



Association between screen time and developmental and behavioral problems among children in the United States: evidence from 2018 to 2020 NSCH

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ARTICLE INFO

Keywords:

Screen time
Digital media use
Development
Behavior

ABSTRACT

Excessive digital media use has become the common phenomenon among children's lifestyle, and its influences on the plausible accompanying psychological and behavioral problems are gradually investigated. This study aimed to examine the association between screen time and developmental and behavioral problems of children in the United States (US). A secondary analysis based on the data from the 2018 to 2020 National Survey of Children's Health (NSCH) was conducted. Seven types of developmental and behavioral problems and screen time on weekdays of children were collected through parents/caregivers' recall. Logistic regression models were constructed to determine the associations. Overall, 101,350 children aged between 0 and 17 years old were included in this study and 70.3% of preschoolers aged 0–5 years old and 80.2% of children and adolescents aged 6–17 years old had excessive screen time. Excessive screen time was positively associated with behavioral and conduct problem, developmental delay, speech disorder, learning disability, autism spectrum disorders (ASD), and attention deficit hyperactivity disorder (ADHD) and there were significant dose-response relationships. The association between excessive screen time and developmental and behavioral problems was stronger among preschoolers than among children and adolescents. Boys with excessive screen time showed high odds of most types of developmental and behavioral problems. It can be concluded that children with excessive screen time are at high odds of developmental and behavioral problems, especially for preschoolers and boys. Early intervention of digital media use is urgent and essential for children in the US.

1. Introduction

Along with the advance in science and technology and popularity of electronic products, digital media and screens are pervading every aspect in the lives of children. It has been reported that approximately 91% of children aged 0–8 years in the United States (US) have a home computer, and 98% have a mobile device at home (Common Sense Media, 2018). Consequently, in recent decades, the average screen time of children aged 8–18 years had increased from 6.21 h per day to 7.38 h

per day (Magee et al., 2014). In addition, children aged 0–8 years in the US are also reported to spend two-and-a-quarter hours a day on screens (Common Sense Media, 2018), which extensively exceeds guidelines of World Health Organization (WHO) on physical activity and sedentary behavior that infants aged 1 years old should not have digital screen exposure, no more than 1 h per day of digital media is recommended for infants aged 2–4 years old (World Health Organization, 2019), and children and adolescents aged 5–17 years old should not have exceed 2 h per day of recreational screen time (World Health Organization, 2020).

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Early screens exposure is not always beneficial. Although there are evidences that moderate or high-quality and interactive screen time is benefit for learning and cognitive (Radesky et al., 2015; Kirkorian et al., 2016), a range of psychological and physical problems of children have been increasingly identified which are caused by excessive exposure to screen media in early childhood development (Domingues-Montanari, 2017; Kushima et al., 2022; Varadarajan et al., 2021). Accordingly, comprehensive exploration of potential consequences of excessive screen use are instructive for pediatricians and other health care practitioners.

Health development and behavior of children are always the hot topic of pediatrics. During childhood, individual psychology and behavior develop rapidly and gradually stabilize, but developmental delay and behavioral problems are easily induced under the impact of various external risk factors (Miguel et al., 2019). It has been identified that development delay and behavioral problems are common among US children that 7.4% of children aged 3–17 years in the US had current behavioral/conduct problems (Ghandour et al., 2019), the overall prevalence of any developmental disability among children aged 3–17 years in the US was 16.93% and there was an increasing trend (Zablotsky et al., 2019). Therefore, early detection of risk and protective components associated with developmental and behavioral problems is essential and urgent for the intervention and prevention.

With the increasing attention to digital screens in recent years, evidence of the effects of digital screen use on the developmental and behavioral problems has gradually emerged but is mixed. A few longitudinal and cross-sectional studies have demonstrated the positive association between excessive digital media exposure and developmental and behavioral problems in younger children (Vohr et al., 2021; Zhao et al., 2022; Varadarajan et al., 2021; McArthur et al., 2022; Hill et al., 2020; Kushima et al., 2022; Madigan et al., 2019). However, no significant association between screen time and behavioral problems is also supported by some longitudinal studies (Levelink et al., 2021). This discrepancy in findings of the association between screen time and developmental and behavioral problems may be partially accounted for methodological variations that the measurement of screen time differed between studies and the influence of mediators (Twenge et al., 2020), which implies that it is necessary to further extensively examine accurate associations. Moreover, most previous studies have examined association between digital media use and single or several types of developmental and behavioral problems of children, and few had determined its association with a broader spectrum of developmental and behavioral problems. Therefore, examination of the association between digital media use and extensively spectrum of developmental and behavioral problems of children is deserved and necessary.

It should be noted that there is the sensitive or critical period for children's health development (Alberga et al., 2012; Meredith, 2015), and the effect of digital media exposure on the health of children may be varied by the exposure periods. For example, a cross-sectional study has indicated that the first three years following birth might be a sensitive period for children when screen exposure increases the risk of experiencing autistic-like behaviors (Chen et al., 2021). Previous studies have also highlighted that infants and toddlers with excessive media use are more likely to show abnormal in health (Reid Chassiakos et al., 2016). It has been demonstrated that associations between screen time and lower psychological well-being were larger among adolescents than younger children (Twenge and Campbell, 2018). Therefore, it can be speculated that the strength of the association between digital media exposure and children's developmental and behavioral problems may differ across the childhood. However, most of studies explored the association between early digital media exposure and developmental and behavioral delays mainly focus on early or middle childhood, but less is explored the associations expand all childhood periods. It is well-known that early childhood is an important period and rapid stage for brain development and healthy development, and cognitive and behavior patterns are gradually stable in later childhood and adulthood. We therefore

speculate that excessive screen time may be more harmful to younger children than older adolescents. Apart from that, importantly, sex difference of the effect of digital media use on mental or behavioral health of children has also been identified (Twenge and Martin, 2020; Kushima et al., 2022). Summarily, some study have indicated that the effect of digital media use was stronger for girls than boys (Twenge and Martin, 2020), but no significant effect of digital media use on girls has also been observed (Kushima et al., 2022). Similarly, whether the associations between digital media use and various developmental and behavioral problems exist sex difference needs further explored.

A better understanding of the association of screen time with developmental and behavioral problems may be helpful to earlier and more effective interventions as well as the promotion of healthy child development. Therefore, to expand the knowledge on the effect of digital media use on the development of children, the current study utilized the data of 2018–2020 National Survey of Children's Health (NSCH) in order to examine the following questions: (1) how excessive screen time of children relate to developmental and behavioral problems; (2) whether the associations between screen time and developmental and behavioral problems exist age difference; (3) whether girls with excessive screen time are at greater risk for developmental and behavioral problems compared with boys. The findings of this study will provide additional evidences on the association between digital media use and developmental and behavioral problems of children and help to develop and implement policies and programs for policy makers, health practitioners, educators, and social support workers.

2. Methods

2.1. Data source and study design

NSCH is a representative national cross-sectional survey in the US. It is conducted annually in order to collect a broad range of information about health and well-beings among children between 0 and 17 years old, which is supported by the U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau (National Survey of Children's Health (2016 - present)). <https://www.childhealthdata.org/browse/survey>). NSCH utilized a stratified random sampling design that the survey first identified families with children from a national sample (50 states across the United States) of addresses, then randomly selected one child from each of the eligible families, who then took a more detailed thematic questionnaire. For more information, detailed sampling methodology can be seen in Methodology Report and Sampling and Administration Diagram on the Data Resource Center (DRC) website (www.childhealthdata.org). In this study, we conducted a secondary analysis by using 2018 to 2020 survey data with the full sample sizes ranged from 21,599 to 50,212, and the weighted overall response rate was ranged from 37.4% to 43.1%. A total of 102,740 samples aged 0–17 years were initially included in our study. Samples with missing data on screen time were deleted, and 101,350 children were finally included for data analysis. The flowchart is presented in Fig. 1.

2.2. Measurements

2.2.1. Assessment of screen time

In NSCH, screen time of children was assessed by asking the family caregivers about the media device use on weekdays that “On most weekdays, about how much time does this child usually spend in front of a TV, computer, cellphone or other electronic device watching programs, playing games, accessing the internet or using social media, not including schoolwork?”. The response was selected with five categories (Less than 1 h per day; 1 h per day; 2 h per day; 3 h per day; and 4 or more hours per day). According to the guidelines on screen time (World Health Organization, 2019; World Health Organization, 2020), excessive screen time of preschoolers (0–5years old) was defined with ≥ 1

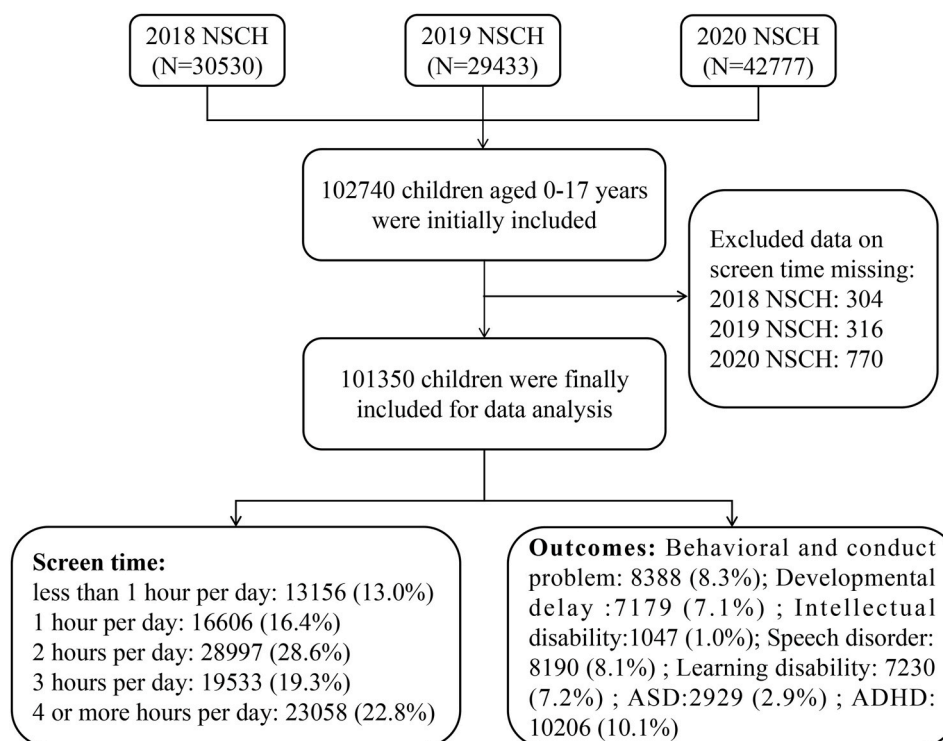


Fig. 1. The flowchart of this study.

h/day of screen time, and excessive screen time of children and adolescents (6–17 years old) was defined with ≥ 2 h/day of screen time.

2.2.2. Assessment of developmental and behavioral problems

The information about children's health conditions is based on caregivers recollection that 10 conditions of mental, emotional, developmental or behavioral (MEDB) problems of children were asked, including Tourette Syndrome, anxiety problems, depression, behavioral and conduct problem, developmental delay, intellectual disability, speech or other language disorder, learning disability (also known as mental retardation), Autism or Autism Spectrum Disorder (ASD), Attention Deficit Disorder or Attention-Deficit/Hyperactivity Disorder (ADHD) that "has a doctor, other health care provider, or educator ever told you that this child has these problems". The parents were separately answered what is the condition of each MEDB problem of the child. In this study, the behavioral and conduct problem, developmental delay, intellectual disability, speech or other language disorder, learning disability, ASD, and ADHD were selected as the outcomes to reflect developmental and behavioral problems of children. Each outcome was respectively coded as no or yes based on the response of parents/caregivers.

2.2.3. Potential confounding variables

To eliminate the influence of confounding factors as much as possible and examine the accurate relationships, potential available confounding variables in NSCH related to the children, family and caregivers/parents were adjusted. Specially, characteristics of children including age, sex, race/ethnicity, premature, low birth weight, participation in organized activities after school or on weekends and physical activity were considered, characteristics of family and caregivers/parents including type of primary caregivers, highest education of caregivers, household income, family structure, and number of child in family were considered. In addition, parenting is also closely associated with children's behavior and development (Crowell et al., 2019), parental aggravation from parenting was adjusted. It has been demonstrated that parent-child interaction is also an important factor which can affect the digital media

use and development of children (Wong et al., 2020). Therefore, parent participation in children's activities was selected and adjusted in the multivariate models.

Details about the assessment of selected confounding variables can be seen in the handbook of NSCH survey. Briefly, the age, sex and race/ethnicity, premature, low birth weight of children, type of primary caregivers, highest education of caregivers, household income, family structure and number of child in family were collected in the section of Child and Family Demographics through the response of caregivers. Parental aggravation from parenting was surveyed by the question: "Does this child have parents who felt aggravated by parenting during the past month?". The information of parent-child interaction was collected through the question: "During the past 12 months, how often did you attend events or activities that this child participated in? (applied for children aged 6–17 years old)". Children participation in organized activities were surveyed by the question: "During the past 12 months, did this child participate in any organized activities or lessons, after school or on weekends? (applied for children aged 6–17 years old)". Physical activity of children were surveyed by the question: "During the past week, on how many days did this child exercise, play a sport, or participate in physical activity for at least 60 min? (applied for children aged 6–17 years old)".

2.3. Statistical analysis

The number and percentage was used to describe the category of screen time, the positive of each type of developmental and behavioral problems, and other characteristics of children, family, parents/caregivers. Chi-square tests were used to compare the prevalence of each type of developmental and behavioral problems among different categories of screen time. Logistic regression analysis was performed to assess the association between screen time and developmental and behavioral problems of children and represented as odds ratios (ORs) and 95% confidence intervals (CIs). We constructed three logistic regression models to stepwise examine the accurate associations. Model 1 was the crude model without any covariate, model 2 was adjusted

demographic characteristics of children and families and model 3 was further adjusted for other variables (parental aggravation, parent-child interaction, participation in organized activities and physical activity) based on Model 2. Given that some confounding variables was only available for children between the ages of 6 and 17 and there is much difference between preschooler and school-age children, we divided the samples into two sections (preschooler: 0–5 years of age; children and adolescents: 6–17 years of age) for analysis separately. For the preschooler, based on the guidelines on screen time for children under 5 years of age (World Health Organization, 2019), we used screen time of less than 1 h per day as the reference to assess the associations between excessive screen time and developmental problems. For children and adolescents, the screen time of less than 2 h per day as the reference to examine associations according to the guidelines on the screen time for children and adolescents (World Health Organization, 2020). Age differences of the association between screen time and developmental and behavioral problems were explored through subgroup analyses based on age subgroups that samples of children and adolescents were divided into two age subgroups (children aged 6–11 years old and 12–17 years old). Sex difference on the associations were also examined by different sex subgroups. Considering that screen use in adolescents is particularly prevalent and the teens have higher levels of screen time (Twenge and Campbell, 2018), We further adjusted for screen time of less than 3 h/day as the reference to explore whether the association of excessive screen use with developmental and behavioral problems was stable and robust. All analyses were performed by SPSS 23.0 software, and *P* value less than 0.05 at two-side test was considered statistical significance.

3. Results

3.1. Characteristics of subjects

Of 101,350 children, 52,659 (52.0%) were boys, and most children (77.4%) were White race. For the screen use of all included children, 13,156 (13.0%) were reported with less than 1 h/day of screen time, 16,606 (16.4%) with 1 h/day, 28,997 (28.6%) with 2 h/day, 19,533 (19.3%) with 3 h/day, and 23,058 (22.8%) with 4 or more hours/day. For the prevalence of excessive screen time, 70.3% of preschoolers aged 0–5 years old and 80.2% of children and adolescents aged 6–17 years old had been identified with excessive screen time. For the outcome of developmental and behavioral problems, 8388 (8.3%) had behavioral

and conduct problem, 7179 (7.1%) had developmental delay, 1047 (1.0%) had intellectual disability, 8190 (8.1%) had speech disorder, 7230 (7.2%) had learning disability, 2929 (2.9%) had ASD, and 10,206 (10.1%) had ADHD. There were significant differences for the prevalence of all types of developmental and behavioral problems among different categories of screen time and the trend of the prevalence of developmental and behavioral problems was increased with the category of screen times (Fig. 2). The detailed characteristics of children are presented in Table 1.

3.2. Association between screen time and developmental and behavioral problems

The results of associations between screen time and developmental and behavioral problems among preschoolers are shown in Table 2. Overall, preschoolers with excessive screen time showed higher odds of developmental and behavioral problems. Specially, it can be seen that excessive screen time was positively associated with all seven types of developmental and behavioral problems without adjusting confounding factors. After adjusting potential confounding factors, compared with less than 1 h per day, children with 2, 3, 4 or more hours of screen time per day significantly showed 1.34 to 2.12 times odds of developmental delay, 1.54 to 2.38 times odds of speech disorder and 2.08 to 3.49 times odds of ASD, preschoolers with ≥ 4 h of screen time per day significantly had 1.76 times (95%CI: 1.33–2.33) odds of behavioral and conduct problem, 1.96 times (95%CI: 1.38–2.78) odds of learning disability and 1.85 times (95%CI: 1.17–2.93) odds of ADHD. In addition, there were significant dose-response relationships between the level of screen time and odds of each type of developmental and behavioral problems. Conversely, compared with less than 1 h screen time per day, children who had 1 h of screen time per day showed significant lower odds of intellectual disability (adjusted OR = 0.41, 95%CI: 0.21–0.80, *P* = 0.009), but there was no significant association between other categories of screen time and intellectual disability.

The results of associations between screen time and developmental and behavioral problems among children and adolescents aged 6–17 years old are presented in Table 3. Children and adolescent with excessive screen time showed higher odds of behavioral and conduct problem, developmental delay, speech disorder, learning disability, ASD and ADHD. Specially, with adjusting confounding factors, children and adolescents with 3 h of screen time per day significantly showed 1.11

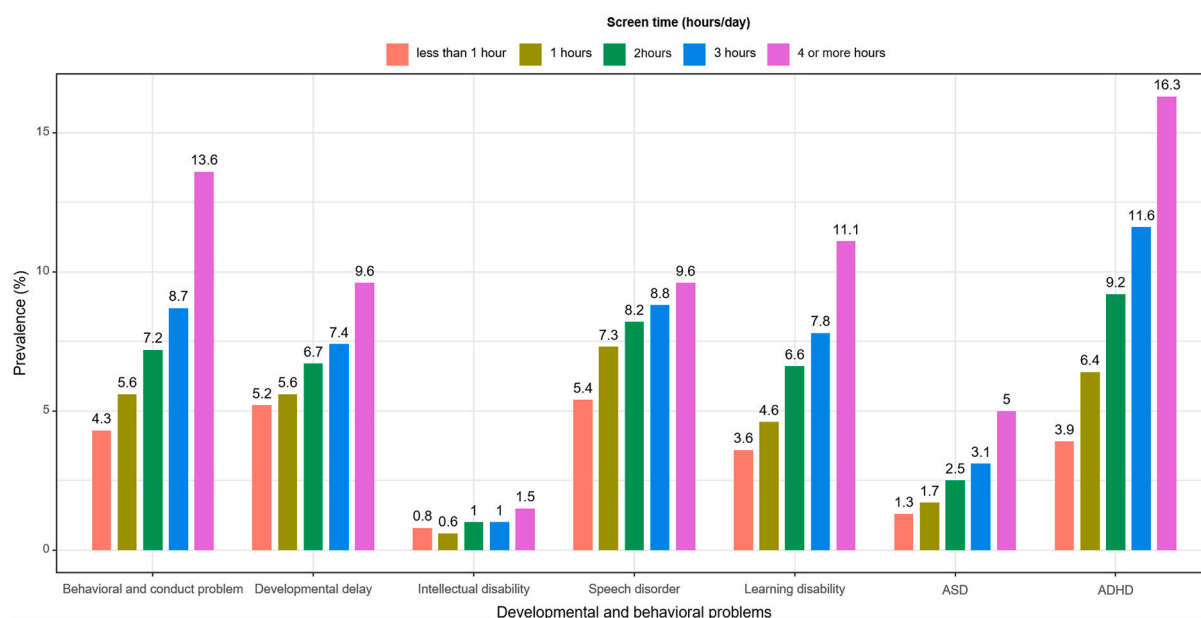


Fig. 2. The prevalence of developmental and behavioral problems among different categories of screen time.

Table 1

Characteristics of children, family and caregivers/parents among different category of screen time.

Characteristics	Total	Screen time (hours/day)					P-value
		<1	1	2	3	≥4	
Sex of children							
Boys	52,659 (52.0)	6677 (50.8)	8182 (49.3)	14,849 (51.2)	10,461 (53.6)	12,490 (54.2)	<0.001
Girls	48,691 (48.0)	6479 (49.2)	8424 (50.7)	14,148 (48.8)	9072 (46.4)	10,568 (45.8)	
Race/Ethnicity							
White alone	78,440 (77.4)	10,310 (78.4)	13,337 (80.3)	22,889 (78.9)	14,993 (76.8)	16,911 (73.3)	<0.001
Black or African American alone	7129 (7.0)	722 (5.5)	784 (4.7)	1859 (6.4)	1562 (8.0)	2202 (9.5)	
Other	15,781 (15.6)	2124 (16.1)	2485 (15.0)	4249 (14.7)	2978 (15.2)	3945 (17.1)	
Age of children							
0-5	28,484 (28.1)	8465 (65.7)	6701 (40.4)	7620 (26.3)	3337 (17.1)	2181 (9.5)	<0.001
6-11	31,090 (30.7)	3090 (23.5)	6277 (37.8)	10,426 (36.0)	6011 (30.8)	5286 (22.9)	
12-17	41,776 (41.2)	1421 (10.8)	3628 (21.8)	10,951 (37.8)	10,185 (52.1)	15,591 (67.6)	
Type of primary caregivers							
Parents	93,324 (93.5)	12,254 (94.8)	15,479 (94.7)	26,909 (94.3)	17,823 (92.7)	20,759 (91.4)	<0.001
Grandparents	5231 (5.2)	538 (4.2)	702 (4.3)	1344 (4.7)	1164 (6.1)	1483 (6.5)	
Others	1302 (1.3)	132 (1.0)	165 (1.0)	291 (1.0)	247 (1.2)	467 (2.1)	
Highest education of caregivers							
Less than high school	2562 (2.5)	352 (2.7)	317 (1.9)	611 (2.1)	547 (2.8)	735 (3.2)	<0.001
High school or GED	13,274 (13.1)	1329 (10.1)	1802 (10.9)	3709 (12.8)	2755 (14.1)	3679 (16.0)	
Some college or technical school	23,445 (23.1)	2176 (16.5)	3311 (19.9)	6878 (23.7)	4780 (24.5)	6300 (27.3)	
College degree or higher	62,069 (61.2)	9299 (70.7)	11,176 (67.3)	17,799 (61.4)	11,451 (58.6)	12,344 (53.5)	
Household income							
0–99% FPL	11,985 (11.8)	1529 (11.6)	1755 (10.6)	3276 (11.3)	2337 (12.0)	3088 (13.4)	<0.001
100–199% FPL	16,764 (16.5)	1930 (14.7)	2507 (15.1)	4773 (28.5)	3378 (17.3)	4176 (24.9)	
200–399% FPL	31,351 (30.9)	3715 (28.2)	4997 (30.1)	9078 (31.3)	6133 (31.4)	7428 (32.2)	
400% FPL or greater	41,250 (40.7)	5982 (45.5)	7347 (44.2)	11,870 (40.9)	7685 (39.3)	8366 (36.3)	
Family structure							
Two parents	76,239 (76.4)	10,811 (83.6)	13,266 (81.1)	22,219 (77.8)	14,231 (73.9)	15,712 (69.2)	<0.001
One parent	19,544 (19.6)	1713 (13.2)	2542 (15.5)	5313 (18.6)	4158 (21.6)	5818 (25.6)	
Others	4039 (4.0)	415 (3.2)	551 (3.4)	1023 (3.6)	864 (4.5)	1186 (5.2)	
Number of child in family							
1	41,162 (40.6)	4328 (32.9)	5819 (35.0)	11,416 (39.4)	8341 (42.7)	11,258 (48.8)	<0.001
2	40,370 (39.8)	5779 (43.9)	7107 (42.8)	11,786 (40.6)	7577 (38.8)	8121 (35.2)	
3	13,941 (13.8)	2007 (15.3)	2552 (15.4)	4094 (14.1)	2596 (13.3)	2692 (11.7)	
4 or more	5877 (5.8)	1042 (7.9)	1128 (6.8)	1701 (5.9)	1019 (5.2)	987 (4.3)	
Parental aggravation							
Always	5168 (5.1)	549 (4.2)	558 (3.4)	1154 (4.0)	921 (4.7)	1986 (8.6)	<0.001
Seldom	95,878 (94.9)	12,568 (95.8)	15,993 (96.6)	27,758 (96.0)	18,559 (95.3)	21,000 (91.4)	
Parent-child interaction^a							
Always	47,592 (65.8)	3070 (68.8)	6986 (71.0)	14,624 (68.9)	10,492 (65.2)	12,420 (60.0)	<0.001
Usually	18,185 (25.2)	1040 (23.3)	2311 (23.5)	5196 (24.5)	4204 (26.1)	5434 (26.3)	
Sometimes	3950 (5.5)	207 (4.6)	387 (3.9)	977 (4.6)	904 (5.6)	1475 (7.1)	
Rarely or never	2568 (3.6)	143 (3.2)	152 (1.5)	435 (2.0)	483 (3.0)	1355 (6.6)	
Participation in organized activities^a							
Yes	60,479 (83.0)	3806 (84.4)	8686 (87.7)	18,322 (85.7)	13,564 (83.7)	16,101 (77.1)	<0.001
No	12,387 (17.0)	705 (15.6)	1219 (12.3)	3055 (14.3)	2632 (16.3)	4776 (22.9)	
Premature							
Yes	10,777 (10.8)	1300 (10.0)	1661 (10.1)	3045 (10.7)	2202 (11.4)	2569 (11.3)	<0.001
No	89,098 (89.2)	11,703 (90.0)	14,714 (89.9)	25,513 (89.3)	17,049 (88.6)	20,119 (88.7)	
Low birth weight							
Yes	8210 (8.4)	976 (7.7)	1286 (8.0)	2343 (8.4)	1664 (8.9)	1941 (8.8)	<0.001
No	89,420 (91.6)	11,752 (92.3)	14,755 (92.0)	25,598 (91.6)	17,091 (91.1)	20,224 (91.2)	
Physical activity (≥ 60 min)^a							
0–3 days per week	35,980 (49.7)	1454 (30.6)	3365 (34.2)	9027 (42.4)	8402 (52.2)	13,732 (66.4)	<0.001
4–6 days per week	21,188 (29.3)	1353 (30.3)	3347 (34.0)	7037 (33.1)	4960 (30.8)	4491 (21.7)	
7 days per week	15,188 (21.0)	1653 (37.1)	3125 (31.8)	5193 (24.4)	2734 (17.0)	2483 (12.0)	
Behavioral and conduct problem							
Yes	8388 (8.3)	567 (4.3)	931 (5.6)	2085 (7.2)	1688 (8.7)	3117 (13.6)	<0.001
No	92,684 (91.7)	12,554 (95.7)	15,633 (94.4)	26,832 (92.8)	17,785 (91.3)	19,880 (86.4)	
Developmental delay							
Yes	7179 (7.1)	687 (5.2)	920 (5.6)	1928 (6.7)	1435 (7.4)	2209 (9.6)	<0.001
No	93,798 (92.9)	12,417 (94.8)	15,636 (94.4)	26,973 (93.3)	18,020 (92.6)	20,752 (90.4)	
Intellectual disability							
Yes	1047 (1.0)	110 (0.8)	105 (0.6)	277 (1.0)	201 (1.0)	354 (1.5)	<0.001
No	10,010 (99.0)	13,003 (99.2)	16,463 (99.4)	28,638 (99.0)	19,275 (99.0)	22,631 (98.5)	
Speech disorder							
Yes	8190 (8.1)	712 (5.4)	1210 (7.3)	2362 (8.2)	1705 (8.8)	2201 (9.6)	<0.001
No	92,878 (91.9)	12,400 (94.6)	15,354 (92.7)	26,521 (91.8)	17,773 (91.2)	20,790 (90.4)	
Learning disability							
Yes	7230 (7.2)	468 (3.6)	768 (4.6)	1913 (6.6)	1519 (7.8)	2562 (11.1)	<0.001
No	93,802 (92.8)	12,638 (96.4)	15,787 (95.4)	26,987 (93.4)	17,960 (92.2)	20,430 (88.9)	
ASD							
Yes	2929 (2.9)	164 (1.3)	284 (1.7)	725 (2.5)	613 (3.1)	1143 (5.0)	<0.001
No	98,037 (97.1)	12,926 (98.7)	16,260 (98.3)	28,170 (97.5)	18,849 (96.9)	21,832 (95.0)	

(continued on next page)

Table 1 (continued)

Characteristics	Total	Screen time (hours/day)					P-value
		<1	1	2	3	≥4	
ADHD							
Yes	10,206 (10.1)	509 (3.9)	1058 (6.4)	2652 (9.2)	2253 (11.6)	3734 (16.3)	<0.001
No	90,484 (89.9)	12,569 (96.1)	15,430 (93.6)	26,165 (90.8)	17,154 (88.4)	19,166 (83.7)	

ASD, Autism Spectrum Disorder; ADHD, Attention Deficit Hyperactivity Disorder.

FPL, federal poverty level.

^a These variables were available for children aged between 6 and 17 years old.

Table 2

Association between screen time and developmental and behavioral problems among preschoolers aged 0–5 years old.

Outcomes	Screen time (hours/ day)	Model 1				Model 2				Model 3			
		OR	95% CI	P-value	P for trend	OR	95% CI	P-value	P for trend	OR	95% CI	P-value	P for trend
Behavioral and conduct problem													
	<1	Ref			<0.001	Ref			<0.001	Ref			<0.001
	1	1.65	1.30–2.08	<0.001		0.87	0.68–1.12	0.285		0.95	0.73–1.23	0.678	
	2	2.42	1.96–3.00	<0.001		1.14	0.90–1.43	0.280		1.15	0.90–1.46	0.268	
	3	3.29	2.60–4.17	<0.001		1.34	1.04–1.74	0.026		1.24	0.95–1.63	0.120	
	≥4	5.41	4.27–6.84	<0.001		2.06	1.58–2.67	<0.001		1.76	1.33–2.33	<0.001	
Developmental delay													
	<1	Ref			<0.001	Ref			<0.001	Ref			<0.001
	1	1.25	1.07–1.45	0.006		0.96	0.81–1.14	0.674		1.01	0.85–1.21	0.891	
	2	1.78	1.55–2.05	<0.001		1.31	1.12–1.54	0.001		1.34	1.14–1.57	<0.001	
	3	2.02	1.71–2.38	<0.001		1.41	1.17–1.70	<0.001		1.33	1.09–1.61	0.004	
	≥4	3.40	2.88–4.02	<0.001		2.33	1.93–2.82	<0.001		2.12	1.74–2.58	<0.001	
Intellectual disability													
	<1	Ref			<0.001	Ref			0.741	Ref			0.459
	1	0.59	0.32–1.08	0.085		0.38	0.20–0.72	0.003		0.41	0.21–0.80	0.009	
	2	1.20	0.75–1.94	0.449		0.61	0.36–1.04	0.069		0.63	0.36–1.09	0.095	
	3	1.49	0.85–2.63	0.165		0.69	0.37–1.28	0.242		0.58	0.31–1.11	0.099	
	≥4	2.29	1.30–4.04	0.004		0.95	0.50–1.78	0.864		0.69	0.36–1.34	0.271	
Speech disorder													
	<1	Ref			<0.001				<0.001	Ref			<0.001
	1	1.79	1.54–2.09	<0.001		1.17	1.00–1.38	0.058		1.22	1.04–1.44	0.018	
	2	2.49	2.16–2.86	<0.001		1.52	1.30–1.76	<0.001		1.54	1.32–1.79	<0.001	
	3	3.25	2.78–3.81	<0.001		1.86	1.56–2.21	<0.001		1.80	1.51–2.15	<0.001	
	≥4	4.55	3.86–5.37	<0.001		2.57	2.14–3.08	<0.001		2.38	1.97–2.87	<0.001	
Learning disability													
	<1	Ref			<0.001	Ref			<0.001	Ref			<0.001
	1	1.45	1.06–1.97	0.019		0.88	0.63–1.23	0.450		0.96	0.68–1.35	0.808	
	2	2.06	1.56–2.72	<0.001		1.05	0.77–1.42	0.781		1.07	0.78–1.47	0.691	
	3	2.63	1.91–3.60	<0.001		1.17	0.82–1.65	0.384		1.05	0.73–1.51	0.785	
	≥4	5.88	4.38–7.89	<0.001		2.33	1.67–3.24	<0.001		1.96	1.38–2.78	<0.001	
ASD													
	<1	Ref			<0.001	Ref			<0.001	Ref			<0.001
	1	1.80	1.20–2.69	<0.001		1.01	0.66–1.55	0.951		1.09	0.71–1.69	0.689	
	2	3.80	2.68–5.40	<0.001		2.03	1.40–2.94	<0.001		2.08	1.43–3.04	<0.001	
	3	4.62	3.15–6.80	<0.001		2.11	1.40–3.19	<0.001		1.93	1.26–2.95	0.002	
	≥4	9.54	6.60–13.81	<0.001		4.07	2.73–6.08	<0.001		3.49	2.31–5.27	<0.001	
ADHD													
	<1	Ref			<0.001	Ref			<0.001	Ref			
	1	1.81	1.21–2.72	0.004		0.94	0.61–1.47	0.797		1.04	0.66–1.64	0.864	0.002
	2	2.54	1.75–3.69	<0.001		1.09	0.73–1.65	0.668		1.15	0.75–1.75	0.529	
	3	3.81	2.54–5.71	<0.001		1.40	0.89–2.18	0.142		1.38	0.88–2.19	0.163	
	≥4	6.62	4.45–9.84	<0.001		2.11	1.35–3.28	0.001		1.85	1.17–2.93	0.009	

ASD: Autism Spectrum Disorder; ADHD: Attention Deficit Hyperactivity Disorder. Model 1 was not adjusted confounders. Model 2 was adjusted for age, sex, race/ethnicity, prematurity, low birth weight, type of primary caregivers, highest education of caregivers, household income, family structure, and number of child in family. Model 3 was additionally adjusted for parental aggravation.

times (95%CI: 1.01–1.22) odds of behavioral and conduct problem and 1.16 times (95%CI: 1.07–1.25) odds of ADHD, and children and adolescents with ≥4 h of screen time per day significantly showed 1.46 time (95%CI: 1.34–1.59) odds of behavioral and conduct problem, 1.13 times (95%CI: 1.02–1.24) odds of developmental delay, 1.12 times (95%CI: 1.02–1.22) odds of learning disability, 1.27 times (95%CI: 1.10–1.47) odds of ASD and 1.32 times (95%CI: 1.22–1.43) odds of ADHD. There was also significant dose-response relationships between the level of screen time and odds of each type of developmental and behavioral problems. Similar to preschoolers, there was negatively association

between screen time and intellectual disability that compared with children with less than 2 h of screen time per day, children with 3 and ≥4 h of screen time per day significantly had lower odds of intellectual disability (adjusted OR = 0.77, 95% CI: 0.61–0.98 for 3 h/day of screen time, adjusted OR = 0.67, 95% CI: 0.54–0.84 for ≥4 h/day of screen time).

Table 3

Association between screen time and developmental and behavioral problems of children and adolescents aged 6–17 years old.

Outcomes	Screen time (hours/ day)	Model 1				Model 2				Model 3			
		OR	95% CI	P-value	P for trend	OR	95% CI	P-value	P for trend	OR	95% CI	P-value	P for trend
Behavioral and conduct problem													
	<2	Ref			<0.001	Ref			<0.001	Ref			<0.001
	2	1.02	0.94–1.10	0.669		1.04	0.96–1.13	0.317		1.05	0.96–1.14	0.302	
	3	1.14	1.06–1.24	0.001		1.17	1.08–1.28	<0.001		1.11	1.01–1.22	0.026	
	≥4	1.80	1.68–1.94	<0.001		1.92	1.77–2.08	<0.001		1.46	1.34–1.59	<0.001	
Developmental delay													
	<2	Ref			<0.001	Ref			<0.001	Ref			0.017
	2	1.01	0.93–1.10	0.822		1.06	0.97–1.16	0.212		1.06	0.96–1.16	0.271	
	3	1.13	1.03–1.23	0.009		1.16	1.05–1.27	0.003		1.08	0.98–1.19	0.143	
	≥4	1.47	1.36–1.59	<0.001		1.56	1.43–1.71	<0.001		1.13	1.02–1.24	0.018	
Intellectual disability													
	<2	Ref			<0.001	Ref			0.001	Ref			<0.001
	2	0.98	0.80–1.19	0.825		0.91	0.74–1.12	0.383		0.95	0.76–1.19	0.669	
	3	0.97	0.79–1.20	0.781		0.82	0.66–1.04	0.097		0.77	0.61–0.98	0.031	
	≥4	1.39	1.16–1.68	0.001		1.11	0.90–1.37	0.316		0.67	0.54–0.84	<0.001	
Speech disorder													
	<2	Ref			0.003				<0.001	Ref			0.048
	2	0.96	0.89–1.04	0.356		1.05	0.97–1.14	0.201		1.04	0.95–1.13	0.392	
	3	1.00	0.92–1.08	0.979		1.14	1.05–1.24	0.003		1.08	0.98–1.18	0.110	
	≥4	1.09	1.01–1.18	0.020		1.35	1.24–1.47	<0.001		1.09	1.00–1.19	0.063	
Learning disability													
	<2	Ref			<0.001	Ref			<0.001	Ref			0.031
	2	1.13	1.04–1.22	0.003		1.06	0.98–1.15	0.174		1.07	0.98–1.17	0.122	
	3	1.22	1.12–1.32	<0.001		1.08	0.99–1.18	0.105		1.04	0.95–1.14	0.381	
	≥4	1.66	1.54–1.79	<0.001		1.40	1.29–1.52	<0.001		1.12	1.02–1.22	0.014	
ASD													
	<2	Ref			<0.001	Ref			<0.001	Ref			0.001
	2	1.14	1.00–1.30	0.058		1.12	0.98–1.30	0.105		1.09	0.94–1.27	0.232	
	3	1.39	1.21–1.59	<0.001		1.30	1.12–1.50	0.001		1.15	0.99–1.35	0.068	
	≥4	2.12	1.88–2.40	<0.001		2.02	1.76–2.31	<0.001		1.27	1.10–1.47	0.001	
ADHD													
	<2	Ref			<0.001	Ref			<0.001	Ref			<0.001
	2	1.20	1.12–1.28	<0.001		1.11	1.03–1.19	0.005		1.11	1.03–1.20	0.005	
	3	1.38	1.28–1.48	<0.001		1.20	1.11–1.29	<0.001		1.16	1.07–1.25	<0.001	
	≥4	1.88	1.76–2.00	<0.001		1.58	1.47–1.70	<0.001		1.32	1.22–1.43	<0.001	

ASD: Autism Spectrum Disorder; ADHD: Attention Deficit Hyperactivity Disorder. Model 1 was not adjusted confounders. Model 2 was adjusted for age, sex, race/ethnicity, premature, low birth weight, type of primary caregivers, highest education of caregivers, household income, family structure and number of child in family. Model 3 was additionally adjusted for parental aggravation, parent-child interaction, participation in organized activities and physical activity.

3.3. Association between screen time and developmental and behavioral problems among different age and sex subgroups

The results of associations between screen time and developmental and behavioral problems among different age subgroups are presented in [Tables S1 and S2](#). Consistent with the main findings, children aged 6–11 years with excessive screen time showed higher odds of behavioral and conduct problem, developmental delay, speech disorder, learning disability, ASD and ADHD and significant dose-response relationships were identified. However, adolescents aged 12–17 years with excessive screen time did not showed significant association with most types of developmental and behavioral problems except for behavioral and conduct problem, intellectual disability and ADHD. Compared with non excessive screen time, adolescents aged 12–17 years old with ≥4 h/day of screen time showed 1.42 times (95%CI: 1.24–1.63) odds of behavioral and conduct problem and 1.34 times (95%CI: 1.20–1.49) odds of ADHD. Conversely, adolescents with 3 and ≥4 h/day of screen time showed 0.61 times (95%CI: 0.45–0.83) and 0.50 times (95%CI: 0.38–0.67) odds of intellectual disability.

The results of associations between screen time and developmental and behavioral problems among different age subgroups are presented in [Tables S3–S6](#). Boys aged 0–5 years with excessive screen time showed higher odds of developmental and behavioral problems. Boys aged 0–5 years old with 2, 3, ≥4 h/days of screen time had 1.32 to 1.99 times odds of developmental delay, 1.46 to 2.29 times odds of speech disorder, and 2.16 to 3.59 times odds of ASD. Boys aged 0–5 years old with ≥4 h/days of screen time had significantly higher odds of behavioral and conduct problem (adjusted OR = 1.99, 95%CI: 1.43–2.77), learning disability

(adjusted OR = 2.14, 95%CI: 1.38–3.33) and ADHD (adjusted OR = 2.53, 95%CI: 1.43–4.47). However, therefore was no significant association between excessive screen time and most types of developmental and behavioral problems among girls with 0–5 years old ([Table S4](#)). For children and adolescents, boys aged 6–17 years old with excessive screen time showed higher odds of developmental and behavioral problems except intellectual disability, but no significant associations between excessive screen time and developmental delay, speech disorder and ASD were also found among girls aged 6–17 years old ([Tables S5 and S6](#)).

3.4. Sensitivity analysis based on the reference of screen time

After adjusting the reference for screen time (<3 h/day), we reanalysis the association between screen time and developmental and behavioral problems among children and adolescents. Overall, children and adolescents with ≥3 h/day of screen time showed higher odds of behavioral and conduct problem, developmental delay, speech disorder, learning disability, ASD and ADHD, but lower odds of intellectual disability, which is consistent with the mainly findings among children and adolescents using the <2 h/day of screen time as the reference ([Table S7](#)). There was differences on the results of association between screen time and developmental and behavioral problems between difference age groups of children and adolescents. Specially, children aged 6–11 years old with 3 and ≥4 h/day of screen time showed significantly higher odds of developmental delay, speech disorder and ASD and children aged 6–11 years old with ≥4 h/day of screen time showed significantly higher odds of behavioral and conduct problem and ADHD

(Table S8). However, among adolescents aged 12–17 years old, screen time was not associated with developmental delay, speech disorder, learning disability and ASD (Table S9). We also observed sex difference on the association between screen time and developmental and behavioral problems using the <3 h/day of screen time as the reference. Boys aged 6–17 years old with ≥ 3 h/day of screen time showed significantly higher odds of behavioral and conduct problem, developmental delay ASD and ADHD, but no significant association between screen time and developmental delay, speech disorder, learning disability and ASD among girls aged 6–17 years with ≥ 3 h/day of screen time was found (Tables S10 and S11).

4. Discussion

We have identified that more than three quarters of children had ≥ 1 h per day of screen time and almost one quarters of children had ≥ 4 h per day of screen time, and more than 70% of children had excessive screen time, which reflects the universality and severity of the frequency of digital media use among children in the US. The prevalence of excessive screen time of US children is consistent with the findings in India children aged <5 years (Varadarajan et al., 2021) and meta-analysis in Brazilian adolescents (Schaan et al., 2019), but obsessively higher than the results of national youth risk behavior survey among adolescents in the US (Onyeaka et al., 2022). This discrepancy may be due to the different measurement of screen time between studies that in US national youth risk behavior survey, children were asked to response the screen time behavior which may cause withholding reports. For the association between screen time and developmental and behavioral problems of children, this study has indicated that among preschoolers, ≥ 4 h/day of screen time was significantly associated with behavioral and conduct problem, learning disability and ADHD and ≥ 2 h/day of screen time was significantly associated with developmental delay, speech disorder and ASD; among children and adolescents, excessive screen time was significantly associated with ADHD, ≥ 4 h/day of screen time was significantly associated with developmental delay, learning disability and ASD. The findings in preschoolers are partially in line with previous studies (McArthur et al., 2022; Rocha et al., 2021; Hill et al., 2020; Kushima et al., 2022; Varadarajan et al., 2021; Chong et al., 2022) that higher level of screen time can increase the risk of behavioral problems, delayed achievement of developmental milestones, speech delay, ASD and ADHD, but inconsistent with a cohort study in US which implied that screen media exposure was not associated with ASD and ADHD risk (Heffler et al., 2020). The findings of this study in children and adolescents are consistent with previous studies which identified excessive screen time was associated with conduct and hyperactivity problems (Ozmert et al., 2022; Vohr et al., 2021). Unexpectedly, we also have identified an interesting result that preschoolers with 1 h/day of screen time showed significantly lower risk of intellectual disability and children and adolescents with 2 or more hours/day of screen time showed significantly lower odds of intellectual disability. These findings indicate that small time of screen media exposure seem to be beneficial for intellectual development among preschoolers, but youth with higher screen time may be less likely with intellectual disability. Inconsistently, a cohort study in extremely preterm children found that children with high screen time had lower mean full-scale IQ scores but not significant (Vohr et al., 2021), and a cross-sectional study in India indicated that excess screen time was not significantly associated with the intelligence of preschool children (John et al., 2021). It should be noted that in this study, the ratio of intellectual disability is relatively low (1.0%) among children in the US, which is different from the intelligence indicators of previous studies (Vohr et al., 2021; John et al., 2021), and intellectual disability is mainly caused by inheritance or perinatal risk factors such as premature birth or diseases and children with intellectual disability may be less likely with digital media use. Therefore, intellectual disability of children maybe not affected by screen time of children which need to be examined in the further longitudinal studies.

This study has also identified age differences on the association between screen time and developmental and behavioral problems that most types of developmental and behavioral problems were significantly associated with 2 or more hours/day of screen time in both preschoolers (0–5 years old) and children (6–11 years old), and the strength of association was stronger for preschoolers, but excessive screen time were only significantly associated with behavioral and conduct problem and ADHD in adolescents (12–17 years old). These findings are consistent with previous studies which also found different adverse effect of screen time on physical and mental health of children (Reid Chassiakos et al., 2016; Twenge and Campbell, 2018). This suggests that a time window of the adverse effect of screen time may exist which has been demonstrated in previous studies (Zimmerman and Christakis, 2005; Chen et al., 2021; Zhao et al., 2022). Sex differences on the association between screen time and developmental and behavioral problems of children were also observed that among preschoolers, boys with excessive screen time had significant high odds of all developmental and behavioral problems except intellectual disability, but girls with higher level of screen time had a significant high odds of developmental delay, speech disorder and ASD; among children and adolescents aged 6–17 years old, excessive screen time were associated with most of developmental and behavioral problems among boys, whereas only high amount of screen time per day showed significant and positive association with behavioral and conduct problem, developmental delay, speech disorder, and ADHD among girls. It is similar to the findings of the meta-analysis that boys showed stronger correlations between screen time and externalizing problems compared with girls (Eirich et al., 2022). Conversely, it has been demonstrated that girls showed larger associations between heavy digital media use and low psychological well-being than boys (Twenge and Martin, 2020). The cause for sex differences on the association is not clear and the possible explanation may be that boys have a longer screen time and are demonstrated to show more screen compliance than girls (Hinkley et al., 2013) and there are differences in digital media activities that girls spending more time on social media and smartphones and boys spending more time gaming (Twenge and Martin, 2020). The underlying mechanism needs to be further explored in further studies.

The clinical and public health implication of this study suggests that parents or caregivers should strictly follow recommendations of the guidelines to limit their children's screen time, and early identification and screening factors associated with screen time is beneficial. Furthermore, health care providers should be aware of the hazard of excessive screen exposure and carry out early intervention in children with excessive digital media use to prevent mental and behavioral problems. The differences on the association between screen time and developmental and behavioral problems among different age and sex subgroups imply that more attention should be payed on preschoolers and boys who may be the vulnerable populations of developmental and behavioral problems under the impact of excessive digital media use.

4.1. Strength and limitations

This study utilized a large sample size to comprehensively examine the association between screen time and seven types of developmental and behavioral problems across all childhood, and further explored age and sex differences of the correlations. The findings of this study provided additional evidence for associations between excessive screen time and child development and behavior. However, several limitations in our study should be noted. Firstly, NSCH survey was the cross-sectional design, which limited us to make causal inference that whether digital media use is a cause of developmental and behavioral problems cannot be concluded based on the cross-sectional nature of this study. In addition, there may be a reverse association because children's behavioral problems may cause them to spend more time on screen media devices. A previous longitudinal study have demonstrated bidirectional associations between screen time and internalizing behaviors for preschoolers (Neville et al., 2021). Therefore, longitudinal studies

need to be conducted to verify the findings of this study. Secondly, the information of screen time and developmental and behavioral problems of children were collected through the recalling of caregivers which may cause information bias. It is suggested that reliable clinical diagnosis by pediatricians for developmental and behavioral problems as well as the use of objective screen exposure measurement tools will be beneficial in the future studies focus on digital media use and healthy development of children. Thirdly, it should be noted that different types of digital media use might have various impacts on the development of children, but the effect of total screen time can be examined because no detailed screen time on different types of digital media use was available in 2018–2020 NSCH survey. Fourthly, the unavailability of continues data on screen time makes it difficult to determine the cutoff value for screen time to have a significant effect on developmental and behavioral problems. Fifthly, although some important characteristics regrade to the children, family and caregivers/parents had been adjusted in multivariate models, some potential confounding factors such as mental health of primary caregivers, media time of parents/caregivers and family history of disease were not considered because these information were not surveyed in NSCH. Finally, screen time was limited to weekdays, therefore, whether digital media use in weekend is closely associated with developmental and behavioral problems of children is unknown. Nonetheless, the relationship between screen time and developmental and behavioral problems is crucial to examine as a prerequisite for further investigation of content.

5. Conclusions

This study has revealed the prevalence of excessive screen time among children in the US, and demonstrated positively associations between excessive screen time and developmental and behavioral problems of children and there was age and sex differences. Specially, excessive screen time was positively associated with behavioral and conduct problem, developmental delay, speech disorder, learning disability, ASD and ADHD and these associations were more stronger among preschoolers. The significant dose-response relationships were found for the associations between screen time level and odds of developmental and behavioral problems. Moreover, boys with excessive screen time showed high odds of most types of developmental and behavioral problems. This implies that more attention should be paid on excessive digital media use of preschoolers and boys because they may be more vulnerable to the excessive screen time. Caregivers, educators, policy makers, and health care providers should pay more attention to the screen time of children and it is necessary to take applicable interventions at an early stage for children with excessive digital media use.

Founding

None.

CRedit authorship contribution statement

Yehuan Sun contributed to conceptualization and review and editing of manuscript. Guangbo Qu contributed to data processing, formal analysis and original draft. Wenjing Hu and Jia Meng contributed to formal analysis and review and editing of manuscript. Xingyue Wang, Wenqi Su, Haixia Liu, Shaodi Ma, Chenyu Sun Christy Huang and Scott Lowe contributed to methodology and review and editing of manuscript.

Declaration of competing interest

Authors declared that there was no conflict of interest.

Acknowledgements

We would like to thank NSCH for providing the publicly available data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jpsychires.2023.03.014>.

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