

## Research Article

### Screen Time Exposure and Severity of Autism

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#### Abstract

Literature addressing effects of electronic devices on communication pre-requisite skills is limited. The American Academy of Pediatrics recommends that children under 24 months of age not be exposed to electronic devices. Aims of this study are to evaluate the correlation between screen time and severity of autism. Fifty children with communication delays at the American University of Beirut assessed with the Childhood Autism Rating Scale-2 were classified according to scores. Information was collected through telephone. 86% reported exposure  $\geq$  than 2 hours/day. Statistical analyses uncovered an additional of 7.24 ( $\pm 2.42$ ) points on the CARS-2 score implying an increased severity of autism. This suggests that parents of autistic children should limit screen time and engage children in more active pursuits.

**Keywords:** Autistic Features; Communication Delays; Electronic Device Exposure; Screen Time

Television made its appearance in 1927, followed by computers in the seventies, and after 2007, the use of smart phones became prevalent. Nowadays, technology impacts all aspects of life. It has made access to information global, abolishing borders and improving communication, medical care, and business practices. The deleterious effects of extensive use of electronics in children has been under debate with a growing interest for the past decade.

The potential negative impact on children's physical and cognitive development of electronic excessive use has been highlighted in several recent reports [1-6]. Yet, these devices have been promoted increasingly from the media for their educational, entertaining, and relaxing effects, even on young children to calm them down particularly during feeding time [7]. Data from the recent NHANES study conducted between 2009 and 2012 uncovers that children, between 2-4 years of age, who exceeded 2 hours of screen time per day were more likely to become obese at a later age [8]. Electronic devices were also associated with attention deficit hyperactivity disorder (ADHD) [6], depression, anxiety [9] and sleep problems [10-11].

According to American Academy of Pediatrics (AAP) 2001 guidelines, all children under the age of 24 months should not be exposed to television or any electronic device at all, whereas older children should not exceed 2 hours of screen time per day [12]. Despite these guidelines, children are still subjected to excessive exposure to electronics [11]. Television is the predominant device abused, but this also holds true for video games, tablets, and mobile smartphones. Very young children spend more time watching television and less time playing [13]. 50 % of 3-4 year-old Swedish children are online [14,15]. A US-based study states that half of US children spend more than 3 hours per day on electronic devices exceeding the AAP recommendations [16]. In Australia, more than 40% of children aged 1 and a half years, experience screen times exceeding 2 hours per day [17]. Literature addressing the effects of electronic devices on communication pre-requisite skills in children less than 5 years of age has recently become a subject of interest to scientists, yet studies are still scarce. Most studies addressed television exposure impact on developmental skills and language in typically developing children.

The results of a study by L-Y. Lin et al. about "Infant Behavior & Development" (2015) reveal that children exposed to excessive television time are more likely to experience delays in cognitive,

language, and motor development than those not exposed. The lack of physical activity results in decreased time spent exploring, discovering, and learning, affecting early brain development. Lack of physical activity is associated with a negative impact on physical health, social-emotional and developmental functioning [18]. Screen time correlated positively with adverse changes in fronto-polar and medial prefrontal regions and loss in regional grey matter volume, which all together affect cognitive and intellectual performance [9,19].

Nervous system development starts early in fetal life. Neural tube development occurs in 2 stages: primary neurulation, starting around the 18th day of gestation, and secondary neurulation, starting around the 26th day [20-23]. Once basic brain connections are established, patterns of neuronal activity, including those elicited by experience, modify the synaptic circuitry of the developing brain [24]. The basic shape and location of existing neurons in the mature brain do not change, yet the creation and removal of synapses does. This begins during fetal development, continues after birth, albeit at a slower pace throughout life, as part of an ongoing learning and growing process. Life long experience dependent neuroplasticity induces a remodeling of the synaptic circuits and connections [25].

Autism is a neuropsychiatric disorder characterized by severe and sustained impairment in social interaction, communication, and patterns of behavior and interest that are restricted, stereotyped, or both. Onset is generally before the age of 3 years [26,27]. Abnormal brain overgrowth during infancy and early childhood is described in Autism Spectrum Disorder (ASD) between the age 2 to 6 years-old, especially in the frontal and temporal cortices and the amygdala, implicated in the development of socialization, emotion, language, and communication, that are impaired in children with autism [28-30]. There is, however, evidence of decline and possible degeneration marking adult life [31].

Early epidemiological studies of autism report rates of 2-5 cases per 10 000 children [26]. In the past decade, the prevalence of autism has increased. The current ASD prevalence in Lebanon is 1 in 67 children [1.48% with 95% Confidence Interval (0.84, 2.12)] as reported recently by Saab [32]. This is in line with the United States (US) prevalence estimated at 1 in 68 births by the Center for Disease Control and Prevention in 2010 and updated in 2014 with a 15% increase reaching 1 in 59 children [33]. Compared to neuro-typical children, those with ASD are also interested in electronic devices with similar total daily exposure [16]. They, however, seem to use screen time differently [34] with longer exposure time to solitary screen-based media, such as television and video games, which puts them at a higher risk to deleterious effects. Several factors may be involved. Children with ASD present with sleep disturbances and low melatonin serum levels. Furthermore, screen light may mimic daytime making exposure

to electronics more disruptive of sleeping patterns [35,36]. Also, social communication is impaired in ASD. Screen time hampers development of communication skills, including eye contact and understanding facial expressions and body language [37,38]. There is evidence that serotonin regulation and changes in the amygdala are implicated in exposure to electronics [39] making children with ASD more prone to anxiety. Neuroimaging studies imply that exposure to electronics results in atrophy of gray matter in the frontal lobe and reduced white matter volume [40] putting the autistic brain at a higher risk to be “underconnected” [34].

Several studies have reported an increased risk of psychiatric and mental disorders associated in children who were exposed to prolonged exposure to electronic devices [41]. This risk is enhanced in children with ASD encompassing ADHD, tics, and mood and anxiety disorders [42]. With the increasing prevalence of autism and common prolonged exposure to electronic devices, it is beneficial to quantify this exposure and study its developmental implications as children with ASD experience delays in global development and speech.

The primary aim of this study is to correlate amount of exposure to electronic devices and severity of autistic features.

**Hypothesis 1:** The Child Autism Rating Scale-2 (CARS-2) score is elevated in children with prolonged exposure to electronic devices compared to those with limited exposure.

**Hypothesis 2:** Exposure to electronic devices has a positive impact on imitation skills.

### **Research questions:**

Primary Question: Does prolonged and frequent exposure to electronic devices contribute to severity of symptoms of autism?

Secondary Question: Can exposure to electronic devices have a positive effect on communication variables?

## **Methods**

### **Participants**

Fifty out of a pool of 134 children with developmental and speech delay assessed using the CARS-2 battery at the American University of Beirut Medical Center (AUBMC) Special Kids Clinic (ASKC) were included in the study. Ethical approval from the Institutional Review Board at the AUBMC was sought and secured before beginning this study. Parents of children gave oral consent, prior to collection of data.

### **Materials**

A questionnaire was conducted through a phone call interview to collect data on length of exposure to electronic devices/day, types (television, mobile phone, or tablet) and quality

(e.g.: children television channels, websites, applications.). In addition to the above collected information, the authors retrieved the following data from ASKC medical records of patients including age at initial assessment, gender, attendance of a school/nursery, mother’s employment status (all fathers were employed), and CARS-2 scores.

The CARS-2 is preferred over the older CARS version [43]. The CARS-2 is designed to help differentiate children with autism from those with other developmental delays. Total scores above a cutoff of 29 indicate that a full comprehensive assessment for ASD is warranted. In addition, scores above the cutoff can be broken down into a “mild-to-moderate” level of autism vs. a “severe” level.

In this study, the CARS2-ST was used since the children recruited in this study population were less than 6 years-old. There are 15 components of the CARS-2: relation to people, imitation, emotional response, body use, object use, adaptation to change, visual response, listening response, taste, smell and touch response and use, fear or nervousness, verbal communication, nonverbal communication, activity level, level and consistency of intellectual response, and general impressions. The focus in this study is on the following CARS components: relation to people, imitation, object use, visual response, listening response, verbal communication, nonverbal communication, and activity level.

**Procedures and Data Analysis**

Data was extracted from the medical charts. Information about screen time was collected by telephone in a survey related to type, quality and amount of exposure to electronic devices per day. Children were divided into 3 groups depending on the duration of exposure: minimal (less than 2 hours), moderate (2 to 4 hours), and high (more than 4 hours/day). The CARS-2 score was used to categorize children into 3 sub-groups: no to minimal concerns, minimal to moderate concerns, and severe concerns for autism. Data entry and analysis were performed using the statistical software STATA version 13. Descriptive statistics were reported using means and Standard Deviations (SD) for variables with adequate normal distribution, medians along with Interquartile Ranges (IQRs) for skewed continuous variables and frequency with percentages for categorical variables. Statistical bivariate analysis was performed. The Kruskal-Wallis was used for continuous variables to compare their means. The Pearson chi-square ( $\chi^2$ ) test and Fisher’s exact tests were applied for categorical variables. A multivariate analysis using Multiple Linear Regression was carried out with CARS-2 total score as the dependent variable, to evaluate whether electronic devices and attendance of a nursery significantly predicted the CARS-2 score in the sample. A P-value (two-tailed) of <0.05 was considered statistically significant.

A descriptive univariate analysis (Table 1) of demographic and clinical data is presented as frequencies and percentages

for categorical variables (age and gender of the child, mother’s working status, length of exposure to electronic devices/day, and nursery attendance). Data is represented as means with standard deviations for continuous variables (CARS total score and sub-scores) with normal distribution. If continuous variables were not normally distributed, medians and ranges are presented instead.

	<b>Sample Characteristics N=50 (%)</b>
<b>Median Age in months [IQR]^</b>	36 [9]
<b>% Boys</b>	33 (66%)
<b>% Working mother</b>	25 (50%)
<b>Exposure to electronics</b>	
<2 hours/day (n=7)	7 (14%)
2-4 hours/day (n=16)	16 (32%)
>4 hours/day (n=27)	27 (54%)
<b>% Nursery attendance</b>	26 (52%)
<b>Mean (±sd) CARS-2 score</b>	33.6 (±5.69)
<b>CARS-2 severity level</b>	
No-to-Minimal (n=11)	11 (22%)
Mild-to-Moderate (n=24)	24 (48%)
Moderate-to-Severe (n=15)	15 (30%)
<b>CARS-2 selected components</b>	
Mean (±sd) Relating to People	2.43 (±0.62)
Mean (±sd) Imitation	2.25 (±0.81)
Mean (±sd) Object Use	2.49 (±0.55)
Mean (±sd) Visual Response	2.23 (±0.69)
Mean (±sd) CARS-2 Listening response	2.07 (±0.39)
Mean (±sd) CARS-2 Verbal Communication	2.76 (±0.48)
Mean (±sd) CARS-2 Non-Verbal Communication	2.31 (±0.71)
Mean (±sd) Activity Level	1.9 (±0.72)
^ because not normally distributed IQR: Inter Quartile Range	

**Table 1:** Subject Sample Characteristics.

The data related to the outcome of interest (CARS-2 total score) is approximately symmetrical or normally distributed, in spite of the relatively small sample size (N=50), as depicted by histogram and QQ-plot. It is, therefore, sufficient to apply the sta-

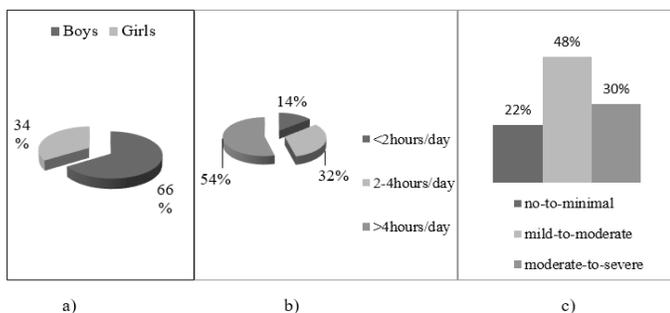
tistical tests that are used for normally distributed data. Data division into three groups according to CARS-2 severity of scores occurred. That said, at the bivariate level, t-tests for independent samples and ANOVA test were used to test differences in scores, whereas Chi-square or Fisher's exact test (when more than 20% of cells have expected frequencies < 5) were used to test differences across the three CARS severity groups.

Assumptions for linear regression were checked. Errors were independent and had constant variance. Multivariable linear regression analysis was conducted to examine the magnitude of the association between the CARS-2 total score and the daily amount of exposure to electronic devices. The latter is the main independent variable whilst controlling for other covariates determined to be important at the bivariate level ( $P \leq 0.2$ ). In order to determine the association between severity of autistic features and the amount of daily exposure to electronic devices, a multinomial logistic regression was adequate, in which the outcomes of interest were the CARS-2 categories.

Owing to the small sample size, linear regression in which the outcome of interest is continuous (i.e. CARS-2 total score) is preferred over multinomial logistic regression since the latter would generate estimates with large variances, thus leading to imprecise conclusions.

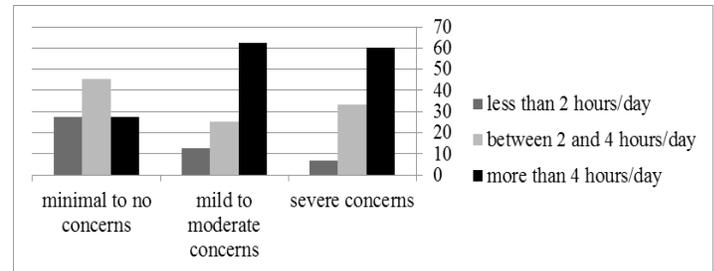
## Results

Fifty children aged between 24-59 months (2-5 years) were selected from a pool of 134 children with developmental and speech delay and assessed using the CARS-2 test at the ASKC. Of the 50 children, 66% were boys (Figure 1a) and 86% reported an amount of exposure to electronic devices of at least 2 hours/day. Seven children had minimal exposure to electronics, 16 were moderately exposed and 27 had high exposure (Figure 1b). The mean CARS-2 score was 33.6 ( $\pm 5.69$ ) with a majority of children (78%) scoring above the CARS-2 cut-off of 29, and, hence, screened positive for ASD. Eleven children were categorized as no-to-minimal concerns (Figure 1c).



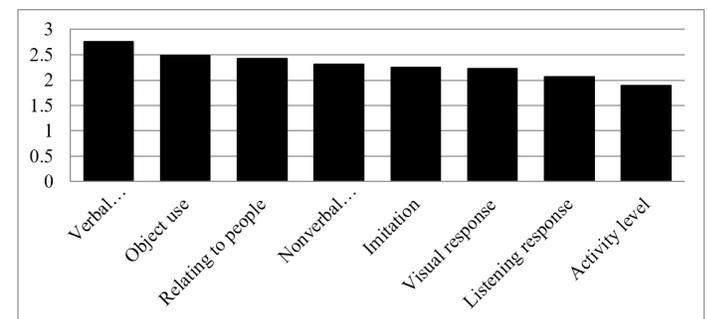
**Figure 1:** a) Gender distribution where 66% were boys vs 34% girls, b) Length of exposure to electronics showing 54% of the exposure exceeding 4 hours/day and only 14% less than 2 hours/day, and c) CARS-2 level distribution screening positive for 78% of children with a score above 29.

Electronic devices included television (always present), mobile phones (72%), and tablets (36%). Exposed children sought hearing songs (80%) and watching cartoons (78%) on baby channels/websites or less frequently, playing solitary application games (12%). 60% of those with severe concerns on the CARS-2 were exposed to electronics for more than 4 hours/day (Figure 2). The clinical and demographic sample characteristics are presented in (Table 1).



**Figure 2:** Distribution of length of exposure according to CARS-2 levels revealing that 62.5% of children with moderate concerns on the CARS-2 and 60% of those with severe concerns were exposed for at least 4 hours/day to electronics.

Of the selected CARS-2 components, “verbal communication” had the highest mean score of 2.76 ( $\pm 0.48$ ) signifying a mild-to-moderate abnormal feature, followed respectively by “object use” [2.49 ( $\pm 0.55$ )], “relation to people” [2.43 ( $\pm 0.62$ )], “non-verbal communication” [2.31 ( $\pm 0.71$ )], “imitation” [2.25 ( $\pm 0.81$ )], “visual response” [2.23 ( $\pm 0.69$ )], “listening response” [2.07 ( $\pm 0.39$ )], and “activity level” [1.9 ( $\pm 0.72$ )] (Figure 3).



**Figure 3:** CARS-2 sub-category scores showing mildly to moderately impaired features in verbal communication, object use, relation to people, nonverbal communication, imitation, visual and listening response with a mean score > 2.

Exposure to electronics was almost the same between children with working mothers and children with non-working mothers. There was no significant statistical difference whether the mother was working or not. All children who did not attend nursery reported an exposure of at least 2 hours per day (Table 2).

	Exposure to electronics % (n)			P-value
	≤ 2 hours	2-4 hours	≥ 4 hours	
<b>Median Age in months [IQR]</b>	37 [20]	37 [16]	35 [9]	k=0.290 (0.865) <sup>a</sup>
<b>Gender</b>				0.419 <sup>b</sup>
Boys	57.14 (4)	56.25 (9)	74.07 (20)	
Girls	42.86 (3)	43.75 (7)	25.93 (7)	
<b>Mother's working status</b>				1.000 <sup>b</sup>
Working mother	57.14 (4)	50 (8)	48.15 (13)	
Non-working mother	42.86 (3)	50 (8)	51.85 (14)	
<b>Attended nursery</b>				0.009 <sup>*b</sup>
Yes	100 (7)	56.25 (9)	37.04 (10)	
No	0	43.75 (7)	62.96 (17)	

<sup>a</sup>Kruskal-Wallis  
<sup>b</sup>Fisher's exact test  
<sup>\*</sup>Significance level alpha <0.05

**Table 2:** Differences of Main Exposure by Covariate Categories.

When looking at the correlation of attending a nursery and CARS-2 severity levels, a significant relationship was found ( $\chi^2=6.922$ ,  $P<0.05$ ) (Table 3). Specifically, while ~ two-thirds (62.5%) of children who scored mild-to-moderate CARS-2 reported never attending nursery, the majority of those who scored moderate-to-severe (80%) reported attending nursery ( $P<0.05$ ). This finding is sufficient to retain this variable in the multivariable regression analysis.

	CARS severity (%n)			P-value
	No-to-Minimal	Mild-to-Moderate	Moderate-to-Severe	
<b>Median Age in months [IQR]</b>	35 [12]	35 [8.5]	38 [12]	K=5.34 (0.0691) <sup>a</sup>
<b>Gender</b>				$\chi^2=1.544$ (0.462) <sup>b</sup>
Boys	72.73 (8)	70.83 (17)	53.33 (8)	
Girls	27.27 (3)	29.1 (7)	46.67 (7)	
<b>Mother's working status</b>				$\chi^2=0.324$ (0.850)
Working mother	45.45 (5)	54.17 (13)	46.67 (7)	
Non-working mother	54.55 (6)	48.83 (11)	53.33 (8)	
<b>Exposure to electronic devices</b>				0.300 <sup>c</sup>
<2 hours/day	27.27 (3)	12.50 (3)	6.67 (1)	
2-4 hours/day	45.45 (5)	25 (6)	33.33 (5)	
>4 hours/day	27.27 (3)	62.50 (15)	60 (9)	
<b>Attended nursery</b>				$\chi^2=6.922$ (0.031) <sup>*</sup>
Yes	45.45 (5)	37.50 (9)	80 (12)	
No	54.55 (6)	62.50 (15)	20 (3)	

<sup>a</sup>Kruskal-Wallis  
<sup>b</sup>Chi square test  
<sup>c</sup>Fisher's exact test  
<sup>\*</sup>Significance level alpha <0.05

**Table 3:** Differences of CARS-2 Severity Concerns by Covariates.

At the bivariate level, the comparison of CARS-2 mean scores across the groups of each covariate showed that there is a small positive correlation between age and CARS-2 total score ( $r=0.27$ ) (Table 4). CARS-2 total score increases with age ( $P=0.051$ ). Girls had higher scores than boys [34.47 ( $\pm 1.31$ ) vs. 33.19 ( $\pm 1.02$ ),  $P=0.459$ ]. Children of non-working mothers had slightly higher scores than those of working mothers [33.9 ( $\pm 1.24$ ) vs. 33.36 ( $\pm 1.04$ ),  $P=0.741$ ]. These differences were not statistically significant.

	a) CARS Total score		b) Unadjusted Coefficients			
	Mean ( $\pm$ sd)	P-value	B ( $\pm$ sd)	t (p-value)	95% CI of B	
					Lower	Upper
<b>Age in months</b>	$\rho=0.27^a$	0.051*	0.16 ( $\pm 0.09$ )	1.80 (0.078)*	-0.19	0.35
<b>Gender</b>		$t=-3.422$ (0.459) <sup>b</sup>				
Boys	33.19 ( $\pm 1.02$ )		-1.27 ( $\pm 1.70$ )	0.75 (0.459)	-2.15	4.7
Girls (Ref)	34.47 ( $\pm 1.31$ )		Ref	-	-	-
<b>Mother's working status</b>		$t=-0.332$ (0.741) <sup>b</sup>				
Working mother	33.36 ( $\pm 1.04$ )		-0.54 ( $\pm 1.62$ )	-0.33 (0.741)	-3.8	2.72
Non-working mother (Ref)	33.9 ( $\pm 1.24$ )		Ref	-	-	-
<b>Exposure to electronic devices</b>		$F=2.41$ (0.101) <sup>c*</sup>				
<2 hours/day (Ref)	30.42 ( $\pm 6.00$ )		Ref	-	-	-
2-4 hours/day	32.56 ( $\pm 6.00$ )		2.13 ( $\pm 2.63$ )	0.81 (0.422)	-0.36	7.43
>4 hours/day	35.09 ( $\pm 5.12$ )		4.66 ( $\pm 2.38$ )	1.96 (0.057)*	-0.13	9.46
<b>Attended nursery</b>		$t=1.179$ (0.244) <sup>c</sup>				
Yes	34.53 ( $\pm 1.10$ )		1.89( $\pm 1.6$ )	1.18 (0.244)	-1.33	5.11
No (Ref)	32.64 ( $\pm 1.16$ )		Ref	-	-	-

<sup>a</sup>Spearman's rank correlation  
<sup>b</sup>t test for independent samples  
<sup>c</sup>Anova test  
\*Variables with unadjusted coefficients with a p-value <0.2 were considered eligible for inclusion in the adjusted regression analysis

**Table 4: a)** Differences of Mean CARS-2 Total Scores by Covariates, and **b)** Simple Linear Regression Analysis of CARS-2 Total Score with all Covariates.

An increasing trend in CARS-2 mean scores is spotted with greater amounts of daily exposure to electronic devices from 30.42 ( $\pm 6.00$ ) in children exposed to less than 2 hours/day to 35.09 ( $\pm 5.12$ ) in those exposed to more than 4 hours per day. As for attending nursery, mean scores were higher in children who attended nursery versus those who did not, but the differences were not statistically significant (34.53 ( $\pm 1.10$ ) vs. 32.64 ( $\pm 1.16$ ),  $P=0.244$ ) (Table 4).

For the multivariable linear regression analysis, variables that had a  $P<0.2$  (Tables 4-5) at the bivariate level were retained. Findings showed that the amount of daily exposure to electronic devices predicted CARS-2 score controlling for age, gender, and attending nursery. Specifically, the increase of exposure to electronic devices from 2 hours to more than 4 hours/day increases the CARS-2 score 7.2 units on average, controlling for age, gender, and nursery attendance ( $P<0.05$ ).

	B (±sd)	t (p-value)	95% CI of B	
			Lower	Upper
<b>Age in months</b>	0.16 (±0.08)	1.87 (0.068)	-0.01	0.33
<b>Attending Nursery</b>				
Yes	3.56 (±1.62)	2.20 (0.03)*	0.30	6.83
No (Ref)	Ref	-	-	-
<b>Exposure to electronics</b>				
<2 hours/day (Ref)	Ref	-	-	-
2-4 hours/day	3.81 (±2.42)	1.57 (0.123)	-1.07	8.70
>4 hours/day	7.27 (±2.39)	3.03 (0.004)*	2.44	12.10

\*Significance level alpha <0.05

**Table 5:** Predictors of CARS Total Scores Adjusting for Covariates.

In the multivariable regression model (Table 5), the presence of interaction was testable by adding all possible interaction terms. None of the interaction terms were significant, suggesting that there was no interaction between any of the variables. Comparing the unadjusted coefficients of “exposure to electronics” categories in the simple linear regression (Table 4) to their respective adjusted coefficients in the multivariable model was accomplished to assess whether age or attending nursery were confounding the relationship between exposure and CARS-2 score.

Adding the variable of attending nursery to the model inflated the magnitude of the adjusted coefficients of exposure to electronics [ $B_1=3.81 (\pm 2.42)$ ;  $P=0.123$  and  $B_2=7.27 (\pm 2.39)$ ;  $P=0.004$ ] compared to their respective unadjusted coefficient [ $B_1=2.13 (\pm 2.50)$ ;  $p=0.399$  and  $B_2=4.66 (\pm 2.34)$ ;  $P=0.053$ ] indicating that the variable of attending nursery is a confounder and should be controlled for. Indeed, attending nursery was associated with exposure to electronics ( $P<0.05$ ). Specifically, the majority (70.83%) of children who did not attend a nursery (versus ~ 38% of those that attended a nursery) reported exposure to electronics for more than 4 hours/day.

The components of CARS-2 are shown in (Table 6). ‘Listening response’ and ‘verbal communication’ scale items are higher in children exposed to electronic devices for 2 or more hours/day than their counterparts and this was statistically significant (2.13 (±0.05) vs. 1.71 (±0.18),  $P<0.05$  and 2.81 (±0.69) vs. 2.42 (±0.20),  $P<0.05$ , respectively). Interestingly, the ‘imitation’ item scale was lower for children who were exposed to electronics for a longer period per day i.e. 2 hours or more vs. less than 2 hours [2.21 (±0.12) vs. 2.5 (±0.36),  $P=0.383$ ] showing less severity in this particular component. This was statistically significant for the >4 hours/day category.

	Relating to People	Imitation	Object Use	Visual response	Listening response	Verbal Communication	Non-verbal communication	Activity level
<b>Gender</b>								
Boys	2.31 (±0.12)	2.21 (±0.12)	2.42 (±0.02)	2.16 (±0.12)	2.03 (±0.07)	2.74 (±0.08)	2.21 (±0.12)	1.84 (±0.13)
Girls	2.64 (±0.09)	2.32 (±0.23)	2.61 (±0.13)	2.35 (±0.17)	2.14 (±0.10)	2.79 (±0.12)	2.5 (±0.17)	2 (±0.16)
P-value	t=1.809 (0.076)	t=-0.457 (0.649)	t=-1.186 (0.241)	t=-0.907 (0.369)	t=-0.999 (0.323)	t=-0.360 (0.720)	t=-1.363 (0.179)	t=-0.699 (0.487)
<b>Mother’s working status</b>								
Working mother	2.38 (±0.12)	2.16 (±0.16)	2.5 (±0.10)	2.16 (±0.12)	2.06 (±0.08)	2.74 (±0.08)	2.26 (±0.14)	1.88 (±0.15)

Non-working mother	2.48 (±0.12)	2.34 (±0.16)	2.48 (±0.12)	2.3 (0.15)	2.08 (±0.07)	2.78 (±0.10)	2.23 (±0.14)	1.92 (±0.14)
P-value	t=0.563 (0.575)	t=-0.783 (0.438)	t=0.128 (0.899)	t=-0.717 (0.476)	t=-0.179 (0.859)	t=-0.294 (0.770)	t=-0.492 (0.625)	t=-0.194 (0.847)
<b>Exposure to electronic devices</b>								
<2 hours/day	2.14 (±0.62)	2.5 (±0.36)	2.14 (±0.24)	1.85 (±0.26)	1.71 (±0.18)	2.42 (±0.20)	2.14 (±0.28)	1.71 (±0.21)
2 or more hours/day	2.47 (±0.09)	2.21 (±0.12)	2.54 (±0.08)	2.29 (±0.10)	2.13 (±0.05)	2.81 (±0.69)	2.33 (±0.11)	1.93 (±0.11)
P-value	t=-1.325 (0.191)	t=0.879 (0.383)	t=-1.849 (0.070)	t=-1.572 (0.123)	t=-2.763 (0.008)*	t=-2.049 (0.046)*	t=-0.664 (0.509)	t=-0.731 (0.468)
<b>Attended nursery</b>								
Yes	2.48 (±0.11)	2.53 (±0.16)	2.63 (±0.11)	2.26 (±0.13)	2.09 (±0.09)	2.78 (±0.08)	2.48 (±0.13)	1.92 (±0.14)
No	2.37 (±0.13)	1.94 (±0.15)	2.33 (±0.11)	2.19 (±0.15)	2.04 (±0.07)	2.73 (±0.11)	2.12 (±0.14)	1.87 (±0.14)
P-value	t=-0.596 (0.554)	t=2.799 (0.007)*	t=1.999 (0.051)	t=0.417 (0.679)	t=0.488 (0.627)	t=0.436 (0.665)	t=1.801 (0.078)	t=0.233 (0.817)
* Significance level alpha <0.05								

**Table 6:** Differences of Mean Scores of CARS-2 Selected Components by Gender, Mother’s Working Status, Amount of Exposure to Electronic Devices, and Attending Nursery.

## Discussion

Studies have shown that children are more prone to undesired side effects of technology [44]. Children with ASD present with delays and difficulties in communication both verbal and nonverbal. They have impaired eye contact, do not respond when called, have speech delay, and demonstrate stereotyped behaviors [27]. Those core features put children with ASD at high risk for overusing electronic devices [45,46]. The use of electronics may be beneficial in several areas [14].

Aided augmentative and alternative communication systems use electronic devices to facilitate communication [45]. Yet, they do not enhance eye contact, response to name, object manipulation, adaptation to change or understanding facial expressions, especially the solitary kind which is the most commonly used in children on the spectrum. The majority of young autistic children spend most of their free time using non-social media or solitary screen-based media (i.e., television and video games) [47]. In this study, television was the predominant electronic device of exposure, as well as mobile phones. Most of the exposed children lis-

tened to and watched songs and cartoons. They also played, less frequently, solitary video games.

The primary objective of the study is to answer the question “Does prolonged and frequent exposure to electronic devices contribute to severity of symptoms of autism?” by assessing more closely the pre-requisites of communication. This question was answered by comparing the CARS-2 score and the amount of daily exposure to electronic devices. After adjustment for age, gender, and nursery attendance, results showed that children with prolonged exposure to electronics (more than 4 hours/day) scored, on the CARS-2, 7.24 (±2.42) (P=0.004) points higher than those who had minimal exposure (less than 2 hours), and this finding was statistically significant. Seven points on the CARS-2 may take a child from the minimal-to-no to the category mild-to-moderate. The range in the mild-to-moderate category is 6.5 points (30 to 36.5). These results answer the first question and confirm that prolonged exposure to electronics and severity of autistic symptoms correlate positively. The longer children are exposed, the more severe their symptoms are. Another way to interpret these results is by suppos-

ing that children with severe autistic symptoms are placed in front of television for a longer period of time because of parent lack of knowledge of how to play or interact with them. This has been documented in a study about the relationship to physical activity and screen time. Children with ASD required more supervision. Parents of children with ASD reported they lack skills to integrate their children because of poor motor skills and behavior problems. Lack of physical activity contributes to increased exposure to television [48]. The majority of the sample (86%) reported an exposure of at least 2 hours per day and 54% of the sample had prolonged exposure (>4 hours/day). This exceeds the recommendations of the AAP for young children (American Academy of Pediatrics, 2001). When scrutinizing CARS-2 components, the most affected pre-requisites of communication were verbal communication, object use, and relation to people.

“Verbal communication” had the highest mean score of 2.81 ( $\pm 0.69$ ) for exposure greater than 2 hours per day ( $P=0.046$ ). This is explained because these children were assessed due to their speech delay, the first sign of concern for parents and the main cause for referral. This conforms to results in the literature revealing speech delay caused by prolonged exposure to television in young children [49]. This was followed by “object use” with a score of 2.54 ( $\pm 0.08$ ) with  $P=0.07$ . When a child is viewing television or watching YouTube videos on the tablet/phone, he/she loses the chance and time to manipulate toys and discover surroundings. “Relating to people” scored 2.47 ( $\pm 0.09$ ), but this was not statistically significant. The solitary kind of electronic device isolates children into their own bubble and narrows their communication channels [46]. “Listening response” was significantly higher with a score of 2.13 ( $P=0.008$ ) when the child was exposed to at least 2 hours/day. The second sign that concerns parents of autistic children is the absence/lack of response to name. They know that their child can hear, but does not answer.

Other components directly or indirectly related to communication were not determined to be statistically significant. Their mean score, however, increased with an exposure of 2 hours or more, except for imitation. Visual response scores (eye contact) increased from 1.85 ( $\pm 0.26$ ) with minimal exposure to 2.29 ( $\pm 0.10$ ) with an exposure of at least 2 hours per day; nonverbal communication scores (pointing) increased from 2.14 ( $\pm 0.28$ ) to 2.33 ( $\pm 0.11$ ); imitation scores decreased from 2.5 ( $\pm 0.36$ ) to 2.21 ( $\pm 0.12$ ), and activity level scores increased from 1.71 ( $\pm 0.21$ ) to 1.93 ( $\pm 0.11$ ).

The secondary research question was “Does some exposure to electronic devices have a positive effect on any communication variable?” This was accomplished by inspecting the sub-categories of the CARS-2, studying their relation to exposure and determining if there was a positive effect or a decrease in score. Imitation was the only component where the score dropped while exposure increased: 2.5 ( $\pm 0.36$ ) with less than 2 hours exposure/day to 2.21

( $\pm 0.12$ ) with more than 2 hours of screen time/day. This, however, was not statistically significant, and this may be due to the small sample size. This fact should be taken into consideration. Screen time may assist in developing imitation skills. Children are mostly interested in watching animated songs, whether on television, tablet or phone. This could enhance imitation of gestures and actions.

The results of a survey by Shane & Albert in 2008 [50] (Electronic Screen Media for Persons with Autism Spectrum Disorders) suggest that media can be used as a learning tool combining motivation of autistic children and their observed imitative behaviors. The variable of whether mother works [33.9 ( $\pm 1.24$ )] or not [33.36 ( $\pm 1.04$ )] did not significantly affect the CARS score in this study and was not retained. The exposure to electronics did not differ between children of working mothers and those of non-working mothers. This is inconsistent with results reported by Benjamin et al. (2009) [51] where children with non-parental caregivers tend to have more screen time than those with parents. This, again, could be due to the small sample size.

The variable “attending nursery” had a significant input in the analysis. It appeared as a risk factor with higher mean CARS score for children who attended nursery. This, however, was not statistically significant ( $P$ -value=0.244) in the simple linear regression, and requires more in depth analysis. Many factors could be at play.

The presumption is that nurseries have a positive impact on the global development of children [52,53]. Theoretically, this includes gross motor skills (jumping, running, climbing, etc.), fine motor skills (coloring, playing with pegs or clay, etc.), sensory skills (playing with sand, sliding, swinging, etc.), speech (reading stories, singing nursery rhymes, etc.), communication (dealing with peers), problem solving, and adaptation to change.

Engaging in learning and playing are essential for the development of every child [54]. When parents notice their children as having speech and/or communication delays, they seek medical help from their pediatrician. The first common recommendation is to enroll children in a nursery to enhance interaction with their peers with the assumption of a positive impact on children with delays in communication. Modifying their environment from solitary to interactive can influence development of the nervous system by enhancing synaptic formation.

Exposure of children to television in some nurseries is a potential problem and an open and valid question. Directors of nurseries should be aware of this finding. Some nurseries use screen time to calm children down or put them to sleep. In this study, the majority of those who scored moderate-to-severe symptoms (80%) attended nurseries, while 62.5% of those with mild-to-moderate symptoms never attended nursery. Interpretation could be that

children who scored high on CARS-2 present with severe symptoms. Parents are more likely to notice severe symptoms, while it is easier to misinterpret or ignore minimal to moderate autistic features or red flags. Attending nurseries is not the cause for severity of features, but maybe a consequence or way to deal with them.

## Limitations

Despite significant findings in this study, several limitations exist.

The current study was dependent on the number of children available from the ASKC (finite population). 50 participants is a relatively small sample size. This can diminish the power in detecting statistical significance. For future studies, additional treatment centers for autism should be included for subject recruitment to increase sample size and statistical power.

The interview with the parents contained questions and answers about exposure and nursery. What is unknown is whether the screen time exposure occurred before, after or during nursery attendance. What is also unknown is whether the child attended nursery because of developmental delay or not. Why children attended nurseries in the first place is unknown. The type of nursery and amount of exposure to television within nurseries also is unknown.

Bias resulting from a retrospective study design and difficulty in accurate recall by parents during the telephone interview as to exact amount of exposure to electronics is a limitation.

Finally, the reliance on a non-experimental research design only allows the researcher to understand correlation and prediction relationships between the variables. According to Christensen, Johnson, Turner and Christensen (2011), [55] regression and correlational analysis can aid in understanding the predictive relationship between variables, however, causation inferences are not to be inferred.

## Conclusion

Before television, smart phones and tablets, children engaged in simpler, less sophisticated games. Children had to be creative, more interactive, more imaginative and definitely more active to engage in play. All these elements assist in developing gross and fine motor, sensory, proprioception, stereognosis, memory, logic, speech, and social interaction skills. Technology is essential to all and is here to stay. Limits should be in place for all children and particularly to those more sensitive to negative effects of screen time. This study uncovers a strong correlation between length of exposure to electronic devices and severity of autistic symptoms. Verbal communication, listening response and object use were significantly affected. Limiting exposure to screen time does not eliminate autistic features, but prevents an enhanced negative impact.

Television does not assist in developing cognitive abilities [56] or speech in young children, but the opposite [57]. Books and stories remain the best home-based activity to enhance development of speech. Children learn new vocabulary from book-reading sessions [58-61]. Recommendations are for parents to limit screen time, not use electronic devices as baby-sitters, and engage children in interactive activities. Autism is a complex disorder, but the risk factor of exposure to electronics is easily modifiable. Adding such studies and results to the literature may help in preventing autistic traits from worsening at an early stage.

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