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Neurodevelopmental profiles of 4-year-olds in the Navajo Birth Cohort Study

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Abstract

Objective: Native American children disproportionally face many risk factors for poor developmental outcomes; these factors include poverty, environmental toxicant exposure, and limited medical, and intervention services. To understand these risks, comprehensive documentation of developmental and behavioral phenotypes are needed. In the current descriptive study, we assessed the neurodevelopment of young Diné (Navajo) children using standardized assessment instruments in combination with expert clinician judgment.

Methods: As part of an ongoing, population-based, prospective birth cohort study, we conducted comprehensive neurodevelopmental assessments of 138, 3-5-year-old, Diné children residing on or near the Navajo Nation. We report results from standardized parent reports, psychiatric examinations, and direct assessments of children's language, cognitive, adaptive, and social-emotional development, as well as best estimate clinical diagnoses.

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Ethics approval and consent to participate.
This study was approved by the University of New Mexico, Health Sciences Center's Human Review Committee, as well as the Navajo Nation Human Research Review Board. All participants received informed consent about the purpose of the research project, possible risks and benefits, and the contact information of the researcher and the institutional program for the Protection of Human Subjects Office.

Competing interests
No authors have any competing interests

Results: Forty-nine percent of our sample met DSM-5 criteria for a neurodevelopmental disorder (NDD) diagnosis. Language and speech sound disorders were most common, although autism spectrum disorder (ASD) was also elevated compared to the general population. Though language performance was depressed amongst all groups of children with, and without, NDDs, those meeting criteria for certain NDDs performed significantly lower on all language measures, when compared to those without. Social-emotional, behavioral, and nonverbal cognitive ability were in the average range overall.

Conclusions: Diné children in our study were found to have a high percentage of clinically significant developmental delays. Overall, children presented with a pervasive pattern of depressed language performance across measures, irrespective of diagnosis (or no diagnosis), while other domains of functioning were similar to normative samples. Findings support the need to identify appropriate intervention and educational efforts for affected youth, while also exploring the causes of the specific developmental delays. However, longitudinal studies are necessary to establish best practices for identifying delays and delineating resilience factors to optimize development of Diné children.

Keywords

Native American; American Indian; indigenous; neurodevelopment; language

Introduction

The Navajo Nation is the largest Native American reservation in the United States, spanning more than 27,000 square miles. Approximately 47% of the 330,000 enrolled tribal members, or Diné (the preferred term for the Navajo people), live on the reservation [1]. The history of colonial violence, such as destruction of land, forced assimilation, and displacement, directed at the Diné can be specifically tied to current disparities in public health welfare [2]. Furthermore, cumulative impacts of historical trauma and the stripping away of resources and culture increases the potential for altering developmental trajectories [3]. More proximally, Diné children may be exposed to multiple environmental risk factors that adversely impact healthy development; these include toxic metal exposures (e.g., arsenic and uranium [4]), extreme poverty, and low levels of parental education. These risks are embedded in a uniquely rich and multifaceted cultural context. Moreover, the complexity of this context can potentially limit early identification of developmental delays and limit utilization of intervention services, particularly for children living within the Navajo Nation. Unfortunately, there are limited empirical data available to document the developmental profiles of this vulnerable population. Thus, there is a significant need to characterize the early development of Diné children to generate the information necessary for creating effective identification, education, and intervention programs to optimize developmental and academic outcomes.

Limited work-to-date has focused primarily on standardized assessments of cognitive abilities and suggests that Diné children show specific vulnerabilities in measures of verbal abilities. For example, in an older study, the use of the *Wechsler Intelligence Scales for Children, Revised Edition* (WISC-R) with Diné children resulted in large discrepancies between verbal and performance (nonverbal) subscales (e.g., approximately 30 points) [5], a similar profile discussed in a multitribal literature review of Wechsler cognitive measures [6]. Investigating these discrepancies, two studies have suggested that performance IQ, as opposed to verbal IQ, measures may be more predictive of academic achievement in Diné children [7,8]. However, results of individually administered assessments need to be understood in sociocultural and historical contexts, which has been a major challenge for this work. For example, prior researchers have questioned the adequacy of assessment instruments and interpretation of results in populations that may have differing cultural values, child-rearing practices, and communication styles [9,10]. Standard norming samples typically include, at best, a census-representative percentage of Native American children, approximately 1-2%, which make it unlikely that a sufficient number of indigenous children could be separately analyzed to determine the performance within that population, compared to the US national norm. As a result, standard scores on most assessment instruments may not validly capture the abilities of these children, or be useful in predicting outcomes in the same way as for majority population groups.

Despite ongoing questions about the appropriateness of norm-referenced, standardized measures for this population, a few studies do support their validity. Atkinson [11] found that the *Wechsler Intelligence Scale for Children, Third Edition* (WISC-III) differentiated between children referred and not referred for special education evaluation in a Diné sample. The authors suggest that test scores were functioning as intended, even if scores were lower among the Diné children, as a group. Similarly, Nakano and Watkins [12] examined the WISC-IV for bias in a sample of primarily Diné children, using confirmatory factor analysis; they found no evidence of bias in structural validity. Finally, a technical report of measures administered in tribally-run Head Start programs suggested strong psychometric properties for most of the standardized measures used, including standardized, norm-referenced cognitive and language instruments across tribal Head Start programs [13].

Due to limitations in “normative” group representation, there are concerns that standardized measures may over-identify verbal and/or language impairments in Diné children [9,10]. To the best of our knowledge, there have not been attempts to contextualize these observed differences by constructing more comprehensive developmental profiles that include both cognitive and language measures, together with measures of social-emotional and adaptive functioning. Questions regarding the adequacy of assessment results and the need to understand Diné children in context mean that clinical decision-making must rely heavily on professional expertise. Furthermore, it is imperative that clinical judgment be informed by multiple sources of information across developmental domains [14]. The lack of standardized assessment measures validated for use in Diné children calls into question the utility of results from individual tests; rather, this suggests a need for comprehensive, multi-modal assessment batteries to more accurately estimate “true” rates of language, or other developmental difficulties, as well as testing of larger groups of children from the general population of Diné children to understand typical development in this group. Meaningful delays and impairments can then be the target of valid and responsive interventions.

The current study reports on the results from 138 children enrolled in the Navajo Birth Cohort Study (NBCS) who completed a comprehensive neurodevelopmental assessment at approximately age 4 years, as part of the Environmental influences on Child Health

Outcomes (ECHO) study. The primary objective was to describe the developmental profiles of a group of children ascertained from a prospective birth cohort study, NBCS. Given that these children were not clinically referred or ascertained specifically for developmental problems, data from this cohort provide an opportunity to describe a general population sample. Further, given concerns about the validity of standardized measures in this population, we capitalized on the availability of data from multiple assessment modalities, including parent report, direct assessment, and expert clinical judgment to characterize children's neurodevelopmental profiles and identify those with clinically significant developmental delays. In addition, Diné trained research staff were present at the assessment sites to provide their perspectives on language or cultural difficulties in comprehension or responses that may have affected test administration. Doing so is in alignment with best practice guidelines for clinical assessment and allows for a more comprehensive understanding of children's development.

The overall goal of this study is to describe the early childhood neurodevelopmental profiles of Diné children enrolled in the NBCS using comprehensive clinical assessment data. Based on findings from previous studies of Diné children showing relative weaknesses in verbal cognitive ability when compared to nonverbal and spatial reasoning skills [5,11], we expect to see developmental delays in language and verbal cognitive abilities but not in nonverbal cognitive abilities in the current sample.

Methods

Participants

Participants in this study were enrolled in the NBCS, a prospective birth cohort study initiated to examine the effects of environmental metal-mixture exposures on the health and developmental outcomes of Navajo children [15]. During pregnancy, women were recruited into the study from across the Navajo Nation (see [4,16] for more on the NBCS sample). It is the first large-scale assessment of environmental exposures and children's health in Indigenous populations, tracking trajectories of neuro- and physical development of enrolled children. The original NBCS began recruiting pregnant women in 2013, with child assessments through the age of 12 months. The NBCS became part of the ECHO program beginning in 2016 (see [18]), with assessments continuing through age 8 years. In addition to recruiting new pregnant women, children could be re-consented into the NBCS/ECHO at any age if they had participated in the original study. Of 723 children originally consented, 472 families with children have re-consented into the new study. Children were assessed as they became eligible for neurodevelopmental assessments between 42 and 71 months. Participants in the current analyses include 138 children (71 male, 67 female) from the NBCS who were enrolled into the new study and who completed the early childhood neurodevelopmental assessment between October 2017 and November 2019. The current sample is 82% of the 168 children who were in the assessment age range during this time frame. The study was approved and is monitored by the University of New Mexico Health Sciences Center's Human Research Protection Office, as well as the Navajo Nation Human Research Review Board. At the time of the assessment, participants had a mean age of 51.7 months (see Table 1 for demographics). All children spoke English as a primary language.

Procedures

Neurodevelopmental assessments were conducted at field sites across the Navajo Nation in New Mexico and Arizona, including Gallup, NM; Shiprock, NM; Fort Defiance, AZ; Chinle, AZ; Tuba City, AZ; and Kayenta, AZ. The assessments lasted 180 to 240 minutes and included standardized child cognitive and language assessments, parent interview about child's adaptive skills, parent questionnaires, medical and developmental history, and physical examinations. Multidisciplinary teams consisted of psychologists, child and adolescent psychiatrists, psychology and psychiatry trainees, and Diné research staff. Standardized child assessments and parent questionnaires were presented in English. All NBCS field research staff supporting the project were fluent Diné bizaad and English speakers and able to provide translation or clarification, when needed. Thirty percent of participants reported using both English and Diné bizaad in the home, none of the children in the current study spoke Diné bizaad exclusively.

Measures

A combination of parent-report and clinician-administered measures was used to assess developmental domains of interest (in bold type below). To ensure cultural appropriateness, all data collection instruments, procedures, and interpretation of results have been, and continue to be, collaboratively and iteratively reviewed by Diné and non-Diné researchers and clinicians, traditional healers, Navajo Nation government representatives, and other community members.

Cognitive Abilities—The *Differential Ability Scale – Second Edition* (DAS-II) [17] is a comprehensive assessment of cognitive abilities for children ages 2-years, 6-months through 17-years, 11-months. We used the early years cognitive battery, which is for children between the ages of 2-years, 6-months and 6-years, 11-months. Standard scores from the Verbal, Nonverbal Reasoning, and Spatial Clusters were analyzed for the current study.

Language Abilities—The *Oral and Written Language Scales, Second Edition* (OWLS-2) [18] is an assessment of language including listening comprehension (i.e., receptive language) and oral expression (i.e., expressive language) skills for children ages 3- to 21-years. We used standard scores from the Listening Comprehension and Oral Expression scales.

Adaptive Behavior—The *Vineland Adaptive Behavior Scales, Third Edition* (Vineland-3) [19], is a measure of adaptive functioning for individuals from birth to age 90. The Vineland-3 Parent/Caregiver Comprehensive Interview Form was administered by parent interview. We used standard scores from the Communication, Daily Living Skills, Socialization, and Motor Skills Domains, as well as the Adaptive Behavior Composite.

Behavior Problems—A primary caregiver completed the *Child Behavior Checklist (CBCL)*, Preschool Form [20]. We used T-scores from the internalizing, externalizing, and total problem domains.

Autism Symptoms—Clinicians completed the *Childhood Autism Rating Scale, Second Edition* (CARS-2) [21] Standard Version based on direct observations made during the child assessment. Primary caregivers also completed the *Social Responsiveness Scale, Second Edition* (SRS-2) [22]; the SRS assesses the presence and severity of social impairments and restricted and repetitive behaviors associated with a diagnosis of autism spectrum disorder (ASD). A primary caregiver for each child completed the SRS Preschool form for children under the age of 4, and the SRS School Age form for children aged 4 and older.

Clinical Diagnosis

Following the assessment of each child, the team of clinicians met to discuss all test results and determine whether the child met criteria for a neurodevelopmental disorder, based on criteria specified in the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5) [23]. The clinical assessment team always included at least one doctoral level clinical psychologist, and one or more child and adolescent psychiatrists, all of whom had extensive experience in the assessment and diagnosis of neurodevelopmental disorders. Assessment team members who had worked directly with the child and family during the 3-4-hour visit reviewed all available information, including assessment results, behavioral observations, and any contextual information provided by field staff who work with the family in an ongoing manner. "Rule-out diagnoses" were also assigned when a child was suspected, but could not be confirmed, to fulfill the DSM-5 criteria based on the available information. To resolve differences of opinion, final DSM-5 diagnostic decision deferred to the team member who worked most directly with the child (i.e., the person conducting cognitive and language assessments). When a child met full criteria for more than one DSM-5 diagnosis, a clinical consensus hierarchy was used to establish a primary diagnosis most inclusive of observed criteria. The hierarchy is autism spectrum disorder (ASD); intellectual disability/global developmental delay (ID/GDD); language disorder; speech sound disorder; attention-deficit/hyperactivity disorder (ADHD). For example, if a child met criteria for ASD and language disorder, he/she was assigned ASD as the primary diagnosis.

Statistical Analysis

We generated descriptive statistics for demographics and standardized measures for the whole sample and across different primary diagnostic groups, including frequencies and percentages of primary and comorbid diagnoses.

To assess relative performance across the main developmental domains assessed, scores from standardized measures were normalized to be on the scale with mean of 0 (representing average in the normative sample) with a standard deviation of 1. Specifically, standard scores (i.e., on DAS-II, OWLS, Vineland-3) were converted by subtracting 100 (location) from the original score then dividing by 15 (scale), while T-scores (i.e., on CBCL and SRS-2) were converted by subtracting 50 (location) from the original scores and dividing by 10 (scale). Then, the normalized scores across measures were plotted for both the whole sample and all the diagnostic groups to depict the profiles of the sample.

To compare the characteristics of children determined to have clinically significant language problems versus those with no NDD diagnosis, independent sample T-tests were conducted between children with any language disorder diagnosis (either primary or comorbid), and those with no NDD diagnosis.

Results

Descriptive information is shown in Table 1. Our sample was 50.7% male. The majority of households earned less than $20,000 annually (57.3%) and the second largest income group was Unknown (did not report; 22%). Most children had married parents (73.2%) with maternal education at or below high school level (56.5%).

Table 1 also shows the number of children receiving a primary diagnosis in each NDD area and those receiving secondary (comorbid) diagnoses. Almost half (49.3%) of the children in the current sample met DSM-5 criteria for one or more NDDs. Language disorder was the most common diagnosis (primary: 29%; total: 32.6%) followed by speech sound disorder (primary: 10.9%; total: 28.3%). Nine children met criteria for autism spectrum disorder (6.5%). Four children met criteria for a primary diagnosis of GDD/ID, with 4 others meeting criteria secondary to ASD.

Table 2 presents the results of each standardized measure, for the group as a whole and for all diagnostic groups. Overall, Diné preschoolers in this sample were largely performing in the average ranges across multiple direct assessments and parent-report measures (e.g., behavior rating scales and nonverbal cognitive scales), except in verbal domains as measured by the DAS-II verbal standard score, the OWLS-2, and in the Vineland-3 Communication Domain. However, between diagnostic groups, the discrepancy between verbal and nonverbal abilities was more evident in children with a diagnosis of language disorder. Specifically, when compared to those with no NDDs, children with a language disorder diagnosis showed significantly lower verbal abilities. Table 3 shows comparisons between those with language disorders and those with no NDD across measures. Children with language disorder scored significantly lower on all verbal measures (as expected), and slightly lower on other domains of adaptive functioning, whereas they were rated similarly in social, emotional, and behavioral domains.

Figure 1 depicts the normalized scores across measures of ability (i.e., DAS-II, Vineland-3, and OWLS-2) by diagnostic groups. Figure 2 provides severity scores from parent reported impairment measures with T-scores (i.e., CBCL and SRS). Examination of the figures further illustrates the consistent pattern of depressed language ability across diagnostic groups in the absence of consistently abnormal findings in other domains. As expected, there were clear differences in mean scores between primary diagnostic groups, with the language disorder group showing the lowest scores on measures of verbal ability, except as compared to children meeting criteria for ASD and ID/GDD. Children with language disorder also showed the largest discrepancy between their verbal and non-verbal performance across ability measures. Scores on parent reported measures of social, emotional, and behavioral impairments were more variable, with most parents not reporting scores in the range of clinical concern for their children.

Discussion

Children on Navajo Nation may face challenges in development, in part due to the consequences of poverty, economic disparity, chronic exposures to environmental toxicants, paucity of educational and social programs, and limited access to health care facilities and services. The consequences of historical/transgenerational trauma associated with the "conquest" and chronic maltreatment of indigenous peoples also has an impact on daily life and resources available on Navajo Nation, multiplying the effects of other adversity. These factors have been demonstrated to increase risk for developmental delays in other populations [24,25]. Early identification and intervention for at-risk Diné children is further complicated by substantial challenges, including limited availability of validated assessment tools, few comprehensive normed data on developmental trajectories for Diné children, and limited access to trained indigenous or other clinicians. Despite myriad risk factors, Diné children, as a group, did not demonstrate vulnerabilities across most developmental domains assessed. They did demonstrate consistently delayed performance in language and communication.

We found that the percentage of children meeting criteria for clinical diagnoses, including ASD, language disorder, and speech sound disorder, was higher than would be expected in general, non-indigenous populations [26-28]. Although the sample size is small, the percentage of children meeting ASD criteria was 2-3 times greater than the expected prevalence [29,30]. The percentage of children meeting criteria for speech and language disorder was especially elevated, with 29% of children meeting criteria for a primary diagnosis of language disorder, compared to rates of 6-8% seen in the general population [28]. Additionally, even among those children who did not meet formal diagnostic criteria for a language disorder, scores on measures of verbal ability differed from age-related norms in the general population, while measures of nonverbal ability, spatial skills, and behavior problems did not. These results are not completely unexpected, given our previous demonstrations that infants in our cohort demonstrate more developmental risk on screening measures [16], although communication was not consistently depressed in these infants. Additionally, socio-environmental risk factors and indigenous status may interact in a manner that compounds risk for adverse outcomes [31] and make children more vulnerable to the harmful effects of socio-environmental exposures [32].

Regarding the high percentage of children with concern for ASD, this is something that has not been previously documented and needs further investigation. However, language impairments and ASD are related in terms of comorbidity and symptomatology [23]. It could be that etiological factors involved in increasing risk for one condition also increase risk of multiple neurodevelopmental conditions, and shared risk has been documented for language impairment and ASD [33]. Considering the qualitative behavioral differences needed to meet criteria for ASD and higher reliance on clinical observations and parent reported symptoms than language disorder, we are not as concerned about instrument bias for this finding, however, investigating screening instruments in relation to ASD in our sample is currently underway.

Unlike ASD, language differences in Native American populations have been discussed for some time. There has been a long-standing concern that typically developing Native American children, including Diné, are overidentified by standardized language assessments [34]. Childhood speech and language disorders have been shown to have long-term and broad negative impacts on outcomes, such as social and emotional functioning and academic achievement [35]; this indicates the importance of differentiating speech and language disorders from poor performance that is merely an artifact of test development and norming. Long and Christensen [10] suggest that cultural factors may contribute to early differences in language development for Native American children when compared to White children. Henderson and Restrepo posit several reasons why Diné children, in particular, may score lower on language measures, including linguistic and cultural differences as well as inadequate representation in test development [9]. While it is important to be cautious about over-pathologizing Diné children, focusing solely on the inadequacy of validated clinical measures and tools increases the potential to miss individual-level developmental delays requiring substantial resources for amelioration, or to identify the contributions of disparities in infrastructure and environmental exposures whose reduction could also improve population outcomes.

The present study design attempted to address some of the weaknesses intrinsic to work in this community. In order to address concerns about the cultural-sensitivity of our measures and assessments, we involved Diné staff at multiple levels of our evaluation process, including recruitment, instrument selection, direct assessment, and obtaining parent reports. We also used comprehensive, multi-modal assessment protocols, sampled from multiple locations, and a birth-cohort sample that was not recruited due to presence or history of developmental delay.

The fact that language measures differentiated between children with and without clinical diagnoses in an expected manner suggests that standardized measures were functioning as intended in this sample. However, similar to other studies, those of our study children classified as having no developmental disorders also scored below the norm group averages, scoring approximately one standard deviation below the general population mean on direct assessment using language-based measures and one-half standard deviation below the mean when using parent reported language adaptive skills.

We have arrived at four possible explanations for these findings, individually, or in combination:

1. There are no validated standardized language measures for Diné children:

   The lack of standard measures leads to lower scores for Diné children, even if their language skills are actually typical. The variance is due to the lack of adequate Diné representation in norming samples and resulting bias.

2. Language disorder is more prevalent in Diné children:

   While the standard instruments are not validated with adequate samples of Diné children, they are still validly measuring language levels. This may mean that Diné children are at higher risk for developing language disorder than are children in the general population.

3. There is a different developmental trajectory for language development in Diné children:

Social and biological factors may contribute to developmental patterns for language development that appear to be delayed when compared to the general population of preschoolers, however, on follow-up at a later age, Diné children "catch up" and score similarly to the general population.

4. Environmental factors cause unique patterns of language development:

Diné children are exposed to an extraordinary and atypical pattern of deleterious environmental factors, including low SES, limited educational opportunity, historical trauma, limited access to healthcare, exposure to environmental toxicants, etc. Through yet to be discerned mechanisms, these exposures may create a unique pattern of language development.

We are keenly aware that, to date, we have not included measurements of traditional culture and customs which may function in a protective manner [36]. Future studies and analyses should include cultural and historical contexts and examine a variety of cultural practices and how they may interface with historical trauma to impact child development [3]. Further limitations of this study include issues related to the sample. Our sample was drawn from the larger NBCS cohort which has strengths in being prospective and representative. Participants have re-enrolled in this follow-up as they have become eligible, however, not all eligible participants were included in this sample, and some have not been contacted, chosen not to re-enroll, or moved out of the sampling area, creating potential for bias in our sample. In particular, the potential exists in this smaller subset of participants for an enrollment bias toward caregivers who are concerned about their child's development. Given these limitations, we cannot assume these findings generalize to the population, and a larger sample size is necessary. Additionally, the ability for assessment team members to make diagnostic decisions was limited by lack of validated assessment instruments and existing normative data.

From a clinical perspective, we are reasonably confident that children who scored very low on language and cognitive standardized measures require interventions. This is important in light of prior literature documenting poor academic performance and outcomes among Native American students. Disparities in both reading and math scores have widened since 2005, with Native American students demonstrating severe deficits in academic progress when compared to their non-Native peers [37]. Consequently, relative to other racial and ethnic groups, Native American students have one of the lowest high school graduation rates [38-40]. Before assuming that lower performance on verbal measures is explained by reduced cultural validity of standardized tests, careful longitudinal studies will be necessary to understand the long-term implications of reduced performance that is apparent in preschool. It is possible that clinicians and educators could miss important educational opportunities by overlooking or minimizing below average language performances if there are long-term negative effects on academic and vocational functioning.

Irrespective of the cause of the delays found in our sample, we have an ongoing concern that low language performance in young Diné children may lead to poorer performance in other cognitive and academic domains as the children age. In order to address concerns about developmental trajectory, diagnostic stability, and predictive validity, we have begun a follow-up assessment study. Children are now being seen at age 8-years using similar assessments. These data will be reported when the follow-up is completed. In addition, we are beginning comprehensive analyses to assess relative contributions of sociodemographic and environmental disparities within our cohort. We are also advocating for parent education and professional development for services providers to increase awareness of early signs of neurodevelopmental delays, and appropriate interventions for this at-risk population through close collaborations with local providers on the Navajo Nation.

In conclusion, findings from this NBCS follow-up study indicate that there is an unusually high percentage of children with language disorder and other neurodevelopmental disorders in a sample of Diné preschool children. The current findings also need to be interpreted in a cultural context and not strictly one of child development. Investigating development in this context is vitally important to Diné and other under-represented minoritized children, especially those facing exceptional adversity. In the present study, even among children who did not meet criteria for any formal diagnosis, we observed a consistent pattern of relative weakness in verbal ability compared to average performance in other developmental domains. Previous research in the general population suggests that there are long-term effects of early language delays on later functioning. However, the lack of longitudinal studies with Diné children leaves many unanswered questions. Follow-up studies are needed to assess stability of findings, developmental trajectory, risk and protective factors, and functional implications of these study results, as well as to assess the effectiveness of targeted interventions based the results of these assessments.

The results of this study strongly support the need to further understand development and developmental assessment for Diné children to enable effective intervention and support. It is highly likely that many of the children identified as having a neurodevelopmental disorder in our study will benefit from intervention; however, until issues in assessment and diagnosis are better resolved, resource allocation is difficult. It is imperative that research continues to identify best practices in delineating need and supporting children’s development. Researchers, funding agencies, and public policy makers should also acknowledge and address current disparities in the development of Diné and other Native American children. Clinicians, educators, and researchers can already work with local communities to identify services that can make a difference for children that will significantly benefit from intervention.

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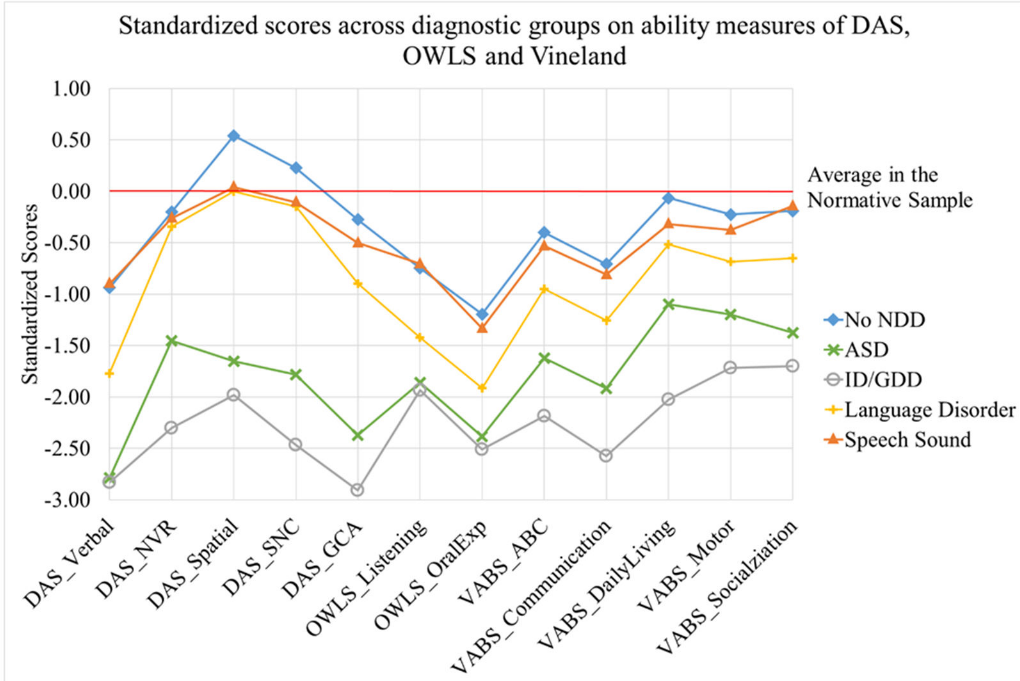

Figure 1.

Line Plot of mean Standardized Scores on Main Abilities Measures across Groups (Higher Scores Better Functioning).

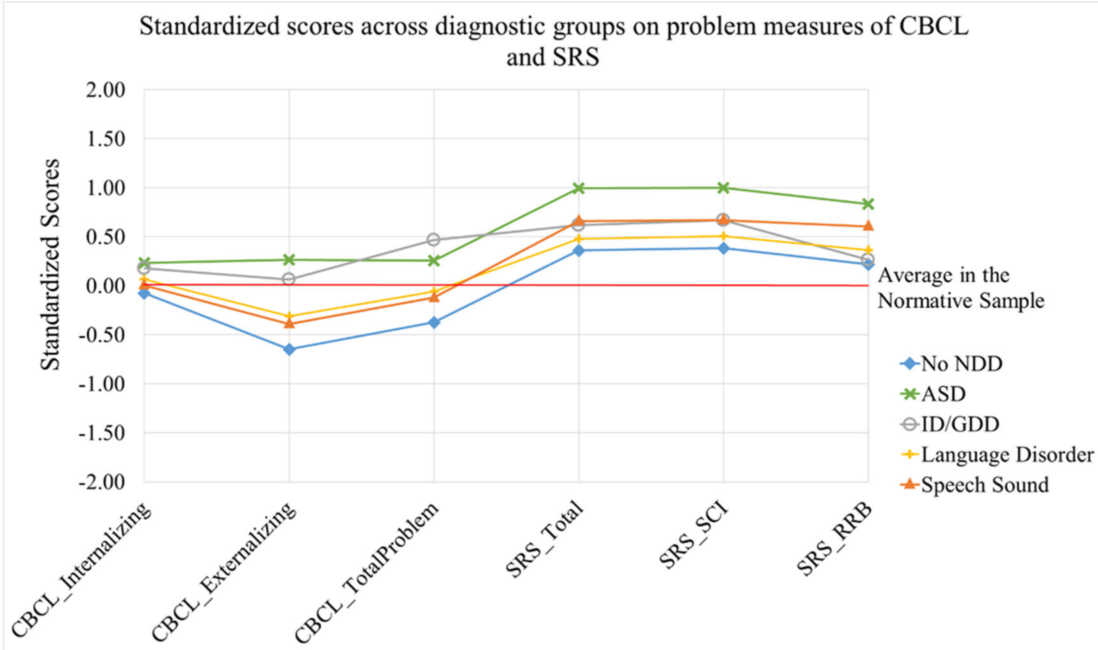

Figure 2. Line Plot of Standardized Scores on Main Impairments Measures across Groups (Higher Scores More Impairments).

Note: Reference Case (Red, Square Markers) was with t scores of 50 before conversion to z scores.

Table 1

Sample Characteristics and Descriptive

		Whole Sample (N=138)		No NDD Diagnosis (N=70)		ASD (N=9)		ID/GDD (N=4)		Language Disorder (N=40)		Speech Sound Disorder (N=15)	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Gender	**Male**	70	50.7%	31	44.3%	8	88.9%	3	75.0%	23	57.5%	5	33.3%
	Female	68	49.3%	39	55.7%	1	11.1%	1	25.0%	17	42.5%	10	66.7%
Income	**Less than 20,000**	79	57.3%	36	51.4%	7	77.8%	3	75.0%	26	65.0%	7	46.7%
	20-39,000	13	9.4%	11	15.7%	0	0.0%	0	0.0%	2	5.0%	0	0.0%
	40,000 or more	15	10.9%	5	7.1%	0	0.0%	1	25.0%	5	12.5%	4	26.7%
	Unknown	31	22.5%	18	25.7%	2	22.2%	0	0.0%	7	17.5%	4	26.7%
Marital Status	**No**	23	16.7%	7	10.0%	3	33.3%	1	25.0%	10	25.0%	2	13.3%
	Yes	101	73.2%	53	75.7%	5	55.6%	3	75.0%	28	70.0%	12	80.0%
	Unknown	14	10.1%	10	14.3%	1	11.1%	0	0.0%	2	5.0%	1	6.7%
Maternal Education Level	**Less than high school**	40	29.0%	22	31.4%	2	22.2%	2	50.0%	12	30.0%	2	13.3%
	Completed high school	38	27.5%	17	24.3%	2	22.2%	2	50.0%	12	30.0%	5	33.3%
	Higher than high school	45	32.6%	21	30.0%	4	44.4%	0	0.0%	14	35.0%	6	40.0%
	Unknown	15	10.9%	10	14.3%	1	11.1%	0	0.0%	2	5.0%	2	13.3%
Primary/Comorbid Diagnoses	**No DD diagnosis**	70	50.72%			**Comorbid Diagnoses**							
	ASD	9	6.52%										
	ID or GDD	4	2.90%			4	44.4%						
	Language Disorder	40	28.99%			4	44.4%	1	25.0%				
	Speech Sound Disorder	15	10.87%			2	22.2%			22	55.0%		

Note: NDD=Neurodevelopmental Disabilities; ASD=Autism Spectrum Disorder; ID/GDD=Intellectual Disabilities or Global Developmental Delays

Table 2

Descriptive Statistics on Developmental and Behavioral Outcome Measures by Diagnostic Groups, including means, standard deviations, and ranges

Mean(SD), Range	Whole Sample (N=138)	No NDD Diagnosis (N=70)	ASD (N=9)	ID/GDD (N=4)	Language Disorder (N=40)	Speech Sound Disorder (N=15)
Child Age (in months)	51.74(4.90), 42.6-66.8	52.49(5.38), 42.6-66.8	50.59(3.25), 45.2-55.8	48.48(2.26), 46.3-51.6	51.54(4.75), 43.7-63.1	50.41(3.75), 43.8-60
DAS Verbal StdScore	79.28(15.28), 34-117	85.69(11.28), 59-117	57.44(16.87), 34-81	56.75(12.23), 49-75	72.92(13.68), 39-107	86.27(10.10), 69-111
DAS NVR StdScore	94.06(12.40), 48-121	96.99(10.58), 74-119	78.22(13.32), 61-102	65.50(12.29), 48-75	94.85(9.20), 78-113	96.07(11.34), 78-121
DAS Spatial StdScore	101.55(17.81), 54-149	108.10(17.09), 75-149	75.22(17.22), 54-103	70.25(7.80), 59-77	99.95(12.32), 63-118	100.60(10.22), 70-115
DAS SNC StdScore	97.94(15.19), 45-132	103.43(13.16), 74-132	72.89(15.67), 50-94	62.50(12.37), 45-73	97.74(8.55), 77-115	98.40(9.26), 77-115
DAS GCA StdScore	89.78 (14.61), 44-123	95.99 (12.31), 70-123	65.33(13.05), 44-83	71 (1), 70-72	86.89 (8.31), 67-108	92.67 (10.40), 71-116
OWLS Listening StdScore	84.22(11.13), 61-114	88.78(10.78), 66-114	72.11(7.20), 61-82	71.00(1.00), 70-72	78.70(7.62), 64-104	89.40(9.66), 71-106
OWLS Expression StdScore	76.93(10.76), 58-107	82.06(10.10), 63-107	64.22(4.38), 58-71	62.33(4.04), 60-67	71.28(6.53), 58-89	80.00(10.50), 68-107
Vineland ABC StdScore	89.72(14.54), 55-124	94.17(13.71), 67-124	76.44(9.77), 63-96	68.25(6.08), 61-75	86.22(13.72), 55-113	92.27(12.80), 76-123
Vineland Communication StdScore	84.63(15.14), 40-115	89.27(12.61), 56-115	71.00(16.73), 42-100	61.00(11.83), 52-78	80.97(15.53), 40-108	87.73(12.47), 71-115
Vineland Daily Living StdScore	94.82(14.68), 62-126	99.03(13.98), 73-126	83.89(11.77), 70-102	70.25(2.22), 67-72	92.41(13.62), 62-120	95.33(13.74), 72-120
Vineland Motor Skill StdScore	92.67(13.16), 65-138	96.62(13.27), 72-138	82.00(12.48), 71-106	74.25(8.69), 65-85	89.74(10.05), 73-109	94.33(12.78), 72-121
Vineland Socialization StdScore	93.34(13.86), 58-126	97.15(13.33), 70-126	79.33(9.25), 68-92	74.50(12.37), 58-84	90.24(12.98), 60-116	97.87(10.06), 81-118
CBCL Total Problems Tscore	50.22(11.49), 29-84	49.46(12.69), 29-84	52.56(9.26), 43-65	52.00(17.69), 33-68	50.88(10.24), 33-75	50.27(9.71), 33-68
CBCL Internalizing Tscore	45.34(10.45), 28-82	43.21(10.47), 28-82	52.78(7.36), 42-62	50.67(13.05), 37-63	46.75(10.25), 28-68	45.93(10.17), 28-64
CBCL Externalizing Tscore	48.07(11.65), 28-85	46.27(12.38), 28-85	52.56(8.20), 40-65	54.67(15.28), 38-68	49.43(11.09), 29-74	48.80(10.26), 31-68
SRS Total Tscore	54.90(10.28), 0-74	53.71(12.25), 0-74	60.22(6.65), 49-71	56.33(3.06), 53-59	54.93(7.43), 41-73	56.80(8.92), 42-74
SRS Social Communication Impairments Tscore	55.20(10.45), 0-75	54.00(12.36), 0-75	60.44(6.52), 50-72	57.00(4.58), 52-61	55.28(7.84), 40-74	57.00(9.13), 43-75
SRS Repetitive Restricted Behaviors Tscore	53.46(10.85), 0-78	52.19(12.79), 0-78	58.33(9.33), 46-70	52.67(3.06), 50-56	53.63(7.97), 43-69	56.07(9.03), 40-72
CARS Total Raw Score	18.21(4.64), 14-43	16.96(2.69), 15-27	31.17(6.35), 21-43	21.75(3.80), 17-25.5	17.85(2.79), 15-25	16.10(1.11), 14-18.5

Note: DAS=Differential Ability Scales; NVR=nonverbal reasoning; SNC=Special Nonverbal Composite; GCA= General Conceptual Ability; OWLS=Oral & Written Language Scales; ABC=Adaptive Behavior Composite; CBCL=Child Behavior Checklist; SRS=Social Responsiveness Scale; CARS=Childhood Autism Rating Scale

Table 3

T-test Results Comparing Developmental and Behavioral Outcome between Children with Clinically Significant Language Problems and Those without NDDs

	Language Disorders	No NDD Diagnosis		
	Mean(SD)	**Mean(SD)**	**t Value**	***p***
DAS Verbal StdScore	76.63 (14.05)	85.69 (11.28)	3.93	<.001
DAS NVR StdScore	95.19 (9.75)	96.99 (10.58)	0.96	0.337
DAS Spatial StdScore	100.1 (11.68)	108.1 (17.09)	2.92	0.004
DAS GCA StdScore	88.53 (9.23)	95.99 (12.31)	3.67	<.001
OWLS Listening StdScore	91.62 (9.45)	88.78 (10.78)	3.82	<.001
OWLS Expression StdScore	73.65 (8.65)	82.06 (10.10)	4.86	<.001
Vineland ABC StdScore	88.00 (13.62)	94.17 (13.71)	2.42	0.017
Vineland Communication StdScore	82.92 (14.91)	89.27 (12.61)	2.51	0.014
Vineland Daily Living StdScore	93.25 (13.58)	99.03 (13.98)	2.26	0.026
Vineland Motor Skill StdScore	93.04 (10.96)	96.62 (13.27)	2.45	0.016
Vineland Socialization StdScore	92.40 (12.62)	97.15 (13.33)	1.98	0.050
CBCL Internalizing Tscore	50.71 (10.01)	49.46 (12.69)	−0.60	0.550
CBCL Externalizing Tscore	46.53 (10.41)	43.21 (10.47)	−1.78	0.077
SRS Social Communication Impairments Tscore	55.75 (8.17)	54 (12.36)	−0.90	0.369
SRS Repetitive Restricted Behaviors Tscore	54.29 (8.26)	52.19 (12.79)	−1.06	0.293

Note: N ranged from 51-55 for measures in Language Disorder group and 64-70 in the No NDD group.