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Use of Ages and Stages Questionnaires™ (ASQ) in a Navajo population: Comparison with the U.S. normative dataset

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Abstract

Background—The Ages and Stages Questionnaires-Third Edition (ASQ-3) is a parent-completed screening to identify young children at-risk for developmental delays in the United States and internationally. Federal programs operating on Navajo Nation use the ASQ-3 to determine the need for early intervention services, even though the ASQ-3 national sample used to establish cutoff scores for referral included only 1% Native American children.

Objectives—The current study aimed to compare the ASQ-3 results from a sample of Navajo infants to those from a representative national U.S. sample and to examine the specificity and sensitivity of the ASQ-3 in Navajo population.

Methods—The sample included 530 Navajo infants (47.3% males) aged between 1 and 13 months who lived in remote and rural areas across the Navajo Nation. Children's development was assessed during home visits at 2-, 6-, 9-, and 12-month assessment windows.

Results—Results showed that after 6 months, Navajo children had lower mean scores and higher percentages of children at-risk for developmental delays than those from the national sample. The sensitivities and specificities, estimated using a Bayesian diagnostic approach under both

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conservative and nonconservative prior range choices, suggested a comparable validity performance to that from other ASQ-3 studies.

Discussion—The results of this study along with our ongoing comprehensive assessments at 4 years of age inform current programs working with Navajo children to improve early identification of developmental delays.

Keywords

Ages and Stages Questionnaire; developmental delays; infancy; Navajo children; screening tool

1 | INTRODUCTION

Early screening for developmental delays using easily administered and inexpensive tools is essential for timely referral and follow-up, especially for children who live in rural areas and/or in isolated racial or ethnic communities that are underserved in early intervention services where children with delays are frequently not identified until after entry into school (Bear, 2004; Janvier et al., 2016; Koegel, Koegel, Ashbaugh, & Bradshaw, 2014). Therefore, ensuring that existing screening tools provide an adequate assessment of children's developmental status in these populations has a significant value (Bear, 2004; Singh, Yeh, & Boone Blanchard, 2017). In this study, we evaluated how children from a Navajo population performed on a widely used screener, the Ages and Stages Questionnaires-Third Edition (ASQ-3; Squire, Twombly, Bricker, & Potter, 2009; Squires, Twombly, Bricker, & Potter, 2010), relative to children in a national U.S. sample, and estimated the sensitivities and specificities of the ASQ-3 at different age windows.

The ASQ-3 is a developmental screening tool widely used by clinicians, researchers, and intervention programs across the United States (Glascoe, 2005) as well as countries outside of the United States (Chong et al., 2017; Lima et al., 2017; Moksnes & Espnes, 2011; Romero Otalvaro et al., 2018; Toghyani, Sharafi Shorabi, Sharafi Shorabi, & Ghahraman Tabrizi, 2015; Vameghi et al., 2013). Because the instrument is parent-completed, it provides an efficient and cost-effective method of collecting information regarding a child's development without the need to involve trained assessors and with the added advantage of including parents' opinions and input in the assessment process (Heo, Squires, & Yovanoff, 2008; Singh et al., 2017; Squires, Bricker, & Potter, 1997). The ASQ-3 is comprised of 21 age-specific questionnaires for children ages 1 to 66 months to assess children's progress in five developmental domains.

Each of the five domains has six questions, resulting in 30 scored items for each age interval. Children who are potentially at-risk for developmental delays at each age-interval may be identified by comparing their scores to cutoff scores. The ASQ-3 cutoff scores (i.e., two standard deviations below the mean) were established using data from over 18,000 completed ASQ-3 protocols from children with diverse ethnic and social backgrounds representative of the U. S. 2006 census population distribution (Squire et al., 2009; Squires et al., 2010).

Although the ASQ-3 is routinely used by several programs serving Native American children (e.g., Growing In Beauty), only a few studies outside of the United States (e.g., Canadian First Nations) have examined the use of this screening tools in Native populations (D'Aprano et al., 2016; Dionne, McKinnon, Squires, & Clifford, 2014). Thus, the goals of this study were (a) to compare ASQ-3 scores for Navajo children between 1 and 13 months to those in a national sample, focusing on average domain scores and proportion of children at-risk for delays, and (b) to examine specificities and sensitivities of the ASQ-3 in this population.

2 | METHODS

2.1 | Participants

Participants in the current study were part of the Navajo Birth Cohort Study (NBCS), a prospective birth cohort study initiated to examine the effects of environmental uranium exposure on Navajo children's health and developmental outcomes across the first year of life. Pregnant Navajo women were recruited across two Indian Health Services (IHS) service unit districts in New Mexico (Gallup and Shiprock) and four in Arizona (Tsehootsooi [Public Law-638], Chinle, Kayenta, and Tuba City [Public Law-638]). Inclusion criteria for mothers in the NBCS were (a) between 14 and 45 years of age with a confirmed pregnancy, (b) willing to deliver at a participating Navajo Area Indian Health Service or PL-638 hospital, (c) willing to have their child followed-up for about 12 months, and (d) residence on the Navajo Nation for at least 5 years. Children in the current study were a subsample of NBCS children who had ASQ-3 screening results between 1 and 13 months of age ($N = 530$, 41.9% females).

2.2 | Ethical approval

The approval for this study was obtained from the University of New Mexico, Health Sciences Center's Human Research Review Committee (no. 11–310), as well as Navajo Nation Human Research Review Board (no. NNR-11.323).

2.3 | Procedure

Trained Navajo field staff conducted up to four home visits with children targeting 2-, 6-, 9-, and 12-month assessment windows (±1 month). In some cases, home visits occurred at different ages (e.g., 4 or 8 months old) due to scheduling issues that also affected the frequency of completed assessments in this remote area with minimal communication infrastructure. During each home visit, the field staff interviewed an infant's mother or alternate caregiver about the child's developmental abilities using the Ages and Stages Questionnaire- INVENTORY (ASQ:I), an alternative measure comprised of all ASQ-3 items organized in a hierarchical order. The ASQ:I includes all the items from the 21 ASQ-3 intervals across all five domains:

1. *communication* (e.g., "Does your baby make high-pitched squeals?"),
2. *gross motor* (e.g., "When your baby is on her back does she kick her legs?"),
3. *fine motor* (e.g., "Does your baby pick up a small toy with only one hand?"),

4. *problem-solving* (e.g., “Does your baby pick up a toy and put it in her mouth?”), and
5. *personal-social* (e.g., “Does your baby feed himself a cracker or a cookie?” and “Does your baby smile at you”).

The main difference between the ASQ:I and the ASQ-3 is that the ASQ-3 presents a limited number of items within an age-specific scale (i.e., six items per domain) to identify risk for delay at one point in time, whereas the ASQ:I presents the entire list of ASQ items (i.e., 65–70 items) by domain as a continuous measure in order to monitor progress over time (Chen, 2013; Clifford et al., 2018).

As the ASQ:I does not yet have established norms, results could not be used to estimate the developmental status of the children in the study. However, initial studies have suggested that ASQ-3 results derived from the ASQ:I are highly correlated with the ASQ-3 scores obtained from direct administration of surveys (J. S. Clifford, 2012b). Because the main goal of this study was to compare prevalence of delays in this population relative to a national sample, a table that aligns items on the ASQ:I with ASQ-3 items was used to extract responses from each child’s ASQ:I in order to complete an ASQ-3 for each child (Clifford, 2012a; J. S. Clifford, 2012b). Children’s scores on the ASQ:3 were then compared with the cutoff scores to determine each child’s developmental status (i.e., at risk for delay or developing on schedule).

In this study, six ASQ-3 age intervals were used for children from 1 to 13 months: 2 months (1 month through 2 months 30 days; *mean* = 2.18), 4 months (3 months through 4 months 30 days; *mean* = 3.55), 6 months (5 months through 6 months 30 days; *mean* = 6.12), 8 months (7 months through 8 months 30 days; *mean* = 8.25), 10 months (9 months through 10 months 30 days; *mean* = 9.56), and 12 months (11 months through 12 months 30 days; *mean* = 12.11). According to recommended ASQ-3 procedures, adjusted age was used to determine the appropriate ASQ-3 for children who were preterm (i.e., gestational age < 37 weeks; $N = 38$, 7.2% of the sample). Three children were excluded from further analysis because their corrected age was less than 1 month.

2.4 | Cultural considerations of ASQ-3 items

Prior to administration, a collaborative group of researchers, clinicians, and Navajo community members assessed items to ensure their cultural appropriateness. Four items involving children’s use of a mirror were noted as potentially culturally irrelevant in the Navajo population. These items were not removed, but our field staff were aware that participants may decline to answer these questions. For these items, we used the score adjustment procedure recommended by developers in the ASQ-3 user’s guide (Squire et al., 2009), which applies in the presence of missing items to ensure that the child’s score is not artificially lowered due to unanswered items. No more than two missing items per domain are permitted. Because Navajo is historically not a written language and is descriptive rather than literal, items were not translated to Navajo. All field staff were fluent Navajo speakers and able to provide description for each item when needed in Navajo; however, only 2.8% of participants in the total NBCS sample reported speaking Navajo at home and all caregivers in the current study opted to complete the questionnaire in English.

2.5 | Plan of analysis

Descriptive statistics were calculated for key socio-demographic variables. All variables including ASQ-3 scores, stratified by age group and domain, were assessed for normality and existence of outliers. Children with ASQ-3 scores and those in the original sample who had no assessment were compared with regard to demographic variables. Given the nonnormal distribution of some demographic variables (e.g., gestational age and infant weight), Pearson's exact chi-square for categorical variables and Kruskal-Wallis tests for continuous variables were performed for these analyses.

ASQ-3 mean scores across five domains and six time points were computed for NBCS data. Given the nonnormality of ASQ-3 data, we performed one-sample *t* tests using 2,000 bootstrap samples and 95% confidence intervals (CIs) to examine differences in ASQ-3 scores between the NBCS and national sample (Hesterberg, 2015; Martin, Razza, & Brooks-Gunn, 2012). Further, the proportion of children with scores below cutoff was determined using Pearson's exact chi-square tests.

The sensitivity and specificity of the ASQ-3 in this population were examined using a Bayesian approach (Joseph, 1997; Joseph, Gyorkos, & Coupal, 1995). This approach gave us the ability to estimate the prevalence of at-risk children (children who have at least one ASQ-3 domain score below the established cutoff), and sensitivity and specificity of the test simultaneously in the absence of a gold standard. A Bayesian approach typically uses the mean of the joint posterior distribution (generated from the existing data) to estimate the parameters, where the joint posterior distribution is proportional to the product of data likelihood and prior distributions (based on assumptions from previous work) of parameters. In the Bayesian approach by (Joseph et al., 1995; Joseph, 1997), prior distributions of sensitivity, specificity, and prevalence were specified as Beta distributions that had the means as the centre of prespecified ranges and standard deviations as a quarter of those ranges. A Gibbs algorithm was used to obtain posterior samples of these parameters, which were further summarized to obtain Monte Carlo means and parameters' 95% Bayesian credible intervals.

Due to a lack of a gold-standard for identifying children with delay in this population, it is necessary to use prior distributions and to borrow information from other studies to reflect assumptions regarding prevalence, sensitivities, and specificities. The prior information used in the current study was borrowed from the ASQ-3 U.S. psychometric study. The established 99% CI for sensitivity in the ASQ-3 U.S. study for age group 2 to 13 months was from 0.698 to 0.993 and for specificity was from 0.826 to 0.999. These CIs were used as approximate ranges for the parameters. Also, although the percentage of children at-risk for delay in the original ASQ-3 study ranged from 0 to 20% across 2 to 13 months, we assumed the prevalence to range from 0 to 30% for the Navajo population to be more conservative. Further, to determine the dependence of our results on our prior assumptions, we analysed how manipulations of priors beyond those from the U.S. study affected the results. Specifically, in one analysis, we changed the priors for the prevalence of delayed children to range from 0 to 0.1 (10%) to establish confidence of lower percentage of children who are truly at risk. In a separate analysis, we changed the priors of sensitivity and specificity to range from 0.5 to 1, indicating that ASQ3 instrument performs better than random guessing

(Juneja, Mohanty, Jain, & Ramji, 2012; Schonhaut, Armijo, Schonstedt, Alvarez, & Cordero, 2013; Singh et al., 2017). Without a gold-standard, the results would be sensitive to prior assumptions. Nevertheless, reasonable prior assumptions help us examine the possible ranges of sensitivities and specificities.

3 | RESULTS

3.1 | Sample demographics and attrition analyses

The summary statistics for demographics are presented in Table 1. Five-hundred and thirty children had ASQ assessment data for two or more assessment window: 2 months (N = 311, 42.4% females), 4 months (N = 72,44.4% females), 6 months (N = 323,42.4% females), 8 months (N = 144, 38.2% females), 10 months (N = 254, 44.1% females), and 12 months (N = 318, 45.6% females). The majority of caregivers interviewed on ASQ:I were mothers (94%), with other caregivers (e.g., fathers and grandmothers) providing responses for the remaining 6%. The number of assessments was fewer at 4 and 8 months because these age groups were not targeted for data collection in the study.

Missing ASQ assessments resulted from participant withdrawal from the study or challenges involved in data collection in these remote Native American communities with minimal infrastructure. Analyses were performed to compare family demographic differences between children with and without ASQ assessment (N = 93). The results showed that the two groups did not differ on demographic variables with one exception. Mothers of children who had no ASQ assessment were slightly younger than mothers of children with ASQ assessments, *means* = 25.96 and 27.60 (p-values = .05), respectively.

3.2 | ASQ-3 scores for NBCS sample

The means and standard deviation values for ASQ scores across various domains and age intervals for children in the NBCS are reported in Table 2. Sex differences observed for 10- and 12-month communication favoured girls: *means* = 47.32 and 53.01 for females compared with *means* = 43.19 and 50.38 for males at 10- and 12-month assessments, respectively (p-values < .01). Females scored slightly higher than males on 10-month problem-solving, *means* = 49.13 and 45.64, p-value = .05. No other significant differences by sex were observed. The demographic variables that were associated with ASQ-3 scores were gestational age, birthweight and height, and annual income. Gestational age was positively associated with all domains at 12 and 6 months, and 2-month gross motor and personal-social scores. Birthweight and height were positively associated with 6-month communication, gross motor, problem-solving, and personal-social scores. Annual income was negatively associated with 2-month problem solving and positively with 12-month fine motor.

3.3 | Comparison of ASQ scores between NBCS and national samples

Significant mean differences between the NBCS and the national samples are illustrated in Figure 1. Mean scores were different for all domains and time points except for 2- and 6-month gross motor, and 12-month gross motor, problem-solving, and personal-social domains. With the exception of communication domains, Navajo children had significantly

lower scores on other domains across 3–13 months, and differences were particularly pronounced at the 10-month assessment window.

The proportion of Navajo children who fell below ASQ-3 cutoff scores was higher than those in the national sample on (a) communication domain at 4 months; (b) gross motor domain at 4, 6, and 10 months; (c) fine motor at 8, 10 and 12 months, (d) problem-solving at 4, 6,10, and 12 months; and (e) personal-social at 4 and 10 months (see Table 3 and Figure 2). The percentages of Navajo children below U.S. cutoff scores (i.e., at-risk for delay) were particularly high at 10-month assessment window. The proportions of Navajo children in the at-risk group generally did not differ by family socio-demographic variables or child's sex. Notably, a higher percentage of males than females were identified as at-risk on 12-month personal-social domain (10.8% versus 3.5% for males and females, respectively, $p < .05$). In addition, children in the at-risk group at 8 and 12 months were associated with lower gestational age at birth, despite the implementation of age correction. Children in the at-risk group at 2 months also had lower birthweight compared with children in other group. No other significant differences were observed in terms of annual family income, maternal age at childbirth, or maternal employment.

3.4 | Specificity and sensitivity of ASQ-3

Sensitivities and specificities across different age intervals using Monte Carlo means of posterior samples and their 95% credible intervals are summarized in Table 4. These results suggested reasonable estimated sensitivity and specificity values (Monte Carlo means) for all age groups between 1 and 13 months. Specifically, the estimated sensitivities were above 80%, indicating that if a child between 1 and 13 months is delayed, there is more than 80% probability for the child to be identified as at-risk for delay using the ASQ-3 instrument. The estimated specificities were all above 85%, indicating that if a child between 1 and 13 months is truly not at risk, there is more than 85% probability for the child to be classified as developing on schedule. The 95% credible intervals show the variability of the posterior distributions of the parameters. For example, the sensitivity of 2-month age group had 95% probability to be between 0.653 and 0.955. When we changed the priors of prevalence to range from 0 to 10%, the estimated sensitivities were 0.843, 0.857, 0.853, 0.857, 0.866, and 0.852, and the estimated specificities were 0.921, 0.806, 0.861, 0.824, 0.634, and 0.869, respectively, for each age group. When we changed the priors of sensitivities and specificities to range from 0.5 to 1, the estimated sensitivities were 0.707, 0.749, 0.727, 0.742, 0.772, and 0.726, and the estimated specificities were 0.926, 0.761, 0.872, 0.816, 0.625, and 0.879. In summary, prior choices on prevalence, sensitivities, and specificities have a significant impact on the corresponding posterior inference. Nevertheless, the estimated sensitivities and specificities were mostly above 70%, suggesting a comparable validity performance to that from other ASQ-3 studies.

4 | DISCUSSION

The current study examined the patterns of mean scores for the ASQ-3 in a sample of Navajo children during the first year of life. Understanding how this widely used and well-validated screener functions in Navajo culture has important implications for Navajo

children ensuring that they can take advantage of early identification and thus appropriate and early interventions, even though the results from screening tools may not always translate to clinical diagnosis. In terms of raw scores, results indicated that across 4 and 10 months, Navajo children scored lower in four developmental domains (i.e., gross motor, fine motor, problem solving, and personal-social) than children in the national sample. Further, the proportions of children identified at-risk for delays across 6 and 13 months in these four domains were higher than the proportions in the ASQ-3 national sample, with largest differences observed at the 10-month window. Lastly, the estimated sensitivity and specificity of each age group between 1 and 13 months showed reasonable performance of the instrument as a screening tool in this population.

The mean differences in domain scores and percentages of children at-risk for delay, particularly at the 10-month window, may be attributed to cultural practices such as cradle boarding (i.e., traditional Native American baby carrier, which may restrict and hinder children's body movement and development of motor skills) or differences between the current and national samples with regard to the families' socioeconomic status. The differences might also be due to variability across cultures in terms of how questions are perceived or how the developmental activities are structured in Navajo communities. For example, in the 10-month gross motor, three items (out of six items) that involved using furniture as a means of support were endorsed as "not yet" by the majority of mothers, which may have affected final mean scores (see Table 5). The use of furniture for facilitating gross motor skills may be common in urban communities where children are surrounded by a fewer number of adults who can assist or hold children. Yet, it is possible that in the Navajo community where childrearing responsibilities are shared among a larger number of adults living in the same household, young children have less opportunity to learn how to use large objects and furniture to promote gross motor skills (e.g., standing upright). The list of items at 10 and 12 months that was more frequently rated as "not yet" by mothers are indicated in Table 5. A closer and detailed analysis of single items using appropriate statistical methods such as item response theory may help in the future to detect item-level differences and item functioning between national and NBCS samples. Lastly, the mean age within the 10-month window was closer to the low-end than upper- end of age range, which may have contributed to low children's mean domain scores in the current sample.

Navajo children scored higher on communication at 12-month compared with children in the national sample. Further, sex differences favouring females were found within the current sample, which are consistent with previous evidence showing that females surpass males in communication and language skills (Johnson, Caskey, Rand, Tucker, & Vohr, 2014; Murray, Johnson, & Peters, 1990). One potential explanation may be due to the large number of people living in the same household in this sample, ranging from 1 to 15 persons and mean of 5.40 persons per room, compared with national sample. Early communication skills (e.g., use of sounds, eye-gaze, pointing, and attention getting) are important predictors of language abilities later in life (Cates et al., 2012; Morales, Mundy, & Rojas, 1998). Through our ongoing studies with this cohort, we are able to examine the course of development of communication skills among Navajo children beyond the first year and the relations between these early communication skills and later language abilities.

We also tested the sensitivity and specificity of the ASQ-3 instrument, which are important forms of validation that need to be considered when implementing a measure in Native American populations such as Navajo that differ culturally and linguistically from the overall U.S, population from which the norms were developed. The estimated sensitivities and specificities, given several different sets of prior distribution assumptions, were above 70% across 1–13 months on average, showing that the ASQ-3 has comparable screening performance for the Navajo population to that for the infants in other populations (Bian, Yao, Squires, Wei, Chen & Fang, 2010; Dionne et al., 2014; Schonhaut et al., 2013; Squires et al., 2010). Future research with this cohort utilizing 4-year assessments, currently being collected, examine other performance measures such as criterion, content, and predictive validity for these early assessments relative to longitudinal measures of development.

The current study has several potential limitations. First, the ASQ: I's administration format is interview-based or parent-assisted compared with the ASQ-3 parent-completed format, which may affect the responses. Thus, it might be optimal to use the same administration format for comparisons across populations in future studies. Second, with the lack of a gold-standard reference, sensitivity and specificity were estimated using the Bayesian inference, which is sensitive to the choice of prior information. We investigated the impact of various priors and concluded that ASQ3 instrument is a reasonable screening tool for this population. However, despite our efforts of examining sensitivities and specificities using reasonable prior guesses, there is still a possibility that these prior distributions are not flexible enough to include the true sensitivities and specificities, for example, when the ASQ-3 instrument performs worse than random guessing for Navajo infants or the prevalence of delay is unusually high. Lastly, the survey was administered once not allowing us check for the stability of parents' responses. Future research with this population needs to consider testing for the reliability including test-retest and interrater reliability in this population.

Nevertheless, the current study was the initial step to examine the utility of ASQ-3 in a large U.S. sample of non-urban Native American children living on a reservation. As Growing In Beauty within the Navajo Department of Education typically sees children after they reach school age, this study and future work through our later assessment focusing on predictive validity of ASQ-3 may allow for earlier assessment and improvement of early intervention services.

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Key Message

- Early screening for developmental delays using easily administered tools is especially important for children with low access to health care centres such as children living in rural and remote areas.
- The Ages and Stages Questionnaires-Third Edition (ASQ- 3) is a screening tool that has been used by several intervention programs across Navajo Nation even though the ASQ-3 measure has not been examined in this population.
- The estimated sensitivities and specificities showed that ASQ-3 can be used to screen Navajo children across 1 and 13 months.
- The proportions of children at-risk for delay in four developmental domains including gross motor, fine motor, problem solving, and personal-social domains were higher than those observed in the national sample.
- Through our ongoing studies with this cohort, we will be able to examine the true predictive validity of this screening tool.

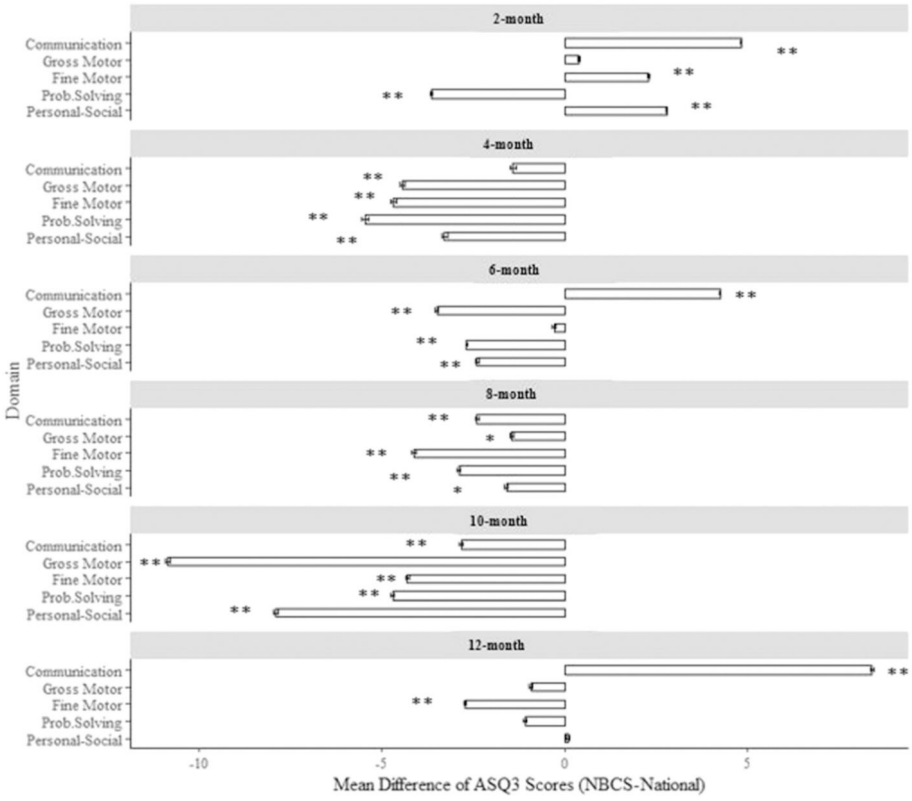

FIGURE 1.

Mean differences between children in Navajo Birth Cohort Study and national samples across developmental domains and time points using 1,000 bootstrapping resampling with 2,000 replicates. Note that the significant differences are indicated by ** $p < .001$ and * $p < .01$

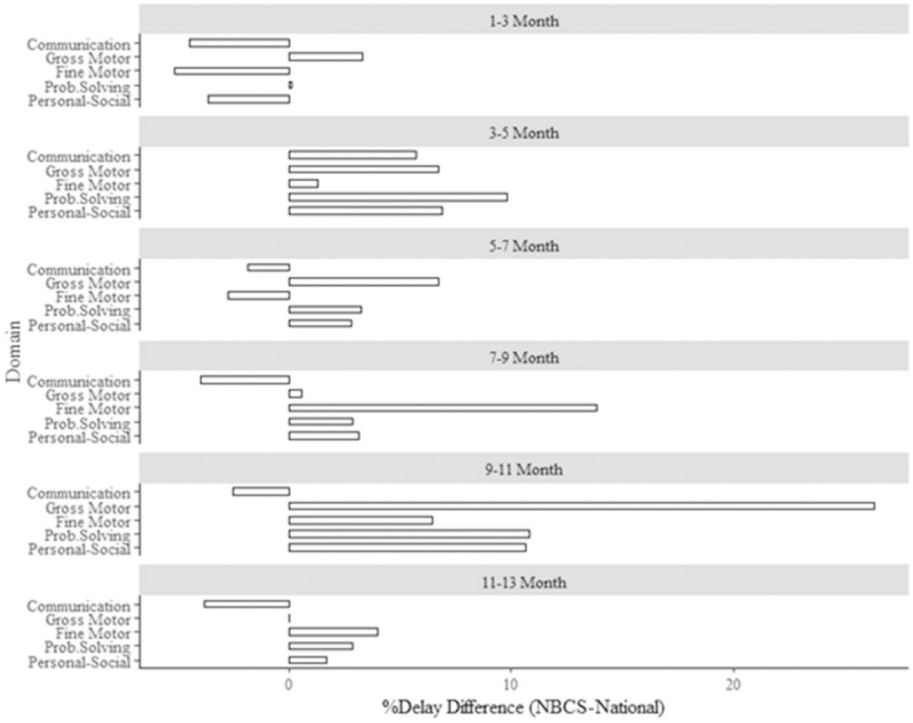

FIGURE 2.
%Delay difference between NBCS and national children

TABLE 1

Demographic and social economic characteristics for study subjects

Categorical variables	***N* (%)**
Annual income	
≤$4,999	103 (19.4%)
$5,000–$9,999	92 (17.4%)
$10,000–$19,999	74 (14.0%)
$20,000–$39,999	76 (14.3%)
$40,000–$69,999	48 (9.1%)
More than $70,000	17 (3.2%)
Do not know	98 (18.5%)
Refused	1 (0.2%)
Maternal education	
Less than high school	115 (21.7)
High school graduate	175 (33.0%)
Bachelor's degree	14 (2.6%)
Some college, no degree	141 (26.6%)
Associate degree	51 (9.6%)
Graduate or professional degree	6 (1.1%)
Other	9 (1.7%)
Marital status	
Married	412(77.7%)
Employment	
Employed full time	102 (19.2%)
Employed Part time	37 (7.0%)
Self-employed	25 (4.7%)
Unemployed	349 (65.8%)
	Mean (*SD*) Min-Max
Maternal age at birth	27.60 (5.89) 16–43
Gestational age (weeks)	38.81 (1.56) 30.00–42.00
Infants' weight at birth (lb)	7.30 (1.21) 2.76–10.27
Number of people per room	5.40 (2.17) 2–15

Note. $N = 530$.

TABLE 2

Summary statistics of ASQ3 scores for NBCS children by domain and age (month)

Age	Statistics	Communication	Gross motor	Fine motor	Problem-solving	Personal-social
2 months	Mean (*SD*)	52.5(7.0)	55.7(7.4)	52.1(8.0)	44.8(9.0)	53.4(7.0)
	Median (Max-Min)	50(30–60)	60(25–60)	53(25–60)	45(10–60)	55(30–60)
4 months	Mean (*SD*)	50.9(11.0)	50.2(9.8)	46.8(11.6)	48.3(12.9)	48.5(11.0)
	Median (Max-Min)	55(20–60)	50(25–60)	48(15–60)	50(10–60)	50(20–60)
6 months	Mean (*SD*)	53.2(8.1)	42.2(13.8)	48.7(12.3)	47.7(13.4)	45.9(13.0)
	Median (Max-Min)	55(20–60)	45(0–60)	50(0–60)	50(0–60)	50(0–60)
8 months	Mean (*SD*)	55.3(7.2)	50.6(11.1)	51.7(12.5)	51.0(11.0)	51.8(9.8)
	Median (Max-Min)	60(30–60)	55(10–60)	60(0–60)	55(5–60)	55(10–60)
10 months	Mean (*SD*)	45.3(11.7)	42.1(14.4)	50.4(11.8)	47.5(13.2)	41.6(15.1)
	Median (Max-Min)	45(15–60)	45(0–60)	55(10–60)	50(0–60)	45(0–60)
12 months	Mean (*SD*)	51.6(11.2)	49.0(13.4)	49.5(11.2)	47.9(13.4)	45.9(13.5)
	Median (Max-Min)	55(10–60)	50(0–60)	50(0–60)	50(0–60)	50(0–60)

Abbreviations: ASQ3: Ages and Stages Questionnaires-Third Edition; NBCS: Navajo Birth Cohort Study.

TABLE 3

Proportion of children with scores below cutoff in national and NBCS samples

	Communication		Gross motor		Fine motor		Problem-solving		Personal-social	
Age	**N.U.S. %Delay**	**NBCS %Delay**	**N.U.S. %Delay**	**NBCS %Delay**	**N.U.S. %Delay**	**NBCS %Delay**	**N.U.S. %Delay**	**NBCS %Delay**	**N.U.S. %Delay**	**NBCS %Delay**
2 months	4.5	0.0**	5.4	8.7	6.8	1.6**	3.1	3.2	4.3	0.6**
4 months	4	9.7*	4.4	11.1*	4.3	5.6	4.1	13.9**	4.2	11.1*
6 months	2.8	0.9	4.1	10.8**	6.5	3.7	5.1	8.4*	5.1	7.9
8 months	5.4	1.4*	6.4	6.9	5.6	19.4**	6.2	9.0	5.2	8.3
10 months	4.1	1.6	5.5	31.9**	5.4	11.9**	5.1	15.9**	4.5	15.1**
12 months	5.7	1.9**	6	6.0	3.6	7.5**	4.7	7.6*	5	6.6

Abbreviations: NBCS: Navajo Birth Cohort Study; N.U.S.: national sample.

*$p < .05$.

**$p < .01$.

TABLE 4

Monte Carlo means and 95% credible intervals of sensitivity and specificity using priors from the U.S. ASQ-3 study

Age	2 months	4 months	6 months	8 months	10 months	12 months
Sensitivity	0.835 (0.653–0.955)	0.859 (0.707–0.963)	0.843 (0.672–0.957)	0.855 (0.698–0.963)	0.891 (0.771–0.969)	0.842 (0.670–0.960)
Specificity	0.941 (0.892–0.982)	0.885 (0.776–0.969)	0.913 (0.840–0.973)	0.897 (0.801–0.971)	0.855 (0.710–0.959)	0.917 (0.848–0.975)

Note. Monte Carlo mean is the numerical mean of posterior samples. The 95% credible interval is the range between 2.5% and 97.5% quantile of posterior samples.

Abbreviation: ASQ3: Ages and Stages Questionnaires-Third Edition.

TABLE 5

List of ASQ-3 items at 10 months by domain that were more frequently answered as “not yet” by mothers

Domain	Item number		% of mothers who endorsed “not yet”
10 months			
Communication	4	“If you ask your baby to, does he play at least one nursery game even if you do not show him the activity yourself (such as ‘bye-bye’, ‘Peekaboo’, ‘clap your hands’, ‘So Big’)?”	33.7
	5	“Does your baby follow one simple command, such as ‘Come here’, ‘Give it to me’, or ‘Put it back’, without your using gestures?”	42.0
	6	“Does your baby say three words, such as ‘Mama’, ‘Dada’, and ‘Baba’?”	48.6
Gross motor	4	“While holding onto furniture, does your child bend down and pick up a toy from the floor and then return to a standing position?”	43.9
	5	“While holding onto furniture, does your child lower himself/herself with control?”	33.9
	6	“Does your child walk beside furniture while holding on with only one hand?”	64.8
Fine motor	6	“Does your baby put a small toy down, without dropping it, and then take her hand off the toy?”	33.3
Problem-solving	5	“Does your child poke at or try to get a crumb or Cheerio that is inside a clear bottle (such as a plastic soda-pop bottle or baby bottle)?”	44.1
Personal-social	4	“When you hold out your hand and ask for her toy, does your child offer it to you even if she does not let go of it?”	36.0
	6	“When you hold out your hand and ask for her toy, does your child let go of it into your hand?”	53.9
12 months			
Gross motor	6	“Does your baby stand up in the middle of the floor by himself and take several steps forward?”	53.0
Fine motor	5	“Does your baby throw a small ball with a forward arm motion?”	62.6
Problem-solving	6	“After you scribble back and forth on paper with a crayon (or a pencil or pen), does your baby copy you by scribbling?”	49.8
Personal-social	4	“When you dress your baby, does she lift her foot for her shoe, sock, or pant leg?”	43.7
12 months			
Gross motor	6	“Does your baby stand up in the middle of the floor by himself and take several steps forward?”	53.0
Fine motor	5	“Does your baby throw a small ball with a forward arm motion?”	62.6
Problem-solving	6	“After you scribble back and forth on paper with a crayon (or a pencil or pen), does your baby copy you by scribbling?”	49.8
Personal-social	4	“When you dress your baby, does she lift her foot for her shoe, sock, or pant leg?”	43.7

Abbreviation: ASQ3: Ages and Stages Questionnaires-Third Edition.