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Assessment of the effects of ethnicity, home language, and socioeconomic status on neurodevelopmental performance in a multiethnic population

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ABSTRACT

Objective To investigate a unique, multicultural population to allow us to examine the association of ethnicity, socioeconomic status (SES) and spoken language at home on performance using developmental assessment tools.

Design Analysis of a prospective cohort study.

Setting Hamad Maternity Hospital, Doha, Qatar.

Methods 271 participants included infants born at Hamad Maternity Hospital between September 2016 and September 2017 (Q-Prem cohort). At 24 months (corrected for gestational age), children were assessed with both the language-based Bayley Scales of Infant and Toddler Development III (Bayley-III) and Babyscreen, a non-verbal tablet-based cognitive assessment tool. Bayley-III cognitive, motor, and language composite scores and Babyscreen scores were the main outcome measures.

Results Median Bayley-III scores in all groups were lower than expected norms (cognitive composite 95 (IQR: 90 to 105), motor 91 (IQR: 85 to 97), language 89 (IQR: 79 to 94)). In contrast, Babyscreen scores were similar to published norms for term infants: mean 13 (IQR: 11 to 15). Children whose main reported language at home was not English had decreased odds for a satisfactory score of >90 for the Bayley-III cognitive and motor composite scores (OR 0.20 (95% CI 0.03 to 0.77) and OR 0.23 (95% CI 0.04 to 0.79) respectively). In contrast, reported language at home had no impact on Babyscreen performance. Higher SES was associated with a mild increase in odds of a satisfactory result on Bayley-III language assessment (OR 1.07 (95% CI 1.01 to 1.13)) but had no effect on Babyscreen. Maternal ethnicity had no significant effect.

Conclusions Performance on developmental assessment may be affected by the language spoken at home rather than true cognitive ability. SES contributed to a lesser extent and maternal ethnicity had no effect. These results highlight the need for non-language-based assessment tools in multicultural cohorts to better compare true cognitive ability.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Ethnicity, spoken language and socioeconomic status (SES) have been seen to have a great impact on neurodevelopment. Scales measuring such impact may be biased by spoken language due to their standardisation in English, which may not reflect the rearing environment of the child.

WHAT THIS STUDY ADDS

⇒ This study, conducted in an ethnically diverse population, highlights the influence of a child's spoken language on Bayley-III cognitive and motor composite scores, more so than SES or ethnicity alone. In contrast, scores on a non-verbal test were consistent with those of the standardisation population, suggesting that non-verbal assessments may provide a more culturally neutral measure of developmental performance.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The interpretation of developmental test results in multiethnic populations must take into account the spoken language of study participants, which could lead to more accurate assessments and influence clinical guidelines and early intervention strategies.

INTRODUCTION

Neurodevelopment is influenced by the dynamic relationship between genetic potential, perinatal events, and childhood environmental exposures, leading to significant variation in early cognitive skills.[1] An individual's first 2 years are among the most important for cognitive development and build the foundations for adult life.[2 3] Many factors play a role in this early development. Ethnicity, parental income, and parental education have all been reported to predict lower cognitive scores globally in very low birth weight or premature infants.[4] In fact, results are not limited to preterm cohorts—it has been shown that socioeconomic status (SES) and parental education are important factors in predicting cognitive development and later outcomes in both premature and full-term infants.[5] In addition, studies have shown that multilingualism early on can be disadvantageous in

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preterm infants.[6] Thus, a diverse cohort of infants may provide insight into understanding neurodevelopment through a global lens.

Increasing global cultural diversity has led to challenges in evaluating developmental outcomes in diverse populations of young children. A child's home language has an impact on the performance of face-to-face evaluations, especially where scales of language are included or the test is administered in a different language.[7] In a multilingual cohort such as that in Qatar, it is important to consider the effects of ethnicity, language, and SES while evaluating neurodevelopment. Qatar has undergone rapid development to become a country of 3.1 million inhabitants.[8–10] Qatari nationals comprise 15% of this thriving and ethnically diverse population, in which there is large disparity in household income and educational opportunity not seen in many developed countries.[4 9] As such, our study uses the Q-Prem cohort data, a longitudinal birth cohort study designed to evaluate the outcomes of a purposefully sampled population comprising most births below 30 weeks of gestation and samples at higher gestation (including full-term).

As part of Q-Prem, investigators undertook a structured assessment at 2 years of age using The Bayley Scales of Infant and Toddler Development (3rd edition; Bayley-III), for which both the original Bayley standardisation and a version translated into Arabic were used.[11] Mindful of the large range of ethnicities and diverse languages spoken, investigators also included the Babyscreen, a non-verbal, tablet-based cognitive assessment.[12] In the present study, we hypothesise that Bayley-III composite scores would vary by ethnicity, SES, and language spoken at home, but that cognitive assessment using a non-verbal tablet-based assessment may be independent of such influences.

METHODS

Study design and participants

This study is an analysis of the Q-Prem prospective cohort study conducted in Doha, Qatar. The study population was recruited from newborn infants at Hamad Maternity Hospital, between September 2016 and September 2017. Hamad Maternity Hospital was, at the time, the single tertiary maternity centre in Qatar. Families were recruited by the Q-Prem team during their neonatal stay, and informed consent was obtained before discharge. Follow-up assessments took place at 24 months of age, corrected for gestational age, occurring between November 2018 and December 2019.

The study population comprised 710 infants, of whom 271 children completed the Bayley-III assessment, achieved a score of ≥3 using Babyscreen and had complete demographic data (figure 1). Patients were not involved in the research question, design, or outcome measures of this study.

Data collection

Research fellows and clinicians received comprehensive training from qualified specialists in the administration of both the Bayley-III and the tablet-based, non-verbal Babyscreen assessment. Bayley-III was administered in the infant's reported primary language spoken at home, using the standardised English version and an Arabic translated version. For toddlers speaking common languages (eg, Urdu, Hindi and Filipino), clinicians who spoke the same language provided support and assisted with on-the-spot translation of specific terms where necessary.

Data were entered, double-entered for accuracy and subsequently cleaned to remove outliers. Pregnancy and

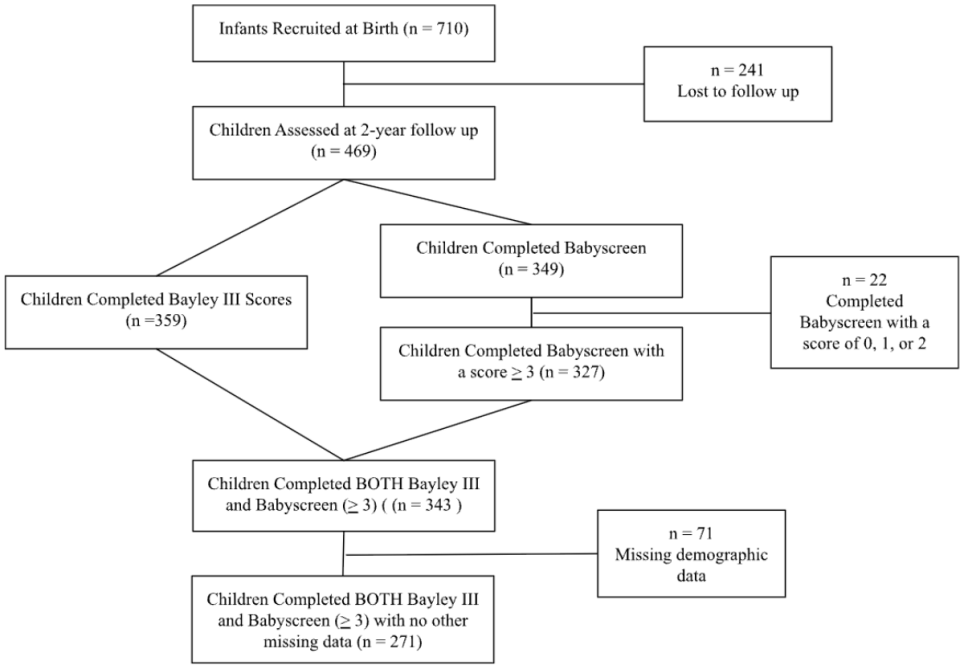


Figure 1 Derivation of 271 infants included in this study.

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birth data were abstracted from the clinical record, and details of the neonatal course were recorded for those admitted to the neonatal intensive care unit. Mothers completed questionnaires including demographic information comprising ethnicity, languages spoken at home, and a social index. We report composite scores for cognitive, motor and language scales, which are norm-referenced to a notional mean score of 100 (SD 15).[11]

Bayley-III scores have been observed to be over-generous by several authors in comparison to the previous edition, so we dichotomised scores based on composite scores of 90 or less (mild/moderate impairment) or >90 (no impairment).[11 13] Babyscreen is a newly developed tool designed to assess cognition through playing tasks of increasing complexity without verbal instruction.[12] Babyscreen has been validated for use in children aged 18–30 months with good internal validity and moderate correlations with Bayley-III on cognition and motor skills in an Irish, English-speaking cohort.[12] The standardised Babyscreen population mean score is 12 (SD 4), and we have implemented the cut-off of 7 or less to indicate mild cognitive delay.[12] This is equivalent to the Bayley-III cut-off of ≤90 and indicates mild cognitive delay to a specificity of 93%.[12]

Social index was measured using the Social Index Classification, developed by Albert Osborn in 1987,[14] which sums several factors (occupation and education of parents, housing tenure, accommodation type, people per room, car and telephone ownership) and represents SES with high sensitivity.[14] Index scores may range from 19 to 73, normed to a base value of 50.[14]

Infants were categorised by self-reported maternal ethnicity and reported language spoken at home. Those reported as speaking English and another language were classified as English speaking (n=17).

Data analysis

Data analytics were performed using the software R V.4.4.1. A Shapiro-Wilk test for normal distribution showed that the total gestational days were not normally distributed (p<0.05). Descriptive statistics were taken for each of the independent variables and dependent variables, including mean or median, SD or IQR where applicable. A Wilcoxon Rank Sum test was conducted on the infants lost to follow-up versus those included in the study to assess for differences in social index scores. A χ^2 test was used to assess differences between those included and those lost to follow-up for sex of the infant, gestational age groups, maternal ethnic groups, and main language spoken at home at 24 months.

Kruskal-Wallis tests were used to compare the differences in outcomes for both the ethnicity and grouped gestational ages of the infants. A Wilcoxon rank sum was used to compare the primary language spoken at home at 24 months (ie, English or non-English) and to compare scores between term and preterm infants. A logistic regression model was performed to adjust for the effects of gestation, ethnicity, reported languages, and social index on scores of each of the Bayley-III and Babyscreen. In total, four models were created, one for each outcome of: Bayley-III cognitive composite, Bayley-III motor composite, Bayley-III language composite, and Babyscreen scores. Log ORs were converted to and presented as their corresponding adjusted ORs for ease of interpretation. Results from different ethnic groups used native Qatari as a reference, and results from different language categories were compared with primary English-speakers.

We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline to draft this manuscript, and the STROBE reporting checklist, included in online supplemental appendix 2.[15 16]

RESULTS

We included 271 infants with complete outcome data. Children not evaluated as part of this analysis had similar distributions of sex, gestational age, ethnicity, and language spoken at home at birth (table 1). χ^2 tests revealed no significant differences between groups (table 1). Similarly, Wilcoxon Rank Sum tests indicate there is no difference between those included and lost to follow-up on the basis of social index (p=0.41).

Of those evaluated, median gestational age was 33.4 weeks (IQR 30.3 to 36.0), 67% were Qatari or non-Qatari Arabs, and at the follow-up visit, 94% did not use English as their main language at home. Mean social index at 24 months corrected age was 50 (IQR 46 to 54). Median Bayley-III composite scores were below standardisation means: cognitive: 95 (IQR 90 to 105); motor: 91 (IQR 85 to 97) and language: 89 (IQR 79 to 94). In contrast, median Babyscreen scores were 13 (IQR 11 to 15).

Bayley-III cognitive and motor composites varied between ethnic groups (p<0.001) in contrast to Bayley-III language composite and Babyscreen scores (figure 2a). Similarly, cognitive and motor scores were higher if English was the main language spoken at home compared with all other languages (p<0.0001), but language and Babyscreen scores were similar across language groups (figure 2b). Please see online supplemental appendix table 1 for more details.

Multivariate logistic regression was used to evaluate the association between maternal ethnicity and language (English vs non-English) and achieving a satisfactory result in either of the outcome measures: >90 for each domain of the Bayley-III and >7 on the Babyscreen assessment. Covariates of gestational age and social index were included in the model to correct for confounding effects, thus providing an adjusted OR. No significant effect of maternal ethnicity was observed. The main language spoken at home showed a strong independent association with cognitive scores (OR 0.20 (95% CI 0.03 to 0.77)) and language scores (OR 0.22 (95% CI 0.04 to 0.79)). Lastly, social index was weakly associated with increased odds of satisfactory language performance (OR 1.07 (95% CI

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Table 1 Population demographics (n=710). Gestational age, maternal ethnicity and main household language at birth, as described below.

Variable	Total (n=710)		Evaluated (n=271)		Not evaluated (n=440)		P value
	n=	(%)	n=	(%)	n=	(%)	
Sex							0.90
Male	379	(53.3)	146	(53.9)	233	(53.0)	
Female	331	(46.6)	125	(46.1)	206	(46.8)	
Gestational age (weeks)							0.15
<27	91	(12.8)	41	(15.1)	50	(11.4)	
28 to 31	162	(22.8)	58	(21.4)	104	(23.6)	
32 to 33	112	(15.8)	48	(17.8)	64	(14.5)	
34 to 36	222	(31.2)	87	(32.1)	135	(30.7)	
>37	123	(17.3)	37	(13.7)	86	(19.5)	
Maternal ethnicity							0.21
Qatari	201	(28.3)	79	(29.2)	122	(27.8)	
non-Qatari Arab	267	(37.6)	103	(38.0)	164	(37.3)	
South Asian	82	(11.5)	36	(13.3)	46	(10.5)	
Filipino	73	(10.3)	19	(7.0)	54	(12.3)	
Other	87	(12.2)	34	(12.5)	53	(12.0)	
Main language spoken at home (at birth)							0.66
English	74	(10.4)	26	(9.6)	48	(10.9)	
Non-English	636	(89.5)	245	(90.4)	391	(88.9)	

In maternal ethnicity, South Asian includes Indian, Bangladeshi and Pakistani. Statistical comparisons between those included and excluded due to incomplete data/lost to follow-up are highlighted, indicating no statistically significant difference between groups. One infant was excluded due to incomplete information at birth.

1.01 to 1.13)). Please see online supplemental table A2 in the Appendix for more details.

DISCUSSION

In a multiethnic, predominantly preterm cohort, an assessment of the effects of ethnicity, language, and SES has revealed that language may play a prominent role in developmental assessment. Overall, the performance of this cohort on the Bayley-III is less than the standardised norms, as expected for a largely preterm cohort. However, performance on the Babyscreen, a non-language-based assessment, is consistently within one SD of the norm. A further analysis of each factor of interest individually shows that there are differences among performance. Maternal ethnicity had significant effects on cognitive and motor composite scores on the Bayley-III scales when considered individually. However, when adjusting for SES and language, there was no such difference based on ethnicity. This suggests that there could be a factor across all ethnic groups that may be contributing to poorer performance in cognitive and motor scores. Our multivariate regression analysis highlighted that this factor may be spoken language at home, among other contextual variables. Infants from non-English speaking households performed poorly compared with their English-speaking counterparts on Bayley-III cognitive and motor scores. Interestingly, this was not the case on the Babyscreen assessment, revealing similar scores between English and non-English groups. Thus, highlighting that a non-language assessment may better capture neurodevelopmental, or specifically cognitive, performance due to potential barriers in language administration or translation. Such findings are despite the Bayley-III being administered in the spoken home language of the child.

In the early days of the development of cognitive testing, the administration of tests in an inappropriate language was frequently misinterpreted as poor cognitive function and development.[17] A recent study from Sweden reported that not speaking Swedish at home was one of the strongest predictors of poor cognitive performance on the Bayley's Scales at 24 months corrected age in preterm children.[18] Similarly, in a machine learning-based model of school-age outcome in an Irish population, non-English speaking was one of the strongest predictors of poor performance, an outcome frequently ascribed to social disadvantage or poor parental education.[19] Our data suggest there may be a discriminating factor between the spoken language of the child and the language of the test. Thus, there is a need to develop comparable assessment tools which are either language-appropriate for the child or language-free.

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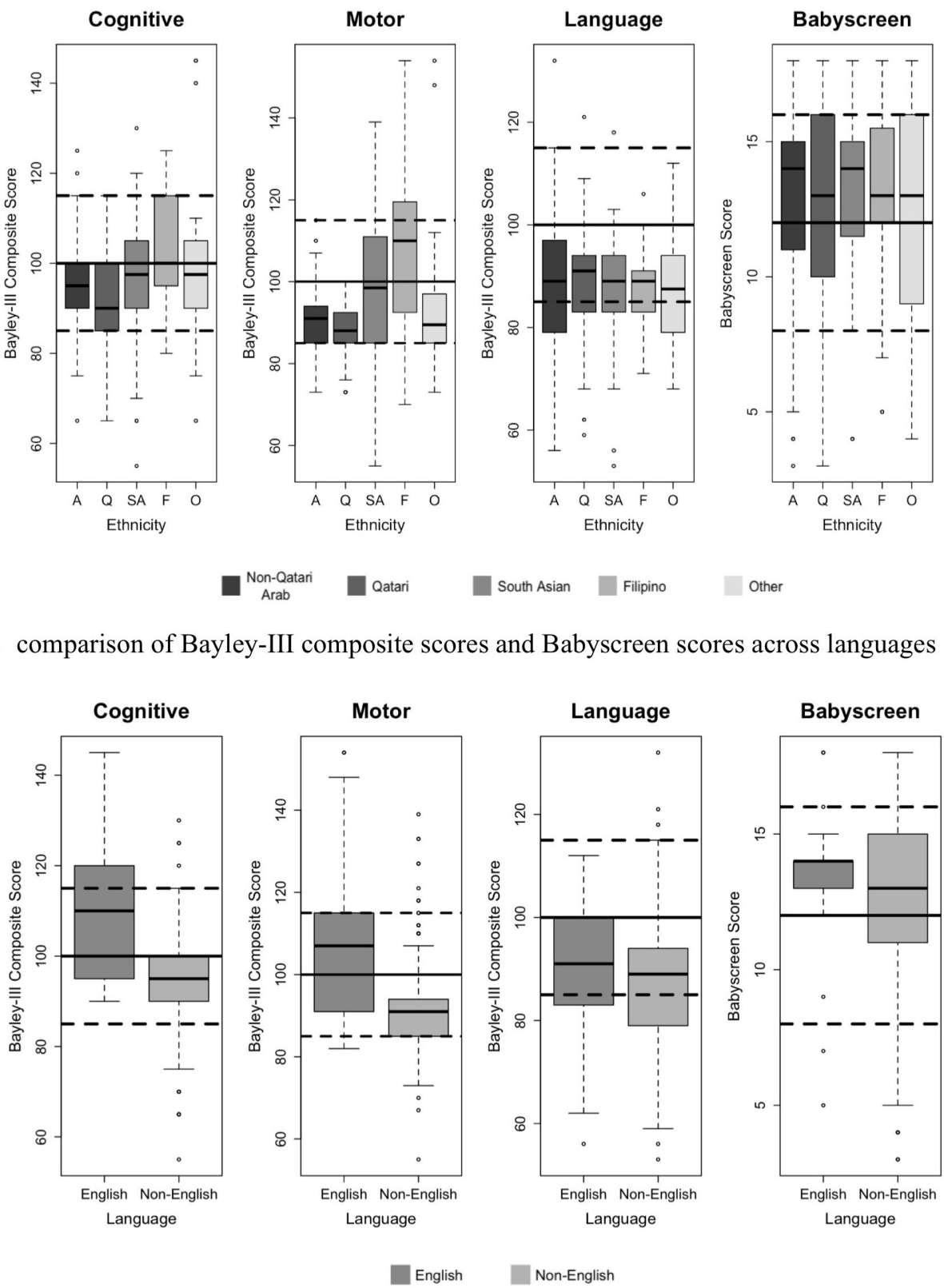


Figure 2 (a) Comparison of Bayley-III composite scores (cognitive, motor, language) and Babyscreen across ethnicities. A=Non-Qatari Arab, Q=Qatari, SA=South Asian (Indian, Pakistani, Bangladeshi), F=Filipino, O=Other. Horizontal lines represent published norms of 100 for the Bayley-III composite scores, and 12 for the Babyscreen. Dashed lines represent the SD of 15 for Bayley-III scores and four for Babyscreen and (b) Comparison of Bayley-III composite scores (cognitive, motor, language) and Babyscreen across languages spoken at home at 24 months.

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This issue is particularly relevant in Arabic-speaking populations. The Arabic language exists in multiple forms, with Modern Standard Arabic—also known as Classical Arabic—predominantly used in formal settings such as literature, education, and media.[20 21] In contrast, daily communication relies heavily on colloquial dialectical Arabic, which varies widely between—and even within—countries, often incorporating elements from foreign languages (eg, French in Lebanon, Morocco, Tunisia and Algeria, or English in Egypt and the Gulf states). These dialectical differences lead to substantial variations in terminology and comprehension across Arabic-speaking regions, which further complicates the implementation of a "single-language" assessment tool. As a result, even when developmental tests are translated into Arabic, variations in dialect may limit their interpretability or fairness.[20 21]

Language mismatch during assessment imposes extraneous cognitive load, particularly problematic in young children with developing processing capacity.[22 23] Sociocultural developmental theories emphasise that cognitive development occurs through culturally embedded language interactions.[24 25] Thus, alignment between home language and institutional settings is crucial,[26] as mismatch can induce stress and hinder performance.[27] Language or phonetic difficulties are often not isolated impairments but may reflect broader underlying cognitive processing challenges.[28] These challenges highlight the need for assessment approaches that minimise cultural and linguistic bias. Language-free electronic tools, such as tablet-based or gamified assessments, offer a promising alternative by evaluating cognitive processes without relying on verbal instructions or culturally bound content.[29 30] By reducing extraneous cognitive load, these tools provide a more equitable and valid means of assessing children from diverse linguistic and cultural backgrounds.

The WHO is currently working on the creation and validation of Global Scales for Early Development, a standardised tool to measure infant development up to 36 months in a range of settings.[31] The current tool has been validated for population use, but not yet for individualised use.[31] In developing a globally standardised tool to measure word acquisition, one major challenge is creating an effective language-free assessment. While the tablet-based Babyscreen offers a non-language option, it does not address the need to evaluate language skills. Therefore, additional tools should be developed to include tasks specifically designed to assess new word acquisition at this age.

Certain limitations of this paper should be addressed when considering the findings. First, the use of the main language reportedly spoken at home does not allow us to quantify the accuracy and ability in each language or which is the preferred language in multilingual households. Thus, we are unable to account for varied exposure over the first 2 years of life. Similarly, language translations of Bayley-III assessments may have been varied between researchers administering the assessment. Some on-the-spot translation was used for aid in non-Arabic languages. This limitation could cause an overestimate in performance for children in those circumstances, causing an effect towards the mean. In addition, cut-off scores for the Bayley-III assessments are standardised to an English-speaking population and there is little research addressing their use in multi-ethnic populations. Similar research from Qatar and surrounding areas often use the standardised global cutoffs.[32 33] Additionally, there were few English speakers, but despite the small numbers, their composite scores on the Bayley-III scales were significantly higher. A vast majority of our population was Arabic-speaking, which is representative of a high prevalence of Arabic speakers globally, estimated at around 473 million, one third of which are under the age of 15.[20 34 35] In addition, medical factors associated with a premature population were not considered independently (eg, intraventricular haemorrhage), but gestational age was considered to adjust for such variations. Similarly, contextual factors such as exposure to tablet-based tools were not considered in this analysis. However, the children were tested in the same clinical setting within a single site, so many contextual factors are controlled. Finally, although there was substantial loss to follow-up from the main study, due to late introduction of Babyscreen and participant dropout, the population included was representative of the main group over a range of markers. The design of this analysis required complete datasets and as such was not susceptible to inclusion bias. This is supported by previous research showing that, although selective dropout is common in longitudinal studies, it does not necessarily bias outcome prediction if the retained sample remains representative across key baseline variables.[28]

Our study has several strengths that contribute to the robustness of its findings. First, the cohort assessed contained detailed information about the infant's status up to 24 months of age. Although we sampled the birth population, we included infants reflecting a diverse population in ethnicity, language and SES, which allowed a unique examination of these factors. The tools used in the study had been previously validated in other populations. Finally, using a non-verbal task allowed specific assessment of language influence. These strengths provide a strong foundation for the study's implications, supporting practical considerations for neurodevelopmental assessment.

CONCLUSION

In a multicultural, predominantly Arab, population of infants at 24 months, we have shown that spoken language at home may affect performance on conventional neurodevelopmental scales. Ethnicity and SES play a more minor role in this cohort on developmental assessment. Despite administration in the reported spoken language of the child, performance on conventional

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Bayley-III scales did not align with performance using a tablet-based, non-verbal assessment. There is a need to develop appropriate assessments to allow us to identify developmental delay in all high-risk children, independently of their rearing language. Our findings highlight that early language-related assessment disparities may stem from sociocultural mismatch and limited ecological validity—highlighting the need for developmentally sensitive, linguistically neutral tools that accurately capture cognitive potential. Incorporating culturally adaptable or language-free digital tools may offer a more equitable and valid approach to early developmental screening and identifying developmental needs in diverse populations.

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Contributors CH - Contributed to research design, data analysis, manuscript writing, editing and creation of figures and tables. DM - Contributed to research design, data analysis, manuscript writing and editing (Guarantor) MS - Contributed to data collection, manuscript editing. HA - Contributed to data collection and manuscript editing. GA - Contributed to data collection and manuscript editing. NM - Contributed to manuscript writing and editing.

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Competing interests Deirdre Murray is the founder and shareholder of Liltoda Ltd., which has licensed Babyscreen software. The authors declare that there are other relationships or activities that could appear to have influenced the submitted work.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Consent obtained from parent(s)/guardian(s).

Ethics approval This study involves human participants and was approved by the Ethical Review Committee. Ethical approval for the study was obtained from the Hamad Medical Corporation Institutional Review Board (HMC-IRB; reference number 14213/14) and the Clinical Research Ethics Committee at University College Cork. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. Data obtained as part of Q-Prem cohort study.

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