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RELATIONSHIP BETWEEN SCREEN TIME, APGAR SCORE, AND COMMUNICATION SKILLS IN CHILDREN

Excessive screen time (ST) has been linked to delays in early communication, while the Apgar score (AS) is a widely used biological indicator of a newborn's condition immediately after birth. This study examined the relationships of child ST, age of first ST exposure, and parental ST with early communication skills, as well as whether AS is related to or modifies these associations. The sample included 2,166 children aged 12–66 months. Communication skills were assessed using the Ages & Stages Questionnaire, Third Edition (ASQ-3), whereas data on ST and AS were collected using a specially designed questionnaire. Exceeding recommended screen time, earlier screen exposure (<12 months), and higher parental screen time (>3 h/day) were associated with lower communication scores. However, the observed associations were statistically significant with small effect sizes. Early exposure and excessive ST were negatively associated with communication, whereas AS showed a positive association but did not modify the relationships between ST variables and communication. These findings underscore the critical relevance of ST-related behaviors in understanding early communication development in children.

Key words: screen time; Apgar score; communication development

INTRODUCTION

From the very definition of communication, which states that it is an active process of exchanging ideas and information (ASHA 2013), we can see its importance. If we add to that the fact that communication is one of the basic prerequisites for further cognitive development, language acquisition, as well as socio-emotional skills (Hart & Risley 1996), it is not surprising that many researchers seek to determine the factors influencing its development. What is certain is that communication does not develop independently but as a result of the interaction of multiple factors, which can broadly be divided into two groups: environmental and biological (Shonkoff & Phillips 2000; Sameroff 2009).

One of the earliest indicators of biological susceptibility is the Apgar score (AS). It assesses five vital parameters: skin color, heart rate, respiration, muscle tone, and reflexes. Each of these parameters is rated on a scale of 0, 1, or 2 points, making the maximum possible score 10. A lower AS is commonly considered if it is less than 7 within the first 5 minutes. Also, it is often inversely correlated with neurodevelopmental delays, such as in communication and gross motor skills (Hassen et al. 2021; Razaz et al. 2016; Razaz et al. 2019). Moreover, a large Japanese cohort study (Tsuchida et al. 2022) found that the AS is a significant predictor of developmental delay. By analyzing data from over 54,000 children, the authors determined that an AS ≤ 8 within the first five minutes after birth was associated with higher odds of developmental delay at the age of three, particularly in the areas of gross and fine motor skills and problem-solving (Tsuchida et al. 2022). In addition, several studies have highlighted the association between poorer communication outcomes and low AS. For example, Stanton-Chapman et al. (2002), found that among early risk factors, a low AS was associated with an increased risk of later being identified as having a specific language impairment. Evidence on the association between AS and delays in the domain of communication is supported by the study of Marschik et al. (2007). The authors identified a link between low AS and reduced word production in 18-month-old children. Moreover, the study by Diepeveen et al. (2013), whose sample included children with an average age of 9 years, showed that children with specific language impairment had lower Apgar scores, even when controlling for gestational age and birth weight. Contrary to these studies, Bishop (1997) did not find an association between low AS and specific language impairment.

However, it should be noted that the AS is neither a diagnostic tool, nor does it determine the etiology of developmental delays. It serves as a sensitive marker of the newborn's speed and capacity to adapt to extrauterine life conditions (American Academy of Pediatrics 2015). This means that, it is possible to identify infants who, while clinically stable, are biologically more vulnerable to environmental stressors that can possibly influence later development – including communication. These findings highlight the need to examine perinatal risk and environmental factors together. This need is more urgent because of the fact that children today are exposed to new environmental influences that may affect their development. With the rapid technological advancement, the most prominent change is exposure to digital media, commonly measured as screen time (ST). This perspective is also supported by susceptibility theory. According to this theory, some children are biologically more sensitive to environmental influences – both positive and negative (Belsky & Pluess 2009). Keeping this in mind, a low AS may indicate increased sensitivity, which means that these children may be more vulnerable to the negative effects of ST during sensitive periods of development, in this case development of communication.

To better understand this concern, it is necessary to define ST. Barber et al. (2017) define ST as the amount of time a person spends using electronic or digital media such as television, smartphones, tablets, or computers. Even the World Health Organization has recognized this issue and defined recommendations related to ST (WHO 2019). According to these recommendations children under the age of two should not be exposed to screens at all, while those aged two to four should be limited to no more than one hour per day. Unfortunately, global evidence suggests that these guidelines are rarely followed, which is concerning because early exposure to and excessive use of electronic/digital media can interfere with an infant's development during the first year of life (Durham et al. 2021). Recent evidence further supports the idea that preschool screen time has negative effects on children's cognitive and language development (Massaroni et al. 2023). In line with this, Bhutani et al. (2024), in their scoping review, found that increased screen time can have a negative impact on children's language development. Although some studies reported no effect or even a positive effect, overall, the negative effects of screen time appear to outweigh any potential positive ones. Additional studies further support this, showing that more program viewing and greater exposure to background television were associated with poorer cognitive outcomes, including executive functioning, language, and academic skills (Mallawaarachchi et al. 2024).

Such research findings have led to excessive ST becoming a global public health concern. Specifically, the WHO (2019) warned that excessive ST may contribute to an increased rate of language delays, shorter sleep duration, and reduced parent–child interaction. However, it is not only the amount of time spent in front of screens that matters. Factors such as the age of first exposure, the content the child is exposed to, and even parental screen behavior – through phenomena like technoference (McDaniel & Radesky 2018) – are now recognized as important factors in communication development. The positive correlation between high parental screen time (ST) and increased child ST has also been reported by other researchers (Dy et al. 2023; Lauricella et al. 2015).

Despite strong evidence linking perinatal and environmental factors to early development, their interaction effect remains insufficiently explored. Specifically, it is still unclear whether perinatal risk, as measured by the AS, may amplify the negative consequences of excessive screen use.

Therefore, this study has two objectives:

1) To examine the relationship between children's communication skills (ages 12–66 months) and their screen time, age of first screen exposure, and parental screen time.
2) To examine whether the Apgar score is associated with communication scores and whether it moderates the relationship between screen exposure and communication scores in children aged 12–66 months.

METHOD

Study design and population

Study design was cross-sectional. It was conducted during the 2023/2024 school year in the Republic of Srpska. Prior to data collection, formal approval was obtained from the Ministry of Education and Culture of the Republic of Srpska (permission number: 07.040/615-7-1/23), followed by ethical approval granted by the Ethics Committee of the Faculty (name removed due to the double-blind review process; approval number: 01-2-7/23).

A total of 20 preschool institutions in the Republic of Srpska, Bosnia and Herzegovina, were randomly selected. Upon obtaining written consent from the directors of these institutions, meetings were held with the professional staff and parents, where the objectives and procedures of the study were explained in detail. Parents who agreed for their child to participate in the study signed an informed consent form.

The final sample consisted of 2,166 children aged 12 to 66 months. The final sample included 1,134 boys (52.4%) and 1,032 girls (47.6%). Inclusion criteria were: age between 12 and 66 months and enrollment in a public preschool institution at the time of data collection. The exclusion criteria were diagnosed developmental disabilities or delays, based on documented medical or psychological records provided by the preschool institutions.

Descriptive characteristics of the sample can be found in Table 1.

Table 1. Descriptive characteristics of the sample

Characteristics	N(%)
Gender	
Male	1134 (52.4)
Female	1032 (47.6)
Apgar score	
≤7 (low)	48 (2.2)
>7 (normal)	2118 (97.8)
Children ST per day (h/d)	
< 1h (or no ST)	677 (31.2)
Allowed recommendation (1 hour)	749 (35.6)
Above the allowed recommendation (>2h)	740 (34.2)
Age of first ST (children)	
< 12 months	910 (42.0)
12 – 23.9 months	883 (40.8)
< 24 months	373 (17.2)
Parents ST per day (h/d)	
< 1h	289 (13.3)
2-3 hours	1148 (53.0)
> 3 hours	729 (33.7)
ASQ-3	
Below cut-off *	88 (4.1)
Monitoring zone*	155 (7.1)
Above cut-off*	1923 (88.8)

Above cut - off score - scores higher than monitoring zone indicate typical development; *Monitoring zone - scores in monitoring zone may need further investigation; *Below cut-off score- scores at or below cut-off indicate a possible delay in development

Measures

Screen time

Data regarding children's screen time (ST), parental ST, and the age of first exposure to screens was collected using a specially designed questionnaire based on WHO recommendations. The exact wording of the questions and response options was as follows: For children's ST, parents were asked, "How much time is your child typically exposed to screens during the day (screens include: TV, tablets, mobile phones, video games)?", with response options: "Less than 1 hour or no ST", "1 hour", and "More than 2 hours per day". Parents were specifically instructed that any child using screens for more than 1 hour per day should be placed in Category 3 ("More than 2 hours per day"). For parental ST, the question was, "How much time are you, as a parent, exposed to screens per day, not including work-related screen use?", with response options: "Less than 1 hour", "2 to 3 hours", and "More than 3 hours per day". Parents were specifically told that if they used screens for more than 1 hour but less than 3 hours, they should select the second option ("2 to 3 hours"), so that all moderate users were grouped consistently, and higher use (>3 hours) remained in the third category.

Finally, regarding the age of first exposure to screens, parents were asked, "What was the child's age at first exposure to screens?", with response options: "Before 12 months", "Between 12 and 23.9 months", and "After 24 months".

Children who use screens for 1.5 hours per day were placed in Category 3 ("more than 2 hours") based on the structure of the questionnaire, because Category 2 was defined as "1 hour" (the recommended limit), and anything above this was considered outside the recommendation. The categories were designed so that the second category includes children within the recommended limit, while the third is defined as "more than 2 hours," thereby reducing overlap and ensuring a clear distinction between groups.

In practice, children who use screens between one and two hours form a relatively small and heterogeneous group – some use 1.1 hours daily, others 1.8 hours – which makes it difficult to accurately interpret their usage patterns and potential developmental impact. In contrast, screen use of two hours or more, clearly represents a substantial exceedance of recommendations. This categorization therefore facilitates statistical analysis by creating a clear contrast group of "excessive exposure" compared to the recommended limit. By merging the intermediate group with the "more than 2 hours" category, a single, analytically justified group of children exceeding the recommended limit is formed, which is important for assessing the effects of excessive screen exposure.

APGAR SCORE

Information about the AS was also collected based on parental report. The questionnaire previously mentioned, designed for the purposes of this study, included this question: What was the child's AS at birth? The question was delivered with a brief instruction advising parents to consult official medical documentation (hospital discharge summary or immunization record) before answering. It was underlined that if they were not completely sure about the AS, they should check the documentation, not to rely solely on memory.

Assessment of communication skills

For the assessment of communication skills, we used the Ages & Stages Questionnaires, Third Edition (ASQ-3) (Squires et al. 2009). ASQ-3 is a standardized, parent-completed instrument designed to evaluate the development of children aged 1 to 66 months. The questionnaire consists of five domains: communication, gross motor, fine motor, problem solving, and personal-social skills. For the purposes of this study, only the communication subscale was used.

The ASQ-3 consists of 21 questionnaires, each tailored to specific age intervals. For example, for children under 24 months, different questionnaires are administered every two months. For children between two and three years of age, questionnaires are used at three-month intervals, while for children between 36 and 66 months, they are administered every six months. The appropriate version of the questionnaire was selected based on the child's chronological age. For children under 24 months with a history of prematurity, their chronological age was adjusted by subtracting the number of weeks they were born early. For this purpose, 15 questionnaires (12 to 66 months) were used.

The communication items encompass both receptive language skills (such as responding to sounds, recognizing names, following simple instructions) and expressive language skills (such as babbling, producing words, combining words into phrases). The items are adapted to the child's age. For instance, if we want to assess communication in children aged between 27 months and 16 days and 28 months and 15 days, we apply questionnaire for 27 months. The items vary across age intervals, starting with vocalizations and gesture recognition in infants, and progressing to more complex language skills such as sentence use.

The questionnaire is completed by parents, who respond to each of the 6 items. For each item, they can choose only one of the following three response options: "YES," "SOMETIMES," or "NOT YET." If they choose "YES," it means their child demonstrates a specific skill or behavior, and this response is scored with 10 points. If they choose "SOMETIMES" it indicates that the child occasionally or inconsistently shows the behavior, and this response is scored with 5 points. If the child does not yet demonstrate the behavior, parents select "NOT YET," which is scored with 0 points. The maximum possible score is 60. In cases where one or two items were left unanswered, an adjusted score was calculated by taking the average of the completed items and assigning that average to the missing responses, in accordance with standard ASQ-3 scoring procedures.

Each subscale on the ASQ-3 has its own cutoff score, including the communication scale. The total score for each participant is compared to the chart from the ASQ-3 User's Guide for the appropriate age range to determine the child's communication abilities. For descriptive purposes, ASQ-3 results were categorized according to the normative cutoff values used in this study are those provided in the ASQ-3 User's Guide, which are based on the U.S. standardization sample. A score above the cutoff suggests that the child's development is progressing as expected. A score near the cutoff indicates a need for developmental monitoring. If the child's score falls below the cutoff, further assessment by professionals is needed. For the statistical analyses, we used the total raw scores of the ASQ-3.

The ASQ-3 User's Guide (Squires et al. 2009) reports that internal consistency reliability of the communication subscale differs among age group, with Cronbach's alpha values ranging from 0.66 to 0.86. These values indicate acceptable to good reliability for parent-reported measures of early communication development. In our study, the Cronbach's alpha value for total sample is 0.762.

Data analysis

For statistical data analysis, we used SPSS (Statistical Package for the Social Sciences, version 26).

Normality of distribution for the ASQ-3 communication scores was examined, with Skewness = –2.074 and Kurtosis = 4.609, indicating deviation from normality, which was confirmed by the Kolmogorov–Smirnov test ($p < .001$). Kolmogorov-Smirnov was chosen due to the large sample size (N= 2,166) and distributional patterns were further inspected visually using scatterplots and Q-Q plots.

Non-parametric tests (Kruskal-Wallis and Mann-Whitney U) were used for group comparisons because of the non-normal distribution of communication scores. For the Kruskal-Wallis test, post-hoc pairwise comparisons were conducted using the Mann-Whitney U test with Bonferroni correction to adjust for multiple comparisons (three comparisons, adjusted $\alpha = 0.017$).

Hierarchical multiple regression was conducted to examine the relationship between ST variables, Apgar score and communication skills, as well as the potential moderating effect of the Apgar score (AS). Categorical predictors (child ST, parental ST, and age of first screen exposure) were dummy coded, with one category serving as the reference group. The AS was treated as a continuous variable and mean-centered. Six interaction terms between AS and each ST variable were created to examine moderation effects; these interaction terms were introduced in the fourth step of the regression model.

Regression assumptions were assessed using residual analysis. Scatterplots of standardized residuals versus predicted values showed points randomly scattered along the entire range, without funneling (no heteroskedasticity) or curvature (no nonlinearity). Multicollinearity was checked using variance inflation factors (VIF), which ranged from 1.260 to 4.237, indicating no concerning multicollinearity.

Model fit and effect sizes were evaluated using R^2 change, standardized beta coefficients, F-change statistics and p-values.

Results

A statistically significant difference in communication scores was found among children grouped by daily ST using the Kruskal-Wallis test, $\chi^2(2) = 20.76$, $p < .001$.

Post-hoc pairwise comparisons were conducted using the Mann-Whitney U test with Bonferroni-adjusted significance level ($\alpha = 0.017$). Children exceeding the recommended ST (>2 hours, representing excessive use in our study) had significantly lower communication scores compared to children within the recommended limit of 1 hour per day ($U = 244{,}493.00$, $p < .001$, $r = 0.11$), indicating a small but meaningful effect according to Cohen's criteria. They also scored lower than children with less than 1 hour of daily ST or no screen exposure (U = 214,963.50, $p = .001$, $r = 0.09$). No significant difference was found between children with less than 1 hour or no ST and those with 1 hour of daily ST, which is the maximum recommended screen time (Table 2).

Table 2. Differences in the achievements on the ASQ-3 scales of communication skills in relation to the children ST per day

ASQ-3/Scales	Childen ST per day	M	SD	< 1h (or no ST)	Allowed recommendation (1 hour)
Communication	< 1h (or no ST)	53.50	10.77		.559
	Allowed recommendation (1 hour)	54.49	9.07	.559	
	Above the allowed recommendation (>2h)	52.14	11.25	**.001* (.11)****	**.000*** (.09)**

*p < .017 (significant after Bonferroni correction); ** Cohen's effect size

A statistically significant difference was found in the communication scale scores in relation to the age at which children were first exposed to screens (χ^2 (2)= 27.228, $p < .001$).

Post-hoc pairwise comparisons using the Mann–Whitney U test with Bonferroni correction ($\alpha = 0.017$) showed that children first exposed to screens before 12 months had significantly lower communication scores compared to those first exposed between 12 and 23.9 months (U = 347,833.00, $p < .001$, $r = 0.095$) and compared to children first exposed after 24 months (U = 135,331.50, $p < .001$, $r = 0.13$). No significant difference was found between children first exposed between 12 and 23.9 months and those first exposed after 24 months (Table 3).

Table 3. Differences in the achievements on the ASQ-3 scales of communication skills in relation to the age of first exposure

ASQ-3/Scales	Age of first ST exposure	M	SD	< 12 months	12 – 23.9 months
Communication	< 12 months	51.55	12.16		**.000*** (.09)**
	12 – 23.9 months	54.28	9.24	**.000***	
	> 24 months	55.41	7.86	**.000*** (.13)**	.101

*p < .017 (significant after Bonferroni correction); ** Cohen's effect size

A statistically significant difference was found in children's communication scale scores across groups of daily parental screen time using the Kruskal-Wallis test, $\chi^2(2) = 6.44$, $p = .040$.

Subsequent tests with Bonferroni correction ($\alpha = .017$) showed a significant difference between children of parents who used screens less than 1 hour daily and those whose parents used screens more than 3 hours daily (U=95527.000 $p = .011$). No significant differences were observed between the other groups. Although the difference reached statistical significance, the effect size was negligible to very small ($r = 0.08$), according to Cohen's criteria (Table 4).

Table 4. Differences in the achievements on the ASQ-3 scals of communication skills in relation to parents ST per day

ASQ-3/Scales	Parents ST per day (h/d)	M	SD	< 1h	2-3 hours
Communication	< 1h	54.27	10.34		.045
	2-3 hours	53.49	10.03	.045	
	> 3 hours	52.77	11.14	**.011*** (.08)**	.341

*p < .017 (significant after Bonferroni correction); ** Cohen's effect size

A hierarchical multiple regression was conducted to examine the contribution of the following predictor variables – age of first exposure, parental screen time, child screen time, the mean-centered Apgar score, and the interaction terms between the mean-centered Apgar score and the respective dummy variables – to communication scale scores.

In the first step, the variables age at first screen exposure and parental screen time were entered, and this model significantly explained variance in communication scores, $F(4, 2161) = 12.00$, $p < .001$, $R^2 = 0.02$, $R = 0.15$. Among these predictors, age at first exposure under 12 months significantly predicted lower communication scores ($\beta = -0.16$, $p < .001$).

In the second step, categories of child screen time were added, significantly increasing the explained variance, $\Delta R^2 = 0.006$, $F(2, 2159) = 6.73$, $p = .001$, resulting in total $R^2 = 0.03$, $R = 0.17$. Child ST of 1 hour per day predicted higher communication scores ($\beta = 0.09$, $t = 3.65$, $p < .001$).

The mean-centered Apgar score was introduced in step 3, accounting for an additional 0.2% of variance, $\Delta R^2 = 0.002$, $F(1, 2158) = 5.12$, $p = .024$, with higher Apgar scores significantly predicting higher communication scores ($\beta = 0.05$, $t = 2.26$, $p = .024$). After this step, total R^2 was 0.03, $R = 0.17$.

In step 4, six interaction terms between the mean-centered Apgar score and the respective screen time variables were added. The addition of these interactions did not significantly improve the model, $\Delta R^2 = 0.001$, $F(6, 2152) = 0.46$, $p = .84$, resulting in a total $R^2 = 0.03$, $R = 0.18$. None of the interaction terms were significant (all $p > .05$), and the main effect of the Apgar score was no longer significant ($\beta = 0.01$, $t = 0.17$, $p = .87$).

Table 5. Hierarchical regression predicting communication scores

Step	**Variable**	**R Square**	**R Square Change**	**Standardized β**	**t**	**p**
1		0.022	0.022			**<.001**
	AGE_EXP_<12M			–.162	–5.526	**<.001**
	AGE_EXP_12_23M			–.035	–1.204	.229
	PARENT_ST_2_3H			.040	1.701	.089
	PARENT_ST_>3H			.034	1.462	.144
2		0.028	0.006			.001
	CHILD_ST<1H			.037	1.457	.145
	CHILD_ST_1H			.090	3.647	**<.001**
3	Apgar (centered)	0.030	0.002	.048	2.263	**.024**
4		0.031	0.001			**.840**
	AGE_EXP_<12M			–.155	–5.272	**<.001**
	AGE_EXP_12_23M			–.036	–1.225	.221
	PARENT_ST_2_3H			.031	1.284	.199
	PARENT_ST_>3H			.022	0.904	.366
	CHILD_ST<1H			.038	1.507	.132
	CHILD_ST_1H			.092	3.736	**<.001**
	Apgar (centered)			.011	0.169	.866
	Apgar × CHILD_ST<1H			.007	0.248	.804
	Apgar × CHILD_ST_1H			.014	0.459	.647
	Apgar × AGE_EXP_<12M			.050	1.332	.183
	Apgar × AGE_EXP_12_23M			.016	0.372	.710
	Apgar × PARENT_ST_2_3H			–.011	–0.426	.670
	Apgar × PARENT_ST_>3H			–.016	–0.451	.652

AGE_EXP_<12M = Screen exposure before 12 months; AGE_EXP_12_23M = Screen exposure between 12–23.9 months; PARENT_ST_2_3H = Parental ST 2–3 hours; PARENT_ST_>3H = Parental ST more than 3 hours; CHILD_ST<1H = Child ST <1hour per day; CHILD_ST_1H = Child ST 1h per day; Apgar × ... = Interaction between mean-centered AS and respective dummy variable

*Note: Reference categories were: Parental ST <1h, Child ST >2h, and Screen exposure after 24 months. AS was mean-centered. Interaction terms reflect moderation effects.

DISCUSSION

The first aim of our study was to determine how ST, age of first exposure, and parental ST are related to communication skills. The difference was found between certain groups of participants. Precisely, our results showed that children exceeding the threshold of two hours of screen time per day exhibit lower communication scores compared to children adhering to or falling below recommended limits. This finding is consistent with emerging evidence on the adverse effects of excessive digital media exposure in early childhood (Madigan et al. 2020; Mustonen et al. 2022; Al Hosani et al. 2023; Rayce et al. 2024; Liu et al. 2025). Recent data further reinforce this pattern: children with developmental language disorder (DLD) have been shown to exhibit longer daily screen exposure, with nearly one-third exceeding two hours per day (Wan et al. 2025). On the other hand, the small effect size that we obtained highlights the multifactorial and complex nature of communication development, which, as previously mentioned, occurs under the simultaneous influence of multiple factors whose interrelations are highly intricate (Christiansen & Charter 1999; Goldberg 2006; MacWhinney 2004; Reali & Christiansen 2005). Indeed, these delays often stem from a complex interaction between biological predispositions and environmental factors, such as socioeconomic status (Hoff 2003), emotional bond with parents (Zeanah & Gleason 2018), verbal stimulation (Rowe 2012; Shneidman et al. 2013). These results lead to the conclusion that communication development must be considered as part of a broader context. It means that ST negatively affects communication development, but it is neither the sole nor the primary factor. As an additional explanation for the small effect size, we can also assume that screen exposure does not necessarily exclude verbal stimulation, especially when the content is educational or when parents are involved, which is why its negative impact on language development can be mitigated. It is also important to note that Sundqvist et al. (2023) have pointed out that prolonged exposure to screens in early childhood can have a cumulative negative effect that may not be immediately apparent. In fact, their study showed that children's screen use tends to increase over time, and that screen exposure at 2 years accounted for the variation in vocabulary development at both 2 and 5 years. Also, our results can be aligned with the hypothesis that excessive screen exposure may displace critical caregiver-child interactions, which serve as foundational scaffolds for language acquisition and socio-communicative competence (Radesky et al. 2015). Indeed, Christakis (2014) discusses how passive ST reduces the quality of caregiver-child interactions, which are critical for providing language input necessary for early communication development. The lack of significant difference between children with <1 hour ST and the recommended 1 hour ST suggests a potential threshold effect, supporting current pediatric guidelines advocating for limited and developmentally appropriate screen use (Hill et al. 2016). However, surpassing this threshold appears to be associated with measurable detriments in communication skills.

These findings on daily ST are further contextualized by our analysis of the age of first exposure to screens. It seems that early exposure carries additional risks, as children who were exposed to screens before 12 months of age demonstrate significantly lower communication scores compared to those who were first exposed between 12 and 23.9 months or after 24 months. This emphasizes the importance of both, the timing and amount of screen exposure for the development of communication skills. Also, this pattern aligns with developmental theories emphasizing the critical importance of the first year of life as a sensitive period for language acquisition (Kuhl 2010). Consistent with these theoretical frameworks, other studies have identified early screen exposure as a risk factor for language delay (Zimmerman et al. 2007; Chonchaiya & Pruksananonda 2008; Duch et al. 2013). One possible explanation for this is the reduction of crucial caregiver–child interactions and, subsequently, reduced language input. Additionally, neuroscience and theories of sensitive periods also suggest that prolonged exposure to screens during early sensitive periods could impact brain connectivity involved in language and cognitive processing (Horowitz-Kraus & Hutton 2018).

Our results also revealed that there was a statistically significant difference between the groups in children's communication scale scores based on parental screen time, with children whose parents reported more than three hours of daily screen time demonstrating significantly lower communication scores compared to children whose parents reported less than one hour per day. Although this association was statistically significant, according to the calculated effect size the practical significance of this relationship is limited.

Nevertheless, these findings are theoretically and empirically noteworthy. Prior research has increasingly emphasized the broader ecological context of child development (Bronfenbrenner & Morris, 2006), in which parental ST may influence not only the quantity but also the quality of parent-child interactions. Our assumption is based on the results of McDaniel & Radesky (2018) which state that parents who overuse screens offer fewer verbal interactions. Furthermore, the aforementioned study revealed that parental ST has been associated with decreased verbal and nonverbal responsiveness during interactions with children, which are foundational for the development of language and socio-communicative skills, consistent with findings reported by Kirkorian et al. (2009).

It is also possible that high parental ST contributes to the establishment of screen-saturated home environments. In such an environment, interactive and developmentally enriching activities such as shared reading, storytelling, and symbolic play are reduced. Although the small effect size cautions against overinterpretation, the statistical significance and consistency with developmental theories indicate a subtle but meaningful relationship between parental ST and children's communication skills.

In line with our second aim, the hierarchical multiple regression analysis was conducted to examine whether the Apgar score is associated with communication scores and whether it moderates the relationship between screen exposure and communication scores in children aged 12–66 months. The first step demonstrated that the age of first exposure, that is exposure before 12 months, was a significant predictor of lower communication scores, reinforcing earlier results that we obtained through non-parametric tests. This early exposure remained a robust predictor even after controlling for other variables in subsequent models, further supporting the hypothesis that the first year of life constitutes a uniquely sensitive window for the development of communication skills (Kuhl 2004; Shneidman et al. 2013).

Interestingly, in the second step, a daily ST of 1 hour was a significant positive predictor of a child's communication score. This finding appears to be contradictory to the previously reported group comparisons, which showed negative associations between excessive ST and communication skills. This may be explained by different statistical approaches: while the non-parametric tests identify group-level differences, the regression models assess individual variation while adjusting for multiple covariates. Additionally, Barr and Linebarger (2017) suggested that content, context, and co-viewing practices may moderate the effects of ST. This means that in some households, ST may be more interactive or educational, thereby mitigating potential negative effects. However, we should be cautious in interpreting this positive association, as the directionality of the relationship cannot be established due to the correlational, cross-sectional study design.

In the third step we introduced a biological risk factor, AS, as a continuous predictor. Although it explained only a small percentage of variance, its significance aligns with some studies showing that early perinatal health can exert long-term, subtle effects on language and neurodevelopmental outcomes (Chavez Hermosilla et al. 2024). Yet, the fourth and final step, which tested for moderation by AS, failed to reveal any significant interaction effects. This indicates that while both biological and environmental risk factors influence early communication, their effects appear to be additive rather than interactive in this sample.

These results, in conjunction with earlier group comparisons, underscore the primacy of environmental influences, i.e. screen-related variables on communication skills. Notably, both the age of first exposure and the amount of ST per day independently predicted communication outcomes, even when controlling for perinatal health status, measured by the AS. This reinforces theoretical frameworks such as Bronfenbrenner's bioecological model (Bronfenbrenner & Morris 2006) which states that developmental trajectories are shaped through dynamic interactions between the child and its immediate environment.

Taken together, our findings suggest that reducing early and excessive screen exposure may represent a feasible and impactful target for early prevention and intervention strategies. Moreover, while biological vulnerabilities such as lower AS merit attention on their own, the results highlight the important role of modifiable environmental factors in shaping early communication development.

LIMITATIONS

Several limitations should be acknowledged. First, the ASQ-3 is not standardized for our population, which may affect the accuracy and cultural validity of the developmental scores. This limitation should be considered when interpreting the findings, as certain items may not fully capture culturally specific developmental expectations or parent–child practices. Second, the correlational, cross-sectional study design cannot indicate causality between ST, Apgar score, and communication skills. Longitudinal studies would certainly provide more information to better understand the directionality and potential long-term impacts of ST. Third, the reliance on parent-reported measures for ST variables, communication skills, and AS may result in reporting biases, such as social desirability or inaccurate recall. This is especially relevant for the AS, which was collected retrospectively, and therefore its accuracy may be limited compared to medical records. Fourth, only 2.2% of the total sample consisted of children with a lower Apgar score, which limits the variability of this variable; future research should aim to better homogenize this variable. Fifth, although the sample was large, it may not fully represent socioeconomically and culturally diverse populations, which can limit the generalizability of the findings. Variations in access to technology and parenting styles across contexts could moderate the observed relationships. Sixth, the content and context of ST were not examined, though these are important factors for its influence on communication skills. Future studies should consider including the type of screen device (e.g., smartphone, tablet, television), as this may differentially affect communication development due to variations in interactivity and usage patterns.

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ODNOS IZMEĐU VREMENA PROVEDENOG PRED EKRANOM, APGAR SKORA I KOMUNIKACIJE KOD DJECE

Sažetak:

Prekomjerno vrijeme provedeno pred ekranom (ST) prepoznato je kao važan sredinski faktor rizika za kašnjenja u ranom razvoju komunikacije, dok je Apgar skor (AS) široko korišćen biološki pokazatelj stanja novorođenčeta neposredno nakon rođenja. Ovo istraživanje ispitivalo je odnose između dječijeg ST, uzrasta pri prvom izlaganju ekranima, i ST roditelja na komunikaciju, kao i to da li je AS povezan sa ovim odnosima ili ih modifikuje. Uzorak je obuhvatao 2.166 djece uzrasta od 12 do 66 meseci. Komunikacija je procjenjenivana pomoću Ages & Stages Questionnaire, treće izdanje (ASQ-3), dok su podaci o ST i AS prikupljeni pomoću posebno dizajniranog upitnika. Djeca koja su prekoračila preporučeno vrijeme pred ekranom ili bila izložena ekranima prije navršenih 12 mjeseci imala su niže rezultate na skali komunikacije, dok je duže vrijeme pred ekranom roditelja (>3 sata dnevno) bilo povezano sa lošijim komunikacijskim ishodima. Rezultati su pokazali da rano izlaganje i prekomjerno vrijeme pred ekranom negativno predviđaju komunikacione sposobnosti, dok je AS imao pozitivan doprinos, ali nije moderirao efekte ST. Ovi nalazi naglašavaju važnost ponašanja vezanih za ST u razumijevanju ranog razvoja komunikacije.

Ključne riječi: vrijeme pred ekranom; Apgar skor; komunikacija

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