HHS Public Access

Author manuscript

J Autism Dev Disord. Author manuscript; available in PMC 2017 April 17.

Published in final edited form as:

J Autism Dev Disord. 2017 February ; 47(2): 285–296. doi:10.1007/s10803-016-2951-x.

Factors Associated with Self-Injurious Behaviors in Children with Autism Spectrum Disorder: Findings from Two Large National Samples

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Electronic Supplementary Material The online version of this article (doi:10.1007/s10803-016-2951-x) contains supplementary material, which is available to authorized users.

Author contributions Dr. Gnakub N. Soke conceptualized and drafted the original proposal of the study, carried out the analyses, drafted the original manuscript, revised the manuscript, and approved the submission of the final manuscript; Drs. Steven A. Rosenberg, Richard F. Hamman supervised the initial manuscript, reviewed and revised the manuscript and approved the submission of the final manuscript; Drs. Cordelia Robinson and Ann Reynolds supervised the initial manuscript, contributed to data acquisition, reviewed and revised the manuscript and approved the submission of the final manuscript; Drs. Tasha Fingerlin and Carolyn DiGuiseppi supervised the initial manuscript, supervised the analyses, reviewed and revised the manuscript and approved the submission of the final manuscript; Drs. Maureen S. Durkin and Lisa Wiggins played prominent roles in reviewing and revising the manuscript and approved the submission of the final version; Drs. Laura Carpenter, Ellen Giarelli, and Li-Ching Lee reviewed and revised the manuscript and approved the submission of the final version.

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. The views expressed in this publication do not necessarily reflect the views of Autism Speaks, Inc.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study is a secondary data analysis of unidentified data previously collected in a surveillance system and a clinic-based registry. Therefore, formal consent is not required.

Abstract

In this study, we explored potential associations among self-injurious behaviors (SIB) and a diverse group of protective and risk factors in children with autism spectrum disorder from two databases: Autism and Developmental Disabilities Monitoring (ADDM) Network and the Autism Speaks-Autism Treatment Network (AS-ATN). The presence of SIB was determined from children's records in ADDM and a parent questionnaire in AS-ATN. We used multiple imputation to account for missing data and a nonlinear mixed model with site as a random effect to test for associations. Despite differences between the two databases, similar associations were found; SIB were associated with developmental, behavioral, and somatic factors. Implications of these findings are discussed in relation to possible etiology, future longitudinal studies, and clinical practice.

Keywords

Autism spectrum disorder; Autism; Self-injurious behaviors; Challenging behaviors; Maladaptive behaviors; Children

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that includes social and communication impairments, and restricted and repetitive patterns of behaviors, interests, or activities (APA 2013). Behavioral disturbances, including self-injurious behaviors (SIB), are frequently reported in ASD (Ando and Yoshimura 1979; Baghdadli et al. 2003; Duerden et al. 2012; Minshawi et al. 2014a; Rattaz et al. 2015; Soke et al. 2016; Weiss 2002).

SIB typically occur without an apparent intent of willful self-harm (Fee and Matson 1992), but unintentional harm is common. SIB are often highly repetitive and rhythmic, and include diverse behaviors, such as head banging, head rubbing, eye poking, hair pulling, and self-biting (MacLean and Symons 2002; Minshawi et al. 2014a; Weiss 2002). The etiology of SIB is not completely understood, however, both biological (e.g., genetic and somatic conditions) and environmental factors (i.e., inability to communicate and interact with others) have been implicated (Carr 1977; Devine 2014; Guess and Carr 1991; Kurtz et al. 2012). In some children with developmental disabilities, SIB may serve a number of functions, including getting attention, avoiding challenging tasks, and self-regulation (Kurtz et al. 2003).

Intensive behavioral and pharmacological interventions that target challenging behaviors, including SIB, may lead to better outcomes in some children with developmental disabilities (Eikeseth 2009; Minshawi et al. 2014b; Richman 2008). However, in general, SIB are difficult to manage and may result in injuries, hospitalizations, death, and exclusion from educational or vocational activities, or admission to residential facilities (Devine 2014; Ianuzzi et al. 2015; Mandell 2008; Minshawi et al. 2014b). Further, SIB have a negative effect on the well-being of other family members and increase the societal costs of services in those with developmental disabilities (Devine 2014; Ianuzzi et al. 2015; Kalb et al. 2012).

In order to improve the management of SIB in ASD, a better understanding of their risk factors is needed, but large epidemiological studies are lacking. Some previous studies on SIB in individuals with ASD failed to find significant associations between SIB and sex, race/ethnicity, developmental regression, or gastrointestinal (GI) problems (Baghdadli et al. 2003; Horovitz et al. 2011; Kozlowski et al. 2012; Lance et al. 2014; Maenner et al. 2012; Wiggins et al. 2009). Significant associations between SIB and low intelligence quotient (IQ) or low adaptive skills have been reported (Ando and Yoshimura 1978; Baghdadli et al. 2003; Duerden et al. 2012). SIB have also been associated with the presence of other psychiatric comorbidities and challenging behaviors (e.g., aggression, anxiety) (Carroll et al. 2014; Kanne and Mazurek 2011), sleep problems, or abnormalities in sensory processing (Duerden et al. 2012; Goldman et al. 2011). In some studies, associations between SIB and child age were found (Baghdadli et al. 2003; Esbensen et al. 2009), while others did not (Duerden et al. 2012; Murphy et al. 2009). In two studies, associations with autism severity were reported (Baghdadli et al. 2003; Rattaz et al. 2015), however, another study did not find such an association (Duerden et al. 2012). The effects of parental or family characteristics on the occurrence of SIB is an area that is understudied. Baghdadli et al. (2003) and Schroeder et al. (2014) did not find an association between parental social class, maternal education and SIB, respectively.

Many of the above studies used small clinical samples. Findings from these small studies may be subject to selection bias, since these studies were more likely to include those with the most severe symptoms or those who can access services. Further, small clinic-based studies may be under-powered and have limited external validity. Large epidemiological studies of a range of risk factors for SIB in a more diverse sample of persons with ASD are needed. IQ and maternal education have been found to modify some associations in those with ASD. For example, the relationship between ratings of autism symptoms and maternal age varied according to the level of maternal education (Hattier et al. 2013). Similarly, Kalkbrenner et al. (2012) found that the association between maternal smoking and ASD was only significant in those with higher IQ. The possibility of an effect modification by IQ or maternal education on the factors associated with SIB have not been considered in studies of SIB in ASD.

The primary goal of this study was to assess factors associated with SIB in two large and distinct national samples of children with ASD, allowing consistency of the findings in two datasets to be examined. Based on results from past studies, the following factors were considered: child variables (e.g., sex, cognitive and adaptive delays, co-occurring conditions). Additionally, we included parent (parental age and maternal education), and family variables (e.g., type of health insurance and census tract median income). A secondary goal was to determine if any associations found were modified by child sex, IQ, or maternal education.

Methods

Study Design

This is a cross-sectional, secondary analysis of data from a surveillance system and a clinic-based registry of children with ASD. This study was approved by both the Autism and

Developmental Disabilities Monitoring (ADDM) Network and the Autism Speaks-Autism Treatment Network (AS-ATN) data sharing committees.

Sample

We included children with ASD from two different samples, the ADDM Network and the AS-ATN. In ADDM, children from all study sites who met the surveillance case definition for ASD during the 2000, 2006, and 2008 surveillance years were included (CDC 2007, 2009, 2012). Data from 2002 and 2004 were excluded, since changes in data collection procedures impacted the reporting of SIB. Data after 2008 were not available at the time of these analyses. The ADDM Network was started by the Centers for Disease Control and Prevention in 2000. It is an active, record-based, multiple site surveillance system for ASD and other developmental disabilities among 8-year-old children in selected areas of the United States. The ADDM methodology has been evaluated and validated by others (Avchen et al. 2011; Bakian et al. 2014; Van Narden Braun et al. 2007) and detailed descriptions of the process for surveillance classification of cases can be found in a number of publications (CDC 2007, 2009, 2012; Rice et al. 2007; Sell et al. 2012; Wiggins et al. 2012). In short, during a given surveillance year, available health records in all sites (e.g., clinician notes, results from standardized tests), and school records in some sites, of a sample of 8-year-old children with specific ICD-9 codes or eligibility for special education services, who lived in different ADDM catchment areas, were screened for trigger words describing social deficits associated with ASD, a documented diagnosis of ASD from a community provider, or an educational eligibility for services under the ASD category. Records that satisfied any of the above criteria were abstracted verbatim. Records from multiple sources for each child were combined to a composite summary that was reviewed by an expert clinician at each ADDM site using an objective coding scheme to decide whether the child met the surveillance definition for ASD based on the Diagnostic and Statistical Manual for Mental Disorders-IV-Edition-Text Revision [DSM-IV-TR] criteria (APA 2000). Census data were linked to the final ADDM dataset. In order to maintain a high quality of data, all sites were required to adhere to a common protocol; ongoing training and quality control checks were implemented for record abstractors and clinician reviewers with a reliability of 90% or greater.

The AS-ATN, initiated by Autism Speaks in 2005, is a network that currently consists of 14 academic health centers in North America. The network maintains a registry of children with ASD diagnosed in any of the participating centers. The details of the AS-ATN registry methodology have been previously published and data from this registry have been used by other researchers in the past (Coury et al. 2009; Kanne et al. 2014; Kuhlthau et al. 2010; Lajonchere et al. 2012; Perrin et al. 2012; Sikora et al. 2012). In summary, families of children, aged 2–18 years, diagnosed with ASD within the preceding 12 months and who planned to receive care in one of the AS-ATN centers were invited to participate in the registry. The diagnosis of ASD was based on clinical judgment based on the DSM-IV-TR criteria and confirmed by the Autism Diagnostic Observation-Schedule (ADOS) (Lord et al. 2000a). Children in foster care or whose parents were not fluent in both written and spoken English were not eligible for the registry. In these analyses, we included all children enrolled in the registry between 2008 and 2012.

Measures

In ADDM, data on SIB and the potential risk factors examined were obtained from available children's health records in all sites, and school records in some sites. In the AS-ATN registry, data were collected from several instruments, including the AS-ATN demographic form, a modified questionnaire developed from the Parental Concerns Questionnaire (PCQ) (McGrew et al. 2007), as well as standardized tests, such as the Stanford Binet Scales of Intelligence-5th Edition Abbreviated Battery IQ (Roid 2003), the Mullen Scales of Early Leaning (Mullen 1995) and the Vineland Adaptive Behavior Scales (Sparrow et al. 2005).

The outcome of interest in both datasets was SIB (yes/no). In ADDM, SIB were determined by coding of their presence in available records by clinicians trained in the surveillance coding process based on the following definition of SIB: any self-directed behavior that could cause physical harm or a sign or bodily mark of the act, such as picking fingers until bleeding, sucking fingers until chapped, slapping self in face, head banging, etc. In AS-ATN, the presence of SIB was based on a parental questionnaire asking parents whether the child displayed SIB (bangs head, pinches, bites, hits oneself). Though many factors examined were similar in both datasets, some were only evaluated in one dataset. In both datasets, we examined potential associations with sex, race/ethnicity, IQ, adaptive skills, developmental regression, sleep and sensory abnormalities, maladaptive behaviors/co-occurring conditions (aggression, hyperactivity, attention problems, anxiety, mood problems). Child age, severity of ASD, parental age, maternal education, type of health insurance, and the presence of gastrointestinal (GI) disturbances were only examined in the AS-ATN dataset. Severity of ASD was based on ADOS calibrated scores (Gotham et al. 2009; Hus and Lord 2014). IQ and adaptive skills scores were analyzed as continuous in the AS-ATN, since the plots of these variables versus SIB showed continuous distributions. Sleep and GI problems, parental age were examined only in sub-analyses because these variables were only available in specific study years. We assessed potential associations with census tract median income, documentation of a previous diagnosis of ASD in the records, and genetic and neurologic conditions only in the ADDM dataset. Previous diagnosis of ASD in the records was considered a proxy for access to services.

Since a high number of variables were included in these analyses, we first estimated the variance inflation factor (VIF) and the tolerance for each variable to assess multicollinearity. None of the variables had a VIF >10 or a tolerance <0.10 (Cheng et al. 2010). Because of missing data on important variables (e.g., IQ and adaptive behaviors), we imputed missing data using the fully conditional specification (FCS) technique (Janssen et al. 2010; Langkamp et al. 2010; Lee and Carlin 2010; Rubin 1987; Van Buuren 2007). We used Proc MI in SAS to impute 10 datasets within each site to account for within site correlation. We used PROC GLIMMIX (SAS® version 9.3, Cary, NC) with an alpha level of 0.05 to assess the associations between SIB and the above factors in each imputed data-set using a non-linear mixed model because SIB was categorized (yes/no). Site was included as a random effect to account for between-site variability. Results from the 10 imputed datasets were combined using Rubin's formula to obtain the final results (Rubin 1987). Effect modification by child sex and IQ were assessed in ADDM, while in ASATN, child sex, IQ,

and maternal education were evaluated, using the same analytical approach described above. We primarily reported results from multiple imputation analyses.

Results

A total of 8065 participants were included in ADDM analyses and 5102 in the main AS-ATN analyses; 4615 in the first AS-ATN sub-analysis (GI and sleep problems) and 3017 in the second AS-ATN sub-analysis (parental age). The characteristics of participants are presented in Table 1.

In both datasets, SIB were significantly associated with child characteristics of impairment in adaptive behavior, developmental regression, maladaptive behaviors (e.g., aggression, hyperactivity, anxiety), sleep problems, and abnormalities in sensory processing. No significant associations were reported with child sex or race/ethnicity. In AS-ATN, SIB were significantly associated with younger child age, lower maternal education attainment, or having public health insurance, but no associations were found with GI problems, severity of ASD, or parental age. In ADDM, a significant relationship was found with lower median income in the census tract, previous diagnosis in the records, neurologic conditions, but not with genetic conditions (Table 2). No significant effect modifications by child IQ or sex were observed in either dataset nor by maternal education in AS-ATN. In general, findings from multiple imputation analyses were consistent with those from complete case analyses concerning the directionality and the significance of the associations, except in few cases (adaptive impairment and developmental conditions in ADDM; maternal age, other health insurance, and severity of ASD in the AS-ATN). Results from complete case analyses are included in the supplemental table.

Discussion

We found similarities in the results for both samples, despite differences between the two datasets (samples, way SIB were assessed, age of the participants, and methods of data collection of the different factors examined), which supports the validity of these findings.

In line with previous studies (Carroll et al. 2014; Matson et al. 2008; Rao and Landa 2014; Schroeder et al. 2014), SIB were related to behavioral factors (i.e., aggression, hyperactivity, anxiety, and mood problems). The causal nature and direction of these associations could not be determined from the cross-sectional data in our study. It is possible that these associations are due to a shared etiology. SIB and other challenging behaviors may all be the result of deficits in inhibitory mechanisms secondary to a lack of impulse control. Emotional dysregulation has been found to be among the factors that may explain this lack of impulse control (Prizant and Laurent 2011; Quek et al. 2012). Further, reporting bias may also explain these associations, as parents of children with SIB may consider these children as being “difficult” and report the presence of these other challenging behaviors. The associations between SIB and other challenging behaviors suggest that clinicians should inquire about SIB when there is a parent report of other challenging behaviors.

Similar to results reported by others (Baghdadli et al. 2003; Duerden et al. 2012), we found significant relationships between low adaptive or cognitive skills and SIB, though the

association with low IQ was not statistically significant in the AS-ATN dataset. These associations support past findings that having limited social and communication skills, as in those with low IQ or low adaptive scores, may lead to self-injury, since these children may use SIB as a way of communication (Devine 2014). Further, in some children with limited adaptive skills, SIB may reflect frustration, since these children have limitations in their abilities to independently perform important activities of daily living and communicate their needs. The loss of previously-acquired skills (e.g., communication or social skills) in children who experience developmental regression may increase the likelihood of these children to use SIB as a way of communication and may explain the association between SIB and developmental regression.

The results of this study also confirmed previous reports of associations of SIB with abnormalities in sensory processing (Duerden et al. 2012, 2014) and sleep problems (Goldman et al. 2011; Sikora et al. 2012). Children with sensory disturbances may use SIB as a mechanism to regulate arousal (hypo or hyper arousal) and under these circumstances, SIB may play a function of autoregulation. As suggested by others, it is also possible that SIB are consequences of alterations in pain sensitivity secondary to structural abnormalities in the somatosensory system (Duerden et al. 2014). In their study, Goldman et al. (2011) reported that the association between SIB and sleep problems was the strongest among all the behaviors evaluated. The mechanism explaining the relationship between SIB and sleep problems is complex and not completely understood and a reverse association is also a possibility (Symons et al. 2000). Nevertheless, studies have shown that improvement in sleep has led to less SIB and repetitive behaviors in some children (Malow et al. 2014; Schreck et al. 2004).

Unlike studies done elsewhere: Baghdadli et al. (2003) in France and Schroeder et al. (2014) in Peru, we found significant associations with four factors related to socioeconomic status (SES): lower maternal level of education or having public health insurance in AS-ATN, lower median income in the census tract or having a previous diagnosis of ASD in the records in the ADDM network. It is possible that children from families with low SES are more likely to receive services if they have SIB and this may explain the documentation of SIB in their records. On the other hand, because disparities in access to ASD specialized services based on individual (Irvin et al. 2012; Liptak et al. 2008) and community factors (Thomas et al. 2012) have been reported in the United States, it is also possible that children from families with low SES are less likely to access specialized services that may address associated factors that impact SIB (e.g., sensory, sleep). Mothers with low educational attainment may also have limited coping skills or understanding of child's development (Yu et al. 2002). Since these results have not been reported previously, these findings need to be evaluated in future studies.

A few variables were only available in one dataset. In AS-ATN, we found an association of SIB with younger chronological age, which is similar to findings from others (Baghdadli et al. 2003; Esbensen et al. 2009). This age effect may reflect the general developmental maturation with age, or differences in the duration of interventions received between younger and older children. Further, though these analyses were adjusted for study year, this age effect might also suggest high reporting of SIB in the most recent cohort of children

with ASD because of an increase in awareness of co-occurring conditions, including SIB. Similar to others, we also did not find significant associations with GI problems or severity of ASD (Duerden et al. 2012; Maenner et al. 2012; Nikolov et al. 2009). In ADDM, we found a positive association of SIB with the presence of neurologic conditions, such as seizure disorders or cerebral palsy, as have others (Viscidi et al. 2014). While neurologic conditions are associated with developmental regression, our findings were still significant after controlling for developmental regression.

This study has several strengths, including large samples of children with ASD from two national datasets, diverse factors tested, the ability to assess consistency of the findings in two different datasets, use of multiple imputation to account for missing data, and exploration of effect modification. However, it has some limitations. We examined a set of factors potentially related to SIB that were retrospectively collected. Variables such as perinatal and neonatal factors, metabolic diseases, factors related to the physical and social environments of the child (quality of social interaction with caregivers, exposure to environmental toxins, parental psychiatric conditions) or the types of interventions received that might be related to SIB, were not available in our datasets. These findings may have been influenced by a selection bias since only families who were fluent in English, had access to specialized care, and agreed to be part of the registry were included in the AS-ATN and in the ADDM Network, sites are not selected to include representative samples of children with ASD. Therefore, these findings might not be representative of all the children with ASD, and might not be generalizable to the entire nation. In AS-ATN, the presence of co-occuring conditions was based on parental responses, while in ADDM, they were documented by a review of the child's records. This difference in methods of ascertainment may explain the differences in the proportion of co-occuring conditions between the two databases. As mentioned, due to the cross-sectional design of this study, we cannot infer the temporal relationship between SIB and other behavioral factors. Multiple testing may also have influenced our findings because of the high number of statistical tests. We did not adjust for multiple comparisons because of the exploratory nature of the study and the consequences of false negative findings (Goldman 1998; Greenland 2008).

Despite these limitations, results from this analysis of two different datasets found significant associations between SIB and behavioral (aggression, hyperactivity, anxiety) developmental (adaptive behaviors, IQ, regression), and somatic (sensory abnormalities, sleep problems) factors. The consistency of our findings in two distinct datasets shows the robustness of these results and mitigates against chance alone as the explanation. Overall, though, the findings from this study require confirmation in future longitudinal studies, they are in line with past findings and also support recommendations for a comprehensive and multidisciplinary approach to evaluating and treating SIB in ASD (Isaksen et al. 2013; Minshawi et al. 2014b). In providing a comprehensive assessment of children with SIB, clinicians could identify causative or exacerbating conditions that can be managed through available interventions. Similarly, early intervention provided by clinicians could target some of the factors associated with SIB (sleep, abnormalities in sensory processing, adaptive skills), since such interventions might lead to prevention or amelioration of SIB in some children. Researchers can use these data to inform future studies, which could examine other factors (e.g., prenatal and perinatal factors, metabolic factors), in addition to those included

in this study and employ longitudinal designs, allowing evaluation of temporal relationships over the life course between SIB and other factors in individuals with ASD.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We acknowledge CDC ADDM project personnel, ADDM projects coordinators, clinician reviewers, abstractors, data managers, and ADDM investigators at each site who contributed to the ADDM surveillance project and data collection. We acknowledge AS-ATN project coordinators and all families who provided data into the AS-ATN registry. This Network activity was supported by Autism Speaks and cooperative agreement UA3 MC11054 through the U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Research Program to the Massachusetts General Hospital. This work was conducted through the Autism Speaks-Autism Treatment Network.

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Table 1

Characteristics of children with autism spectrum disorder (ASD) included in the Autism and Developmental Disabilities Monitoring (ADDM) Network and Autism Speaks-Autism Treatment Network (AS-ATN), analyzed for factors associated with self-injurious behaviors

Variable	ADDM	AS-ATN main analyses	AS-ATN sub-analysis (GI, sleep)	AS-ATN sub-analysis (parental age)
Sample size	8065	5102	4615	3017
Study year	2000, 2006, 2008	2008–2012	2009–2012	2008–2010
SIB				
Yes	2234 (27.70)	1683 (32.99)	1528 (33.11)	1042 (34.54)
No	5831 (72.30)	3419 (67.01)	3087 (66.89)	1975 (65.46)
Sex				
Female	1432 (17.76)	820 (16.07)	739 (16.29)	474 (15.71)
Male	6633 (82.24)	4235 (83.01)	3816 (82.69)	2541 (84.22)
Missing	0	47 (0.92)	47 (1.02)	2 (0.07)
Child's age (years)				
Mean (SD)	8.00 only	5.71 (3.40)	5.64 (3.40)	5.86 (3.45)
Race				
NHW	4563 (56.58)	3866 (75.77)	3471 (75.21)	2276 (75.44)
NHAA	1818 (22.54)	333 (6.53)	300 (6.50)	211 (6.99)
Hispanic	940 (11.66)	419 (8.21)	390 (8.45)	267 (8.85)
Others	448 (5.55)	291 (5.70)	271 (5.87)	186 (6.17)
Missing	296 (3.67)	193 (3.78)	183 (3.97)	77 (2.55)
Regression				
Yes	1422 (17.63)	1398 (27.40)	129 (27.95)	882 (29.23)
No	6643 (82.37)	3677 (72.07)	3298 (71.46)	2132 (70.67)
Missing	0 (0.00)	27 (0.53)	27 (0.59)	3 (0.10)
Aggression				
Yes	3955 (49.04)	2495 (48.90)	2244 (48.62)	1558 (51.64)
No	4110 (51.96)	2591 (50.78)	2355 (51.03)	1450 (48.06)
Missing	0 (0.00)	16 (0.32)	16 (0.35)	9 (0.30)
Temper tantrums				
Yes	4266 (52.90)	N/A	N/A	N/A
No	3799 (47.10)	N/A	N/A	N/A
Missing	0	N/A	N/A	N/A
Argumentative behaviors				
Yes	5127 (63.57)	N/A	N/A	N/A
No	2938 (36.43)	N/A	N/A	N/A
Missing	0	N/A	N/A	N/A
Psychiatric conditions/anxiety				
Yes	419 (5.20)	3269 (64.07)	2858 (61.93)	2345 (77.73)
No	7646 (94.80)	1806 (35.40)	1730 (37.49)	659 (21.84)

Variable	ADDM	AS-ATN main analyses	AS-ATN sub-analysis (GI, sleep)	AS-ATN sub-analysis (parental age)
Missing	0	27 (0.53)	27 (0.58)	13 (0.43)
Psychiatric conditions/mood problems				
Yes	419 (5.20)	2946 (57.74)	2633 (57.05)	1900 (62.98)
No	7646 (94.80)	2135 (41.85)	1961 (42.49)	1106 (36.66)
Missing	0	21 (0.41)	21 (0.46)	11 (0.36)
Developmental conditions/hyperactivity				
Yes	3191 (39.57)	3553 (69.64)	3185 (69.01)	2225 (73.75)
No	4874 (60.43)	1533 (30.05)	1414 (30.64)	784 (25.99)
Missing	0	16 (0.31)	16 (0.35)	8 (0.26)
Developmental conditions/attention problems				
Yes	3191 (39.57)	4236 (83.03)	3809 (82.54)	2614 (86.64)
No	4874 (60.43)	841 (16.48)	781 (16.92)	395 (13.09)
Missing	0	25 (0.49)	25 (0.54)	8 (0.27)
Neurologic conditions				
Yes	581 (7.20)	N/A	N/A	N/A
No	7484	N/A	N/A	N/A
Missing	(92.80)0	N/A	N/A	N/A
Genetic conditions				
Yes	35 (0.43)	N/A	N/A	N/A
No	8030 (99.57)	N/A	N/A	N/A
Missing	0	N/A	N/A	N/A
IQ				
Mean (SD)	N/A	76.17 (23.50)	76.27 (23.62)	76.31 (23.55)
Missing (%)	N/A	1089 (21.34)	1027 (22.25)	522 (17.30)
Cognitive ability				
Above intellectual disabled range	3613 (44.80)	N/A	N/A	N/A
Intellectual disability	2399 (29.75)	N/A	N/A	N/A
Missing	2053 (25.46)	N/A	N/A	N/A
Adaptive behaviors scores				
Mean (SD)	N/A	71.62 (12.32)	71.70 (12.28)	71.85 (12.63)
Missing (%)	N/A	640 (12.54)	562 (12.18)	339 (11.24)
Adaptive impairment				
No (adaptive score >70)	1516 (18.80)	N/A	N/A	N/A
Yes (adaptive score ≤70)	3061 (37.95)	N/A	N/A	N/A
Missing (%)	3488 (43.25)	N/A	N/A	N/A
Severity of autism				
Mean (SD)	N/A	7.06 (2.27)	7.04 (2.26)	7.15 (2.23)
Sensory abnormalities				
Yes	1572 (19.49)	3922 (76.88)	3528 (76.45)	2377 (78.79)
No	6493 (80.51)	1164 (22.81)	1071 (23.21)	631 (20.91)
Missing (%)	0(0.00)	16 (0.31)	16 (0.34)	9 (0.30)

Variable	ADDM	AS-ATN main analyses	AS-ATN sub-analysis (GI, sleep)	AS-ATN sub-analysis (parental age)
Sleep problems				
Yes	2101 (26.05)	N/A	1635 (35.43)	N/A
No	4671 (57.92)	N/A	2187 (47.39)	N/A
Missing	1293 (16.03)	N/A	793 (17.18)	N/A
Gastrointestinal problems				
Yes	N/A	N/A	1533 (33.22)	N/A
No	N/A	N/A	2288 (49.58)	N/A
Missing	N/A	N/A	794 (17.20)	N/A
Maternal age (years)				
Mean (SD)	N/A	N/A	N/A	29.74 (5.99)
Missing (%)	N/A	N/A	N/A	138 (4.57)
Paternal age (years)				
Mean (SD)	N/A	N/A	N/A	32.42 (6.86)
Missing (%)	N/A	N/A	N/A	298 (9.88)
Mother education				
No college degree	N/A	2547 (49.92)	2318 (50.23)	1464 (48.53)
College or higher	N/A	2259 (44.28)	2045 (44.31)	1377 (45.64)
Missing	N/A	296 (5.80)	252 (5.46)	176 (5.83)
Father education				
No college degree	N/A	2374 (47.37)	2152 (46.63)	1384 (45.87)
College or higher	N/A	2064 (41.18)	1868 (40.48)	1251 (41.47)
Missing	N/A	664 (13.25)	595 (12.89)	382 (12.66)
Health insurance				
Private	N/A	3130 (61.35)	2781 (60.26)	1984 (65.76)
Public	N/A	1182 (23.17)	1078 (23.36)	613 (20.32)
Others	N/A	731 (14.33)	697 (15.10)	416 (13.79)
Missing	N/A	59 (1.15)	59 (1.28)	4 (0.13)
Previous diagnosis of ASD				
Yes	5329 (66.08)	N/A	N/A	N/A
No	2736 (33.92)	N/A	N/A	N/A
Missing	0	N/A	N/A	N/A
Census tract median income quartiles				
<$35,000 (lowest)	2071 (25.68)	N/A	N/A	N/A
$35,000 to <$50,000	2208 (27.38)	N/A	N/A	N/A
$50,000 to <$65,000	1724 (21.38)	N/A	N/A	N/A
≥$65,000 (highest)	1700 (21.08)	N/A	N/A	N/A
Missing	362 (4.48)	N/A	N/A	N/A

IQ intelligence quotient, *NHAA* non-hispanic African American, *NHW* non-hispanic white, *SD* standard deviation

Table 2

Associations between self-injurious behaviors (SIB) and different factors in children with autism spectrum disorder (ASD) included in the Autism and Developmental Disability Monitoring (ADDM) Network and Autism Speaks-Autism Treatment Network (AS-ATN)

Variable	ADDM dataset		AS-ATN dataset	
	OR and 95% CI	P-value	OR and 95% CI	P-value
Sex				
Female	0.90 (0.59, 1.37)	0.58	0.96 (0.78, 1.15)	0.67
Male	1.00	1.00	1.00	1.00
Child's age (per year)	N/A	N/A	0.95 (0.93, 0.97)	**0.002**
Race of the child				
NHAA	0.85 (0.71, 1.01)	0.06	0.72 (0.55, 1.01)	0.05
Hispanic	0.91 (0.74, 1.12)	0.32	0.97 (0.76, 1.24)	0.80
Others	0.75 (0.56, 1.00)	0.05	1.10 (0.81, 1.49)	0.56
NHW	1.00	1.00	1.00	1.00
Regression				
Yes	1.31 (1.12, 1.54)	**0.003**	1.35 (1.16, 1.57)	**0.003**
No	1.00			
Aggression				
Yes	2.40 (2.10, 2.73)	<**0.0001**	3.38 (2.93, 3.90)	**0.0001**
No	1.00	1.00	1.00	1.00
Temper tantrums				
Yes	2.02 (1.76, 2.31)	<**0.0001**	N/A	N/A
No	1.00	1.00	N/A	N/A
Argumentative behaviors				
Yes	1.30 (1.13, 1.50)	**0.003**	N/A	N/A
No	1.00	1.00	N/A	1.00
Psychiatric conditions/anxiety				
Yes	1.56 (1.20, 2.04)	**0.003**	1.46 (1.24, 1.73)	**0.002**
No	1.00	1.00	1.00	1.00
Psychiatric conditions/mood problems				
Yes	1.56 (1.20, 2.04)	**0.003**	1.75 (1.50, 2.05)	**0.0001**
No	1.00	1.00	1.00	1.00
Developmental conditions/hyperactivity				
Yes	1.13 (1.01, 1.29)	**0.05**	1.47 (1.24, 1.76)	**0.002**
No	1.00	1.00	1.00	1.00
Developmental conditions/attention problems				
Yes	1.13 (1.01, 1.29)	**0.05**	0.96 (0.78, 1.20)	0.75
No	1.00	1.00	1.00	1.00
Neurologic conditions				
Yes	1.34 (1.05, 1.71)	**0.02**	N/A	N/A
No	1.00	1.00	N/A	N/A

Variable	ADDM dataset		AS-ATN dataset	
	OR and 95% CI	P-value	OR and 95% CI	P-value
Genetic conditions				
Yes	0.80 (0.29, 2.16)	0.66	N/A	N/A
No	1.00	1.00	N/A	N/A
IQ scores (per 1 unit)	N/A	N/A	0.99 (0.99, 1.01)	0.17
Cognitive ability				
Above intellectual disabled range	0.73 (0.62, 0.85)	**0.002**	N/A	N/A
Intellectual disability	1.00	1.00	N/A	N/A
Adaptive skills scores (per 1 unit)	N/A	N/A	0.97 (0.96, 0.98)	**0.0001**
Adaptive impairment				
No (adaptive score >70)	0.80 (0.70, 0.92)	**0.006**	N/A	N/A
Yes (adaptive score ≤70)	1.00		N/A	N/A
Severity of autism[a]	N/A	N/A	0.98 (0.95, 1.02)	0.21
Sensory problems				
Yes	1.39 (1.20, 1.61)	**0.0007**	1.49 (1.24, 1.79)	**0.002**
No	1.00	1.00	1.00	1.00
Sleep problems[b]				
Yes	1.47 (1.25, 1.72)	**0.0004**	1.39 (1.17,1.65)	**0.004**
No	1.00	1.00	1.00	1.00
Gastrointestinal problems[b]				
Yes	N/A	N/A	1.09 (0.93, 1.29)	0.29
No	1.00	N/A	1.00	1.00
Maternal age (per year)[b]	N/A	N/A	0.99 (0.97, 1.01)	0.30
Paternal age (per year)[b]	N/A	N/A	0.99 (0.94, 1.05)	0.90
Maternal education				
No college degree	N/A	N/A	1.44 (1.24, 1.67)	**0.001**
College degree or higher	N/A	N/A	1.00	1.00
Health insurance				
Public	N/A	N/A	1.32 (1.10, 1.57)	**0.01**
Other	N/A	N/A	1.25 (0.99, 1.55)	0.05
Private	N/A	N/A	1.00	1.00
Previous diagnosis of ASD				
Yes	1.23 (1.09, 1.42)	**0.007**	N/A	N/A
No	1.00	1.00	N/A	N/A
Census tract median income quartiles				
<$35,000 (lowest)	1.26 (1.05, 1.52)	**0.02**	N/A	N/A
$35,000 to <$50,000	1.02 (0.86, 1.22)	0.86	N/A	N/A
$50,000 to <$65,000	1.04 (0.86,1.25)	0.68	N/A	N/A
≥$65,000 (highest)	1.00	1.00	N/A	N/A

Estimates are adjusted for the other variables included in the model

P-values less than 0.05 are in bold

CI confidence interval, *IQ* intelligence quotient, *NHAA* non-hispanic African American, *NHW* non-hispanic white, *OR* odds ratio

[a] Severity of autism was based on ADOS standardized scores

[b] Collected only during specific study years in the AS-ATN dataset