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Frequency and Pattern of Documented Diagnostic Features and the Age of Autism Identification

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Abstract

Objective—The *DSM-IV-TR* specifies 12 behavioral features that can occur in hundreds of possible combinations to meet diagnostic criteria for autism spectrum disorder (ASD). This paper describes the frequency and variability with which the 12 behavioral features are documented in a population-based cohort of 8-year-old children under surveillance for ASD, and examines whether documentation of certain features, alone or in combination with other features, is associated with earlier age of community identification of ASD.

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Method—Statistical analysis of behavioral features documented for a population-based sample of 2,757 children, 8 years old, with ASD in 11 geographically-defined areas in the US participating in the Autism and Developmental Disabilities Monitoring Network in 2006.

Results—The median age at ASD identification was inversely associated with the number of documented behavioral features, decreasing from 8.2 years for children with only seven behavioral features to 3.8 years for children with all 12. Documented impairments in nonverbal communication, pretend play, inflexible routines, and repetitive motor behaviors were associated with earlier identification, whereas impairments in peer relations, conversational ability, and idiosyncratic speech were associated with later identification.

Conclusions—The age dependence of some of the behavioral features leading to an autism diagnosis, as well as the inverse association between age at identification and number of behavioral features documented, have implications for efforts to improve early identification. Progress in achieving early identification and provision of services for children with autism may be limited for those with fewer ASD behavioral features, as well as features likely to be detected at later ages.

Keywords

autism; autism spectrum disorder; identification; diagnosis; population-based

Autism spectrum disorders (ASDs) refer to a heterogeneous group of neurodevelopmental disorders involving impairments in social interaction and communication along with the presence of repetitive or stereotyped behaviors. The *DSM-IV-TR* identifies 12 behavioral features that contribute to ASD and its subtypes.[1] The diagnostic criteria for each ASD subtype can be fulfilled by different patterns of combinations of the 12 behavioral features. For the autistic disorder sub-type alone, there are 616 possible combinations of the 12 behavioral features that meet the minimum required number (6) and pattern of domain-specific criteria for a diagnosis. When more than the minimum symptoms are considered, there are 2,027 configurations of the 12 criteria that meet autistic disorder criteria.[2]

Despite the categorical nature of the *DSM-IV-TR* ASD criteria and subtypes, leading diagnosticians have pointed out that the distribution of ASD-related symptoms in the population can be described as a continuum rather than a discrete category, and that the boundary between ASD and other disorders is based on clinical judgment.[3–6] Among persons receiving a diagnosis of ASD, there is heterogeneity in the following: etiology (although the causes of ASD are not well understood, they are assumed to be heterogeneous and to involve multiple biological, developmental, and/or environmental factors); phenotypic characteristics such as the core behavioral features as well as co-occurring conditions such intellectual disability, epilepsy, motor impairments, gastrointestinal disorders, sleep disorders, and other medical conditions; and functional independence, as well as needs for support and services. Even though the heterogeneity of ASD is widely appreciated and the boundaries of ASD subtypes are debated,[7–9] epidemiological studies of ASD typically use a dichotomous “case-versus-noncase” categorization. Despite the elusive nature of establishing clear diagnostic boundaries based on phenotypic symptom clusters, better understanding of the variability of symptoms detected among individuals with ASD

may be relevant to the following: efforts to promote early identification and treatment; the design and evaluation of interventions; etiological investigations; and future changes to the ASD diagnostic criteria.

Analyses of data from the Autism and Developmental Disabilities Monitoring (ADDM) Network have shown the median age at first diagnosis or identification of ASD by community professionals among 8 year-old children with ASD to be as late as 5.7 years,[10] with little improvement on this indicator in recent years.[11] In light of these findings, and the therapeutic importance of early identification, the Healthy People 2010 objectives recognized that reducing the average age of ASD diagnosis is a national public health objective in the United States, and early screening continues to be a target for Healthy People 2020.[12] Information on the age at which different behavioral features are documented in the records of children evaluated for ASD may highlight opportunities to improve the early detection of ASD in community settings. Clinical studies of young children have demonstrated that characteristics such as limited social orientation and initiation, reduced use of gestures and pointing, and the presence of stereotyped or repetitive movements or lack of appropriate gaze to be helpful in identifying autism in children before 2 years of age.[13–15] Even with the evidence provided by such studies—and the public health campaigns promoting early identification of ASD—little is known about whether certain features of ASD are actually identified earlier than others in community health and educational settings.

The ADDM Network offers an opportunity to observe how children with autism are evaluated by professionals in non-research settings. Many population-based studies of ASD are composed entirely of participants with an ASD diagnosis, but the ADDM Network includes children without an autism diagnosis who have documented behavioral features consistent with ASD. Thus, the research-based recommendations for early autism identification can be compared to the community practices observed by the ADDM Network.

This article has two objectives. The first is to describe how diagnostic features of ASD documented by community professionals in a large and recent US population–based cohort are distributed with regard to sex, race/ethnicity, age at evaluation, co-occurring intellectual disability, and history of developmental regression. The second objective, which is limited to children meeting criteria for autistic disorder, is to determine whether some behavioral diagnostic features of ASD tend to be identified earlier by community health and education professionals than other behaviors relevant to the ASD diagnostic criteria. Based on previous clinical findings,[13–15] we hypothesize that 3 of the 12 ASD behavioral features—impairments in nonverbal communication, sharing of interests, and repetitive motor behaviors—are associated with earlier age of autism identification.

METHOD

Study Design and Sample

The ADDM Network performs periodic population-based surveillance for ASDs among 8-year-old children residing in numerous geographically defined study areas in the United

States.[11] The ADDM methodology is based on reviews of health and special educational records from multiple sources that see children within each study area. In total, 2,757 children eight years of age with ASD were ascertained by 11 surveillance sites participating in the ADDM Network for Study Year 2006. These sites were located in Alabama, Arizona, Colorado, Florida, Georgia, Maryland, Missouri, North Carolina, Pennsylvania, South Carolina, and Wisconsin. Although not nationally representative, these sites cover racially and socioeconomically diverse populations (ranging from 23.3% non-Hispanic white in Florida to 69.7% in Maryland).[11,16] A detailed description of the surveillance regions was previously published, and the 8-year-old population under ADDM surveillance was 308,038 (individual site populations ranged from 7,184 in Colorado to 46,624 in Georgia).[11]

Autism Diagnostic Criteria

DSM-IV-TR criteria for ASDs are based upon 12 behavioral features in three domains: social interaction; communication; and repetitive behavior or restricted interests. Of the 12 criteria, four are measures of social interaction, four are measures of communication, and four are measures of repetitive or restricted behavior (see Table S1, available online). For a autistic disorder, an individual must have at least 6 of the 12 criteria and must meet a minimum of two criteria in the social interaction domain, and one each in the communication and repetitive/restricted behaviors domains. In addition, to fulfill *DSM-IV-TR* criteria for autistic disorder, onset of impairments in social interaction, communication, or imaginative play must occur before age 3 years. Fewer criteria are required for Asperger's disorder and pervasive developmental disorder–not otherwise specified (PDD-NOS) (these require three and two criteria, respectively). No single behavioral feature is essential for any ASD diagnosis, and distinctions between subtypes are based on the total number and pattern of impairments (see Table S1, available online).

ADDM Surveillance and ASD Case Definition

Using the ADDM Network surveillance methodology, records were reviewed for children seen at community health and education sources who also met the study eligibility criteria: born in 1998 (and thus age 8 in 2006), had a legal guardian residing in the designated surveillance area at a given site, and had documentation of one or more diagnostic codes or special education eligibilities that indicated a developmental concern (these included a range of developmental diagnoses and special education placements deemed potentially related to ASD). Records for children meeting these criteria were screened for developmental evaluations containing an ASD diagnosis, suspicion of an ASD, or descriptions of social behaviors suggestive of one or more of the diagnostic features for ASD. Records containing an indication of possible ASD were fully abstracted for: verbatim descriptions of behaviors associated with ASD from each developmental evaluation conducted at or before age 8; developmental history or concerns; previous ASD and other developmental diagnoses (such as intellectual disability); and special education classifications. Basic demographic information was also abstracted.

Record abstractions from different sources for the same child were concatenated, and the composite record was then reviewed by one or more trained clinicians using a standard

protocol to code descriptions of behaviors and symptoms. Inter-rater agreement for clinician review ranged from 82%to 100%across the 11 ADDM sites.[11]

Composite records for each child were reviewed by ADDM clinician reviewers using a systematic coding guide based on the *DSM-IV-TR* criteria to determine whether the child met the ADDM case definition for ASD. This case definition is based on the *DSM-IV-TR* diagnostic criteria for autistic disorder (299.0) and PDD-NOS (299.8). Although the case definition was not designed to make distinctions between ASD subtypes, clinician reviewers indicate whether criteria for autistic disorderof or "ASD-NOS" (PDD-NOS or Asperger's disorder) are met. Because the reviewers defined case status based on the behavioral descriptions contained in the abstracted evaluations, some children (24.6%) were classified as meeting the ADDM case definition even though they did not have a previous diagnosis or classification of an ASD in their records. Case criteria for ADDM autistic disorder required evidence of the *DSM-IV-TR* criteria for autistic disorder in the child's records and no clinician judgment that the developmental profile was likely accounted for by another disorder. Compared to the less restrictive *DSM-IV-TR* PDD-NOS diagnostic criteria, the ADDM ASD-NOS case definition is more stringent. Besides requiring at least one impairment in the social domain and one in the communication or repetitive/restricted behavior domain, the ADDM ASD-NOS case definition requires an additional behavior common to children with ASD, or a documented ASD diagnosis. This additional requirement responds to the concern that a literal interpretation of *DSM-IV-TR* criteria would identify more children than clinically appropriate.[17,18] Thus, not all children who met the minimum criteria for PDD-NOS met ADDM case status, and those who did were more likely to have an existing ASD diagnosis from a community professional. Extensive details of the ADDM Network surveillance methodology and the interrater reliability of the clinician reviewers have previously been published.[11,19,20]

Age of ASD Identification

We operationalized "ASD identification" as the age at which a child was recognized as having ASD by a qualified community medical or education professional. A child was considered to be "identified" if there was documentation in existing records of a clinical ASD diagnosis, or an autism classification for special education services. The earliest known age of identification was extracted from the evaluations, and includes descriptions of historical diagnoses that predate the evaluations available to the surveillance system. Children meeting ADDM case status without an indication of an ASD diagnosis or classification in their records were considered "unidentified" through age 8 years.

Descriptive Analyses

We calculated the frequency of the 12 behavioral features documented in evaluation records among children meeting ADDM case status, and within sex, age, racial/ethnic, and select groups based on co-occurring conditions (such as intellectual disability and developmental regression). We also examined the distribution of the total number of diagnostic criteria among ADDM ASD cases, and the frequency of each behavioral feature when a given number of total features were documented. Because of the large sample, many small differences will reach statistical significance. To help recognize meaningful differences, we

computed Cohen's effect size for proportions.[21] We chose to highlight differences between groups with effect sizes greater than 0.2 (termed by Cohen as "small" effect sizes). In this sample, effect sizes of this magnitude or larger would also have *p* values of less than .05 using t tests.

We also investigated how often ASD diagnostic features are described among children at different ages. If any evaluations during a given year contained a description of an ASD diagnostic item, children were included in the numerator for that item and age (e.g., age 3 contains evaluations from 36 to 47 months old). Children were included in the denominator for 1 year if the surveillance system contained an evaluation for the child at that specific year of age. Children might not be evaluated every year; this analysis describes the documented characteristics of children with ASD as they are evaluated by community professionals at different ages, rather than a longitudinal progression of symptoms.

Association Between Diagnostic Behaviors and Identification

To determine whether certain ASD diagnostic behaviors were related to earlier identification of ASD, we restricted the sample to the 2,136 (77.5% of 2,757) ASD cases meeting ADDM surveillance criteria for autistic disorder. Restricting the sample to autistic disorder was necessary because this is the only ASD subgroup for which the ADDM Network surveillance case definition corresponds exactly to *DSM-IV-TR* criteria. For 58 of the 2,136 autistic disorder cases (2.7%), the records indicated a previous ASD diagnosis or classification, but the age of identification was missing. These children were excluded from the analyses. Figure 1 describes the overall sample used in this study.

Because of variability in the number of diagnostic behavioral features noted in children with ASDs, the total number of diagnostic criteria met may confound the association between specific criteria and the age of ASD identification. To evaluate potential confounding by the total number of ASD criteria, we compared the median age of identification between children with and without a behavioral feature described in their records, stratified by the total number of features described. Children who were not identified as having ASD are included as censored observations (acknowledging that they reached age 8 without being identified; see Supplement 1, available online, for a description of how median age of identification is calculated). We also performed a multivariable accelerated failure time analysis showing the association between diagnostic behavioral features and age of identification (see Supplement 2, available online). Multivariable adjustment for the other behavioral diagnostic features, intellectual disability, sex, race/ethnicity, and ADDM site are included in the accelerated failure time models.

Analyses were performed in SAS 9.2 (SAS Institute, Cary, NC). The Wilcoxon test (via PROC LIFETEST in SAS) was used to indicate statistically significant ages of ASD identification between groups ($p < .05$). The Wilcoxon test is a variation of the log-rank test and applies different weights to the distribution of ages of ASD identification; although we present the median age of identification in each stratum, this test statistic compares the equivalence of the survival curves.[22] Effect sizes were calculated in R (R Foundation for Statistical Computing) with the pwr package, and plots were created with ggplot2.[23] This study was approved by the University of Wisconsin Institutional Review Board.

RESULTS

Frequency of Documented ASD Diagnostic Behavioral Features

The frequency with which each ASD diagnostic behavioral feature was documented in the records of the 2,757 ADDM Network children who met the ADDM ASD case definition, along with the distribution of demographic and co-occurring characteristics are displayed in Table 1. Impairments in sharing enjoyment and interests (*DSM* 1c) is the least frequently noted feature, documented for 1,354 (49.1%) of the cases. Impairments in emotional reciprocity (*DSM* 1d) is the most often-described feature, with 2,493 (90.4%) of the sample noted to have this symptom in at least 1 evaluation. Table 1 also compares the frequency of each criterion by sex, race/ethnicity, intellectual disability, history of developmental regression, and previous ASD identification (ASD diagnosis or classification documented in records). Most of the characteristics are documented with similar frequency among boys and girls, except restricted interests (*DSM* 3a) are more likely to be noted in boys than in girls (effect size, 0.24). In addition, boys and girls have documented descriptions of regression or IQ ≤ 70 with similar frequency (effect sizes of −0.06 and −0.10, not shown). There are few differences by race/ethnicity; the largest difference between non-Hispanic white and non-Hispanic black children is in the criterion of delayed language (*DSM* 2a) (85.3% of white children versus 95.0% of black children; effect size, 0.33). Relative to other groups, Hispanic children meeting ASD ADDM case criteria are less likely to have features endorsed in the repetitive/restricted domain (Table 1). The documented frequency of impairments in nonverbal social communication (*DSM* 1a), sharing enjoyment or interests (*DSM* 1c), language delays (*DSM* 2a), impairments in pretend play (*DSM* 2d), and repetitive motor behaviors (*DSM* 3c) is substantially higher among children meeting ADDM case criteria with intellectual disability or developmental regression than children without intellectual disability or regression (all effect sizes >0.2; Table 1).

The frequency of some of the behavioral features varies by the age of the child when the evaluation occurred. Figure 2 shows the probability that each behavioral feature appeared in an evaluation among children who were evaluated at each year of age. The mean number of evaluations (among children evaluated at each age) is shown at the bottom of the figure. Several features are more likely to be described in evaluations of children at age 2 or 3 years than at age 8 years. Most notably, 54.8% of children evaluated at age 2 were noted to have impairments in pretend play (*DSM* 2d), compared with only 12.2% of children evaluated at age 8 (Figure 2). Other features, such as restricted interests (*DSM* 3a), were equally likely to appear in evaluations of children age 2 and 8 years. Compared with children with an IQ > 70, children with a known intellectual disability were somewhat more likely to have documented language delays (*DSM* 2a) and repetitive motor behaviors (*DSM* 3c) across the age range (Figure S1, available online); however, the direction of the trend across ages was similar for both groups. Children with an intellectual disability were also more likely to be evaluated at younger ages than children with IQ > 70 (Table S4, available online).

Among the children classified by ADDM as having ASD, nearly 60% had records identifying nine or more of the 12 *DSM* criteria (Table 2). Only 5% met four or fewer criteria. Nonverbal communication (*DSM* 1a), emotional reciprocity (*DSM* 1d), and spoken

language (*DSM* 2a) were among the most common criteria, irrespective of the total number of documented criteria. Each of these was reported in one-third or more of the children in each criteria number group, 2 through 12. Other behaviors, such as impairments in pretend play (*DSM* 2d) or sharing enjoyment or interest (*DSM* 1c), were much more likely to be noted among children with a greater total number of criteria. All behaviors are common in children meeting nine or more total criteria.

Diagnostic Features and Association with Early Identification

Of the 2,136 children meeting criteria for ADDM autistic disorder case status, the overall median age of identification was 63 months, and only 21% (444 of 2,136) were identified by 36 months. The overall inverse association between the total number of behavioral diagnostic criteria met and the median age of ASD identification is shown in Figure 3 (lower left). Similarly, the proportion of ASD-identified children steadily increases from 47.7% of children with six features to 93.4% of children with all 12 features (Supplement 1 and Table S2, available online). Among children meeting ADDM Network autistic disorder criteria, the median age of ASD identification is more than 4 years earlier for children whose evaluations contained all 12 features than among children with only six of the features. This relationship appears to confound the association between some of the individual diagnostic criteria and the age of ASD identification (Figure 3). After stratifying by the total number of *DSM-IV-TR* criteria described in a child's records, four criteria remain consistently and significantly associated with earlier identification: impairments in nonverbal communication (*DSM* 1a), impairments in pretend play (*DSM* 2d), inflexibility regarding routines or rituals (*DSM* 3b), and repetitive motor behavior (*DSM* 3c; Figure 3). Three other criteria are consistently and significantly related to later identification after stratifying by the total number of criteria: problems developing peer relations (*DSM* 1b), impaired ability to initiate or sustain conversations (*DSM* 2b), and stereotyped or repetitive language (*DSM* 2c). For these items, the difference in the median age of identification among children with and without these features is often greater than 1 year (Figure 3).

DISCUSSION

This study provides population-based information on the frequency with which specific behavioral features that are diagnostic of ASD are documented in the health and educational records of children with ASD. Although previous population-based studies have examined the relationship between ASD diagnosis and sociodemographic characteristics and co-occurring ASD features,[9,24–25] this study describes the frequency and patterns of behavioral features used as a basis for making ASD diagnoses in the population, and examines their relationships to the timing or age of ASD diagnosis and identification.

Heterogeneity of Diagnostic Behavioral Features

The diagnostic behavioral features documented among the 2,757 children in this study included hundreds of different combinations of symptoms meeting ASD criteria (see Figures S2 and S3, available online). Despite the variability of symptoms among children meeting the ADDM ASD case definition, there was little overall that would readily differentiate ASD in boys versus girls, or white children versus black children. Our findings are

consistent with those of previous studies based on clinical samples and survey results showing that, among children with ASD, boys were more likely to have the criterion for restricted interests than were girls,[26–27] and black children were more likely to have documentation of language deficits than were white children.[28] Additional studies are needed to determine whether these differences are due to sociodemographic differences in the ASD phenotype or biases in ascertainment or measuring or reporting of symptoms.[29,30]

Similar to previous studies,[31] children with intellectual disability were more likely to have several diagnostic features documented in their evaluations, including repetitive motor behaviors. Repetitive motor behaviors have been hypothesized to represent the "severe" end of the ASD continuum within the repetitive behavior domain (and more likely to co-occur with intellectual disability), whereas fixated interests or compulsions may represent the "higher functioning" end.[32,33] Even though repetitive motor behaviors were more commonly documented among children with intellectual disability than without intellectual disability, these behaviors were relatively frequent in both groups. Although repetitive behaviors are elevated in ASD, these behaviors occur with other developmental delays and are not specific to autism.[32,34,35]

Age of Identification

Public health programs promoting the recognition and early detection of ASDs often highlight "early warning signs" that may be indicative of ASD and could be used to improve screening practices.[36] We found that the number and pattern of documented behavioral features were at least as predictive of the age of ASD identification as previously reported sociodemographic variables[10,24,25] or having an intellectual disability (Supplement 2, available online). The association between age of ASD identification and certain behavioral features documented in evaluation records may be due to their developmental appropriateness and the corresponding age at which these behaviors are most apparent to evaluators. Impairments in pretend play (*DSM* 2d) were more likely to be described in evaluations of children at age 2 versus age 8 years, whereas impairments in peer relations (*DSM* 1b), holding a conversation (*DSM* 2b), and restricted interests (*DSM* 3a) may not be evident to evaluators before a child has reached a certain age or developmental level. These three criteria may have limited applicability for very young children,[37] and the age differences in this study could reflect referral and evaluation practices rather than actual patterns of symptom progression. Training community professionals in the recognition of ASD symptoms in young children—and the availability of sensitive diagnostic tools—could lead to earlier diagnoses at the population level.

Two of the three hypothesized behavioral criteria were associated with earlier ASD identification: impairments in nonverbal communication (*DSM* 1a), and repetitive motor behaviors (*DSM* 3c). Contrary to our hypothesis, impairments in sharing of interests (*DSM* 1c) was not associated with earlier ASD identification. We also did not hypothesize that inflexibility with routines or rituals (*DSM* 3b) and pretend play (*DSM* 2d) would be associated with earlier ASD identification. One potential reason for the incongruency between our predictions and findings is that many previous studies have focused on very young children or toddlers,[13–15] whereas most of the evaluating and diagnosing in the

present study involved children several years older. The Centers for Disease Control and Prevention (CDC) “Learn the Signs: Act Early” milestones classify a lack of interest in make play or lack of variety in types of play activities (comparable to *DSM* 2d and *DSM* 3b), to be developmental “warning signs” for 4- and 5-year-olds.[36] Another possibility is that the *DSM-IV-TR* criteria used by the ADDM Network are less specific (or are measured differently) than the behavioral indicators used in research studies of early detection of ASD.

Despite the variability in the age and likelihood of community ASD identification, all children meeting ADDM criteria for autistic disorder had documented histories of concerns about developmental delay before age 3 years, but only 21%were identified as having ASD by age 3. There exists a considerable gap between research showing stable and reliable ASD diagnoses made by age 2 years[38,39] and the average age at which ASD is identified in community settings. If the primary benefit of an early diagnosis of autism is to facilitate therapies and interventions, it is worth considering whether a clinical ASD diagnosis should be necessary to receive some services.[40] Children exhibiting some developmental delays—but not identified as meeting ASD criteria—could then participate in early interventions without having to wait until their symptoms meet the threshold for an ASD and are confirmed by a diagnostician. On the other hand, limited funding for services makes it challenging even for some children diagnosed with ASD to receive interventions.[3] A population-based estimate of the prevalence of all toddlers presenting at least some (sub-threshold) ASD symptoms at a young age could help to inform therapy decisions for this group.

Timely evaluation and identification of ASD continues to be an important public health goal, and it will be essential to consider how the use of the ASD diagnostic criteria will influence the age at which children are diagnosed with autism or other developmental conditions. Hypothetically, increasing the minimum required number of *DSM-IV-TR* criteria for autistic disorder to eight items (instead of the current six) would decrease the median age of ASD identification, while simultaneously reducing the number of children meeting criteria for ASD. Conversely, increased sensitivity to diagnosing those with fewer or less-obvious symptoms would result in more children being identified for services and interventions, but would also increase the median age at identification. Measuring ASD screening performance in terms of the average age of ASD diagnosis could mask actual improvements in screening through the inclusion of relatively older children who would be missed under more stringent criteria.

The publication (in 2013) of the *DSM-5* will likely change the way that clinicians evaluate children for ASD. Compared with the *DSM-IV-TR*, the proposed *DSM-5* ASD criteria comprise fewer (but perhaps more general) behavioral features, and social and communication impairments will be conceptualized as a single domain.[41] The *DSM-5* criteria will not include spoken language delay as a criterion for ASD, and we observed that a language delay—which was among the most frequent criteria—was not strongly associated with age of ASD identification. Several studies suggest that children with *DSM-IV-TR* autistic disorder are more likely to meet *DSM-5* ASD criteria than children with PDD-NOS.[2,42,43] Because we restricted the timing of identification analysis to autistic

disorder (n = 2,136), this group may be more comparable to children meeting *DSM-5* criteria. Further studies are needed to examine how the new criteria will be used in clinical practice, and how diagnosticians evaluate symptoms among different age groups.

This study has some limitations, as it is based on a retrospective review of evaluations. The descriptions of behavioral criteria are coded as being present or absent from the evaluations; the intensity or reliability of each of these behaviors cannot be confirmed. The children were not all evaluated in the same manner; we cannot differentiate children with more obvious or severe symptoms from children who may be under closer observation (possibly due to an intellectual disability or other developmental problem) or have greater access to services. It is possible that children who were identified as having ASD were perceived as having greater “impairment” than children who were not identified. Likewise, we cannot distinguish whether observed symptoms depend on the disciplinary focus of the evaluator (e.g., speech therapists identify more language delays) or whether the behaviors are reflective of the case mix for different services (e.g., children with language delays are more likely to visit speech therapists). We did not have information about the types or amount of interventions and therapies that children received, or whether they affected a child’s symptoms over time.

Another limitation is that we have incomplete access to all evaluations for some children. Some evaluations described ASD diagnoses from earlier evaluations unavailable to the surveillance system. Thus, descriptions from previous ASD diagnoses were used to determine the earliest age of ASD identification, but behavioral details were limited to the records captured by the surveillance network. Other nondiagnostic behavioral features (e.g., delayed motor milestones or hyperactivity) were coded at the child level and not for each evaluation, limiting our ability to examine these by age. Analyses describing these nondiagnostic features are in progress.

This study also has several important strengths, including its population-based design, use of multiple sources of records, sample size, and inclusion of same-aged children. Another advantage of this study is that its case ascertainment documents descriptions of behaviors satisfying the *DSM* diagnostic criteria for autism, providing additional detail beyond a categorical classification of ASD. Perhaps most importantly, this study provides insight into how ASD diagnostic behaviors are used and documented by professionals when children are assessed in typical community settings.

In this population-based study of children, the number and type of documented behavioral features were strongly associated with the age at which children were identified as having ASD. Behaviors associated with later identification of ASD, such as the ability to hold a conversation or impairments in peer relations, may be less likely to be detected (or documented) at younger ages or less evident during a short office visit than behaviors such as repetitive motor impairments or impairments in nonverbal communication. Given the variety of patterns of impairments that meet the requirements for ASD, a closer consideration of the manner in which individuals fulfill ASD criteria would be useful for future research and to guide strategies for early ASD detection and developmental screening.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Clinical Guidance

- The *DSM-IV-TR* criteria for one of the autism spectrum disorders (ASD) can be met in many ways. For autistic disorder alone, 616 different combinations of diagnostic behaviors meet the minimum requirements for a diagnosis.
- All children meeting criteria for autistic disorder through age 8 years in this study had documentation of developmental concerns before age 36 months, although only 21% had been identified by a community professional as having an ASD by 36 months, and their median age of ASD identification was 63 months.
- The number of diagnostic behaviors documented in medical and educational records was inversely associated with the age at ASD identification. In addition, documented impairments in nonverbal communication, pretend play, inflexible routines, and repetitive motor behaviors were associated with earlier identification.
- Impairments in peer relations, conversational ability, and idiosyncratic speech were associated with later identification. These findings have potential implications for improving early detection of ASD.

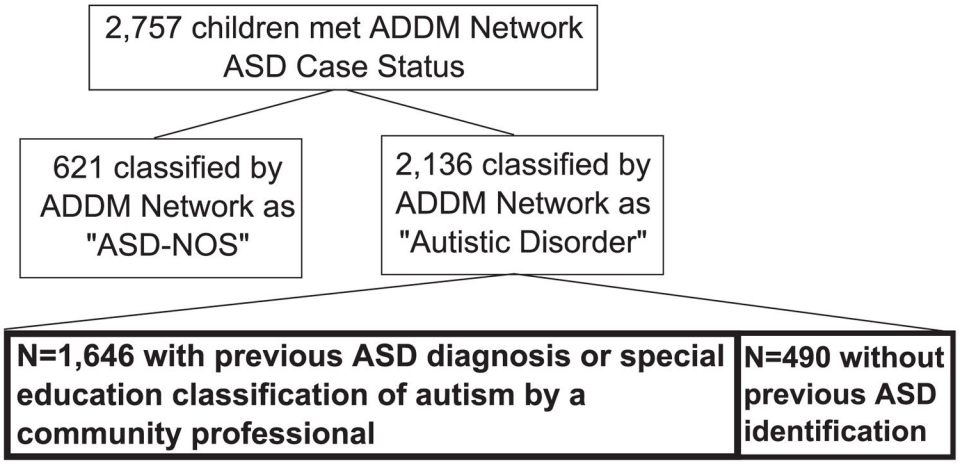

FIGURE 1.

Flow chart showing how the Autism and Developmental Disabilities Monitoring (ADDM) Network autism spectrum disorder (ASD) sample was selected and classified in this study. Note: 2,757 children met the overall ADDM Network ASD case definition, and 2,136 met the ADDM Network Autistic Disorder case status. Of the 2,136 children, 490 had no record of previous ASD identification by a community professional. ASD-NOS = autism spectrum disorder–not otherwise specified.

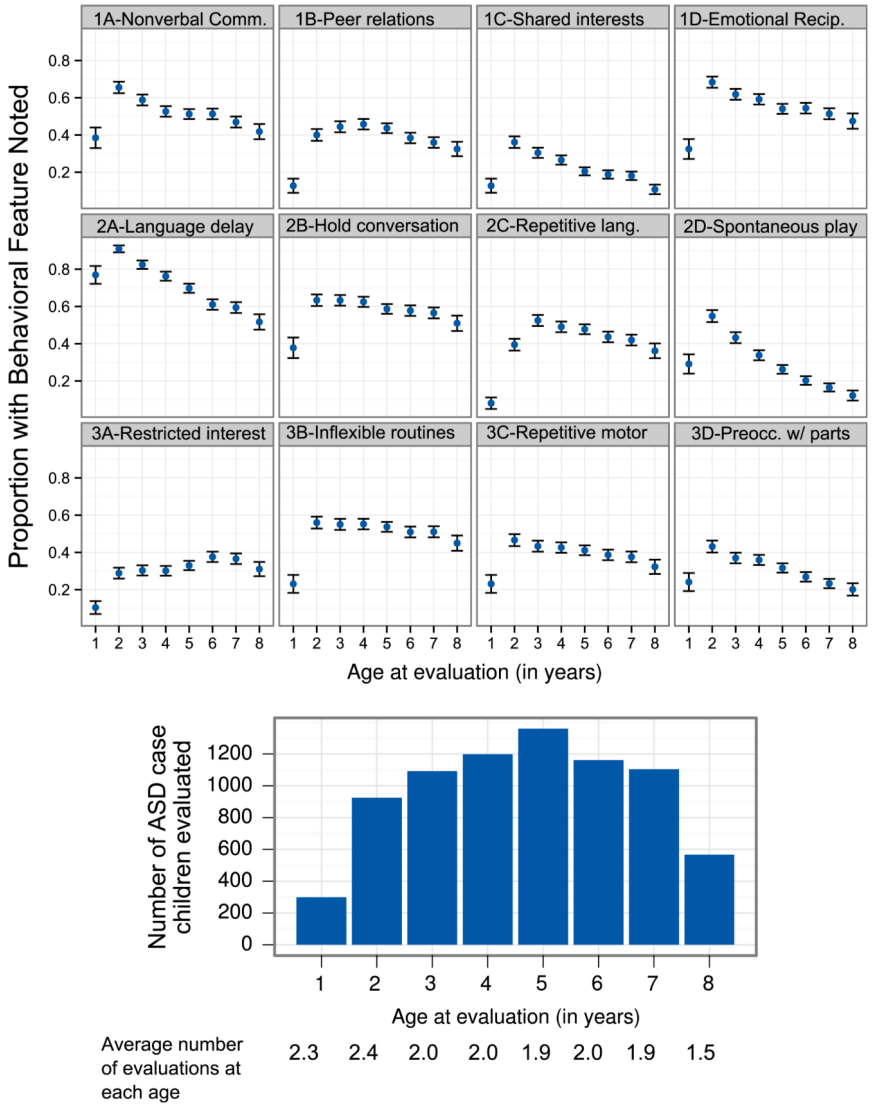

FIGURE 2.

Frequency of documented autism spectrum disorder (ASD) behavioral features by age at evaluation (years), with 95% confidence intervals. Note: Bar chart displays the number of case children (out of 2,757) were evaluated at least once during each year of age.

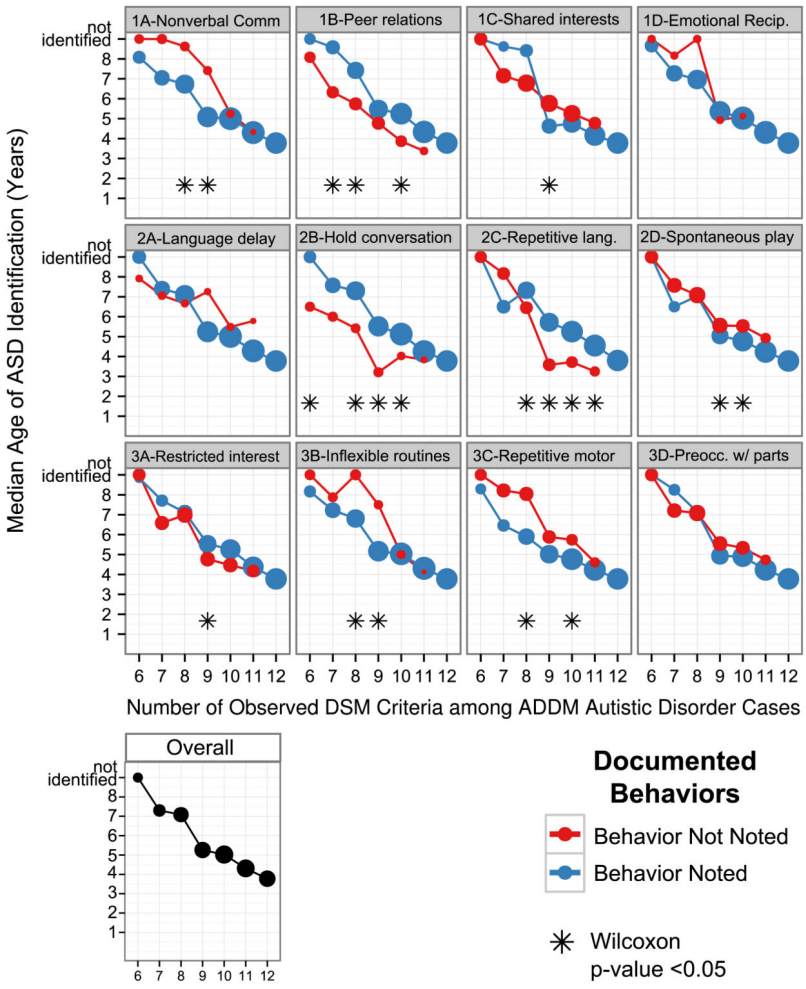

FIGURE 3.

Association between median age of autism spectrum disorder (ASD) identification and documented behavioral criteria by total number of observed behavioral criteria, among 2,136 children meeting Autism and Developmental Disabilities Monitoring (ADDM) Network case status. Note: Asterisks denote Wilcoxon test $p < .05$ in the distribution of age of identification in each stratum (number of criteria). Point sizes are scaled to reflect the number of children within each stratum.

TABLE 1

Frequency of *DSM-IV-TR* Behavioral Criteria for Autism Spectrum Disorder (ASD) Among 2,757 Autism and Developmental Disabilities Monitoring (ADDM) Network ASD Cases Grouped by Sex, Race, Intellectual Disability, History of Regression Status, and Previous ASD Identification

	Demographic Characteristic												
	Total	**Boys**	**Girls**	**White**	**Black**	**Hispanic**	**IQ ≤70**	**IQ >70**	**IQ Unknown**	**Regression Noted**	**No Known Regression**	**Previous ASD Identification**	**No Previous ASD Identification**
No. of cases (% of Total)	2,757 (100)	2,283 (82.8)	474 (17.2)	1,597 (57.9)	579 (21.0)	317 (11.5)	782 (28.4)	1,243 (45.1)	732 (26.6)	603 (21.9)	2,154 (78.1)	2,080 (75.4)	677 (24.6)

ASD Diagnostic Criteria	**%**	**%**	**%**	**Boy: Girl Effect Size**	**%**	**%**	**%**	**Race Effect size (max: min)**	**%**	**%**	**%**	**IQ Effect Size (IQ≤70: IQ>70)**	**%**	**%**	**Regression Effect Size**	**%**	**%**	**ASD Identification Effect Size**
1a (nonverbal communication)	84.8	85.6	80.8	0.13	83.7	87.4	85.2	0.11	89.1	83.7	82.0	0.16	**91.0**	**83.0**	**0.24**	**88.7**	**72.7**	**0.41**
1b (peer relations)	74.0	74.4	71.9	0.06	73.5	71.2	77.9	0.15	78.0	78.5	62.0	−0.01	75.0	73.7	0.03	74.3	73.1	0.03
1c (sharing enjoyment/ interests)	49.1	48.9	50.2	−0.02	46.3	54.1	53.3	0.16	**64.8**	**46.9**	36.1	**0.36**	**64.3**	**44.8**	**0.39**	**52.6**	**38.4**	**0.29**
1d (emotional reciprocity)	90.4	90.0	92.6	−0.09	91.1	90.5	92.1	0.06	93.4	91.7	85.1	0.06	92.7	89.8	0.10	91.1	88.3	0.09
2a (spoken language)	88.9	88.2	92.2	−0.14	**85.3**	**95.0**	**95.6**	**0.36**	**98.2**	**83.8**	87.4	**0.56**	**98.0**	**86.3**	**0.47**	89.4	87.3	0.07
2b (conversation)	85.9	85.5	87.6	−0.06	85.7	86.7	86.8	0.03	90.5	91.0	72.3	−0.02	87.1	85.6	0.04	85.9	86.6	0.02
2c (stereotyped language)	74.1	74.4	73.0	−0.03	73.2	77.5	73.5	0.10	75.1	79.7	63.7	−0.11	76.5	73.5	0.07	**77.1**	**65.0**	**0.27**
2d (spontaneous pretend play)	57.6	57.6	57.8	0.00	55.0	61.0	63.1	0.16	**73.0**	**51.8**	51.0	**0.44**	**75.5**	**52.6**	**0.48**	**62.0**	**44.0**	**0.36**
3a (restricted interests)	62.4	**64.4**	**52.7**	**0.24**	**67.3**	**58.7**	**47.9**	**0.40**	59.5	67.9	56.1	−0.17	63.0	62.2	0.01	**66.3**	**50.2**	**0.33**
3b (inflexible routines/rituals)	84.0	84.9	79.7	0.14	**86.9**	**81.7**	**75.7**	**0.29**	84.7	86.0	79.9	−0.04	87.9	82.9	0.14	**87.4**	**73.7**	**0.35**
3c (stereotyped motor)	69.2	69.2	69.6	−0.01	69.0	72.2	66.6	0.12	**79.4**	**64.0**	67.3	**0.34**	**82.6**	**65.5**	**0.39**	**74.2**	**54.1**	**0.42**
3d (preoccupation with parts)	60.2	60.2	60.1	0.00	**63.1**	**57.7**	**51.1**	**0.24**	**71.0**	**57.9**	52.7	**0.27**	**71.8**	**57.0**	**0.31**	**63.9**	**49.0**	**0.30**

Note: Comparisons with effect size >0.2 are shown in boldface type. Within the IQ categories, only children with known IQ scores were compared because children with unknown IQ (26.6% of children) may not represent a meaningful group.

TABLE 2

Documented Frequency of *DSM-IV-TR* Behavioral Criteria for Autistic Disorder, Pervasive Developmental Disorder–Not Otherwise Specified (PDD-NOS), and Asperger Disorder Among 2,757 Autism and Developmental Disabilities Monitoring (ADDM) Network Autism Spectrum Disorder (ASD) Cases Stratified by Number of Total Items Documented

		No. of Documented ASD Criteria										
ASD Cases	**Total**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
N/n (% of total)	2,757 (100.0)	17 (0.6)	47 (1.7)	83 (3.0)	121 (4.4)	225 (8.2)	273 (9.9)	367 (13.3)	396 (14.4)	452 (16.4)	425 (15.4)	351 (12.7)
ASD Diagnostic Criteria												
% Documented With Each Diagnostic Criterion												
1a (nonverbal communication)	84.8	47.1	34.0	54.2	52.1	62.2	75.8	81.2	91.4	94.5	98.8	100.0
1b (peer relations)	74.0	5.9	34.0	31.3	48.8	48.9	58.6	66.8	73.2	84.3	94.4	100.0
1c (sharing enjoyment/interests)	49.1	11.8	6.4	6.0	14.0	19.6	26.4	31.3	41.4	54.4	78.8	100.0
1d (emotional reciprocity)	90.4	35.3	51.1	59.0	70.2	75.1	86.1	90.2	94.7	98.0	100.0	100.0
2a (spoken language)	88.9	64.7	42.6	67.5	71.1	77.8	82.1	87.7	92.2	94.2	97.4	100.0
2b (hold a conversation)	85.9	11.8	36.2	49.4	53.7	71.6	81.0	86.6	88.6	94.7	97.2	100.0
2c (stereotyped language)	74.1	0.0	10.6	22.9	38.8	52.0	61.2	74.7	76.5	84.5	89.2	100.0
2d (spontaneous play)	57.6	0.0	2.1	8.4	15.7	20.4	34.4	37.9	55.8	74.3	88.0	100.0
3a (restricted interests)	62.4	0.0	19.1	22.9	27.3	34.7	41.4	53.7	64.9	71.7	79.8	100.0
3b (inflexible routines/rituals)	84.0	17.6	36.2	37.3	51.2	63.6	74.7	83.4	90.7	92.5	99.3	100.0
3c (stereotyped motor)	69.2	0.0	6.4	26.5	31.4	46.7	44.3	62.9	70.2	84.1	89.4	100.0
3d (preoccupation with parts)	60.2	5.9	21.3	14.5	25.6	27.6	34.1	43.6	60.4	72.8	87.8	100.0