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Use of a Teacher Nomination Strategy to Screen for Autism Spectrum Disorders in General Education Classrooms: A Pilot Study

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Abstract

Given a rising prevalence of autism spectrum disorders (ASD), this project aimed to develop and pilot test various teacher nomination strategies to identify children at risk for ASD in a timely, reliable, cost-effective manner. Sixty participating elementary school teachers evaluated 1323 children in total. Each teacher nominated students who most fit a description of ASD-associated characteristics, and completed the Autism Syndrome Screening Questionnaire (ASSQ) on every child in the classroom. The proportion of overall agreement between teacher nomination and ASSQ was 93–95%, depending upon the nomination parameters. Nomination required 15 min per class versus 3.5–5.5 h per class for the ASSQ. These results support the need for further study of teacher nomination strategies to identify children at risk for ASD.

Keywords

Autism; Screening; Schools; Nomination

Introduction

The Diagnostic and Statistical Manual of Mental Disorders (APA, 1994) defines three neurodevelopmental disorders that are first evident in childhood and share a pattern of qualitative impairments in social interaction, communicative functioning, and behavioral flexibility. These conditions (Autistic Disorder, Pervasive Developmental Disorder-Not Otherwise Specified, and Asperger syndrome) are commonly referred to as Autism Spectrum Disorders (ASD), due to overlapping symptomology, similarities in developmental course, and common prognostic indicators and associated outcomes (Wing, 1980).

As has been covered extensively in both the popular and scientific press, it is possible that the prevalence of autism is increasing (Chakrabarti & Fombonne, 2005; Yeargin-Allsopp et al., 2003). Fombonne's (2005) review of epidemiological studies suggests that ~4 per 1,000 children have an ASD. Gillberg, Cederlund, Lamberg, and Zeitlun (2006) screened the entire population of Goteborg Sweden in 2001 and reported 20.5 children per 10,000 with Autistic Disorder and 32.0 children per 10,000 with other ASDs (i.e., PDD-NOS, AS). Relying on the Danish Psychiatric Central Registry, Lauritsen, Pedersen, and Mortensen (2004) reported 31.4 children per 10,000 with an ASD. The apparent increase in prevalence from previous estimates of 4–5 per 10,000 could be due to the inclusion of broader diagnostic criteria, better methods for diagnosis, or an increased awareness of the disorder (Fombonne, 2003; Yeargin-Allsopp et al., 2003). Conversely, the apparent increase could be a real phenomenon, suggesting an increase in some unidentified environmental teratogen or biological vulnerability associated with the disorder (Blaxill, 2004).

Given the rise in prevalence, developing effective screening procedures for ASD has become an important research priority within the past decade (Baird et al., 2001; Bristol et al., 1996; Filipek et al., 2000; Howlin, 2000; Rogers, 1999). The delay in diagnosis is due, in part, to a lack of expertise, competence, and resources to utilize available measures (Stone et al., 1999). In addition, children with high-functioning conditions (i.e., intellectual functioning within the average range) are more likely to be missed by current school-based assessment procedures, due to the complexity of the clinical picture and a lack of differential diagnostic expertise in community settings (Howlin, 2000; Klin, Volkmar, Sparrow, Cichetti, & Rourke, 1995).

Several screening tools that rely upon teacher report of child behavior, are now available for identifying school-aged children and adolescents with high-functioning ASDs (Campbell, 2005; Howlin, 2000). The Autism Spectrum Screening Questionnaire (ASSQ; Ehlers, Gillberg, & Wing, 1999) has been utilized in at least three prevalence studies to date. Webb et al. (2003) asked teachers of primary grades in Cardiff, Wales to complete the ASSQ on their students and reported a minimum prevalence of 20.2 children per 10,000 with an ASD, which is consistent with the Gillberg et al (2006) study, that relied upon registry data. Posserud, Lundervold, and Gillberg (2006) used the ASSQ to screen 7–9-year-old children in a population-based study in Sweden and reported that rates of autism symptoms were continuously distributed, with low-to-moderate agreement between parent and teacher report. “High-scorers”—Or those presenting with clinically significant symptoms,

comprised 5.6% of the study sample ($n = 9,430$), suggesting a prevalence rate of ~52 children per 1,000 with an ASD. Follow-up studies on high-scoring children are underway in an effort to examine the validity of the screening procedures, as compared to comprehensive clinical evaluations. Similarly, Kadesjo, Gillberg, and Hagberg (1999) used the ASSQ to screen 826 7-year-old children in central Sweden and reported a prevalence rate of 60 children per 10,000 with an ASD using a cutoff of 17 or greater. Given that effective screening tools “cast a wider net” than will be confirmed by comprehensive evaluations, the results of these studies suggest that teacher report on the ASSQ may provide a sensitive measure of problems in socialization and adaptive behavior.

Unfortunately, it is difficult for schools to have the resources to screen all children in general education classrooms for an ASD using measures such as the ASSQ, as the time required to use these instruments is typically a significant barrier to their use. Strategies that streamline the screening process increase the likelihood that school systems will be able to proactively identify children with ASD in general education classrooms. However if valid screening procedures can be developed that allow teachers to identify 1–2 children in each classroom who fit an overall social-behavioral profile consistent with ASD, it would be possible to reduce the number of children who require more detailed screening and evaluation, thus substantially reducing the time required for screening and increasing the efficiency of the process.

Several researchers have examined the feasibility and reliability of teacher nomination strategies with regard to social and behavioral competence in public education settings. Teacher report is thought to be highly ecologically valid (i.e., relevant to real-world functioning), and may be of particular relevance when examining social-communicative competence (Ehlers et al., 1999). Yugar and Shapiro (2001) studied teacher knowledge of social networks within their classrooms and found that teachers and peers were highly reliable in identifying friendships and noting peer rejection. Teachers were described as “highly accurate” in identifying children in their classrooms with academic and/or behavioral concerns, as compared to school district assessment data (Lane & Menzies, 2005). Teacher nomination of socially withdrawn children in the fourth grade was a significant predictor of social adjustment problems 5 years later, suggesting that teachers can provide accurate reports of poor social competence in the elementary school years (Ollendick, Greene, Weist, & Oswald, 1990). La Greca (1981) suggests that teacher report ascertains social competence more quickly than peer report, and is thus more practical for use in large settings.

Agreement between teachers and other respondents (such as child peers and parents), usually is estimated to be fairly good across a variety of behaviors, including bullying behavior and experience of victimization (Coie & Dodge, 1988; Huesmann, Eron, Guerra, & Crawshaw, 1994; Perry, Williard, & Perry, 1990), adolescent aggression (Henry, Miller-Johnson, Simon, Schoeny, & The Multi-site Violence Prevention Project, 2006), and other psychiatric conditions, both internalizing and externalizing (Achenbach, McConaughy, & Howell, 1987; Leff, Kupersmidt, Patterson, & Power, 1999). Reports of children in the elementary school years tend to be more similar to teacher report than the reports of children in middle or high school are with their teachers (Achenbach et al., 1987). This could be due

to more interaction in the early school years and fewer social contexts within which to assess a child's social competence (Leff et al., 1999).

The main goal of this project was to test a classroom-based teacher nomination strategy to screen for ASDs in general education settings. The teacher is presented with a brief, bullet-pointed list of child characteristics, chosen to convey a gestalt impression of a child with social and communicative difficulties, and asked to nominate two children in the class who best fit the profile. The validity of using nominations to identify children at risk for ASD was evaluated by comparing the results of the nomination strategy to ASSQ scores obtained on all children in the classroom. Sensitivity and specificity of the teacher nominations were determined with respect to ASSQ scores. Parameters of the nomination process were systematically evaluated. If effective in identifying children at high risk for ASD who require further testing, a nomination strategy could conserve resources (e.g., time, expertise, and money) and be used both for future epidemiological inquiries and for identification of school children requiring further assessment or services.

Methods

Participants

Participants in this study were 60 teachers in elementary schools within a large school district (Cherry Creek) in metropolitan Denver, Colorado. After review and approval of the study protocol by school district administrators, all 35 elementary schools in the district received a detailed information packet. The principals of seven schools agreed to take part in the study (see Fig. 1). Teachers at participating schools were recruited through flyers and a meeting presentation. Teachers were offered financial compensation for the time required to complete the measures related to this study.

Within each of the seven participating schools, an average of nine (range 5–14) general education teachers chose to participate. Characteristics of enrolled teachers are shown in Table 1. All 60 teachers had at least a Bachelor's degree; almost half (47.5%) of these were in education or elementary education. Forty-eight percent of teachers, compared to 62% district-wide, also had Master's degrees, of which 37.9% were in literacy and/or reading and 17.2% were in curriculum development. Three teachers (5%) had a Bachelor's or Master's degree in special education.

Measures

Two measures were used in this study: (1) a previously validated screening tool for high-functioning ASD—ASSQ (Ehlers et al., 1999); and (2) a measure developed by the authors designed to obtain teacher nominations of at-risk children—"Teacher Nomination Form."

Autism Spectrum Screening Questionnaire (ASSQ; Ehlers et al., 1999)—The ASSQ is a 27-item checklist completed by the teacher on each child in his/her classroom. The ASSQ uses an ordinal scale, with each item rated from 0 to 2 based on whether the child stands out as different from other children his/her age on that item, with 0 being "No," 1 being "Somewhat," and 2 being "Yes." A total score, ranging from 0 to 54, is calculated. The ASSQ has been used to screen children for ASDs within school settings (Campbell,

2005; Posserud, Lundervold, & Gillberg, 2006). The tool requires ~10–15 min to complete per student. Teachers enrolled in this study completed the ASSQ on every child in the class. The checklist was identified for the teachers as the School Screening Questionnaire (SSQ) to avoid biasing the answers. The child's gender was also reported on the ASSQ.

A total ASSQ score of 17 or above was used to define a possible ASD. This cut-off was based on a previous population-based study in the typical school population, in which all children identified with Asperger syndrome had ASSQ scores of 17 or higher (Kadesjo et al., 1999). For this study, the group of interest was those children who had not been identified as having an ASD and were being served within the general education classroom. Children who have not been identified by the elementary school years are likely to be less severely affected than other children on the spectrum and are at specific risk for Asperger syndrome (Howlin, 1998); therefore, it seemed reasonable to choose the cutoff score of 17. Given that the screening tool does not include any information with regard to early history (which is essential in differentiating high-functioning autism from Asperger syndrome), it is not known whether children who score above 17 would be best described as having Asperger syndrome, in particular, or another form of high-functioning pervasive developmental disorder. The goal of this project, therefore, is to identify those children at risk for having an ASD of any kind.

When one or more items were missing on the ASSQ, a total score could not be calculated. In these cases, we added together the scored items, then calculated the maximum score possible if all missing items were assigned a score of two, and the minimum possible score if all missing items were assigned a score of zero. When the maximum possible score was <17, we assigned the child to the group of children with ASSQ scores <17. Similarly, if the minimum possible score was 17 or higher, we assigned the child to the group of children with ASSQ scores ≥ 17. If neither condition was met, the score was excluded from analysis.

Teacher Nomination Form—A draft “Teacher Nomination Form” was developed by the authors and piloted with 28 teachers in five school districts in the Rocky Mountain region prior to initiation of this study. The draft “Teacher Nomination Form” contained a list of child characteristics associated with ASD, which were culled from a larger list obtained through brainstorming with clinicians and educators who had extensive experience working with students with autism and Asperger syndrome. Piloting involved giving general education teachers the nomination form and asking them to complete it with regard to the children in their current classroom. Teachers were then asked several questions about the readability of the description, clarity of the questions, and the process they underwent when trying to identify nominated children. After revisions in wording and format, the revised draft of the form was piloted within four classrooms that included children who had been identified in a local clinic with an ASD. In this final piloting stage, all four previously identified children were nominated using the “Teacher Nomination Form.” With minor changes in wording and formatting, the form was then finalized for study use by the research team.

Enrolled teachers were provided with the one-page “Teacher Nomination Form” and asked if any children in their class fit the description, and if so, how many children. Descriptors

included the following items: “Socially awkward”; “doesn't seem to understand the feelings of others”; “talks a lot about own interests, but not very good at conversations”; “doesn't really chat to be friendly”; “not very flexible—Tends to insist on certain rules and routines”; and “is intensely interested in just a few topics or activities.” They were then asked to nominate two children in their classroom who best fit the descriptors on the Nomination Form, ranked in order of who fit the description best. The form requested that exactly two children be nominated, regardless of how many children in the class fit the description, and even if they did not feel that any child fit the description well. This instruction enabled us to model different definitions of a “positive” nomination (see *Outcome Definitions* below). For each nominated child, the teacher was asked to choose which one of the six nomination descriptors was most relevant for the child identified. In a few cases where the teacher listed more than one descriptor ($n = 14$ children), one descriptor was randomly selected for analysis in order to make the assessment comparable to that of other children whose teachers had followed the instructions to choose one. Teachers were also asked to indicate if each nominated child had an existing Individual Education Plan and if there were other characteristics relevant to the child that were not included in the description. The nomination form was estimated to require ~5–10 min per classroom.

Additional information was collected concerning teacher and classroom characteristics through teacher self-report.

Procedure

Participating teachers attended two meetings in their school. During the first meeting, they were asked to transfer their class rosters to a form containing a randomly ordered list of unique identification numbers. Only the unique identification numbers were used on the test measures, thereby enabling results of the nomination and questionnaire processes to be linked, while protecting the confidentiality of the children in the classrooms. A member of the school staff at the district managed the confidential coded class roster, so that the research team was blind to student identity.

In order to examine whether the order in which the instruments were completed influenced the results, teachers were randomly assigned to two groups based on order of instrument completed: Group A = Teacher Nomination Form, then ASSQ; Group B = ASSQ, then Teacher Nomination Form. Group A teachers stayed at the meeting to complete the Teacher Nomination Form and were given instructions for the ASSQ to be completed for each child in their class, and to wait at least 2–3 days after the meeting before completing the ASSQ. Group B was given instructions for the ASSQ to be completed over the next week and released.

Both groups were asked to return the completed ASSQs the following week at the second meeting. Group A teachers were released after turning in their study materials and receiving compensation. Group B teachers stayed to complete the Teacher Nomination Form, turned in all study materials, received compensation, and then were released.

Outcome Definitions

Using the set of instructions described above on how to complete the nomination forms, we were able to examine four different definitions of a positive teacher nomination to predict an ASSQ score of 17 or higher, by analyzing varying groups of children as “positive” according to these definitions. “*Any Child Nominated, Forced Choice*” was defined to include every nominated child. Using the nomination form question of whether any child fit the description, and if so, how many, we defined “*Any Child Nominated, Unforced Choice*” to include any nominated child unless the teacher had indicated that the child did not fit the descriptors used to guide nomination. That is, if the teacher said no child fit the descriptors, we excluded both nominations, and we excluded the second child nominated if the teacher said only one child fit. “*First Child Nominated, Forced Choice*” included any child who was nominated first (i.e., the one who best fits the description), regardless of how many children, if any, the teacher indicated fit the description. Lastly, the sample for “*First Child Nominated, Unforced*” included any child who was nominated first when the teacher indicated that at least one child fit the description.

Data Analysis—For each nomination strategy, we calculated the sensitivity (ability of the strategy to detect children with ASSQ ≥ 17), specificity (ability of the strategy to identify correctly children with ASSQ <17), predictive value of being nominated (proportion of nominated children who have an ASSQ score ≥ 17), and predictive value of not being nominated (proportion of children not nominated who have an ASSQ score <17). For each strategy, we calculated the likelihood ratio for a positive result [sensitivity/(1-specificity)]; the greater the ratio, the more likely that the nomination strategy will correctly identify children with high-ASSQ scores compared to children with low scores. We also calculated the likelihood ratio for a negative result [(1-sensitivity)/ specificity]; the smaller the ratio, the less likely that the nomination strategy will miss children with high scores compared to children with low scores. To examine agreement between nomination and high-ASSQ scores, we calculated raw agreement indices (observed proportions of overall agreement, agreement on positive ratings, and agreement on negative ratings) and kappa statistics (Spitzer & Fleiss, 1974). We plotted Receiver Operating Characteristic (ROC) curves and calculated the area under the ROC curve (AUC) with 95% confidence intervals for each strategy. AUC estimates were computed non-parametrically. The AUC represents the probability that the nomination strategy result for a randomly chosen ASSQ-positive case will exceed the result for a randomly chosen ASSQ-negative case. If $p < 0.05$, then nomination is better than guessing for identification of high-ASSQ scores.

We analyzed the association of each nomination strategy with the ASSQ cut-off of 17 or higher using logistic-binomial analysis models for distinguishable data (Egret Version 1.02.10, Cytel Software Corporation, Cambridge, MA, 1997), matching on teacher and controlling for school. We assessed the effect of possible confounding factors including child sex, grade, number of children in the classroom, teacher sex, years of teaching experience, and any special education training or experience. Crude and adjusted odds ratios and 95% confidence intervals are presented.

Results

ASSQ Results

A total of 1,355 children were included in the study. Their characteristics are shown in Table 1. The mean ASSQ score for the 1,323 children who were scored was 4.31 (95% CI 3.94–4.68); the median was 2.0. As expected, the ASSQ scores were not normally distributed, with 36% of children scoring 0, and 66% of children scoring three or less. Mean scores for each class varied widely among enrolled teachers, from 0.1 to 12.9 (Table 1).

Of 32 children for whom total scores could not be calculated due to failure of the teacher to score one or more items on the ASSQ, 31 children had only one missing item. All could be assigned to the group with minimum scores at or above 17 or the group with maximum scores below 17. No ASSQ was completed for one child.

Ninety-five children (7%) scored at least 17 on the ASSQ, of whom 65 (68%) were boys. The percentage of children who received ASSQ scores ≥ 17 differed significantly by gender, with 5% of girls and 9.2% of boys receiving high scores (OR = 2.00; 95% CI 1.26–3.16; $p = 0.012$). The percentage of children with ASSQ scores ≥ 17 also differed significantly by teacher, ranging from 0.0 to 33.3% ($p < 0.0001$). Nineteen teachers (31.7%) gave ASSQ scores < 17 to all children in the class. The percentage of children with ASSQ scores ≥ 17 varied by school, ranging from 4.0 to 13.3%. Once clustering of scores by teacher was taken into account, there was no association between high-ASSQ score and school, teacher sex, grade taught, number of students in the class, years of teaching experience, or special education training, and experience. There was also no significant association between high-ASSQ scores and teacher group status (i.e., allocation to perform the “Teacher Nomination Form” first or complete the ASSQ tests first) (OR = 0.73; 95% CI 0.41–1.32; $p = 0.305$).

Teacher Nomination Form

Of the 60 teachers, 57 (95%) stated that the Nomination description fit at least one child in the class. The number of students reported to fit the description ranged from 0 to 6, with a mean of 2.5 (SD 1.4) children per class. Teachers nominated a total of 116 children (8.6% of included children); four teachers nominated only one child even though two nominations were requested. There was a significant association between child gender and nomination status; 70% of the 110 nominees whose sex was known; were boys ($p < 0.001$). Because every teacher was asked to nominate two children, associations between nomination status and school, teacher, and teacher characteristics could not be tested.

Among children who were nominated first (i.e., “most fits the description”), the nomination characteristic considered by the teacher to be most relevant for the child identified was A (“socially awkward”) (45%). Other characteristics commonly identified as the most relevant for the nominated child included B (“Doesn't seem to understand the feelings of others”) (16.7%), and E (“Not very flexible”) (15%). Results were similar among children who were nominated second; the most relevant items were A (48%), followed by B (20%), and E (15%). The items chosen least for all nominated children were C (“not very good at conversations”) and F (“intensely interested in just a few topics or activities”) (6% each).

Among 116 nominated children, 31 (27%) had a current Individualized Educational Plan (IEP). In addition, four had an IEP in progress and two had previously had an IEP, for a total of 37 children, or 32% of those nominated. The educational eligibility specified among current IEP's was autism or pervasive developmental disorder in three cases, and speech-language disorder or emotional-behavioral disorders (including ADHD) in 12 cases. The remaining IEPs listed certifications such as "Other Health Impaired" or "Perceptual/Cognitive."

Teachers were asked if there were any areas of difficulty not included in the nomination strategy that she or he had noticed for the nominated children. Other areas of difficulty named included problems socializing with peers (24.3% of nominated children), and problems with attention or focus (10.3%), anger control (8.6%), and academics (6.0%).

Nomination Status in Relation to ASSQ Scores

The proportion of overall agreement between the two measures ranged from 93 to 95% for the four nomination strategies, with the proportions of specific agreement for positive ratings being substantially lower than for negative ratings (Table 2). The kappa scores between ASSQ scores ≥ 17 and the four nomination strategies ranged from 0.4 to 0.6. Based on ROC curves, all four strategies correctly identified ASSQ-positive children better than would be expected by chance ($p < 0.001$). The areas under the ROC curves were greatest for "Any Child Nom Unforced" and "Any Child Nom Forced, but the 95% confidence intervals for all four AUC estimates overlapped (Table 2).

Nomination strategies were most sensitive when teachers were asked to nominate two children (Any Nom Forced and Any Nom Unforced) (Table 2). Compared to forced choice, the unforced choice definition (Any Nom Unforced) appeared to have higher specificity, positive predictive value, and likelihood ratio of a positive test, and was more strongly associated with a high-ASSQ score as indicated by the odds ratio. Any Nom Unforced identified about three in five children with scores of 17 or higher. However, 45% of children nominated using this strategy scored <17 on the ASSQ.

Nomination definitions that included only one nominated child in each class (First Nom Forced and First Nom Unforced) were less sensitive but more specific. Compared to forced choice, the unforced choice strategy (First Nom Unforced) again had better specificity, positive predictive values, and likelihood ratio of a positive test, and was more strongly associated with a high-ASSQ score as indicated by the odds ratio. This nomination strategy identified only two of five children with scores of 17 or higher (i.e., it missed one in five children who would have been identified with Any Nom Unforced); however, only 30% of children nominated had ASSQ scores <17 .

Whether teachers were asked to nominate two children or only one, forcing the teacher to nominate children, even when she or he did not believe that a child fit the description, did not increase sensitivity, but did reduce both specificity and predictive value.

Post Hoc Subgroup Analyses

Despite the increase in the prevalence of ASD, we expected that most teachers would indicate that no children in their class met the description. To improve sensitivity, we therefore asked all teachers to nominate two children. However, 38% of teachers indicated that there were more than two children in the class who fit the description. Among the children in the latter classes, 12.6% scored 17 or higher, compared to only 3.7% of children among classes where the teacher indicated that two or fewer children fit the description. There was a significant association between proportion of children with high-ASSQ scores and how many children the teacher indicated fit the nomination description (OR = 1.63; 95% CI 1.38–1.923; $p < 0.001$).

Because we did not offer the option of nominating more than two children, our ability to assess the true sensitivity of the nomination description for identifying any children with ASSQ scores of 17 or higher was artificially limited. Therefore, to further examine this issue, we restricted the data set to those teachers who indicated that no more than two children in their class fit the nomination description. Within this subgroup, “Any Nom Unforced” had higher sensitivity and higher negative predictive value than it did in the total population of teachers (74% vs. 61%, and 99% vs. 97%, respectively). The same was true for First Nomination, Unforced (First Nom Unforced) (58% vs. 42%, and 98% vs. 96%, respectively). Conversely, the predictive value of a positive result was lower in this subset (39% vs. 55% for Any Nom Unforced and 53% vs. 70% for First Nom Unforced).

Discussion

The results of this study support the use and further study of a classroom level, teacher nomination strategy to identify children at risk for ASDs. This method saved considerable time and effort and could provide a reliable, cost-effective way of screening for high-functioning ASDs in general education classrooms. As with any screening tool, this method is likely to be overly inclusive and follow-up classroom observations, as well as teacher and parent interviews are recommended for children who are nominated as presenting with social and communicative characteristics associated with ASD. Thus, the nomination strategy may be most helpful for streamlining the screening process, enabling school psychologists, and special education teams to focus upon at risk children in a timely manner.

Our results suggest that the specific screening nomination strategy utilized affects the results generated by the nomination form. The optimal screening strategy would vary, depending upon whether the purpose of the screening is to find every child with ASD (i.e., increase sensitivity) or avoiding referral of children unlikely to have ASD (i.e., increase specificity).

Of the nomination strategies we tested by varying the definition of a positive nomination, the most sensitive strategy would be: Do any children in your class fit the above description? If YES, who (nominate up to two)? Teachers could nominate none, one, or two children. All nominated children would be considered screen positive and referred for further testing. This strategy would identify the majority of children with high-ASSQ scores. However, it is likely that half or more of children nominated would not have ASSQ scores of 17 or higher, and would most likely not have an ASD. Our subgroup analysis suggests that sensitivity

could be further improved by revising the strategy to read: Do any children in your class fit the above description? If YES, who (nominate all)? With this strategy, teachers could nominate none, one, or more children. However, a strategy with no upper limit on the number of students nominated requires study since we did not test it directly.

The most specific strategy, in which the greatest proportion of those nominated would actually have ASSQ scores of 17 or higher, would be: Do any children in your class fit the above description? If YES, who best fits it (nominate one)? Teachers could nominate one child or none, and all nominated children would be considered screen positive and referred for further testing. The majority of children referred would have high-ASSQ scores, but this strategy would miss a substantial proportion of the children with high scores.

Further research into the implications of using specific nomination strategies is warranted. As noted above, examining a strategy with no upper limit is warranted. It would also be informative to test the results of combining both teacher nomination and individual screening in identifying children at risk for ASD. Teachers could, for example, be asked to nominate children using the “Teacher Nomination Form,” and then complete the ASSQ only on those nominated. This method might provide a time-efficient, cost-effective, and reliable method of screening in schools. The combined method should be tested relative to using the ASSQ alone and using the nomination alone.

Before the teacher nomination method is put to the use, a critical next step is to validate it by conducting clinical evaluations using state-of-the-art assessment tools (e.g., ADOS and ADI) to determine whether the nominated children actually have an ASD. The following additional research questions could be addressed: (a) Does being nominated first or second affect likelihood that a child has ASD?; (b) How does nomination perform in predicting ASD as compared to the predictive performance of the ASSQ?

Given the increased prevalence of ASDs, identification of at-risk children is an important educational and clinical issue. For researchers attempting to estimate prevalence of high-functioning ASD, nomination strategies may reduce some of the burden of time and costs associated with school-wide screening.

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Fig. 1.
Flow of schools through recruitment process

Table 1

Characteristics of teachers enrolled in the study and of their students

Characteristics	<i>n</i> (%)	Mean	SD	Range
Teacher				
Total teachers enrolled	60			
Grade taught		2.7	1.6	K-5
#x00A0;#x00A0;#x00A0;#x00A0;K	9(15)			
#x00A0;#x00A0;#x00A0;#x00A0;1	5 (8.3)			
#x00A0;#x00A0;#x00A0;#x00A0;2	10 (16.7)			
#x00A0;#x00A0;#x00A0;#x00A0;3	10 (16.7)			
#x00A0;#x00A0;#x00A0;#x00A0;4	21 (35)			
#x00A0;#x00A0;#x00A0;#x00A0;5	5 (8.3)			
Sex of Teacher				
#x00A0;#x00A0;#x00A0;#x00A0;Female	56 (93.3)			
#x00A0;#x00A0;#x00A0;#x00A0;Male	4 (6.7)			
Years of experience		10.2 ^a	7.3	1-30
#x00A0;#x00A0;#x00A0;#x00A0;BA/BS	31 (51.7)			
#x00A0;#x00A0;#x00A0;#x00A0;MA/MS	29 (48.3)			
#x00A0;#x00A0;#x00A0;#x00A0;PhD	0			
Training/experience in social, behavioral or communication disorders	6(10)			
Other Qualifications (principal's license, administrator's license)	2 (3.3)			
Number of children in class		22.6	2.7	16-28
Class mean ASSQ score		4.3	6.5	0.1-12.9
Student				
Total students enrolled in classes	1,355			
Grade in school		2.9	1.5	K-5
#x00A0;#x00A0;#x00A0;#x00A0;K	175 (12.9)			
#x00A0;#x00A0;#x00A0;#x00A0;1	108 (7.9)			
#x00A0;#x00A0;#x00A0;#x00A0;2	218 (16.2)			
#x00A0;#x00A0;#x00A0;#x00A0;3	226 (16.7)			
#x00A0;#x00A0;#x00A0;#x00A0;4	491 (36.2)			
#x00A0;#x00A0;#x00A0;#x00A0;5	137 (10.1)			
Sex of child^b				
#x00A0;#x00A0;#x00A0;#x00A0;Male	644 (47.5)			
#x00A0;#x00A0;#x00A0;#x00A0;Female	644 (47.5)			
ASSQ score ^c		4.3	6.8	0-47
ASSQ score #x2265;17 ^d	95 (7)			

^a Compared with the district-wide average of 13 years^b Excludes 32 children who were not scored on at least one item on the ASSQ^c Data on child sex were not provided by three teachers (*n* = 67 children)

^dExcludes one unscored child

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Table 2

Test characteristics of each nomination strategy compared to an ASSQ cut-point of 17 or higher

	All Subjects			
	Any nom forced	Any nom unforced	First nom forced	First nom unforced
Number (%) of children nominated	116/1,355 (8.6%)	105/1,355 (7.7%)	60/1,355 (4.4%)	57/1,355 (4.2%)
Overall agreement	93%	94%	95%	95%
Specific agreement for positives	55%	58%	52%	53%
Specific agreement for negatives	96%	97%	97%	97%
Kappa	0.51	0.55	0.49	0.50
Sensitivity	61%	61%	42%	42%
Specificity	95%	96%	98%	99%
Positive predictive value	50%	55%	67%	70%
Negative predictive value	97%	97%	96%	96%
Likelihood ratio, positive test	13.24	16.34	26.48	31.16
Likelihood ratio, negative test	0.41	0.40	0.59	0.59
AUC (95% CI)	0.782 (0.722, 0.843)	0.787 (0.726, 0.847)	0.703 (0.636, 0.769)	0.704 (0.637, 0.771)
Crude odds ratio (95% CI) ^a	68.1 (34.2, 135.5)	85.3 (41.8, 174.1)	129.0 (50.9, 327.0)	148.3 (57.0, 385.6)
Adjusted odds ratio (95% CI) ^b	64.03 (32.29, 127.0)	81.1 (40.0, 164.1)	111.1 (45.18, 273.2)	128.0 (50.9, 321.7)

^a Adjusted for teacher^b Adjusted for teacher, school, grade, and a school by grade interaction term