Diagnostic Utility of the ADI-R and DSM-5 in the Assessment of Latino Children and Adolescents

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Abstract Latino children in the US are systematically underdiagnosed with Autism Spectrum Disorder (ASD); therefore, it is important that recent changes to the diagnostic process do not exacerbate this pattern of under-identification. Previous research has found that the Autism Diagnostic Interview-Revised (ADI-R) algorithm, based on the Diagnostic and Statistical Manual of Mental Disorder, Fourth Edition, Text Revision (DSM-IV-TR), has limitations with Latino children of Spanish speaking parents. We evaluated whether an ADI-R algorithm based on the new DSM-5 classification for ASD would be more sensitive in identifying Latino children of Spanish speaking parents who have a clinical diagnosis of ASD. Findings suggest that the DSM-5 algorithm shows better sensitivity than the DSM-IV-TR algorithm for Latino children.

Keywords DSM-5 · ADI-R · Latino · ASD Diagnosis

Introduction

In 2013, the American Psychiatric Association published an update to the Diagnostic and Statistical Manual of Mental Disorders (DSM, American Psychiatric Association 2013), with significant changes established for neurodevelopmental disorders. The previous classifications under Pervasive Developmental Disorder (Autistic Disorder, Asperger’s Syndrome, and Pervasive Developmental Disorder—Not Otherwise Specified) were reorganized into one overarching diagnostic category, Autism Spectrum Disorder (ASD). This reclassification was met with much concern from parents, self-advocates, and professionals as the potential ramifications of these changes were unclear. Of great concern was that individuals would no longer meet diagnostic criteria and potentially lose services or benefits (e.g., insurance, disability) due to these changes (Halfon and Kuo 2013). Yet others have suggested that the DSM-5 will better address the inconsistencies and limitations of the DSM-IV-TR in identifying certain populations of individuals with ASD (e.g., toddlers, women, racial/ethnic minorities; Dworzynski et al. 2012; Falkmer et al. 2013; Magaña and; Smith 2013). As the stability in diagnostic criteria has stimulated research in ASD, understanding how the DSM-5 ASD conceptualization fits within clinical assessment practices and existing diagnostic tools can provide clarity on the impact of the DSM-5 on the identification of children and youth with ASD (Volkmar and Reichow 2013).

Several studies have examined the potential impact of the DSM-5 on diagnoses of ASD with much variation in the populations being studied, ages of participants, and the conclusions being drawn. A recent meta-analysis of studies using various diagnostic tools found that on average 37% of individuals with a DSM-IV-TR diagnosis of an ASD would no longer meet criteria for ASD under the DSM-5 (Bennett and Goodall 2016). However, the meta-analysis also showed significant discrepancies across studies, with some reporting as few as 16% and extending up to 85% of study participants no longer retaining an ASD diagnosis under the DSM-5. These rates were similar to those reported in a separate systematic review, finding that between 7% and 62% of individuals would lose an ASD diagnosis under...
DSM-5 (Smith et al. 2015). All of the studies in the meta-analysis and review indicated that at least some children would lose ASD diagnostic status. Latino children have been consistently underdiagnosed with ASD under the DSM-IV-TR criteria (Centers for Disease Control and Prevention 2014; Mandell et al. 2009). Therefore, this is a population that requires special attention when evaluating new diagnostic procedures. In the present study, we are interested in learning whether Latino children with a clinical diagnosis of ASD are more likely to retain their diagnosis using the DSM-5 criteria compared to criteria established under the DSM-IV-TR.

Use of the ADI-R with DSM-5 Criteria

Prior to the wide dissemination of the DSM-5, many studies investigated established screening and diagnostic tools to determine if individuals who had met DSM-IV-TR criteria still qualified for a DSM-5 diagnosis. Although these studies typically focused on gold standard instruments including the Autism Diagnostic Observation Schedule-2 (ADOS-2; Lord et al. 2012) and the Autism Diagnostic Interview—Revised (ADI-R; Lord et al. 1994), concerns were raised that the ADOS may not allow for observations of the complete profile of ASD characteristics and thus, may not be sufficient within the DSM-5 framework (Barton et al. 2013; Mazefsky et al. 2013). The ADI-R is a parent interview that is administered, coded, and scored by a trained clinician or examiner. The ADI-R was developed in an effort to capture the early developmental history as well as the current and historical presentation of communication, behavioral, and social skills and difficulties. Individual items are rated and scored based on the level of impairment and its correspondence to the ASD profile, with higher scores indicating greater impairment and greater match to ASD. Thus, the ADI-R may be a more appropriate tool to evaluate its clinical utility in identifying DSM-5 based ASD.

Huerta et al. (2012) utilized data from three large datasets: simons simplex collection, collaborative programs of excellence in autism (CPEA), and the University of Michigan Autism and Communication Disorders Center data bank, to explore how children with DSM-IV-TR PDD diagnoses fared with the proposed DSM-5 criteria for Autism Spectrum Disorders. Using the combined datasets of over 5000 children aged 2–17 years of age, Huerta et al. found a high sensitivity (91%), but low specificity (53%) in using the parent-reported ADI-R to identify children with ASD using the proposed DSM-5 criteria. This was based on exhibiting at least one symptom from each social communication subdomain and at least one symptom for at least two restricted and repetitive patterns of behavior subdomains. Overall, Huerta et al. found that 91% of individuals would continue meeting criteria for a DSM-5 diagnosis of ASD based on the parent-reported ADI-R.

Barton et al. (2013) tested a DSM-5 model comprised of data from the ADI-R and ADOS assessments that were administered to over 400 toddlers with and without ASD. The authors tested various cutoff scores to determine the best balance between sensitivity and specificity, finding that sensitivity (77–93%) and specificity (55–94%) varied significantly depending on the criteria required for each domain and the cutoff score. Further review of the models proposed, suggested that when the criteria reflected the recent DSM-5 update (i.e., meeting all three social communication criteria and meeting at least two criteria for restricted repetitive patterns of behavior domain), sensitivity ranged from 77 to 84%, and specificity ranged from 55 to 94%.

Mazefsky et al. (2013) also analyzed the proposed DSM-5 criteria using ADI-R data of 498 verbally fluent individuals with a range of DSM-IV-TR ASD diagnoses who were between 5 and 61 years of age. All individuals had received a clinical diagnosis based on consensus between clinical opinion, and meeting or surpassing the DSM-IV-TR cutoff scores for the ADOS and/or the ADI-R. The authors reported that 83% of their sample met the full DSM-5 criteria if based solely on information obtained from the ADI-R. Sensitivity and specificity could not be calculated as no comparison or control group was included in the analyses.

These studies have provided a first step in evaluating how the ADI-R can be framed within the new diagnostic criteria. Although informative, these results need to be re-examined given that these analyses were conducted prior to the finalization of the DSM-5 and subsequent updates (American Psychiatric Association 2013, 2016). For example, Barton et al. (2013) required a score of 1 for an individual item (ADI-R and ADOS) to be considered meeting criteria within each subdomain; whereas Mazefsky et al. (2013) required a total score of 2 (one item with score of 2, or two items with score of 1 on ADI-R) as the threshold for meeting criteria for each subdomain. These inconsistencies can be a challenge for clinicians and researchers in utilizing the ADI-R to inform the diagnostic process. These studies suggest that the use of a gold-standard instrument such as the ADI-R may have some advantages in identifying ASD based on DSM-5 criteria, however, the results have been mixed in terms of how to quantify the diagnostic criteria and how this might impact children from typically under-represented populations.

Use of the ADI-R with Latino Populations

There are a few studies that have systematically evaluated the use of the ADI-R in the clinical assessments of Latino
children in the United States. Some studies suggest that parent-report and observations of Latino children may not always coincide. For example, Blacher et al. (2014) compared three sources of information (intake form, ADI-R, ADOS) from Latino and White children and their mothers. Although White mothers reported greater communication impairments in their children than Latina mothers on the ADI-R, Latino children exhibited greater communication challenges than White children on the ADOS. In a different study, researchers found that parent-report of communication items from the Spanish-language ADI-R did not reliably distinguish between Latino children with ASD and children with developmental disabilities (Vanegas et al. 2016). The authors proposed that the match between parent and child language proficiencies might influence how parents gauge their child’s language and communication and thus, might require additional sources of information. This study found that rates of sensitivity and specificity were lower for Latino children than those previously reported for predominantly non-Latino White samples (Vanegas et al. 2016).

Other studies have found that Latino parents may underreport or report fewer impairments in social interactions (Overton et al. 2007) or restricted and repetitive behaviors (Magaña and Smith 2006, 2013). Magaña and Smith (2013) found that three specific items under the domain of restricted and repetitive behaviors were underreported in a Latino sample compared to Whites: circumscribed interests, unusual preoccupations, and compulsions and rituals. The authors suggested that these items and their concepts may be difficult to convey across languages or to low income parents.

Findings from these studies suggest that the ADI-R algorithm that is based on the DSM-IV-TR criteria may not be a good fit for diagnosing Latino children with Spanish-speaking parents. It may be that the DSM-5 criteria will better capture those with ASD in a Latino sample compared to the original ADI-R algorithm that is based on the DSM-IV. This may occur for two reasons. First, because the DSM-5 would warrant using a wider list of items from the ADI-R, some of which Latino parents may be more likely to report. For example in the DSM-5 domain, Restricted, Repetitive Patterns of Behavior and Interests, there are five items that are not included in the DSM-IV based algorithm domain of Restricted and Repetitive Behaviors (i.e., difficulties with minor changes in routines/environment, resistance to trivial changes in environment, unusual attachment to objects, undue general sensitivity to noise, abnormal response to specific sensory stimuli). Similarly, the DSM-5 category, Social Communication and Social Interaction includes more items (i.e., attention to voice, social disinhibition) than its counterpart in the DSM-IV algorithm. Second, previous studies demonstrate that reporting of communication deficits by Latino parents in the ADI-R may not be as reliable which raises questions of the validity of the ADI-R communication domains (Blacher et al. 2014; Vanegas et al. 2016). In the DSM-5 model, the communication and social reciprocity domains are combined to comprise the domain of social communication. Latino parents may be more likely to recognize deficits in social communication given the cultural emphasis on social relationships (Blacher et al. 2014; Blanche et al. 2015).

Aims of Current Study

In the present study, we build on previous research regarding the use of the ADI-R in Latino populations and recent research that assesses whether children continue to meet criteria for an ASD diagnosis when using DSM-5 criteria. In our first research question we ask, do Latino children who were diagnosed with ASD based on the DSM-IV-TR still qualify for an ASD diagnosis based on DSM-5 criteria when using the ADI-R? We hypothesize that an algorithm based on the DSM-5 will better capture Latino children who have received a clinical diagnosis of ASD than the ADI-R algorithm based on the DSM IV-TR for reasons stated above. In our second research question, we ask whether there is an algorithm that better identifies Latino children with ASD using the ADI-R and DSM-5 criteria. For research question one, we use an algorithm based on past studies that have explored the impact of the DSM-5. For the second research question, we explore alternative algorithms based on Receiver Operating Characteristics (ROC) curve analysis with an emphasis on higher sensitivity while maintaining moderate levels of specificity.

Methods

Participants

Participants in the present analysis were part of a study evaluating the validity of the Spanish-language ADI-R (withheld for peer-review). The sample included 50 Spanish-speaking parents of children with either ASD or developmental disability/delay (DD) and were recruited from clinics and parent support groups across two cities in the Midwestern United States. Inclusion criteria required parents to be of Latin American descent who spoke Spanish as their primary language and to be the primary caregiver of a child between 4 and 16 years of age with a clinical diagnosis of a developmental or neurological disability (e.g., communication disorder, intellectual disability, Down syndrome, or ADHD) or Autism Spectrum Disorder. All children received a clinical evaluation prior to the release of the DSM-5, thus their diagnostic classification was based on DSM-IV-TR criteria.
The majority of parents in our sample were foreign born (96%), with 86% born in Mexico and 98% of our sample were mothers (only one parent was a father). Parents were on average 40 years old and 80% were married or living with a partner. Only 22% of parents had greater than a high school education and about 65% had an annual household income of $30,000 or less. The majority of children (98%) were born in the U.S. Children with clinical diagnoses of ASD (n = 29) were on average 9.1 years of age (range 4.1–16.9 years), primarily male (78%), with 21% reported by parents to have a co-occurring intellectual disability, and 66% reported by parents to be verbal. Children with clinical diagnoses of other developmental disabilities (n = 21) were on average 8.8 years of age (range 4.0–15.2 years), primarily male (81%), with 14% reported by parents to have an intellectual disability, and 67% reported by parents to be verbal. Additional information regarding cognitive functioning for all children were not available in the medical records. We found no differences between those with a clinical diagnosis of ASD and those diagnosed with other developmental disabilities on demographic characteristics.

Measures

The primary study measure used in the current study is the Spanish-language ADI-R, a standardized, investigator-based interview administered to primary caregivers to collect an extensive developmental history and current symptoms of individuals. The ADI-R is based on the definitions of Autism determined by the International Classification of Diseases (ICD-10; World Health Organization 1992) and was matched to the DSM-IV criteria for Autistic Disorder (American Psychiatric Association 1994). The ADI-R structure allows the examiner to present a series of questions and probes to the caregiver to gather information and to record, code, and score the responses based on its pre-established criteria. Behaviors and symptoms are coded on the degree of correspondence with autism symptomatology and the degree of severity, with low scores of 0 indicating no abnormality and high scores of 3 indicating severe autistic type abnormality. In the final algorithm for the determination of cutoff scores, scores of 3 are recoded to 2 (Lord et al. 1994). The Spanish version of the ADI-R was translated, but not culturally adapted, using a forward and back translation method (Vrancevic et al. 2002) and is the official Spanish version available through Western Psychological Services.

The diagnosis of DSM-IV-TR ASD or Developmental Delay in our sample was determined by review of medical records obtained from the clinical site that provided the child with the medical diagnosis. Diagnoses were based on clinical judgment by the respective clinicians and were not involved in the current study. Classification of ASD included clinical diagnoses of Autistic Disorder, Asperger’s Disorder, and Pervasive Developmental Disorder—Not Otherwise Specified. Classification of Developmental Delay included other developmental disabilities such as down syndrome, ADHD, Intellectual Disability, or Communication Impairment. All parents provided informed consent prior to their participation in the study and all procedures were approved by the Institutional Review Board at the academic institution overseeing the current study.

Sociodemographic variables were collected and included parent characteristics such as age, marital status, level of education, annual household income, place of birth, and ethnicity; and child characteristics such as age, presence of an intellectual disability, verbal status, gender, age, and place of birth.

Procedures

The ADI-R was administered by trained bilingual clinicians who were blind to the clinical diagnosis of the child. We used converted scores for all items from the ADI-R to allow for a comprehensive mapping of the ADI-R to the final DSM-5 ASD criteria. We determined the final DSM-5 items for analyses by reviewing how they were mapped in previous studies (Barton et al. 2013; Christiansz et al. 2016; Grzadzinski et al. 2016; Huerta et al. 2012; Mazefsky et al. 2013). Specifically, we compared how the ADI-R items were mapped in these studies to identify the most consistent endorsement of the item for each domain and subdomain of the DSM-5 ASD criteria. For each subdomain, we included items that were endorsed by two or more studies for that specific subdomain. We clarified and reached consensus on other discrepancies (e.g., item endorsed across two subdomains equally) by reviewing the individual item and the DSM-5 criteria. No items were included in more than one subdomain or domain. The final mapping of ADI-R items with the DSM-5 ASD criteria can be seen in Tables 2 and 3.

We modified the DSM-IV diagnostic algorithm for the ADI-R to reflect the changes made to correspond with the final DSM-5 ASD criteria. The criteria establishes that individuals must exhibit impairments in social communication across three areas: socio-emotional reciprocity (A1), nonverbal communicative behaviors (A2), and social relationships (A3); and must exhibit restricted or repetitive patterns of behavior in at least two areas: motor movements (B1), adherence to routines/resistance to change (B2), highly restricted, fixated interests (B3), or hyper- or hypo-reactivity to sensory input (B4). However, the specifics on how each subdomain is quantified in relation to the ADI-R item scores, has not yet been determined. Cutoff benchmarks used in past studies (Barton et al. 2013; Christiansz et al. 2016; Huerta et al. 2012; Mazefsky et al. 2013) and
new ones developed in the current study using ROC curve analyses were evaluated against clinical diagnoses (ASD, DD) obtained through medical records to determine the model that yielded the most adequate psychometric properties (see Tables 1, 4).

Results

Research Question #1: Do Latino Children Who Were Diagnosed with ASD Based on the DSM-IV-TR Still Qualify for an ASD Diagnosis Based on DSM-5 Criteria?

To assess whether children with DSM-IV TR diagnoses of ASD would still qualify for a DSM-5 based ASD diagnosis, we assessed the sensitivity of the DSM-5 criteria. Meeting each subdomain criteria was determined by having a score of 2 on at least one ADI-R item included in that subdomain (A1–A3, B1–B4). Furthermore, to determine overall classification of ASD, the child would need to meet all three subdomain criteria for the Social Communication domain (A1, A2, and A3), and meet at least two subdomain criteria for the Restricted Interests, Repetitive Behaviors (B1, B2, B3, or B4) domain. If either domain criteria was not met, then the child would be classified as No ASD. These classifications were then compared to the child’s clinical diagnosis (Autism Spectrum Disorder, Developmental Disability) to identify the clinical validity of this scoring model. The DSM-5 classifications were also compared to the ADI-R algorithms used under DSM-IV. The DSM-IV algorithms for the ADI-R correctly identified 20 out of 29 (69.0%) children with clinical diagnoses of ASD, whereas with the DSM-5 ADI-R criteria, 23 out of 29 (79.3%) children with clinical diagnoses of ASD continued to meet criteria for DSM-5 based ASD diagnosis. We further assessed whether the proportion of children identified as having ASD was significantly different across the DSM-IV-TR and DSM-5 criteria using McNemar’s test. This analysis showed that the proportion of children with ASD did not vary significantly across ADI-R algorithms, \( p = 0.453 \). Additional comparisons of the DSM-IV and DSM-5 clinical validity are included in Table 1.

We further compared domain, subdomain, and individual item scores between ASD and DD groups in a one-way ANOVA to determine if the restructuring and addition of items could accurately distinguish between children with ASD and children with DD. No covariates were entered into the model as no differences were found between the ASD and DD groups on demographic characteristics (all \( p’s > 0.05 \)). Social communication (Domain A) scores for children with ASD were significantly different than children with DD, with a similar pattern observed in the restricted and repetitive patterns of behavior (Domain B).

Further inspection of the social communication subdomains also showed that children with ASD had greater deficits in socio-emotional reciprocity (A1), nonverbal communicative behaviors (A2), and in social relationships (A3). Subdomain scores for the restricted and repetitive patterns of behavior domain also found significantly greater impairment among children with ASD than children with DD on stereotyped/repetitive motor movements, speech (B1), inflexible adherence to routines/rituals (B2), and hyper- or hypo-reactivity to sensory input (B4). No significant differences were found between children with ASD and children with DD on highly restricted/fixated interests (B3). These findings indicate that overall, children with ASD had greater impairments in social communication and a higher level of restricted and repetitive patterns of behavior when compared to children with DD (see Tables 2, 3).

Table 1 Clinical Validity of ADI-R DSM-IV-TR and DSM-5 Criteria of Autism Spectrum Disorders

|                         | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) |
|-------------------------|----------------|-----------------|---------|---------|
| Overall DSM-IV-TR Criteria | 69.0           | 76.2            | 80.0    | 64.0    |
| Individual domains      |                |                 |         |         |
| Social reciprocity      | 93.1           | 38.1            | 67.5    | 80.0    |
| Communication           | 79.3           | 52.4            | 69.7    | 64.7    |
| Restricted interests, repetitive behaviors | 79.3 | 76.2 | 82.1 | 72.7 |
| Overall DSM-5 criteria  | 79.3           | 66.7            | 76.7    | 70.0    |
| Individual domains      |                |                 |         |         |
| Social communication    | 82.8           | 47.6            | 68.6    | 66.7    |
| Restricted interests, repetitive behaviors | 93.1 | 47.6 | 71.1 | 83.3 |

PPV positive predictive value, NPV negative predictive value; DSM-IV-TR criteria = met cutoff scores for each domain on ADI-R, social reciprocity ≥10, communication verbal ≥8, communication nonverbal ≥7, restricted interests, repetitive behaviors 3 DSM-5 criteria = social communication: must score at least two on any item in A1 and A2 and A3; restricted interests, repetitive behavior: must score at least two on any item in at least two sub-criteria (B1, B2, B3, or B4)
Research Question #2: Is There an Algorithm that Better Identifies Latino Children with ASD Using the ADI-R and DSM-5 Criteria?

To identify an algorithm to classify children with DSM-5 based ASD diagnoses, we examined the subdomain scores (i.e., social communication and restricted interests, repetitive behaviors) to ascertain cutoff values with the best balance between sensitivity and specificity using Receiver Operating Characteristic (ROC) curves. These cutoff values were then used to classify children as meeting or not meeting each subdomain criteria. To merit a final ROC DSM-5 diagnosis of ASD, the child would need to meet or surpass the cutoff scores for all three criteria in the Social Communication domain (A1, A2, and A3) and surpass the cutoff scores on at least two criteria for the Restricted Interests, Repetitive Behaviors domain (B1, B2, B3, or B4). The final ROC DSM-5 diagnosis was then compared to children’s clinical diagnosis ( Autism Spectrum Disorder, Developmental Disability) to determine the clinical validity of the revised ADI-R cutoff scores and a DSM-5 diagnosis of ASD. Overall, this model showed high sensitivity (89.7%), low specificity (57.1%) and moderate positive predictive value (74.3%) and negative predictive value (80.0%).

Using the ROC based algorithm, 26 out of 29 children with clinical diagnoses of ASD would continue to meet DSM-5 criteria for ASD. We then compared the proportion of children who were identified as having ASD based on ROC DSM-5 algorithms with the proportion of children identified as having ASD based on the original DSM-IV-TR criteria using McNemar’s test. This analysis showed a trend for a significant difference in the proportion of children...
Table 3  ADI-R restricted and repetitive patterns of behavior domain, subdomains, and individual item scores based on DSM-5 criteria for children with clinical diagnoses of ASD and DD

| Restricted, repetitive patterns of behavior, interests domain | M (n=29) | SD | M (n=21) | SD | F | Partial η² |
|-------------------------------------------------------------|---------|----|---------|----|---|-----------|
| Restricted patterns of behavior, interests domain          | 14.31   | 6.50| 6.95    | 5.31| 18.10**| 0.27      |
| B1. Stereotyped/repetitive speech, motor, use of objects   | 5.41    | 2.61| 2.76    | 2.41| 13.40**| 0.22      |
| 33. Stereotyped utterances/echolalia                        | 1.26    | 0.81| 0.57    | 0.76| 6.26*  | 0.17      |
| 37. Pronominal reversal                                     | 1.32    | 0.89| 1.07    | 0.92| 0.60   | 0.02      |
| 38. Neologisms/idiosyncratic language                       | 0.63    | 0.76| 0.50    | 0.85| 0.22   | 0.01      |
| 69. Repetitive use of objects                               | 1.38    | 0.82| 0.48    | 0.75| 15.86**| 0.25      |
| 77. Hand/finger mannerisms                                  | 1.00    | 0.93| 0.48    | 0.81| 4.31*  | 0.08      |
| 78. Other complex mannerisms                                | 0.93    | 0.92| 0.38    | 0.74| 5.08*  | 0.10      |
| B2. Excessive adherence to routines, resistance to change   | 3.21    | 2.34| 1.10    | 1.30| 13.97**| 0.23      |
| 39. Verbal rituals                                          | 0.79    | 0.92| 0.29    | 0.61| 3.17†  | 0.09      |
| 70. Compulsions/rituals                                     | 0.86    | 0.95| 0.29    | 0.64| 5.76*  | 0.11      |
| 74. Difficulties with changes to routines/environment        | 1.28    | 0.88| 0.38    | 0.67| 15.23**| 0.24      |
| 75. Resistance to trivial changes in environment            | 0.55    | 0.83| 0.24    | 0.54| 2.30   | 0.05      |
| B3. Highly, restricted, fixated interests                   | 1.79    | 1.86| 1.05    | 1.66| 2.14   | 0.04      |
| 67. Unusual preoccupations                                  | 0.21    | 0.49| 0.29    | 0.64| 0.24   | 0.01      |
| 68. Circumscribed interests                                 | 1.10    | 0.98| 0.38    | 0.67| 8.56** | 0.15      |
| 76. Unusual attachment to objects                           | 0.48    | 0.38| 0.87    | 0.74| 0.19   | 0.00      |
| B4. Hyper- or hypo-reactivity to sensory input              | 3.90    | 1.63| 2.05    | 1.72| 14.96**| 0.24      |
| 71. Unusual sensory interests                               | 1.10    | 0.77| 0.24    | 0.44| 21.36**| 0.31      |
| 72. Undue general sensitivity to noise                      | 1.62    | 0.78| 1.00    | 0.89| 6.86*  | 0.13      |
| 73. Abnormal response to sensory stimuli                    | 1.17    | 0.85| 0.81    | 0.87| 2.18   | 0.04      |

**p < .01; *p < .05; †p < 0.10;
a ADI-R item added for DSM-5 criteria

Table 4  Clinical validity of ADI-R DSM-5 criteria of autism spectrum disorders based on ROC curve cutoff scores

| ADI-R ROC score algorithms | Cutoff score | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) |
|----------------------------|--------------|-----------------|-----------------|---------|---------|
| A1. Deficits in social-emotional reciprocity               | 8            | 93.1            | 38.1            | 67.5    | 80.0    |
| A2. Deficits in nonverbal communicative behaviors used for social interaction | 3            | 93.1            | 23.8            | 62.8    | 71.4    |
| A3. Deficits in developing, maintaining, and understanding relationships | 7            | 93.1            | 33.3            | 65.9    | 77.8    |
| B1. Stereotyped/repetitive motor movements, use of objects, or speech | 2            | 96.6            | 33.3            | 66.7    | 87.5    |
| B2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal/nonverbal behavior | 1            | 82.8            | 42.9            | 66.7    | 64.3    |
| B3. Highly restricted, fixated interests that are abnormal in intensity or focus | 1            | 58.6            | 57.1            | 65.4    | 50.0    |
| B4. Hyper- or hypo-reactivity to sensory input or unusual interest in sensory aspects of environment | 2            | 93.1            | 42.9            | 69.2    | 81.8    |
| Individual domains                                          |              |                 |                 |         |         |
| Social communication                                        | 89.7         | 42.9            | 68.4            | 75.0    |
| Restricted interests, repetitive behaviors                   | 96.6         | 28.6            | 65.1            | 85.7    |
| Overall DSM-5 Criteria                                     | 89.7         | 57.1            | 74.3            | 80.0    |

PPV positive predictive value, NPV negative predictive value

aMeeting overall DSM-5 criteria required meeting or surpassing the cutoff score for all social communication subdomains (A1, A2, and A3), and meeting or surpassing the cutoff score of any combination of at least two restricted interests, repetitive behaviors subdomains (B1, B2, B3, or B4)
identified as having ASD between ROC DSM-5 algorithms and the original DSM-IV-TR algorithms, \( p = 0.070 \). Subdomain cutoff scores and additional psychometric properties of the ROC based algorithm for DSM-5 are included in Table 4.

**Discussion**

In this study, we examined the potential impact of the change in DSM classification of autism spectrum disorder (ASD) on diagnosing Latino children with ASD. Latino children in the US are systematically under-diagnosed with ASD (Centers for Disease Control and Prevention 2014; Mandell et al. 2009). There may be numerous factors that contribute to under-identification including family and community cultural beliefs, limited English proficiency, limited knowledge about autism diagnosis and services, and health care system barriers (Zuckerman et al. 2014). On the health care systems level, there are many layers of barriers that parents have to overcome to get to an ASD diagnostic evaluation such as insurance and payment barriers, obtaining provider referrals, knowledge about which clinics have trained staff, and long waiting lists (Magaña and Smith 2013). Therefore, it is important than when a Latino child reaches the level of clinical evaluation, best practices are used in the assessment process. Best practices recommended for a diagnosis of ASD have included the use of the Autism Diagnostic Interview-Revised (ADI-R) and the Autism Diagnostic Observation Schedule (ADOS). However, using DSM-IV criteria, a study that examined the validity of the Spanish version of the ADI-R found lower rates of sensitivity and specificity among Latino children with Spanish speaking parents than previous studies of non-Latino children (Vanegas et al. 2016).

In this study, we asked whether the new DSM-5 classification would be more likely to include Latino children with a clinical diagnosis of ASD than the DSM-IV classification when using the ADI-R. We hypothesized that the DSM-5 criteria would be a better fit for Latino children than the DSM-IV because it includes a wider array of symptoms to meet criteria in each of the categories, given previous research that has shown that Latino parents may underreport symptoms compared to White parents (Blacher et al. 2014; Magaña and Smith 2013). Furthermore, the combination of communication and social reciprocity in the DSM-5 classification may address the limitations that emerged for Spanish speaking parents in the communication domain (Vanegas et al. 2016). Consistent with our hypothesis, we found that a higher percentage of Latino children with ASD whose parents were administered the Spanish version of the ADI-R continued to meet clinical criteria using a DSM-5-based algorithm than when using the original DSM-IV-based algorithm. More specifically, three additional children were correctly identified using the DSM-5 algorithm (23 out of 29) compared to the DSM-IV algorithm (20 out of 29). These findings demonstrate a higher rate of sensitivity for the DSM-5 criteria. However, the specificity rate is slightly lower indicating that the DSM-5 criteria is somewhat less likely to rule out ASD when no ASD is present than the DSM-IV criteria.

We presented domain, subdomain, and item by item level comparison between children with a clinical diagnosis of ASD and those with developmental disabilities (DD) and found significant differences between the two groups on the two DSM-5 domains: social communication and social interaction; and restrictive and repetitive patterns of behaviors and interests. This contrasts with previous research which found that the communication domains based on the DSM-IV criteria do not significantly distinguish the between Latino children with ASD and children with DD (Vanegas et al. 2016). By combining the communication and social reciprocity domains and including items that relate to social communication and not communication alone, the overall distinction between the ASD and DD groups is improved.

Most of the subdomains were significantly different between the two groups with the exception of the subdomain, highly restricted fixated interests. This finding is consistent with Magaña and Smith’s (2013) comparison of Latino and White children on ADI-R items that found that Latinos reported some of these restrictive and repetitive items at lower levels. For the DSM-5 criteria, the item, unusual attachment to objects was added to this subdomain, however there were no differences between the ASD and DD groups on this item, therefore, the addition of this item did not strengthen this subdomain in distinguishing between the two groups. A new subdomain under the restrictive and repetitive domain, hyper- or hypo reactivity to sensory input included two new items that were not included in the DSM-IV algorithm, undue general sensitivity to noise, and abnormal response to sensory stimuli. This subdomain was significantly different between the two groups. There were two additional items included in the domain of social communication and social interaction: attention to voice and social disinhibition. The former did not significantly distinguish between the ASD and DD groups, and the latter did. The inclusion of additional items in the DSM-5 criteria may have helped to improve sensitivity of the ADI-R, but only slightly. However, the social communication and social interaction domain was significantly different between the ASD and DD groups overall. These findings contrast with the DSM-IV validity analysis of Latino children with Spanish speaking parents which found that the two communication domains did not
distinguish between Latino children with ASD and with DD (Vanegas et al. 2016).

Our second research question focused on exploring alternative ADI-R algorithms using DSM-5 criteria to better fit the Latino children in our sample. We explored the cutoff scores for each domain that would produce the highest sensitivity while maintaining moderate levels of specificity using receiver operating characteristics (ROC) curve analysis. We focused on higher sensitivity because of the concern expressed by parents, self-advocates and professionals that individuals already diagnosed with ASD may lose their diagnosis and consequently lose needed services. We identified cutoff scores which produced an overall sensitivity of 89.7% and specificity rate of 57.1%. In this model, 26 of the 29 children with a clinical diagnosis of ASD continue to meet DSM-5 criteria which is more inclusive than either the DSM-IV algorithm or the algorithm based on previous DSM-5 studies. So far to our knowledge, only one past study has used ROC curve analyses to identify cutoff scores for the ADI-R, providing a useful foundation (Barton et al. 2013). However, Barton et al. based their algorithm scores on the combination of the ADI-R and the ADOS, complicating the use of algorithms in clinical practice. For example, the module of administration for the ADOS varies based on the individual’s developmental and linguistic level (Lord et al. 2012) and the ADOS may not always be feasible to administer in low-resource settings (Durkin et al. 2015). The proposed cutoff scores that were derived from ROC curve analyses may be more sensitive than DSM-IV-TR criteria in identifying children with ASD. However, these findings were not quite significant, thus, caution is warranted in utilizing the proposed cutoff scores pending further validation. Consequently, the cutoff scores developed in the present analysis may provide a valuable first step in adapting existing clinical algorithms when using the ADI-R with Spanish-speaking Latino families.

This study has several limitations which reduce the generalizability of findings. First, the sample size was small; second the sample only included Latinos living in the Midwest who were predominantly of Mexican descent; and third the primary language of parents in our study was Spanish and only the Spanish version of the ADI-R was used. Therefore, findings cannot be generalized to Latino families whose primary language is English, who reside in different regions of the U.S., or who have different countries of origin. The age of children in our sample was between 4 and 16 years old; a larger sample size would allow for examination of different age cohorts. Additional limitations concern the exploratory nature of evaluating DSM-5 ASD algorithms. Although we utilized medical records to confirm children’s clinical diagnoses, further studies are needed to validate our proposed ADI-R algorithms with best estimate diagnoses (e.g., ADOS-administration).

Furthermore, additional evaluation of the proposed ADI-R algorithms within larger, more diverse samples are needed to better understand if the proposed algorithms function in the same way across age, communication, and cognitive ability levels.

Despite these limitations, our findings have implications for clinical practice and future research. Our findings indicated that the use of the DSM-5 criteria may enhance clinical evaluation of Latino children. To obtain the highest levels of sensitivity, a modified version of the algorithm might be considered for clinical use so as not to exclude Latino children that may have an ASD. However, because of low specificity rates, it will be important to include observational diagnostic tools such as the ADOS in order to provide additional data beyond parent report. These additional sources of information may be important to rule out other potential diagnoses (e.g., Attention-Deficit Hyperactivity Disorder, Social Communication Disorder).

Future research is needed to determine which additional diagnostic tools would be best to supplement the ADI-R in order to make an accurate diagnosis of ASD among Latino children within the DSM-5 classification. For example, observational tools such as the ADOS have never been validated with a Latino population of children and the standardization samples have been limited in terms of the racial/ethnic and linguistic diversity of the US. There may be important adaptations for both the ADI-R and ADOS with respect to cultural norms of play and interaction that could enhance the diagnostic process. Qualitative studies that examine the cultural meanings of the items embedded in the standardized diagnostic tools are needed to develop useful adaptations.

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Author Contributions SM designed the overall study, co-conceptualized the analysis of the current manuscript and contributed to writing the introduction, methods and discussion. SM also conducted final editing of the article. SBV co-conceptualized the analysis, conducted the analysis, co-wrote the methods section, wrote the results section and co-wrote the discussion.

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Compliance with Ethical Standards

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

Ethical Approval All procedures performed in this study involving human participants were in accordance with the ethical standards of
the University Institutional Review Board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent  Informed consent was obtained from all individual participants included in the study.

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