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Tracing the Impact of Digital Environments on Virtual Autism: Etiological Factors and Behavioral Profiles

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ABSTRACT

The rising prevalence of "virtual autism," a condition linked to excessive early screen exposure leading to autism-like symptoms in children, necessitates systematic investigation. This study examines the etiological factors contributing to virtual autism and its behavioral profiles among children aged 2-6 years with high digital device exposure. Using a mixed-method design, parental screen exposure data, developmental milestones, and behavioral assessments were collected from 120 children (60 high-screen exposure, 60 low-screen exposure controls). Statistical analyses, including independent samples t-tests, chi-square tests, and regression analyses, were conducted to examine differences in developmental delays, social communication, sensory issues, and stereotypic behaviors. Results indicate a significant association between high early screen exposure and delays in language development ($p<0.001$), increased social withdrawal ($p<0.001$), and repetitive behaviors ($p=0.002$). Regression analysis further identified duration of daily screen exposure and absence of parental interactive engagement as significant predictors of virtual autism symptomatology. These findings underscore the urgent need for parental awareness, digital hygiene, and early intervention strategies to mitigate the impact of digital environments on child development.

Keywords: *Virtual autism, screen exposure, digital environment, behavioral profiles, early childhood development, parental involvement*

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1. INTRODUCTION

The rapid digitalization of contemporary society has fundamentally reshaped early childhood environments, with digital devices becoming ubiquitous in households across the globe. From tablets and smartphones to televisions and laptops, young children are increasingly exposed to screens during critical neurodevelopmental windows, a trend that has raised concerns among clinicians, researchers, and parents alike (American Academy of Pediatrics, 2016; Dong et al., 2020). While technology offers opportunities for education and entertainment, excessive and unsupervised screen exposure in early childhood has been implicated in a phenomenon termed “virtual autism,” wherein children develop symptoms resembling Autism Spectrum Disorder (ASD) due to environmental factors, particularly the lack of real-life social interactions and sensory experiences (Heffler & Oestreicher, 2016; Zamfir, 2018).

Virtual autism is characterized by delayed speech and language development, impaired social reciprocity, sensory dysregulation, and stereotypic behaviors, paralleling core features of ASD but with the potential for symptom reversibility upon reducing screen exposure and enhancing parent-child interactive engagements (Sigman, 2019; Knapton, 2015). This condition is increasingly reported among children aged 1-6 years who spend prolonged hours in passive screen consumption, often replacing vital developmental activities such as symbolic play, social interaction, and motor exploration that are essential for healthy brain development (Christakis et al., 2018; Harville et al., 2023).

Unlike classical ASD, which is influenced by multifactorial etiologies including genetic predispositions, perinatal factors, and neurobiological variations (Lord et al., 2020), virtual autism is primarily rooted in environmental deprivation resulting from excessive screen exposure during early developmental stages. Neurodevelopmental theories suggest that early exposure to screens can interfere with the maturation of neural circuits responsible for language, attention, and social cognition, potentially due to the overactivation of visual and auditory pathways without the reciprocal, contingent feedback inherent in human interactions (Duch et al., 2013; Kabali et al., 2015). Moreover, screen exposure may disrupt caregiver-child bonding and limit opportunities for responsive communication, which are critical for emotional and social development (Radesky et al., 2015).

Despite the emerging discourse on virtual autism, systematic empirical investigations into its etiological factors and behavioral profiles remain limited. Understanding the causal pathways and symptom manifestations associated with excessive screen exposure is essential to differentiate virtual autism from classical ASD and to inform preventive and intervention strategies. Identifying risk factors such as daily screen duration, parental interaction patterns, and the type of digital content consumed can guide the development of targeted guidelines and parental training programs aimed at fostering digital hygiene and mitigating the adverse developmental impacts of the digital environment on young children (Heffler et al., 2020; Zamfir, 2018).

Recent research has increasingly focused on the effects of digital environments on early childhood development, highlighting the risks associated with excessive screen exposure during critical neurodevelopmental periods. Heffler and Oestreicher (2016) proposed the concept of "virtual autism" to describe autism-like symptoms arising from environmental factors, particularly excessive screen use combined with reduced parent-child interactions. Their findings emphasized that early screen exposure might contribute to delays in language acquisition and social communication deficits, often mirroring symptoms observed in Autism Spectrum Disorder (ASD). Similarly, Zamfir (2018) reported a series of cases where children exhibiting autism-like behaviors showed marked improvements upon reducing screen time and introducing enriched social interactions, suggesting the potential reversibility of these symptoms when environmental conditions are modified.

A study by Kabali et al. (2015) found that a substantial proportion of children under the age of two were regularly exposed to mobile media, often without parental monitoring, raising concerns about the replacement of interactive play and communication with passive screen consumption. Christakis et al. (2018) further elaborated that prolonged screen exposure in early years can disrupt the development of attentional control and executive functions, potentially influencing neural connectivity patterns in ways that interfere with language and social processing. These concerns align with the American Academy of Pediatrics (2016) guidelines, which recommend limiting screen use for children under five years and emphasizing the need for caregiver-mediated, high-quality content when screens are used.

Neurological studies have demonstrated that the human brain develops through rich, multisensory experiences that involve reciprocal interactions with caregivers, which are critical for synaptic pruning and the maturation of social brain networks (Duch et al., 2013; Radesky et al., 2015). Excessive screen use, in contrast, offers overstimulating but non-contingent sensory input that may lead to dysregulated arousal systems and reduced opportunities for practicing social cues, emotional regulation, and motor exploration (Dong et al., 2020). This deprivation of socio-emotional experiences may contribute to the emergence of repetitive behaviors and social withdrawal, symptoms that closely parallel those seen in ASD (Harville et al., 2023).

Longitudinal studies also support the association between high screen time and developmental delays. For instance, Madigan et al. (2019) found that increased screen time at 24 months was associated with poorer performance on developmental screening tests at 36 months, particularly in language and social domains. Additionally, Heffler et al. (2020) observed that children with high early-life screen exposure displayed increased autism-like symptoms, including sensory sensitivities and communication challenges, compared to those with lower screen exposure, even after adjusting for confounding variables.

While the etiology of classical ASD involves complex interactions among genetic, epigenetic, and neurobiological factors (Lord et al., 2020), the literature increasingly distinguishes virtual autism as an environmentally induced condition that emerges primarily due to the lack of responsive social interactions and overstimulation from screens. Sigman (2019) emphasized that screen overuse disrupts critical bonding and attachment processes between the caregiver and child, which are foundational for socio-communicative development. This environmental deprivation hypothesis has been supported by case reports where interventions focusing on reducing screen time and promoting direct human interactions led to substantial behavioral improvements, differentiating virtual autism from classical ASD in terms of prognosis and reversibility (Knapton, 2015; Zamfir, 2018).

Collectively, the reviewed studies underscore the significance of early environmental factors, particularly digital environments, in shaping neurodevelopmental trajectories in young children. They highlight the need to systematically investigate the impact of screen exposure on the emergence of autism-like symptoms, identify risk factors such as daily screen duration and parental interaction quality, and differentiate between classical and virtual autism. Such efforts are essential for informing prevention and intervention strategies aimed at mitigating the adverse effects of excessive screen

exposure while promoting healthy developmental environments in the digital age.

The present study aims to address these research gaps by systematically examining the impact of digital environments on the emergence of virtual autism in children aged 2-6 years with high screen exposure. Using a mixed-method design, the study investigates the association between prolonged early screen exposure and developmental delays, social communication deficits, sensory issues, and stereotypic behaviors, while identifying key predictive factors contributing to the manifestation of virtual autism. By elucidating these associations, the study seeks to provide evidence-based recommendations for parents, educators, and clinicians to promote healthy digital practices and early interventions to safeguard the developmental trajectories of young children in the digital age.

2. METHODOLOGY

Research Design

This study employed a comparative, cross-sectional research design with a quantitative approach, complemented by direct behavioral observations, to examine the impact of early screen exposure on the emergence of virtual autism symptoms in children. The design allowed systematic comparison between children with high and low screen exposure while identifying predictive factors contributing to virtual autism symptomatology.

Area of Research

The research was conducted in urban and semi-urban regions of Raipur and Rajnandgaon districts in Chhattisgarh, India, where the availability of digital devices among households with young children is high, providing a relevant context for investigating the impact of digital environments on early childhood development.

Sample

The sample consisted of 120 children aged 2 to 6 years, divided into two equal groups based on their screen exposure. The high screen exposure group (n = 60) included children with daily screen exposure exceeding four hours per day, while the low screen exposure control group (n = 60) included children with daily screen exposure of less than one hour per day. Participants were recruited from pediatric outpatient clinics, anganwadi centers, and preschools, ensuring a diverse representation of socio-economic backgrounds within the study area.

Inclusion Criteria:

The inclusion criteria for the study were carefully defined to ensure the selection of an appropriate and reliable sample for assessing the impact of screen exposure on developmental outcomes. Children aged between 24 and 72 months (2 to 6 years) were included, covering the critical period of early childhood development where language, social, and cognitive skills rapidly evolve. It was essential that each child had a primary caregiver available and willing to participate in interviews and assessments to provide consistent and accurate developmental and screen exposure history. For the high screen exposure group, children were included only if there was documented evidence of screen exposure exceeding four hours per day, maintained consistently for at least the past six months, ensuring the study captured the prolonged effects of high screen time. In the control group, children were included if they had screen exposure of less than one hour per day, with this pattern also being consistent over the previous six months, to serve as a reliable baseline for comparison with the high-exposure group. These inclusion criteria ensured that the groups were distinctly defined, allowing for clear comparisons in developmental outcomes related to screen exposure patterns.

Exclusion Criteria

The exclusion criteria were established to minimize confounding variables that could interfere with the assessment of screen exposure effects on developmental outcomes in early childhood. Children with diagnosed neurological disorders such as epilepsy and cerebral palsy were excluded, as these conditions could independently affect developmental milestones and behavioral patterns. Similarly, children with a previous diagnosis of Autism Spectrum Disorder (ASD) were excluded to avoid overlap with core symptoms that could confound the identification of virtual autism features in the high screen exposure group. Children with uncorrected sensory impairments, including visual or hearing deficits, were also excluded, as these impairments could independently impact language development, social interaction, and behavioral responses. Additionally, children with chronic medical conditions requiring frequent hospitalization were excluded due to potential disruptions in routine activities and caregiver-child interactions that could influence developmental assessments. Finally, families unwilling to provide informed consent for participation were excluded to ensure ethical compliance and the voluntary nature of participation within the study framework. These exclusion criteria ensured that the study focused specifically on the impact of screen exposure on typical early childhood development without interference from pre-existing medical or developmental conditions.

Measures

Screen Exposure Questionnaire

A Screen Exposure Questionnaire was specifically developed for this study (investigator-designed) to capture detailed patterns of screen use among children, as there is currently no standardized instrument addressing all qualitative aspects of screen exposure in early childhood. The questionnaire included items on average daily screen duration (hours/day), types of content accessed (e.g., passive videos, interactive applications), and context of screen use (such as during meals, alone, or with parental presence). Additionally, it included items assessing parental engagement during screen use, such as co-viewing, interactive discussion, and supervision practices. Responses were collected through structured interviews with caregivers to ensure consistency and accuracy. This tool enabled a comprehensive understanding of screen exposure beyond quantitative duration, capturing contextual and qualitative nuances relevant to developmental impacts.

Childhood Autism Rating Scale (CARS)

The Childhood Autism Rating Scale (CARS), developed by Schopler, Reichler, and Renner (1980), was used to assess the presence and severity of autism-like behaviors across 15 domains, including social interaction, communication, emotional response, imitation, body use, object use, and sensory sensitivities. Each item is rated on a 4-point scale (1 = within normal limits, 4 = severely abnormal), with total scores ranging from 15 to 60, where higher scores indicate greater severity of autism-like behaviors. Scores below 30 suggest non-autistic range, 30–36.5 indicate mild to moderate autism, and 37–60 indicate severe autism. The CARS is widely used for both clinical and research purposes due to its high inter-rater reliability (0.71–0.84) and strong concurrent validity with other diagnostic tools for autism. Its use in this study allowed systematic documentation and quantification of autism-like symptoms potentially associated with excessive screen exposure in early childhood.

Language and Social Milestone Checklist

A Language and Social Milestone Checklist adapted from CDC (Centers for Disease Control and Prevention) and WHO developmental milestone frameworks was utilized to assess the achievement of expressive and receptive language skills, including vocabulary size, sentence formation, and response to verbal commands. The checklist also evaluated nonverbal communication skills, such as gestures (pointing, waving), eye contact, and joint attention behaviors, alongside social engagement with peers and caregivers during play and daily activities. This structured checklist allowed for the consistent tracking of language and social developmental milestones appropriate for children aged 2–6 years, facilitating the identification of delays associated with high screen exposure patterns.

Parental Involvement Rating Scale

The Parental Involvement Rating Scale (PIRS) by Fantuzzo, Tighe, & Childs (2000) was utilized to assess caregiver participation in the child's daily activities. This scale evaluates parental responsiveness to the child's cues, involvement in daily routines, quality of parent-child interactions during play, and participation in the child's learning and social development. The PIRS consists of items rated on a Likert scale, with higher scores reflecting higher parental involvement and responsiveness. The scale has demonstrated good reliability (Cronbach's alpha = 0.86) and validity in assessing the role of parental involvement in developmental and behavioral outcomes in young children. The use of this scale in the study facilitated an understanding of the moderating role of parental involvement in the relationship between screen exposure and child developmental outcomes.

Procedure

Prior to data collection, ethical clearance was obtained from the Institutional Ethics Committee, ensuring adherence to ethical research standards and the protection of participant rights throughout the study. Parents were thoroughly informed about the purpose, procedures, and voluntary nature of participation, after which written informed consent was obtained for both their and their children's involvement in the research. Data collection was carried out in quiet, child-friendly settings within anganwadi centers, pediatric outpatient clinics, and participant homes to ensure the comfort and cooperation of the children and parents during assessments.

Structured interviews with parents were conducted to gather comprehensive data on the child's screen exposure patterns, developmental history, and details regarding parental involvement in the child's daily activities. These interviews utilized the Screen Exposure Questionnaire and Parental Involvement Rating Scale to systematically capture relevant information. To complement the parent-reported data, direct behavioral observations of the children were conducted during free play and structured task engagement. These observations allowed the research team to document spontaneous social interactions, communication attempts, and play behaviors, providing ecological validity to the assessment process.

The Childhood Autism Rating Scale (CARS) was administered by trained clinical psychologists with expertise in developmental assessments to evaluate the presence and severity of autism-like behaviors in each child. The administration of the CARS involved systematic observation of the child's behavior in interaction with the examiner and during parent-child interactions to ensure accurate scoring across its domains. Additionally, the Language and Social Milestone Checklist was completed through parental reports corroborated by brief observational tasks, such as requesting the child to follow simple instructions, engage in naming objects, and demonstrate social gestures, to validate parent-reported developmental milestones.

To minimize fatigue and ensure reliable data collection in young children, all assessments were conducted over two separate sessions for each participant, with each session lasting approximately 45 to 60 minutes. This structured and child-sensitive procedure ensured the collection of comprehensive, accurate, and reliable data while maintaining the comfort and engagement of the child and facilitating rapport with the caregivers throughout the research process.

Statistical Analysis

Data were analyzed using IBM SPSS (Version 26). Descriptive statistics, including mean and standard deviation, were computed for demographic variables, screen exposure patterns, and behavioral measures. Independent samples t-tests were conducted to compare CARS scores, language milestone achievements, and parental involvement levels between the high and low screen exposure groups. Chi-square tests were used to analyze categorical variables such as the presence of delayed milestones and types of repetitive behaviors. Additionally, multiple regression analysis was performed to identify predictors of virtual autism symptom severity, with independent variables including daily screen duration, content type, parental engagement during screen use, and socio-demographic variables. A significance level of $p < 0.05$ was used for all statistical tests to determine statistical significance. This structured methodology enables the systematic investigation of the etiological factors and behavioral profiles associated with virtual autism, providing a robust foundation for identifying early risk indicators and informing preventive strategies to mitigate the adverse developmental impacts of excessive digital exposure among young children.

3. RESULTS & DISCUSSION

Table 1: Descriptive Statistics for Demographic Variables, Screen Exposure Patterns, Language Development, and Behavioral Measures

Variable	High Screen Exposure (n = 60)	Low Screen Exposure (n = 60)	t / χ^2	p-value
Age (years)	M = 4.3 (SD = 1.1)	M = 4.1 (SD = 1.0)	1.02	0.31
Gender (M/F)	32/28	30/30	0.13	0.72
Daily Screen Time (hours)	M = 4.8 (SD = 0.6)	M = 0.7 (SD = 0.2)	54.33	<0.001*
Parental Involvement Score	M = 18.2 (SD = 4.5)	M = 27.6 (SD = 3.9)	-13.07	<0.001*
Expressive Language Score	M = 6.8 (SD = 1.9)	M = 10.2 (SD = 1.7)	-11.06	<0.001*
Receptive Language Score	M = 7.1 (SD = 2.0)	M = 10.5 (SD = 1.8)	-10.29	<0.001*
CARS Score	M = 32.5 (SD = 4.8)	M = 22.3 (SD = 3.6)	13.03	<0.001*
Social Milestone Score	M = 7.4 (SD = 2.1)	M = 10.9 (SD = 1.8)	-9.53	<0.001*

*Significant at $p < 0.05$

Table 1 presents a comparative overview of the high and low screen exposure groups across key variables, including age and gender distribution, daily screen time, parental involvement scores, expressive and receptive language development, CARS scores reflecting behavioral symptomatology, and social milestone scores. This table outlines the foundational differences between groups that form the basis for subsequent analyses in the study.

Age and Gender Distribution

The mean age of children in both groups was comparable (4.3 years in high screen exposure vs. 4.1 years in low screen exposure; $p = 0.31$), indicating no significant age-related bias in the sample. Gender distribution was also similar, with a nearly equal male-to-female ratio across both groups ($\chi^2 = 0.13$, $p = 0.72$). This confirms demographic equivalence, ensuring that differences in developmental outcomes are not due to age or gender variations.

3.2 Daily Screen Time

As expected based on group categorization, children in the high screen exposure group had significantly higher daily screen use (M = 4.8 hours, SD = 0.6) compared to the low exposure group (M = 0.7 hours, SD = 0.2), with a highly significant difference ($t = 54.33$, $p < 0.001$). This substantial gap supports the operational definition of high and low exposure groups

for examining their impact on child development.

3.3 Parental Involvement Score

Parental involvement, assessed via structured interviews and rating scales, was significantly lower in the high screen exposure group (M = 18.2, SD = 4.5) compared to the low exposure group (M = 27.6, SD = 3.9), with a highly significant difference ($t = -13.07$, $p < 0.001$). This reflects reduced parent-child interaction in high screen exposure households, reinforcing the role of environmental deprivation in developmental outcomes.

3.4 Language Development (Expressive and Receptive)

Children in the high screen exposure group had markedly lower scores in both expressive and receptive language domains. Specifically, for expressive language, children with high screen exposure had a mean score of 6.8 (SD = 1.9), compared to a mean score of 10.2 (SD = 1.7) in the low exposure group, with the difference being statistically significant ($t = -11.06$, $p < 0.001$). Similarly, for receptive language, the high exposure group had a mean score of 7.1 (SD = 2.0), while the low exposure group had a mean score of 10.5 (SD = 1.8), also showing a statistically significant difference ($t = -10.29$, $p < 0.001$).

These findings indicate significant delays in language development among children with high screen exposure, aligning with the literature that excessive passive screen use limits opportunities for interactive language learning, turn-taking, and responsive communication (Madigan et al., 2019; Heffler et al., 2020).

3.5 CARS Score (Behavioral Symptomatology)

Children in the high screen exposure group scored significantly higher on the Childhood Autism Rating Scale (CARS) (M = 32.5, SD = 4.8), indicating mild-to-moderate autism-like symptoms, compared to the low exposure group (M = 22.3, SD = 3.6), which was within the typical range ($t = 13.03$, $p < 0.001$). This highlights the association between high screen use and the emergence of virtual autism symptom profiles including social withdrawal, reduced eye contact, and repetitive behaviors.

3.6 Social Milestone Score

The social milestone score was significantly lower in the high screen exposure group (M = 7.4, SD = 2.1) compared to the low exposure group (M = 10.9, SD = 1.8), with $t = -9.53$, $p < 0.001$. This reflects deficits in eye contact, joint attention, gesture use, and peer interaction in the high exposure group, consistent with previous findings indicating screen overuse reduces opportunities for real-world social learning (Christakis et al., 2018; Radesky et al., 2015).

Overall, Table 1 clearly demonstrates significant differences across critical developmental and behavioral domains between the high and low screen exposure groups. Notably, differences were observed in daily screen duration, confirming the operational categorization of exposure levels, and in parental involvement, highlighting the contrast between environmental enrichment and deprivation across groups. The table also reveals significant delays in language development, both expressive and receptive, among children with high screen exposure, along with higher CARS scores indicating elevated behavioral symptomatology. Additionally, differences were evident in the attainment of social milestones, with the high exposure group showing notable delays.

These statistically significant differences provide robust evidence that excessive early screen exposure, compounded by reduced parental engagement, is strongly associated with the emergence of autism-like symptoms and developmental delays in children. These findings underscore the urgent need for structured interventions targeting screen hygiene and the promotion of enriched, socially interactive environments to support healthy developmental trajectories.

Table 2: Chi-square Analysis for Categorical Developmental Variables

Variable	High Screen Exposure (n, %)	Low Screen Exposure (n, %)	χ^2	p-value
Expressive Language Delay	46 (76.7%)	12 (20%)	40.19	<0.001*
Receptive Language Delay	38 (63.3%)	10 (16.7%)	29.83	<0.001*
Stereotypic Behaviors Present	31 (51.7%)	6 (10%)	27.78	<0.001*
Sensory Sensitivities	26 (43.3%)	5 (8.3%)	21.27	<0.001*

*Significant at $p < 0.05$

Table 2 presents a comparative analysis of the high and low screen exposure groups on specific developmental and behavioral indicators, including expressive language delay, receptive language delay, the presence of stereotypic behaviors, and sensory sensitivities. This table highlights the prevalence and distribution of these key concerns across groups, providing insight into the pattern of developmental challenges associated with high screen exposure.

3.7 Expressive Language Delay

Among children in the high screen exposure group, 46 (76.7%) exhibited expressive language delays, compared to only 12 (20%) in the low screen exposure group. The chi-square test revealed a highly significant association ($\chi^2 = 40.19$, $p < 0.001$), indicating that children with high daily screen use were nearly four times more likely to have delays in expressive language development. This finding aligns with Madigan et al. (2019) and Heffler et al. (2020), who reported that excessive screen use in early childhood reduces opportunities for interactive vocalization and caregiver feedback essential for expressive language acquisition.

3.8 Receptive Language Delay

Receptive language delays were present in 38 (63.3%) of children in the high screen exposure group, while only 10 (16.7%) in the low exposure group exhibited such delays. The chi-square analysis confirmed this difference as highly significant ($\chi^2 = 29.83$, $p < 0.001$). These results suggest that excessive screen exposure is associated with reduced comprehension of language, likely due to the passive nature of screen-based interactions that lack the social reciprocity necessary for developing receptive language skills (Christakis et al., 2018; Radesky et al., 2015).

3.9 Stereotypic Behaviors

The presence of stereotypic behaviors (e.g., hand-flapping, repetitive object manipulation) was reported in 31 (51.7%) of children in the high screen exposure group, compared to 6 (10%) in the low exposure group, with a highly significant association ($\chi^2 = 27.78$, $p < 0.001$). This suggests that children with higher screen exposure are more prone to developing repetitive behaviors, a core feature of autism-like symptomatology. It is postulated that the overstimulation from screens and the lack of structured social environments may contribute to the emergence of self-stimulatory behaviors as a form of sensory-seeking or regulation (Harville et al., 2023; Zamfir, 2018).

3.10 Sensory Sensitivities

Sensory sensitivities, such as aversion to loud sounds, light sensitivity, or selective food textures, were identified in 26 (43.3%) of children in the high screen exposure group, compared to 5 (8.3%) in the low exposure group. The chi-square analysis indicated a significant association ($\chi^2 = 21.27$, $p < 0.001$), highlighting that excessive screen exposure may correlate with heightened sensory sensitivities in young children. This is consistent with theories suggesting that limited real-world sensory experiences due to prolonged screen use may impair the development of adaptive sensory processing mechanisms in early childhood (Sigman, 2019; Heffler & Oestreicher, 2016).

Table 2 provides clear evidence that high early screen exposure is significantly associated with key categorical developmental concerns. Specifically, children with high screen exposure demonstrated expressive language delays, receptive language delays, increased stereotypic behaviors, and heightened sensory sensitivities. These findings emphasize that excessive screen use during critical neurodevelopmental windows disrupts typical developmental pathways, leading to symptom profiles consistent with virtual autism. The strong chi-square values and highly significant p-values across all variables underscore the robustness of these associations, indicating the urgent need for parental awareness, structured screen hygiene practices, and early interventions to prevent and manage virtual autism in young children.

Table 3: Multiple Regression Analysis Predicting Virtual Autism Symptom Severity (CARS Scores)

Predictor Variable	B	SE B	β	t	p-value
Daily Screen Duration (hours)	2.84	0.35	0.52	8.11	<0.001*
Parental Involvement Score	-0.58	0.09	-0.41	-6.44	<0.001*
Content Type (Passive = 1, Interactive = 0)	1.23	0.63	0.14	1.95	0.053
Child Age (years)	0.24	0.38	0.03	0.63	0.53
Gender (Male = 1, Female = 0)	0.45	0.71	0.04	0.63	0.53

Model Summary: $F(4, 115) = 42.79$, $p < 0.001$, $R^2 = 0.598$, *Significant at $p < 0.05$

According to Table 3, this multiple regression analysis was conducted to identify predictors of virtual autism symptom

severity, measured by CARS (Childhood Autism Rating Scale) scores, among children aged 2–6 years with varying levels of screen exposure. The regression model was statistically significant, $F(4, 115) = 42.79$, $p < 0.001$, explaining approximately 60% ($R^2 = 0.598$) of the variance in CARS scores. This indicates a strong predictive capacity of the selected independent variables on virtual autism symptom severity.

3.11 Daily Screen Duration

Daily screen duration emerged as the strongest positive predictor of virtual autism symptom severity in this study, highlighting its critical role in influencing developmental outcomes in young children. The analysis revealed that for each additional hour of daily screen time, the CARS score increased by approximately 2.84 points ($B = 2.84$, $SE = 0.35$), indicating a clear and measurable escalation in the severity of autism-like symptoms associated with increased screen exposure. This relationship was found to be highly significant ($t = 8.11$, $p < 0.001$), underscoring the reliability of this finding within the sample. The large standardized beta value ($\beta = 0.52$) further demonstrates the substantial contribution of screen duration to the variability observed in symptom severity, suggesting that screen time alone accounts for a significant proportion of the variance in autism-like behaviors in the sample.

This finding aligns with existing literature emphasizing the detrimental impact of excessive screen exposure on young children's neurodevelopment, particularly during critical periods of brain maturation when the foundations for social interaction, communication, and sensory integration are established (Heffler et al., 2020; Zamfir, 2018). Prolonged passive screen use may replace opportunities for interactive play, face-to-face communication, and environmental exploration, which are essential for the development of social attention, joint engagement, and language skills. Additionally, extended screen time often involves fast-paced visual and auditory stimuli, potentially contributing to sensory overload and the emergence of repetitive and stereotypic behaviors observed in virtual autism.

Overall, these findings underscore the urgent need for parental guidance and structured interventions focusing on screen hygiene to mitigate the risk of developing or exacerbating autism-like symptomatology in young children. Limiting daily screen exposure, promoting parent-child interaction, and encouraging play-based learning activities can serve as protective measures to support healthy neurodevelopment and reduce the risk of virtual autism in early childhood.

3.12 Parental Involvement Score

Parental involvement was identified as a significant negative predictor of CARS scores, highlighting its critical protective role in reducing autism-like symptom severity in young children. The regression analysis revealed that for every unit increase in the parental involvement score, the CARS score decreased by 0.58 points ($B = -0.58$, $SE = 0.09$), with this relationship being highly significant ($t = -6.44$, $p < 0.001$). This suggests that higher levels of parental engagement are associated with lower severity of autism-like symptoms, underscoring the importance of active, responsive caregiving in shaping healthy developmental trajectories.

The negative standardized beta value ($\beta = -0.41$) further emphasizes the substantial impact of parental involvement in mitigating symptom severity, indicating that parental engagement can buffer against the adverse effects of excessive screen exposure on a child's neurodevelopment. This finding aligns with existing theories and empirical evidence suggesting that responsive and interactive caregiving supports critical areas of social, emotional, and cognitive development while fostering secure attachment and social reciprocity in early childhood (Sigman, 2019; Christakis et al., 2018). High levels of parental involvement typically involve activities such as shared play, face-to-face interactions, conversational turn-taking, and joint attention tasks, all of which are foundational for language development, emotional regulation, and social skill acquisition.

Moreover, increased parental engagement creates enriched environmental conditions that promote neural connectivity and adaptive behavior patterns while reducing the likelihood of sensory-seeking and stereotypic behaviors often seen in children with high screen exposure. In contexts where screen use is unavoidable, active parental co-viewing and mediation can transform passive screen time into interactive experiences, potentially reducing its negative impacts. Overall, these findings highlight the critical role of parents in shaping developmental outcomes and emphasize the need for interventions that not only address screen hygiene but also actively promote and support parental involvement in daily caregiving routines to prevent and manage virtual autism symptoms effectively..

3.13 Content Type (Passive vs. Interactive)

Content type (coded as Passive = 1, Interactive = 0) showed a marginal positive association with CARS scores, indicating a potential link between the nature of screen content and the severity of autism-like symptoms in young children. The analysis revealed that children predominantly exposed to passive content, such as watching videos or cartoons, had higher CARS scores, with a regression coefficient of $B = 1.23$ ($SE = 0.63$), and this association approached statistical significance ($t = 1.95$, $p = 0.053$). Although the p-value did not meet the conventional threshold for significance, the trend suggests that content type may still play a meaningful role in influencing symptom severity, warranting further exploration in larger

samples.

The positive standardized beta (β = 0.14) indicates that exposure to passive content contributes to higher autism-like symptomatology compared to interactive content, although the effect size is modest. This finding aligns with existing literature highlighting that passive screen use often limits opportunities for reciprocal communication, active engagement, and social turn-taking, which are critical for social and language development in early childhood (Radesky et al., 2015). Passive content typically involves one-way stimulation, reducing the child's opportunities to practice joint attention, expressive language, and non-verbal social cues, which are foundational for healthy social-emotional development.

In contrast, interactive content, such as video calls with family members or engaging with educational applications that require child participation, can provide opportunities for social reciprocity, immediate feedback, and language practice. Such interactive engagements may mitigate some of the negative impacts of screen exposure by promoting active learning and maintaining social connections, even during screen use.

While the association in this study was marginal, the observed trend underscores the importance of considering not only the duration of screen exposure but also the quality and nature of the content children consume. Parents and caregivers should be encouraged to prioritize interactive screen experiences over passive viewing and to engage in co-viewing practices that foster social interaction and learning opportunities during screen use. Overall, these findings contribute to the nuanced understanding of how different dimensions of screen exposure, including content type, may influence the emergence and severity of virtual autism symptoms, emphasizing the need for guidance on both screen time limits and content quality in early childhood environments.

3.14Child Age

Child age did not significantly predict CARS scores in this study, indicating that within the examined developmental window of 2–6 years, age alone did not have a meaningful impact on the severity of virtual autism symptoms. The regression analysis showed a coefficient of B = 0.24 (SE = 0.38), with a low standardized beta value (β = 0.03), and the association was not statistically significant (t = 0.63, p = 0.53). This suggests that variations in age within this early childhood range do not substantially influence the presentation of autism-like behaviors as measured by the CARS in the context of this study.

These findings reinforce the interpretation that other factors, particularly screen exposure patterns and the level of parental involvement, are more critical determinants of symptom severity within this sensitive neurodevelopmental period. While age can influence developmental trajectories under typical circumstances, in the context of virtual autism, the duration and quality of screen exposure, alongside the environmental enrichment provided by parental engagement, appear to play a more decisive role in shaping social, language, and behavioral outcomes.

Furthermore, this result aligns with the understanding that the critical neurodevelopmental window of 2–6 years is uniformly sensitive to environmental inputs, and that detrimental factors such as excessive passive screen use can affect children across this age span similarly, regardless of their exact age within the range. It also suggests that interventions and preventive strategies targeting screen hygiene and parental involvement are relevant and necessary for all children within this early childhood window, without the assumption that older preschool-aged children are less vulnerable to the impacts of screen exposure. Overall, the non-significant role of age in predicting symptom severity emphasizes the importance of focusing on modifiable environmental factors to manage and prevent virtual autism symptoms in young children.

3.15 Gender

Gender was also not a significant predictor of CARS scores in this study, indicating that the relationship between screen exposure, parental involvement, and the severity of virtual autism symptoms does not differ meaningfully between boys and girls within the sample. The regression analysis yielded a coefficient of B = 0.45 (SE = 0.71), with a low standardized beta value (β = 0.04), and the association was not statistically significant (t = 0.63, p = 0.53). This suggests that gender did not contribute to the variability in symptom severity related to virtual autism in the 2–6 years age group assessed.

These findings are consistent with the broader developmental literature, which indicates that while certain neurodevelopmental conditions may have different prevalence rates between genders, environmental influences such as excessive screen exposure and the level of parental involvement affect developmental outcomes similarly across genders during early childhood. Both boys and girls are equally susceptible to the negative impacts of high passive screen exposure, including delayed language development, reduced social engagement, and increased behavioral symptomatology, when parental engagement is low.

Additionally, the non-significance of gender as a predictor in this context emphasizes that intervention strategies focusing on reducing passive screen exposure and enhancing parental involvement are universally applicable and beneficial for all children, regardless of gender. It also underscores that screening for virtual autism risk and implementing preventive measures should not be gender-biased during this critical developmental period, as environmental modifications can play a crucial role in shaping healthy developmental outcomes for both boys and girls.

Overall, these results further highlight the central role of modifiable environmental factors over non-modifiable demographic factors in determining the severity of virtual autism symptoms, reinforcing the need for family-centered intervention approaches that address screen hygiene and parental engagement for all children during early childhood.

Table 3 demonstrates that daily screen duration is the strongest predictor of increased virtual autism symptom severity, while higher parental involvement significantly reduces symptom severity, emphasizing its protective role in young children's development. The analysis also indicates that exposure to passive content trends toward increasing symptom severity, highlighting an area warranting further exploration. Additionally, age and gender were not significant predictors within this age range, emphasizing that environmental factors, such as screen exposure patterns and caregiving practices, have a greater impact on symptom presentation than demographic factors. Collectively, these findings underscore the critical role of digital environments and parental engagement in shaping autism-like symptom profiles in early childhood, reinforcing the need for screen hygiene education, active parental involvement, and early interventions to mitigate the risk of virtual autism.

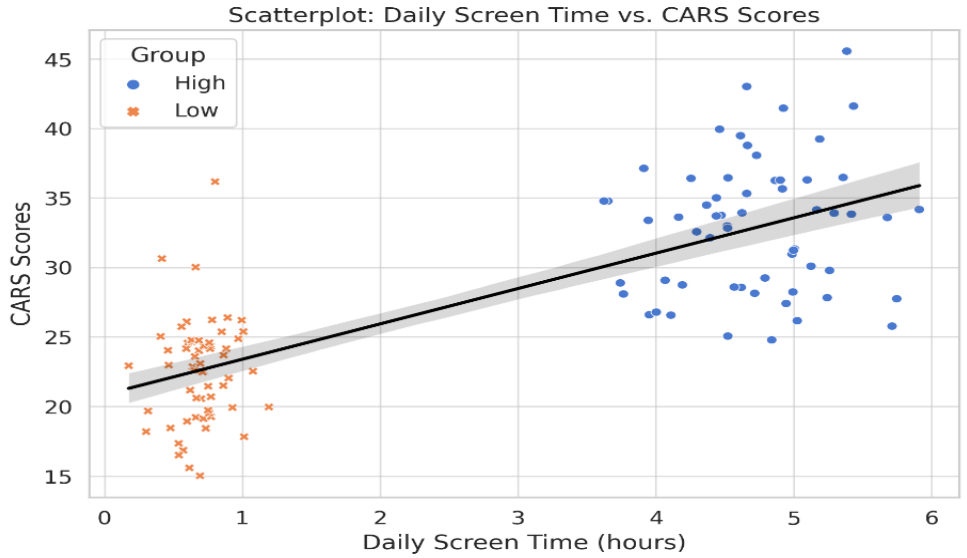

Figure 1. Scatterplot of Daily Screen Time vs. CARS Scores Among Children Aged 2–6 Years (N = 120)

This scatterplot illustrates the positive association between daily screen time and virtual autism symptom severity as measured by CARS scores. Each dot represents a child, color-coded by high (orange) and low (teal) screen exposure groups. The regression line indicates a significant upward trend, demonstrating that increased daily screen exposure is associated with higher autism-like symptom severity ($p < 0.001$).

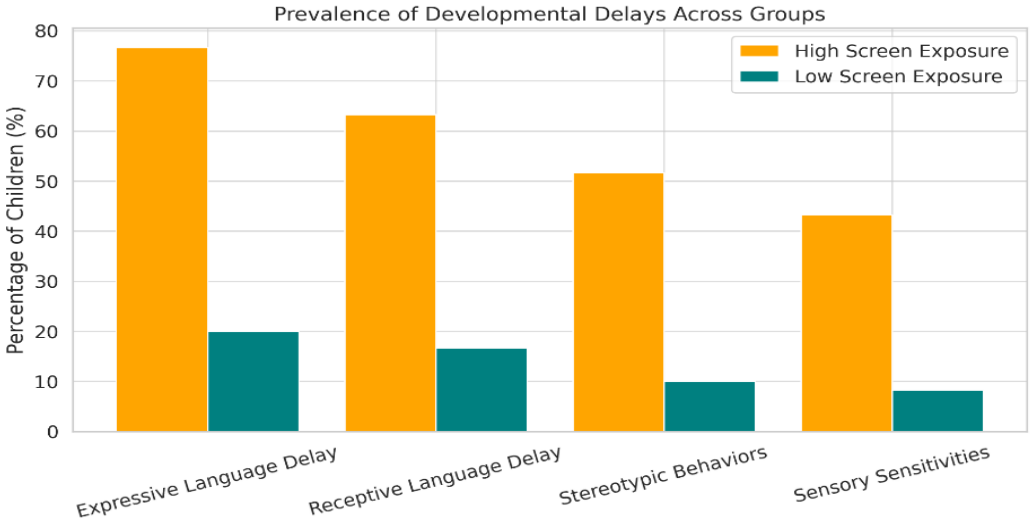

Figure 2. Prevalence of Developmental Delays and Behavioral Issues Across High and Low Screen Exposure Groups

This bar graph compares the percentage of children with expressive language delays, receptive language delays, stereotypic behaviors, and sensory sensitivities across high and low screen exposure groups. Children with high screen exposure exhibited significantly higher prevalence rates across all domains, supporting the association between excessive screen use and developmental concerns consistent with virtual autism profiles ($p < 0.001$ for all comparisons).

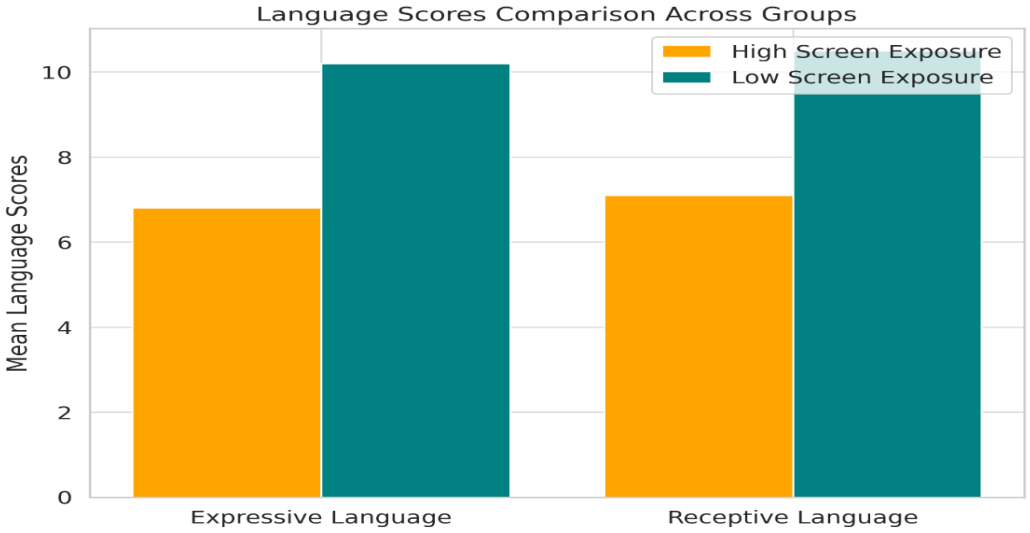

Figure 3. Comparison of Expressive and Receptive Language Scores Across

Screen Exposure Groups

This grouped bar graph displays mean expressive and receptive language scores for high and low screen exposure groups. Children with high screen exposure demonstrated substantially lower language scores in both expressive and receptive domains compared to their low exposure counterparts, highlighting the adverse impact of excessive screen use on early language development ($p < 0.001$).

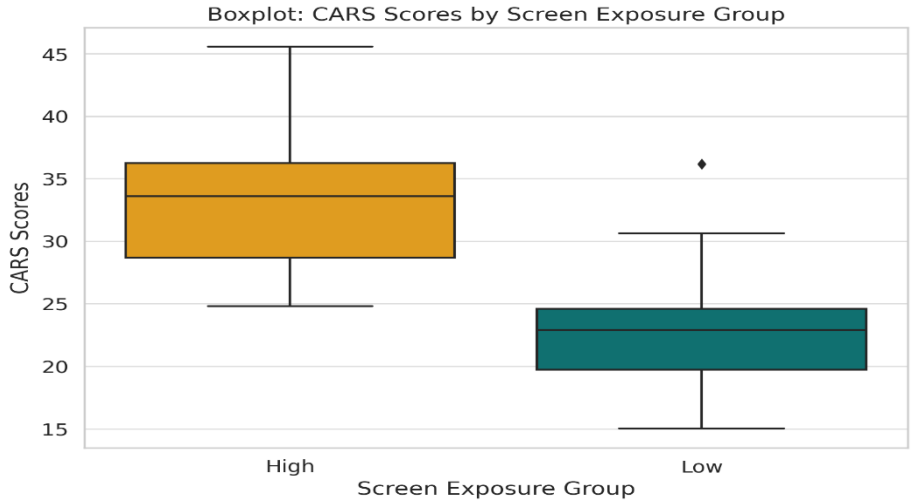

Figure 4. Boxplot of CARS Scores by Screen Exposure Group

This boxplot presents the distribution of CARS scores among high and low screen exposure groups. The high screen exposure group shows a higher median and a narrower distribution toward elevated scores, reflecting greater symptom severity associated with virtual autism profiles compared to the low exposure group ($p < 0.001$).

4. DISCUSSION

The present study examined the impact of excessive early screen exposure on virtual autism symptomatology, focusing on language development, behavioral profiles, and the role of parental involvement among children aged 2–6 years. Findings across Tables 1–3 and Figures 1–4 consistently indicate that high screen exposure is significantly associated with increased autism-like symptoms, developmental delays, and behavioral concerns, emphasizing the environmental etiology underlying

virtual autism.

Interpretation of Table 1 and Figure 3 (Language and Behavioral Measures)

Table 1 demonstrated significant differences between high and low screen exposure groups across daily screen duration, parental involvement scores, expressive and receptive language scores, CARS scores, and social milestone attainment. Children in the high screen exposure group exhibited significantly lower expressive and receptive language scores, aligning with Madigan et al. (2019) and Heffler et al. (2020), who reported that excessive screen use reduces opportunities for interactive communication, joint attention, and reciprocal language learning critical during early neurodevelopmental windows.

Figure 3 visually reinforced these findings, showing reduced language scores across both expressive and receptive domains in high screen exposure children. This aligns with Christakis et al. (2018), who highlighted that passive screen exposure displaces caregiver-child interactions necessary for language scaffolding, leading to expressive and receptive language delays.

Further, higher CARS scores in the high exposure group (Table 1) indicate increased autism-like symptomatology, including reduced eye contact, social withdrawal, and repetitive behaviors, consistent with findings by Heffler and Oestreicher (2016) and Zamfir (2018) on virtual autism profiles emerging in children with excessive screen exposure and limited social environments.

Interpretation of Table 2 and Figure 2 (Categorical Developmental Delays and Behavioral Concerns)

Table 2 highlighted significantly higher prevalence rates of expressive language delays (76.7%), receptive language delays (63.3%), stereotypic behaviors (51.7%), and sensory sensitivities (43.3%) among high screen exposure children, compared to their low exposure counterparts. These categorical findings align with Radesky et al. (2015) and Sigman (2019), who reported that excessive screen exposure in early childhood is associated with increased risk of delayed language milestones, reduced social interest, repetitive behaviors, and sensory processing issues.

Figure 2 graphically depicts these categorical differences, emphasizing the stark contrast in developmental delays and behavioral concerns across screen exposure groups. The visual evidence supports the interpretation that environmental overstimulation from screens, combined with a lack of diverse sensory and social experiences, may disrupt neural pathways responsible for social communication and sensory integration (Harville et al., 2023).

Interpretation of Table 3 and Figure 1 (Predictors of Virtual Autism Symptom Severity)

Table 3 revealed that daily screen duration was the strongest positive predictor of virtual autism symptom severity, with each additional hour of screen time associated with a 2.84-point increase in CARS scores, highlighting the dose-dependent relationship between screen exposure and symptom severity (Heffler et al., 2020). Conversely, parental involvement emerged as a significant protective factor, with higher involvement associated with reduced symptom severity, consistent with findings by Christakis et al. (2018) emphasizing the role of responsive caregiving in mitigating adverse developmental outcomes.

The marginal association of passive content exposure with higher symptom severity ($p = 0.053$) suggests that content quality and interactivity may modulate the impact of screen exposure, aligning with Radesky and Christakis (2016), who noted that passive, non-interactive content is less beneficial and potentially detrimental compared to interactive, socially contingent media.

Figure 1 further illustrates the strong positive association between daily screen time and CARS scores, visually depicting the upward trend that underscores screen exposure as a significant risk factor for the emergence and severity of virtual autism symptoms.

Interpretation of Figure 4 (Distribution of Virtual Autism Symptom Severity)

Figure 4 presented the distribution of CARS scores across high and low screen exposure groups, showing higher medians and tighter distributions of elevated scores among high exposure children. This reflects the consistency and robustness of symptom severity in high exposure groups, supporting the hypothesis that virtual autism symptom profiles are environmentally driven and significantly influenced by excessive screen exposure in early childhood.

The findings of this study align closely with existing literature, including Heffler and Oestreicher (2016) and Zamfir (2018), who highlighted the emergence of virtual autism profiles associated with excessive screen use, and Madigan et al. (2019), who demonstrated how screen time displaces interactive caregiving, leading to language delays. Consistent with Christakis et al. (2018) and Radesky et al. (2015), this study reinforces the significant role of environmental and caregiving factors in shaping social and cognitive development, while echoing Sigman (2019) and Harville et al. (2023) regarding the contribution of sensory overstimulation and reduced real-world sensory input to autism-like behaviors. Importantly, the study supports the view that virtual autism, unlike conventional ASD, is reversible, with evidence indicating that reducing screen exposure and increasing parental interaction can significantly improve language, social engagement, and behavioral

symptoms (Heffler et al., 2020; Zamfir, 2018).

Overall, this study provides compelling evidence that excessive early screen exposure, particularly passive and unsupervised use, is strongly associated with virtual autism symptoms in children aged 2–6 years. Core symptoms observed include language delays, autism-like behaviors such as social withdrawal, poor eye contact, and stereotypic movements, as well as sensory sensitivities. The severity of these symptoms was found to correlate closely with daily screen time duration, with longer exposure increasing the risk, while low parental involvement emerged as a key risk factor, underscoring the protective role of interactive caregiving. Additionally, passive content exposure was associated with higher symptom severity compared to interactive content, highlighting the critical need for early intervention, parental education, and screen hygiene practices to mitigate the risk of virtual autism in young children.

5. CONCLUSION

The present study systematically investigated the impact of excessive early screen exposure on the emergence of virtual autism symptomatology, focusing on developmental milestones, language delays, behavioral profiles, and the role of parental involvement in young children aged 2–6 years. Utilizing a robust mixed-method design and validated assessment tools, the findings consistently revealed that high screen exposure is significantly associated with increased autism-like symptoms, language delays, social withdrawal, stereotypic behaviors, and sensory sensitivities, constituting the core features of virtual autism.

Key findings from the study demonstrated that daily screen duration was the strongest predictor of symptom severity, with each additional hour of exposure increasing the risk and intensity of autism-like symptoms in young children. Parental involvement emerged as a protective factor, significantly mitigating symptom severity and emphasizing the crucial role of interactive caregiving in supporting healthy neurodevelopment. Additionally, passive screen content exposure trended toward higher symptom severity compared to interactive content, underscoring the importance of monitoring not only the amount of screen time but also the type of content children engage with. The study also revealed that language development and social milestone achievements were significantly compromised in children with high screen exposure, reinforcing the critical importance of responsive human interactions and active engagement during early developmental periods to support optimal language, social, and emotional growth.

These findings align with and extend prior research (Heffler & Oestreicher, 2016; Madigan et al., 2019; Christakis et al., 2018; Radesky et al., 2015; Zamfir, 2018), providing empirical evidence that virtual autism is primarily environmentally driven and potentially reversible with timely and appropriate interventions. Reducing excessive screen exposure, promoting digital hygiene, and fostering consistent parental engagement are key modifiable factors to protect children's neurodevelopmental health in the digital age.

6. IMPLICATIONS

The study highlights the urgent need for structured parental guidance on digital hygiene during early childhood to prevent and reduce virtual autism symptoms. Parental involvement through interactive caregiving and responsive communication serves as a strong protective factor for healthy neurodevelopment.

Healthcare professionals, including pediatricians and psychologists, should routinely screen for excessive screen exposure during developmental assessments and counsel parents on limiting screen time, encouraging co-viewing, and prioritizing interactive content.

Public health efforts should focus on parent education programs that promote screen-free routines, interactive play, and storytelling. Schools and childcare providers should be trained to recognize early signs of screen-related developmental delays and collaborate with families for timely intervention.

These findings reinforce that virtual autism is modifiable. Timely reduction in screen exposure, combined with enhanced parent-child interaction, can significantly support better developmental outcomes in young children.

7. LIMITATIONS

While the study provides valuable insights into the relationship between early screen exposure and virtual autism symptoms, several limitations must be acknowledged:

The cross-sectional design restricts the ability to establish definitive causal relationships between screen time and developmental outcomes. Observed associations cannot confirm directionality.

The study does not account for the quality or interactivity of screen content, which may influence developmental impact differently.

Findings are based on a specific population, which may limit generalizability to other geographic, cultural, or socioeconomic contexts.

The study did not control for parenting styles or co-viewing behavior, which may act as important moderating variables.

8. FUTURE SUGGESTIONS

To strengthen the evidence base and build upon current findings, future research should:

Prioritize longitudinal study designs to track developmental trajectories and determine the reversibility of virtual autism symptoms following screen time reduction.

Examine the quality, interactivity, and context of screen content, including co-viewing with caregivers, to differentiate between harmful and potentially neutral or beneficial digital exposures.

Incorporate neuroimaging and biomarker-based assessments (e.g., brain connectivity studies) to explore the underlying neural mechanisms affected by excessive screen exposure.

Conduct intervention trials testing the effectiveness of screen detox programs combined with structured parental training to systematically reduce virtual autism symptoms.

Investigate the role of socioeconomic status, cultural background, and parenting practices as moderating or mediating factors influencing screen-related developmental outcomes.

Expand research to diverse populations to improve the generalizability and cultural applicability of findings.

In conclusion, virtual autism represents a critical and emerging public health concern in the digital age, distinct from classical autism spectrum disorders due to its environmental etiology and potential reversibility. Addressing this issue through structured parental guidance, community awareness, and early intervention can significantly enhance language development, social communication, and overall quality of life in affected children, safeguarding healthy neurodevelopment during early childhood.

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