



Prevalence of Autism Spectrum Disorder Among Children and Adolescents in the United States from 2021 to 2022

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Abstract

Purpose The prevalence of autism spectrum disorder (ASD) among children and adolescents seem to be high in countries around the world, and it's worth understanding the latest prevalence and trends of ASD in children and adolescents. The purpose of this study was to examine the latest prevalence and decade trend of ASD among individuals aged 3–17 years in the United States.

Methods A total of 13,198 individuals aged 3–17 years were included. Annual data were examined from the National Health Interview Survey (2021–2022). Weighted prevalence for each of the selected developmental disabilities were calculated.

Results This cross-sectional study estimated the weighted prevalence of autism spectrum disorder were 3.05, 3.79, and 3.42% among individuals aged 3–17 years in the US in 2021, 2022, and the 2-year overall, respectively. We also observed a decade-long upward trend even after adjusting for demographic characteristics (P for trend < .05).

Conclusion The results of this study showed that the prevalence of ASD among children and adolescents aged 3–17 years in the United States remained high and has increased over the past decade. The further investigation is necessary to evaluate potential modifiable risk factors and causes of ASD.

Keywords Autism spectrum disorder · Prevalence · Children and adolescents · NHIS

Introduction

Autism spectrum disorder (ASD) is a category of neurodevelopmental disorders characterized by social and communication impairment and restricted or repetitive behaviors (Association, 2013). Autism spectrum disorder is a multifaceted neurodevelopmental condition that has lifelong

implications. Children diagnosed with ASD require continuous, long-term treatment and care, placing a substantial burden on individuals, families, and society as a whole (Lyll et al., 2017).

According to the 2019 Global Burden of Disease (GBD) estimates, autism spectrum disorder has a profound impact. In 2019, over 28 million people worldwide were affected, however, the prevalence of ASD is highest in high-income regions like North America (Solmi et al., 2022).

In recent years, the prevalence of ASD has been on the rise in the United States (Xu et al., 2019). According to reports, the latest research showed that the ASD prevalence among children and adolescents aged 3–17 years in the United States in 2021 is 3.40% (Wang et al., 2023), which was higher than the prevalence of 3.14% in 2019 to 2020 (Li et al., 2022a, 2022b) and 2.47% in 2014 to 2016 (Maenner et al., 2021) based on the data from National Health Interview Survey (NHIS), and also higher than the prevalence of 2.30% among children aged 8 years in 2018 from the Autism and Developmental Disabilities Monitoring Network (ADDM) (Maenner et al., 2021). These results indicated that the ASD prevalence has been on the rise in the United

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States, prompting researchers and healthcare professionals to explore the factors contributing to this increase. Buescher et al. (2014) estimated that the average annual cost of ASD for children aged 0–5 and 6–17 years was US \$63,292 and US \$52,205, respectively. The impact on children, adolescents and their families is adverse, and may lead to reduced educational attainment, reduced quality of life and increased demand for healthcare. Especially, the COVID-19 pandemic has further raised concerns about the impact of the global health crisis on ASD prevalence. To gain a better understanding of the prevalence of ASD following the COVID-19 pandemic, we conducted a study utilizing the National Health Interview Survey (NHIS) database from 2021 to 2022. Additionally, we also present the long-term trends in ASD prevalence over the past decade, providing valuable information for future research, clinical care, and policy decisions regarding ASD.

Therefore, this study aimed to reveal the ASD prevalence among individuals aged 3–17 years in the US in 2021 and 2022, and to explore the prevalence trend in the recent decade.

Methods

Study Population

We conducted a cross-sectional study using data from the National Health Interview Survey (NHIS), which conducted by the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention (CDC). NHIS is a national representative household survey using a complex, multi-stage, probabilistic sampling survey to collect information on the health status, health use, and social demographic characteristics of the civilian non-institutionalized population (Moriarty et al., 2022). The data are published annually and are available online for public access. NHIS has been approved by the NCHS Ethics Review Board and all respondents provided informed verbal consent prior to participation. The Guangdong Pharmaceutical University Academic Review Board determined the present study was exempt from approval because of the use of de-identified data.

Data Collection

We used NHIS data from 2021 and 2022 to understand the prevalence of ASD after the COVID-19 pandemic. The NHIS collected data on a variety of health topics through household interviews. For each family in the household, one child under 18 years old was randomly selected as a sample. Information for this child was collected by interviewing an adult family who was knowledgeable about

the child's health. The final household response rate was 52.8% in 2021 and 49.6% in 2022 and final response rate for the sample child component was 49.9% in 2021 and 45.8% in 2022.

The information about ASD diagnosed by a physician or other health care professional was reported by a parent/caregiver. From 2021–2022, respondents were asked, “Has a doctor or other health professional ever told you that [the sample child] had Autism, Asperger’s disorder, pervasive developmental disorder, or autism spectrum disorder?” Information on age, sex, race/ethnicity, family income and highest education of family members, and household income level were collected using a standardized questionnaire during the interview. The study divided the race/ethnicity into four groups, Hispanic, non-Hispanic whites, non-Hispanic blacks, and other based on the 1997 Office of Management and Budget Standards. Family income levels were classified as < 1.00, 1.00–1.99, 2.00–3.99 and ≥ 4.00 according to the ratio of family income to federal poverty level. The highest educational level of family members was categorized as less than high school, high school, and college or higher.

Statistical Analysis

All eligible children and adolescents aged 3–17 years who participated in the NHIS from the 2013 and 2022 were included in the present study. We estimated the prevalence estimates with survey weights, strata, and primary sampling units created by the National Center for Health Statistics to allow for national estimates according to NHIS analytic guidelines (NCHS). *P* values for overall differences across strata were calculated using χ^2 tests. The trends in the prevalence from 2013 to 2022 in the NHIS were also examined to understand the trends over the past 10 years. Trends in the prevalence over time were tested using a weighted logistic regression model, which included survey year as a continuous variable and adjusted for age, sex, race/ethnicity, highest parental education, and household income level. To determine whether the secular trends differ across strata, interaction analyses were performed by including multiplicative terms of each strata variable with survey year in the aforementioned logistic regression models.

All of the statistical analyses were performed using SAS Software, version 9.4. All estimates are weighted based on the complex sampling design of NHIS. Two-sided $P < 0.05$ was considered statistically significant.

Results

Prevalence of Diagnosed ASD Among US Children and Adolescents in 2021–2022

This study included 13,198 children and adolescents aged 3 to 17 years (6774 boys [50.96%], 6424 girls [49.04%], 3432 Hispanic [26.00%], 6571 non-Hispanic white [49.79%], 1357 non-Hispanic black [10.28%], and 1838 other race/ethnicities [13.93%]) in 2021 and 2022, 455 children and adolescents (346 boys [76.04%], 109 girls [23.96%], 108 Hispanic [23.74%], 233 non-Hispanic white [51.21%], 56 non-Hispanic black [12.31%], and 58 other races/ethnicities [12.75%]) were reported to have a diagnosis of ASD. The weighted prevalence of ASD diagnosis was 3.05% (95% CI 2.60–3.50%) in 2021, 3.79% (95% CI 3.24–4.35%) in 2022, and 3.42% (95% CI 3.06–3.78%) in 2021 and 2022 overall. There were significant differences in the prevalence observed between sexes (5.14% [95% CI 4.52–5.77%] in boys vs 1.64% [95% CI 1.28–2.00%] in girls; $P < 0.001$) and in family income to poverty ratio (< 1.00 , 4.29% [95% CI 3.13–5.45%]; 1.00–1.99, 4.25% [95% CI 3.38–5.12%]; 2.00–3.99, 3.53% [95% CI 2.85–4.20%]; and ≥ 4.00 , 2.35% [95% CI 1.90–2.80%]; $P < 0.001$) (Table 1).

Trends in Diagnosed ASD Among US Children and Adolescents from 2013 to 2022

To estimate the 10-year trends in diagnosed ASD from 2013 to 2022, we included (81,302) children and adolescents aged 3–17 years (41,964 boys [51.02%], 39,338 girls [48.98%], 20,919 Hispanic [25.03%], 40,760 non-Hispanic white [51.76%], 10,034 non-Hispanic black [13.25%], and 9589 non-Hispanic other race [9.96%]). Among them, 2100 children and adolescents (2.81%; 1624 boys [3.95%], 476 girls [1.29%], 451 Hispanic [2.36%], 1182 non-Hispanic white [2.77%], 244 non-Hispanic black [2.83%], and 223 other races/ [2.53%]) were reported to have ever been diagnosed with ASD. The estimated prevalence of diagnosed ASD increased from 1.25% (95% CI 1.00–1.50%) in 2013 to 3.79% (95% CI 3.24–4.35%) in 2022 (P for trend < 0.001). Almost all subgroups (excluding subgroup with family income to poverty ratio ≥ 4.00) evaluated showed a significant increase in the prevalence from 2013 to 2022 (P for trend < 0.05). (Fig. 1).

Discussion

Based on the nationally representative data in the US, the estimated ASD prevalence was 3.05, 3.79, and 3.42% among individuals aged 3–17 years in 2021, 2022, and the two-year overall, respectively. The prevalence of ASD in 2022 was higher than previously reported (Li et al., 2022a, 2022b; Wang et al., 2023), and it was also higher than that reported in other countries and geographical areas in previous years. Nader Salari et al. (2022) reviewed the prevalence of ASD from 2008 to 2021 in Asia, America, Europe, Africa and Australia was 0.4, 1, 0.5, 1, and 1.7% respectively. Inconsistent with the previous studies that reported a steady trend of ASD prevalence (Li et al., 2022a, 2022b; Wang et al., 2023), we observed a decade-long upward trend even after adjusting for demographic characteristics. Study (Panda et al., 2021) has shown that the negative mental health impact of lockdown measures in various countries on children and adolescents during the COVID epidemic was significant, which may explain the increase in the prevalence of ASD in the post-COVID-19 epidemic era.

In this study, the prevalence of ASD in 2022 was 3.79%, and the prevalence varied significantly by sex and family income, which is consistent with previous reports on the prevalence of ASD in children and adolescents in the US (Christensen et al., 2016; Xu et al., 2018), and it is also consistent with the results of the Brazilian study (Lin et al., 2023). Unlike previously reported five- or six-year prevalence rates that did not show a significant upward trend (Li et al., 2022a, 2022b; Wang et al., 2023; Xu et al., 2018), we found that the prevalence of ASD increased significantly over the decade from 2013 to 2022. We also found a consistent upward trend across subgroups by age, sex, race/ethnicity, family education, and family income, which is consistent with results reported before 2010 (Boyle et al., 2011; Durkin et al., 2017). This trend is also consistent with the ASD birth cohort prevalence from the California Department of Developmental Services (CDDS) (Nevison et al., 2018) and global growth trend of ASD prevalence (Li et al., 2022a, 2022b).

The following factors may partially explain the increased prevalence of ASD in this study. Studies have shown that the emissions of environmental toxins such as bromodiphenyl ether, aluminum adjuvants, and herbicide glyphosate were on the rise and positively correlated with the increase in ASD (Nevison, 2014). In addition, the National Institutes of Health in the United States have been paying strong attention to the development and evaluation of treatments for ASD in the past decade (Cervantes et al., 2021), and with the implementation of mandatory health insurance laws for ASD (Barry et al., 2017; Chatterji et al.,

Table 1 Prevalence of ASD among children and adolescents in the US from 2021 to 2022

Characteristic	2021		<i>P</i> value ^c	2022		<i>P</i> value	2021 and 2022		<i>P</i> value
	Participants with ASD/ Overall ^a	ASD, % (95% CI) ^b		Participants with ASD/ Overall	ASD, % (95% CI)		Participants with ASD/ Overall	ASD, % (95% CI)	
Overall	222/6929	3.05 (2.60–3.50)	NA	233/6269	3.79 (3.24–4.35)	NA	455/13198	3.42 (3.06–3.78)	NA
<i>Age, y</i>									
3–5 y	24/1210	2.05 (1.16–2.93)	.11	42/1197	3.56 (2.36–4.76)	.88	66/2407	2.81 (2.05–3.56)	.26
6–12y	106/2993	3.22 (2.53–3.92)		100/2703	3.99 (3.09–4.89)		206/5696	3.61 (3.03–4.18)	
13–17y	92/2726	3.38 (2.57–4.19)		91/2369	3.67 (2.82–4.53)		183/5095	3.53 (2.94–4.12)	
<i>Sex</i>									
Male	172/3559	4.68 (3.90–5.46)	<.001	174/3215	5.60 (4.64–6.55)	<.001	346/6774	5.14 (4.52–5.77)	<.001
Female	50/3370	1.36 (0.92–1.80)		59/3054	1.92 (1.34–2.49)		109/6424	1.64 (1.28–2.00)	
<i>Race and ethnicity^d</i>									
Hispanic	53/1780	3.12 (2.16–4.07)	.81	55/1652	3.61 (2.55–4.67)	.96	108/3432	3.37 (2.64–4.09)	.98
Non-Hispanic White	109/3487	2.85 (2.24–3.45)		124/3084	3.93 (3.11–4.76)		233/6571	3.39 (2.87–3.91)	
Non-Hispanic Black	27/699	3.39 (1.89–4.88)		29/658	3.81 (2.26–5.36)		56/1357	3.60 (2.54–4.67)	
Other ^e	33/963	3.46 (2.07–4.85)		25/875	3.55 (1.93–5.18)		58/1838	3.51 (2.38–4.63)	
<i>Highest level of educational attainment of family members</i>									
Less than high school	5/415	1.23 (0.00–2.53)	.08	23/398	4.90 (2.47–7.32)	.36	28/813	3.09 (1.70–4.49)	.89
High school	31/1078	2.52 (1.44–3.60)		40/940	4.38 (2.85–5.92)		71/2018	3.43 (2.51–4.35)	
College or higher	186/5428	3.34 (2.80–3.88)		170/4923	3.57 (2.95–4.20)		356/10351	3.46 (3.04–3.87)	
Missing data	0/8	NA	NA	0/8	NA	NA	0/16	NA	NA
<i>Family income to poverty ratio^f</i>									
<1	35/863	4.06 (2.65–5.47)	.14	35/728	4.54 (2.77–6.31)	.001	70/1591	4.29 (3.13–5.45)	<.001
1.00–1.99	52/1465	3.32 (2.30–4.33)		64/1260	5.23 (3.82–6.64)		116/2725	4.25 (3.38–5.12)	
2.00–3.99	68/2064	2.91 (2.10–3.72)		80/1871	4.12 (3.03–5.22)		148/3935	3.53 (2.85–4.20)	
≥4.00	67/2537	2.47 (1.83–3.11)		54/2410	2.24 (1.58–2.90)		121/4947	2.35 (1.90–2.80)	

Data were obtained from the 2021 to 2022 National Health Interview Survey, a nationally representative survey of non-hospitalized civilians that monitors the health of the US population through data collection and analysis on a broad range of health topics

^aUnweighted number of participants

^bPrevalence estimates were weighted

^c*P* values were estimated for the difference in prevalence by strata

^dRace and ethnicity were self-reported and classified based on the 1997 Office of Management and Budget standards

^eOther races and ethnicities included non-Hispanic American Indian or Alaska Native individual only, non-Hispanic American Indian or Alaska Native and any other group, non-Hispanic Asian individual only, and other single and multiple races, or declined to respond, no response, or unknown

^fThe ratio is the total family income divided by the poverty threshold

ASD autism spectrum disorder, NA not applicable

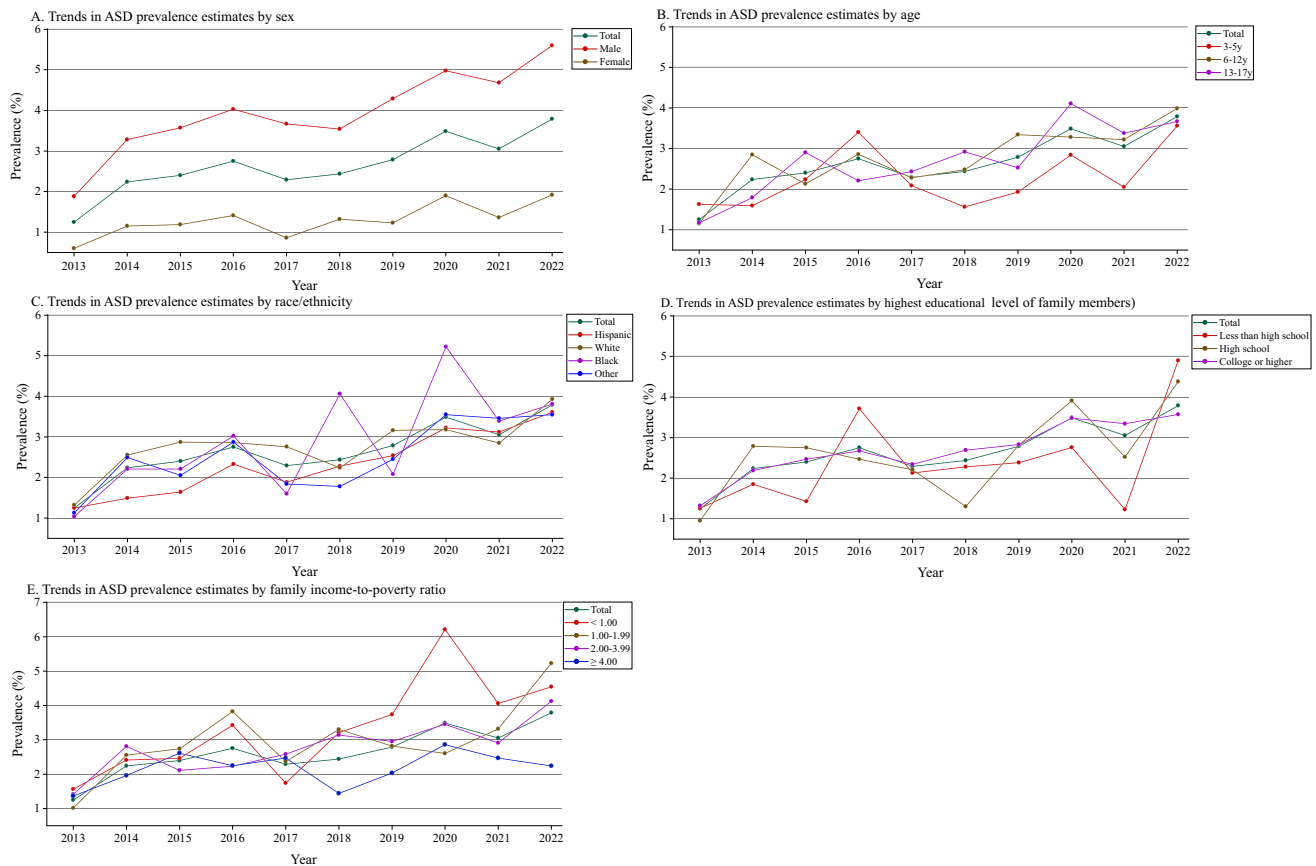


Figure 1 Trend Prevalence of ASD Among Children and Adolescents in the United States From 2013 to 2022.^a Prevalence estimates with 95% CIs (error bars) were weighted. $P < .001$ for trend was calculated using a weighted logistic regression model, which included survey cycle as a continuous variable and adjusted for age, sex, race/ethnicity, highest parental education, and household income level. The weighted prevalence of ASD was 1.25% (95% CI 1.00–1.50%)

in 2013, 2.24% (95% CI 1.89–2.59%) in 2014, 2.40% (95% CI 1.97–2.84%) in 2015, 2.75% (95% CI 2.20–3.30%) in 2016, 2.29% (95% CI 1.91–2.68%) in 2017, 2.44% (95% CI 1.91–2.98%) in 2018, 2.79% (95% CI 2.33–3.24%) in 2019, 3.49% (95% CI 2.82–4.15%) in 2020, 3.05% (95% CI 2.60–3.50%) in 2021, 3.79% (95% CI 3.24–4.35%) in 2022 (P for trend $< .001$)

2015; Mandell et al., 2016), access to health services for the public has improved. This may have a promoting effect on screening and diagnosis of ASD. These factors may explain some of the reasons for the increase in ASD prevalence.

The information of this study was ascertained by parent-reported physicians' diagnosis, which may be subject to misreporting and recall bias. This study provided the latest prevalence of ASD and the prevalence trend in the past decade. In view of the long-term heavy burden brought by ASD and the 10-year rising trend of the prevalence found in this study, all sectors of society should pay close attention to it and propose effective management strategies.

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Author Contributions Wenhan Yang and Jinhua Lu have full access to all of the data in this study and assumes responsibility for study supervision. Concept and design: Wenhan Yang, Jinhua Lu, and Guifeng Xu. Acquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: Xiaofang Yan and Yanmei Li. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: Xiaofang and Yan Yanmei Li.

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Data Availability The original contributions presented in the study are publicly available. The datasets analyzed during current study are available at NHIS online website: <https://www.cdc.gov/nchs/nhis/index.htm>

Declarations

Conflict of interest The authors have no conflict of interest to declare.

Ethical Approval The NHIS protocols were approved by the National Center for Health Statistics research ethics review board. Written informed consent was obtained for all participants. The Guangdong

Pharmaceutical University Academic Review Board determined the present study was exempt from approval because of the use of deidentified data.

Disclaimer The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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