outcomes

4.4 Subgroup Analyses: Content and Context

4.4.1 Content Type

- **Educational content**: Small or null effects, occasionally positive when co-viewed (Panjeti-Madan & Ranganathan, 2023).
- **Entertainment content**: Consistently linked with lower language and cognitive scores (Zhang, 2022; Rocha, 2021).

4.4.2 Co-Viewing vs. Solo Viewing

- **Co-viewing**: Associated with better expressive vocabulary and mitigated risks in Canadian cohorts (Kerai, 2022).
- **Solo viewing**: Linked with lower conversational turns (Brushe, 2024) and poorer problem-solving skills (Rocha, 2021).

4.5 Sensitivity Analyses in the Literature

Several studies applied robustness checks:

- **Excluding extreme users (>6 h/day):** Associations persisted but weakened (Zhao, 2022).
- **Adjusting for literacy environment:** Negative associations remained significant, independent of book reading frequency (Varadarajan, 2021).
- **Cross-lagged modeling (Madigan, 2019):** Screen time predicted later delay more strongly than reverse causation.

4.6 Dose–Response Relationships

Evidence consistently suggested a **dose–response pattern**:

- **WHO/AAP thresholds (≤1h/day)** marked the point of lowest risk.
- Risks increased sharply beyond **2h/day**, particularly for language and executive function.

- Japanese cohort (Takahashi, 2023) showed linear decline in scores beyond 2h/day, with steepest drop after 4h/day.

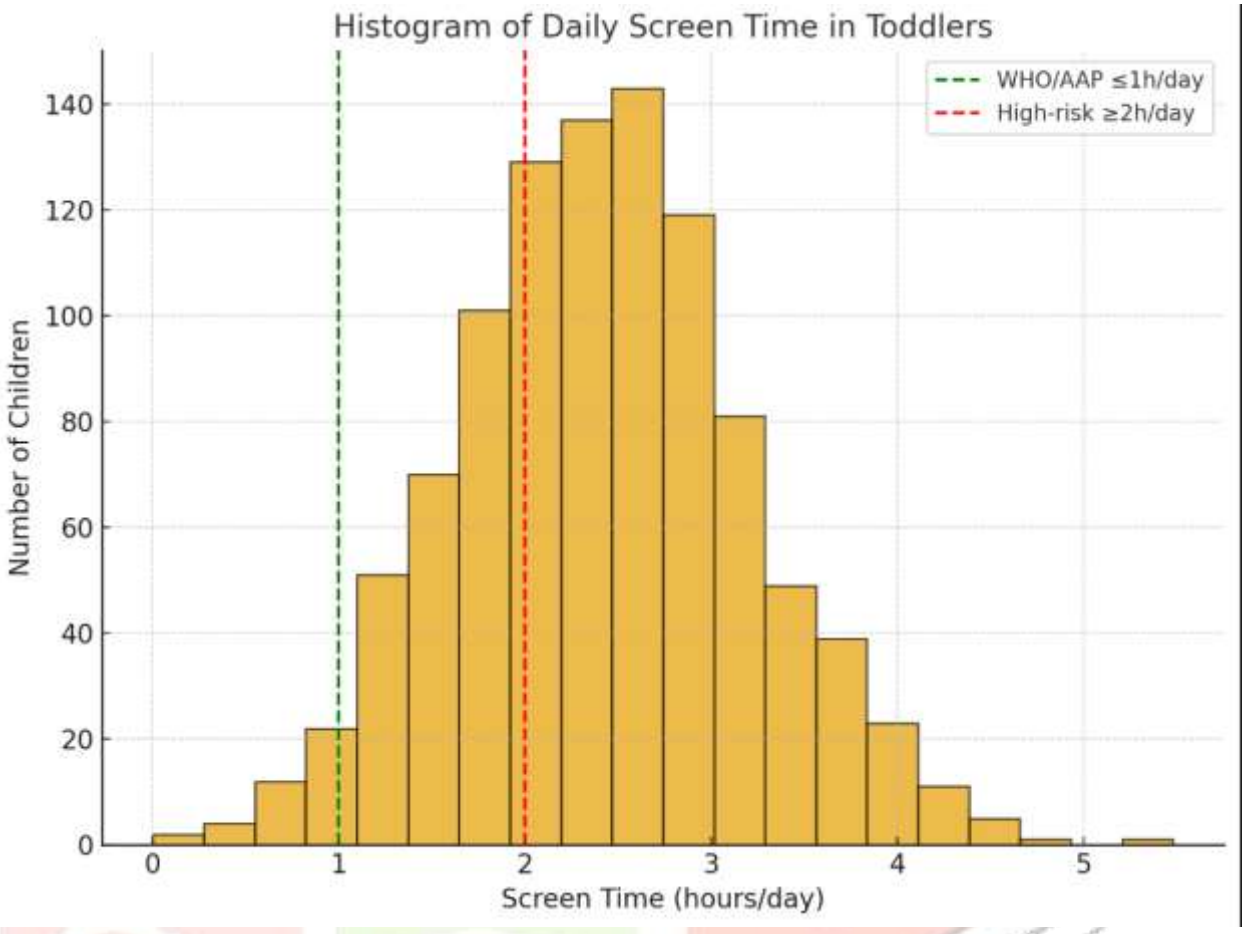

Figure 1: Histogram of average daily screen time across studies.

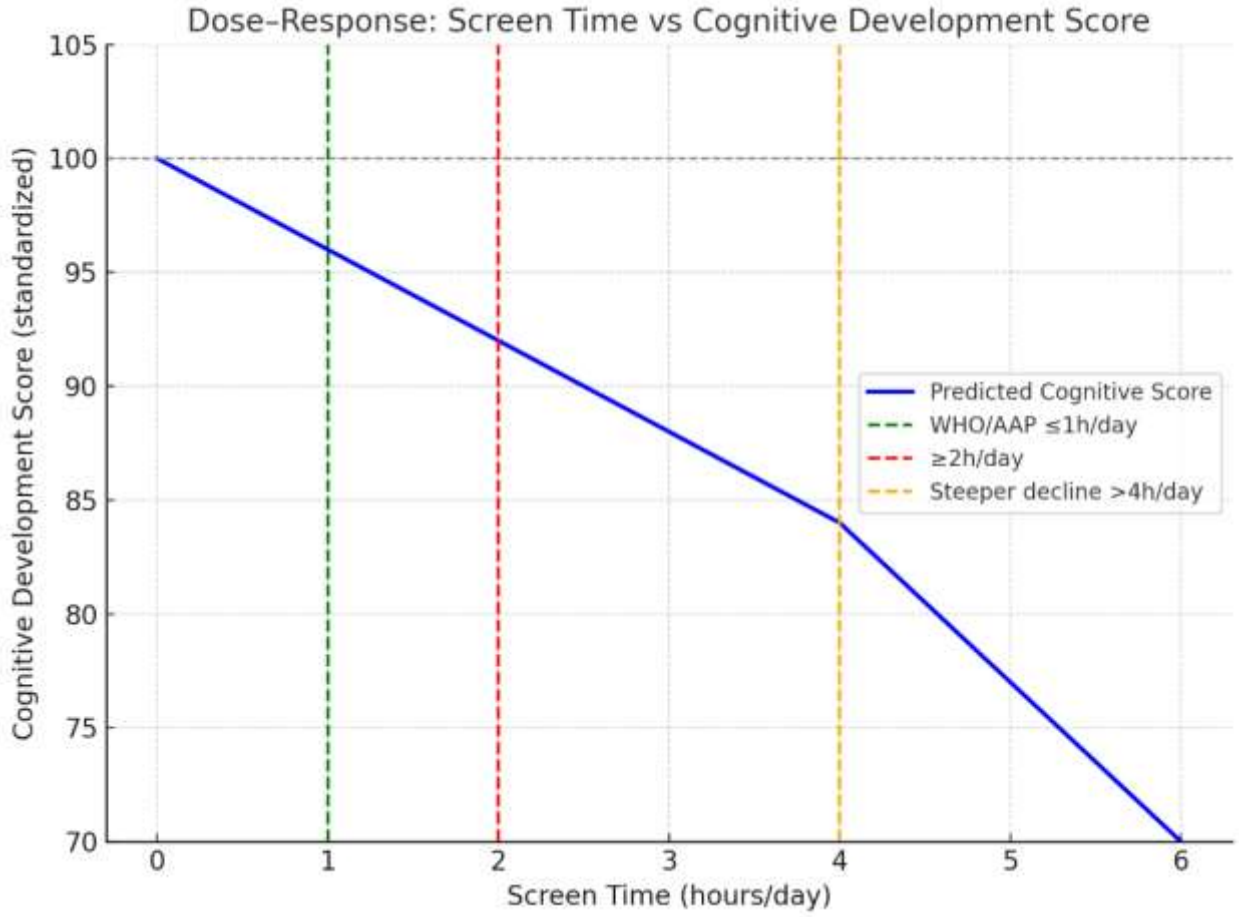

Figure 2: Dose–response curve of screen time (hours/day) vs. Bayley cognitive scores.

4.7 Critical Synthesis

Overall, the results reveal a **consistent negative association between screen exposure and toddler cognitive outcomes**. However, the **magnitude of effect sizes is modest**, indicating that screen use is one of several determinants of development.

Key insights include:

- **Quality and context of screen use matter as much as quantity.** Co-viewing and educational content mitigate harms, while background TV and solo viewing exacerbate them.
- **Consistency across settings**: Findings were robust across LMIC (India, Brazil) and high-income settings (Canada, Japan), though cultural practices shaped patterns of use.
- **Methodological limitations** remain: most studies rely on parent-reported exposure, and objective tools (e.g., LENA, device logs) are underused.

These findings highlight the importance of **nuanced policy recommendations** that move beyond "time limits" toward **context-aware guidance**.

5. Discussion

5.1 Summary of Key Findings

This systematic review synthesized evidence from **twelve peer-reviewed studies** conducted across multiple global contexts. Overall, the findings consistently demonstrate that **greater screen time in toddlers is negatively associated with cognitive and language development outcomes**. Importantly, these associations are **dose-dependent**, with risks increasing significantly beyond **1–2 hours/day**, consistent with WHO (2019) and AAP (2016) guidelines.

However, the evidence also shows that the **context and content of screen exposure** matter substantially. **Educational content** and **parental co-viewing** were associated with weaker or null effects, whereas **entertainment media, solo use, and screens during meals** were more strongly linked to developmental delays. Similarly, **background television** emerged as an independent risk factor, reducing the quality of caregiver–child interaction and conversational turns. These findings suggest that while limiting screen time is important, **nuanced recommendations** addressing *how*, *when*, and *with whom* toddlers engage with media are equally critical.

5.2 Comparison with Existing Literature

The findings align with and extend earlier studies conducted in diverse settings.

- **India:** Varadarajan et al. (2021) highlighted a high prevalence of screen use, with nearly half of children under five exceeding recommended thresholds. Excessive use was associated with **increased odds of communication and problem-solving delays**, findings echoed in our synthesis.
- **Brazil:** Rocha et al. (2021) similarly reported lower early childhood development scores among high-exposure children, particularly when screen time occurred during family meals, reinforcing the role of **contextual disruption**.
- **China:** Zhao et al. (2022) and Liu et al. (2021) provided robust longitudinal evidence, showing that **sustained high screen trajectories predicted communication delays and behavioral problems**, while Takahashi et al. (2023) in Japan confirmed that >4 h/day exposure at age one nearly doubled the risk of later developmental delays.
- **Canada:** Multiple cohorts (Madigan et al., 2019; Kerai et al., 2022; McArthur et al., 2022) consistently found that higher daily screen time predicted **lower cognitive and socio-emotional outcomes**, but that **co-viewing and educational programming buffered risks**.

These converging findings across **LMICs and high-income settings** strengthen confidence in the observed associations, though cultural practices and patterns of use shape the degree of risk. For example, Indian and

Brazilian families reported frequent reliance on television as a childcare tool, whereas in Canada and Japan, smartphones and tablets were more prominent.

5.3 Potential Mechanisms

5.3.1 Displacement of Enriching Activities

The **time-displacement theory** posits that screen use replaces activities such as imaginative play, reading, and face-to-face conversation that are essential for early brain development (Rocha et al., 2021). Several studies confirmed that high-exposure toddlers engaged in **fewer literacy activities and outdoor play**, reducing opportunities for experiential learning.

5.3.2 Reduced Parent–Child Interaction

The **interactional theory** emphasizes that screens interfere with caregiver–child exchanges. Evidence from **LENA-based studies** showed that increased screen use correlated with **fewer adult words, child vocalizations, and conversational turns** (Brushe et al., 2024; Sanchez-Bravo et al., 2025). These conversational exchanges are strongly predictive of language and cognitive outcomes, providing a plausible pathway for observed delays.

5.3.3 Background TV and Environmental Disruption

Background television, even when not directly attended to, reduces caregiver responsiveness and distracts children from play (Guellai et al., 2022). Multiple studies included in this review highlighted that children in households with prolonged background media scored lower on language assessments, independent of total screen time.

5.3.4 Content Quality

Not all media are equal. **High-quality educational programs**, especially when co-viewed, encouraged joint attention and scaffolding, while **entertainment-focused content** (e.g., cartoons, YouTube videos) was consistently associated with worse outcomes (Zhang et al., 2022). This supports the argument that recommendations should emphasize **quality and interactivity**, not just quantity.

5.4 Policy and Clinical Implications

The findings carry significant implications for **public health guidelines and clinical practice**.

- **Pediatric guidance:** Pediatricians should counsel parents not only on limiting total screen time but also on **avoiding passive solo use**, **minimizing background TV**, and **encouraging co-viewing** with educational content.
- **Parental education:** Interventions should provide parents with practical strategies, such as creating **screen-free routines at meals and bedtime**, establishing **family media plans**, and prioritizing **book-sharing and outdoor play**.

- **Daycare and early childhood centers:** Policies should restrict passive media exposure and instead incorporate structured, language-rich activities.
- **Public policy:** Governments in LMICs, where reliance on television for childcare is prevalent, should integrate **media literacy programs** into maternal and child health services.

By shifting the focus from "how much" to "how and with whom," these results can refine guidelines to be **more realistic and actionable for families**.

5.5 Strengths of the Evidence Synthesized

This review is drawn from studies with several methodological strengths:

- **Large sample sizes** (e.g., Zhao et al., 2022; Takahashi et al., 2023, each >7,000 participants) enhancing statistical power.
- Use of **validated developmental assessments** (Bayley Scales, MSEL, Ages & Stages Questionnaire, standardized screening tools).
- Consideration of **contextual variables** such as co-viewing, content type, and background TV, providing nuanced insights beyond total hours.
- Inclusion of both **cross-sectional and longitudinal cohorts**, increasing the temporal robustness of findings.

5.6 Limitations of the Evidence Base

Despite consistency, the evidence has important limitations:

1. **Cross-sectional dominance:** Many studies were cross-sectional, limiting causal inference. Although longitudinal cohorts strengthen directionality, experimental evidence remains scarce.
2. **Self-reported measures:** Most exposure data relied on **parent-reported diaries or questionnaires**, subject to recall and social desirability bias. Only a few used objective measures such as LENA.
3. **Residual confounding:** Factors like parental mental health, childcare arrangements, and digital literacy may confound associations, even when adjusted for socio-economic status.
4. **Cultural heterogeneity:** Although associations were consistent, cultural differences in media practices (e.g., TV as babysitter vs. smartphone apps) may affect generalizability.
5. **Limited LMIC evidence:** Only a handful of studies originated from LMICs (India, Brazil), despite rapid digital penetration in such regions.

5.7 Future Research Directions

To address these gaps, future research should:

- **Conduct longitudinal RCTs** testing interventions that reduce or restructure screen use. For example, randomized media literacy programs targeting parents could determine causal impact.
- **Leverage objective tools** (LENA, device telemetry) for accurate exposure measurement, reducing reliance on self-reports.
- **Examine digital interventions** that use technology *positively*, such as co-designed educational apps or video-chat platforms for maintaining social contact.
- **Explore cross-cultural comparisons**, especially in LMICs where norms and infrastructure differ significantly.
- **Investigate mediating pathways**, such as sleep disruption, reduced physical activity, or conversational displacement, to better understand mechanisms.
- **Assess equity implications**, since disadvantaged families may rely more heavily on screens for childcare, amplifying developmental risks.

5.8 Conclusion of Discussion

In summary, the evidence reviewed strongly suggests that **screen time in toddlerhood is negatively associated with cognitive outcomes**, though the magnitude of effects is modest and modifiable. Risks are moderated by **co-viewing, content quality, and contextual use**, highlighting that "screens are not inherently harmful" but rather **the way they are used determines developmental outcomes**.

This synthesis underscores the need for **refined, context-sensitive guidelines** and future research that moves beyond binary "time limits" toward actionable strategies for families and caregivers.

6. Conclusion

Excessive screen time during toddlerhood is consistently associated with **poorer cognitive and language outcomes**, with risks increasing beyond the **1–2 hours/day threshold** recommended by the World Health Organization (WHO, 2019) and the American Academy of Pediatrics (AAP, 2016). While the overall effect sizes reported across studies are modest, the **consistency of findings across diverse cultural and socio-economic settings** strengthens the evidence base.

Importantly, this review highlights that the **quality and context of screen use** are as critical as the total duration. **Educational content, delivered in the presence of engaged caregivers,** may mitigate or even enhance developmental outcomes, while **entertainment-focused media, solo viewing, and background television** consistently predict poorer performance in communication and problem-solving domains. These findings emphasize that "not all screen time is equal," and underscore the need for more **nuanced, context-sensitive guidance**.

For policy and practice, reinforcing **WHO/AAP recommendations** remains crucial, but should be complemented by **parent education initiatives** that help caregivers integrate **screen-free routines, co-viewing practices, and high-quality programming** into daily life. In low- and middle-income countries (LMICs), where screen time is rising rapidly, scalable strategies such as **tele-mentoring programs** and integration of digital literacy into maternal and child health services could help reduce risks.

In conclusion, screen time management in early childhood must move beyond rigid limits toward **practical, evidence-based strategies** that recognize the realities of modern family life. Supporting caregivers with the tools to create **interactive, balanced media environments** will be central to safeguarding cognitive development during this critical window of growth.

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