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Sociocultural factors associated with detection of autism among culturally and linguistically diverse communities in Australia

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Abstract

Background The age at which parents or caregivers first develop concerns about their child's development has significant implications on formal diagnosis and intervention. This study aims to determine the sociocultural factors that are associated with the age and type of first concern reported by parents of autistic children among culturally and linguistically diverse (CALD) communities in Australia. We also assessed whether sociocultural factors predict autism traits measured in terms of social affect (SA), restricted and repetitive behaviours (RRB), and calibrated severity scores (CSS).

Methods This study is a secondary data analysis of the data collected from six Autism Specific Early Learning and Care Centres (ASELCCs) as part of the Autism Co-operative Research Centre (CRC) program between 2015 and 2019. Data analysed in this study included a family history questionnaire with sociodemographic and sociocultural information, parent-reported age and type of first concern, and clinician/researcher administered Autism Diagnostic Observation Schedule - Second Edition (ADOS-2) which includes standardised domain-wise scores of social affect (SA) and restricted and repetitive behaviours (RRB) as well as calibrated severity scores (CSS), a measure of severity of autism. Primary analysis included multivariable linear regression models to examine the predictive influence of sociodemographic and sociocultural factors on the dependant variables of age of concern (AOC) and the autism traits (SA, RRB, and CSS).

Results The mean AOC in the sample was 18.18 months and the most common concerns were speech/language delay, limited social interaction, and hyperactivity/behavioural changes. The multivariable linear regression models showed factors such as increase in age of child, those from a CALD background, annual family income, sibling's autism diagnosis, and developmental concerns to be significantly associated with parental AOC. Additionally, we also found that increase in child's age and CALD status to be significant predictors of autism trait (RRB) and severity measured

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in terms of the CSS score. Further, females (compared to males) were associated with higher difficulties with social communication and interaction skills.

Conclusion Understanding key factors that contribute to early identification of autism can help tailor awareness programs for parents and caregivers, whilst also informing the development of services focused on serving all CALD communities.

Keywords Autism spectrum disorder, CALD communities, Age of first concern, Sociocultural risk factors

Background

Autism Spectrum Disorder (ASD; hereafter ‘autism’) is a life-long neurodevelopmental condition characterised by social, communication, and behavioural changes ranging in degree and presentation [1]. The global prevalence rate of autism is rising with the current estimate at 1 in 44 children [2]. There is substantial evidence suggesting that early detection and support for autistic children are associated with improved outcomes, with the American Academy of Paediatrics recommending commencing interventions by two years of age [3–8]. For example, a recent systematic and meta-analysis of personalised, non-pharmacological interventions for younger autistic children such as naturalistic developmental behavioural interventions and developmental interventions have shown to be effective forms of early intervention strategies in achieving a range of developmental outcomes [9]. These patient-centred, early assessment and intervention have the potential to leverage the neural plasticity of the developing brain, mitigate regression [10–12], and positively impact developmental outcomes [13, 14].

With the growing interest around early interventions for autism, has come the need to better understand the manifestation of symptoms of autism at a young age. Globally, there are wide disparities in the age of diagnosis of autism. Although some studies have reported that autism can be accurately diagnosed as early as 18 months of age [7, 15], it is not the case in most children, globally. A recent systematic review analysed data from 40 countries and concluded that the average global age of diagnosis of autism was 43.18 months, ranging between 30.90 and 74.70 months [16]. On the other hand, evidence shows that the parental age of first concern (AOC) - the age at which parents or caregivers first develop concerns about their child’s development, has shown to be significantly associated with the age of ASD diagnosis [17, 18]. However, it is important to understand that parental AOC could be influenced by several child-level factors (for example, severity of child’s autism and other co-morbidities) as well as parent-level factors (for example, parental health literacy, socioeconomic status, and cultural influences). Therefore, it is reasonable to consider that there could be several risk factors which might potentially impact the timing and detection of autism. Hence, the identification of key risk factors could

provide an opportunity to implement early interventions to enable better outcomes for autistic children and their families – a key objective of this study.

There is a growing body of evidence suggesting that the presentation, interpretation, reporting of autistic traits as well as treatment strategies for autism appear to be susceptible to cultural influences [19, 20]. In simple terms, culture is defined as “a set of behavioural norms, meanings, and values or reference points utilised by members of a particular society to construct their unique view of the world, and ascertain their identity” [21]. Further, the term ‘culturally and linguistically diverse’ is used to describe communities with diverse languages, ethnic backgrounds, nationalities, traditions, societal structures, and religions [22]. What is considered atypical behaviour in Culturally and Linguistically Diverse (CALD) families may differ from families from Western countries, delaying the recognition of autism traits [22–24]. For example, behaviours such as limited eye contact is considered typical behaviour in certain Indigenous Australian and Asian cultures [25, 26] and may therefore go unrecognized as a potential indicator of autism. Whilst initial parental concerns for Hispanic children were more likely to be related to language and speech delay, motor delay and not responding to their name were also more common in Hispanic compared to non-Hispanic children [27, 28]. These cultural differences in presentation can result in delays in autism diagnosis and intervention if early features remain unrecognized.

Differences in autism presentations are only one of the contributing factors to delays in autism diagnosis in CALD populations. However, cultural attitudes towards autistic children may result in delayed intervention, leading to negative health outcomes. An example of this is seen within certain Indigenous communities associate identifying disability with shame, leading to social isolation from family and community. Therefore, the stigma around disability may lead to individuals less likely to seek support and intervention [29]. Subsequently, screening policies and early intervention services are largely not tailored towards the needs of CALD families, with various cultural and linguistic needs, many of whom experience challenges in accessing these services [30, 31]. Therefore, it is critical to understand the interplay of culture in autism since cultural views regarding appropriate

behaviours and normal development for a certain culture may impact parent/carer reports, and ultimately influence the timing and nature of autism diagnosis and treatment [19, 32].

Besides cultural differences, the social determinants of negative health outcomes such as health illiteracy, inequitable and inadequate access to healthcare, and socioeconomic status could also influence the timing of autism diagnosis and subsequent access to support [33–35]. A recent Australian systematic review found that these barriers included a lack of accessibility due to cost and availability, acceptability of services due to religious/cultural reasons, and affordability [36]. Further, health literacy is crucial for understanding developmental expectations to assist in early identification of autism. Kelly et al. (2017) found higher rates of autism diagnosis among mothers of children with higher levels of education than those with lower levels of education [33]. In addition to this, Thomas et al. [37] demonstrated that a higher household income is related to higher levels of autism diagnosis. However, there is lack of knowledge on the sociodemographic and sociocultural factors associated with parental age and type of first concern among CALD communities in Australia.

To address this knowledge gap, we aim to explore the relationship between sociodemographic and sociocultural factors, age of first concern (AOC), and core autism symptoms, using a large Australian dataset. It is expected the findings will inform service recommendations for community-wide identification, diagnosis, and interventions for autism with a view of providing early detection and support for multicultural populations.

Methods

Aims

The overall aim of this study was to determine the sociocultural factors that are associated with the age and type of first concern reported by parents of autistic children among CALD communities in Australia. Specifically, we sought to identify the average AOC, how types of concerns correlate with autism traits, and the associated sociocultural factors (income, parental employment, CALD background, parental education, family structure, autistic sibling, and country of birth) that predict AOC. We also assessed whether sociocultural factors can predict autism traits measured in terms of social affect (SA), restricted and repetitive behaviours (RRB), and severity of autism based on calibrated severity scores (CSS).

Study hypotheses

We hypothesise that there is a significant association between sociocultural factors and AOC. Additionally, we hypothesise that key sociocultural factors could also predict autism traits (SA, RRB) and severity (CSS).

Study Design, study setting, and sample size

This study is a secondary data analysis of the data collected within ‘The Autism Subtyping Project’ which is a multicentre, controlled, pre-post study measuring autism traits, developmental skills, adaptive functioning, and behaviours, both before and after the implementation of an intervention program [38]. This study utilised data collected from six Autism Specific Early Learning and Care Centres (ASELCCs) as part of the Autism Co-operative Research Centre (CRC) program at the time of the child’s entry to the program between 2015 and 2019. These ASELCCs were located in New South Wales, Queensland, South Australia, Tasmania, Victoria, and Western Australia and provided early intensive intervention programs in a long-day care setting and support to the child’s family. Although minor differences existed across all sites in terms of the number of participants which was dependent on the capacity of each ASELCC centre, the core structure, strategies, and processes of selection, recruitment, consenting of participants, and data collection methods were similar across the centres.

The sample size was calculated based on the capacity of the ASELCCs to enrol approximately 20 children on an annual basis in the early intervention program with one centre able to accommodate up to 44 children per year. Over a 6-year period, this yielded a sample size of approximately 750 children which allowed for 90% power, at a two-sided 5% significance level, to detect a 0.25 standardised difference in mean intentions scores between intervention and control group at follow-up whilst allowing for 20% lost to follow-up.

Participants

The eligibility criteria included families of children enrolled in early intensive intervention programs at one of the six ASELCCs and met criteria for a diagnosis of autism based on the DSM-IV or DSM-5 diagnostic criteria [1] or had features consistent with an autism diagnosis. No other specific inclusion or exclusion criteria and no pre-screening measures were utilised. Participants that met the eligibility criteria were invited to participate in research and gave informed consent if they wished to participate.

Data collection

Data collection was undertaken by either the manager of each ASELCC or a Research Assistant, who have been trained by experts in the field to become familiar with various sets of data collection forms and assessments. Data collectors also attended formal training to administer the Autism Diagnostic Observation Schedule - Second Edition (ADOS-2) [39]. All outcome measures and questionnaires were either administered or collected at the initial assessment (baseline) and at exit from the

centre. Research Electronic Data Capture (REDCap) tools [40, 41] were used for data entry and audit related tasks. Further details about data collection of other clinical data in the Autism Subtyping Project is described elsewhere [38].

Outcome measures

Age of first concern was defined as the age of the child (in months) at which parents or carers first developed concerns regarding their child's development.

Autism behaviours (traits) were measured via the ADOS-2 [39] a semi-structured, standardised diagnostic observational assessment which was used to confirm diagnosis of ASD. The ADOS-2 was administered by a trained clinician or researcher. The administered module was determined by the child's age and expressive language ability. Therefore, Module 1 was given to children aged 31 months and older without phrase speech, Module 2 was given to children who were not verbally fluent with phrase speech, and lastly, Module 3 was given to children who were fluent in language.

The ADOS-2 assessment consists of two behavioural domains such as restricted and repetitive behaviours (RRB) as well as social affect (SA) which includes items relating to communication and social interaction. The item scores in these domains are converted to algorithm scores of 0 to 2, with higher score indicating more severe deficits. Based on the algorithm scores of both domains of SA and RRB, the standardised calibrated severity scores (CSSs) are calculated using validated algorithms [39, 42, 43]. The CSS provides a more accurate measure of core autism symptom severity that is relatively independent of child age and other characteristics [42]. Whilst the CSS score provide some advantages over other measures of general ASD severity, the nature of the symptoms underlying an individual's CSS may vary greatly [43]. Thus, to obtain a clearer picture of ASD dimensions, we used the domain scores of SA and RRB as well as ADOS-CSS as separate models in the multivariable linear regression analyses (see [data analysis](#) section).

All of the above outcome measures were completed at baseline (i.e., within eight weeks of beginning the early intervention program at the ASELCC).

Explanatory variables

The data pertaining to the AOC was part of a family history questionnaire (FHQ) that was completed by the primary caregiver at baseline. The sociodemographic variables considered in this study included child-level and parent/carer-level characteristics. The child-level variables were: gender (male/female); country of birth (Australia/other); CALD status (no/yes); whether the child was a firstborn (no/yes); whether the child had a sibling (no/yes); whether the sibling had a diagnosis of

autism (no/yes); and type of first concern (speech/language delay, unresponsiveness, motor signs, restrictive and repetitive behaviour, eye contact, sensory changes, limited social interaction, developmental delay, and hyperactivity/behavioural changes – no/yes). Further, the parent/carer-level variables included education level (primary or secondary/ tertiary or postgraduate education) and occupation (professional or paraprofessional/ other) of primary and secondary carers as well as annual family income (less than \$40,000/ \$40,001-\$85,000/ \$85,001-\$115,000/ more than \$115,000).

Data Analysis

We used descriptive statistics such as mean and standard deviation to report on data measured on a continuous scale whereas frequency counts and percentages were calculated for categorical measures. The data including dependent variable was checked for normality using the Shapiro-Wilk test and quantile-quantile (Q-Q) plots. Differences in the distribution of the mean AOC according to child-level and parent-level characteristics were tested with independent samples t-test and analysis of variance (ANOVA), and adjusted for multiple comparison with the Bonferroni method. Homogeneity of variances was assessed by the Levene's test for equality of variances. Cohen's d and partial eta squared with 95% confidence intervals were used to report effect sizes for independent samples t-tests and ANOVA analyses, respectively.

Our primary analysis included four multivariable linear regression models to examine the predictive influence of sociodemographic and sociocultural factors on the dependant variables of AOC (model 1), autism traits in terms of SA (model 2) and RRB scores (model 3), and autism severity measured as CSS score (model 4). We used the backward stepwise elimination method where variables based on their non-significant p-values were manually removed at each step of the model until all the variables in the final model were significant (p-value < 0.05). Variable selection in the stepwise analyses was directed by the BIC criterion, which is a penalized likelihood model selection criterion used to compare different models. We used the BIC criterion with the stepwise approach because it favours a model that includes the fewest variables and to reduce the risk of false positives inherent to stepwise analysis [44]. For example, for AOC as outcome variable, three models were assessed (baseline model – CALD; baseline model+sociodemographic factors; baseline model+sociodemographic factors+types of concerns). The assumptions for multivariable linear regression analyses were tested using scatterplots and Q-Q plots to confirm the linearity of associations, normal distribution of the residuals, and homoscedasticity. Further, variance inflation factors (VIF) were used to identify multicollinearity and

Durbin–Watson tests were calculated to determine autocorrelation. All statistical analyses within this report were conducted using RStudio (version 2022.07.0 “Spotted Wakerobin”) and SPSS Statistics v.27 (SPSS for MacOS, SPSS Inc., Chicago, IL, USA).

Results

Descriptive findings

The descriptive characteristics of this study sample can be found in Table 1. About 94% of the respondents who completed the FHQ were mothers who also identified themselves as the primary carer. The mean (SD) age of children at the time of enrolment was 3.43 (0.86) years (i.e., 41.23 (10.36) months). Of the 759 participants in the dataset with recorded gender, 607 (80%) were male and 152 (20%) were female. A majority (84%) of the participants were born in Australia. However, 290 (38%) participants reported as being from a CALD background. The most common type of first concern was speech/language delay (58.2%), followed by limited social interaction (27.8%), and hyperactivity/ behavioural changes (25.3%).

The average AOC and ADOS-2 domain scores of the sample are presented in Table 2. It was found that the average AOC was 18.18 months (see Fig. 1). Given the data was collected from a sample of children attending specialised autism early intervention centres, higher scores reflecting higher severity of autism is observed.

Findings of the independent t-tests and one-way ANOVA are shown in Table 1. Children born outside of Australia reported delayed AOC of mean (SD) 21.78 (7.46) months compared to mean (SD) 17.89 (7.95) months in those born in Australia, $t(664) = -3.37$, $p = 0.02$. Similarly, those from a CALD background were found to have a delayed AOC of mean (SD) 19.78 (7.23) months, compared to those who did not identify as CALD mean (SD) 16.95 (8.27) months, $t(660) = -4.60$, $p = 0.02$. Having a sibling with an autism diagnosis resulted in an earlier AOC of mean (SD) 16.35 (7.54) months compared to mean (SD) of 18.77 (8.13) months in those without an autistic sibling, $t(483) = 3.24$, $p = 0.02$. The types of concerns most strongly related to AOC were speech/language delay ($t(479) = -5.81$, $p = 0.02$) and developmental delay ($t(686) = 5.15$, $p = 0.02$) with medium effect size (Cohen’s $d \sim 0.50$). Lastly, the one-way ANOVA showed statistically significant differences between different levels of annual family income ($F(3,510) = 8.78$, $p = 0.02$). Interestingly, a Tukey post hoc test revealed that the mean AOC was statistically significantly lower among families earning highest (more than \$115,000) ($p = 0.05$) and lowest (less than \$40,000) ($p = 0.05$) compared to low to middle income-earning families (\$40,001 - \$85,000).

Findings of the multivariable analysis

Four multivariable linear regression models to determine the predictive influence of sociocultural factors associated with AOC, SA, RRB, and CSS (Table 3). Models with the higher adjusted R^2 and lower BIC values were chosen.

In terms of AOC as an outcome variable (primary outcome), an increase in age was significantly associated with a 1.02-month delay in AOC ($\beta = 1.02$; 95% CI 0.54, 1.50 at $p < 0.001$). Compared to children from a non-CALD background, children from a CALD background had a 2.2-month delay in AOC ($\beta = 2.15$; 95% CI 0.56, 3.75 at $p = 0.008$). Having a sibling with an autism diagnosis was significantly associated with an earlier AOC of 1.66 months ($\beta = -1.66$; 95% CI -3.25, -0.07 at $p = 0.041$). Similarly, it was also found that affluent households had a significantly earlier AOC of 0.94 months ($\beta = -0.94$; 95% CI -1.63, -0.25 at $p = 0.008$). For types of concern, whilst presence of general developmental delay was significant associated with earlier AOC by 3.3 months ($\beta = -3.32$; 95% CI -5.50, -1.13 at $p = 0.003$), speech/language delay was associated with a 3.21-month delay ($\beta = 3.32$; 95% CI 1.57, 4.85 at $p < 0.001$) in AOC.

With regards to autism traits and severity, the multivariable linear regression found that female children (compared to males) were significantly associated with increase scores for the SA domain of ADOS-2 ($\beta = 1.29$; 95% CI 0.43, 2.16 at $p < 0.001$). However, with regards to RRB, increase in age was associated with a lower RRB score by 0.45 ($\beta = -0.45$; 95% CI -0.64, -0.27 at $p < 0.001$) whereas those from a CALD background were significantly associated with higher RRB scores by 0.60 ($\beta = 0.60$; 95% CI 0.02, 1.17 at $p < 0.001$) compared to those who did not identify as CALD. This trend was consistent with dependent variables as CSS, measuring the severity of autism (Table 3).

Discussion

To our knowledge, this is a comprehensive study with a large sample of Australian preschool children receiving intensive early intervention for autism, assessed using standardised measures at entry to the program and post-intervention. We found that the average AOC within our cohort was 18.18 months whereas the average age of diagnosis was 28 months, a delay of 10 months. Although it is expected that there is a 5-to-6-months difference between the initial concern and diagnosis, studies have shown that this delay is on average at least 1.5 years after initial parental concern [45–47]. Therefore, it is thought that several factors may have contributed to the timing of parental AOC and subsequently, delay in autism diagnosis. In particular, we found factors such as increase in age of child, those from a CALD background, annual family income, sibling’s autism diagnosis, and developmental concerns to be significantly associated with

Table 1 Child-level and parent-level characteristics of the sample by mean age of first concern

Variables	N (%)	Mean AOC (SD)	Effect size (95% CI)	Adjusted p-value*
Child-level characteristics				
Gender			0.24 (0.05, 0.43)	0.24
Males	607 (79.9)	18.56 (8.1)		
Females	152 (20.0)	16.6 (7.4)		
Missing	1 (0.1)			
Country of birth			-0.49 (-0.78, -0.21)	0.02
Australia	634 (83.4)	17.89 (7.9)		
Other	53 (7.0)	21.78 (7.5)		
Missing	73 (9.6)			
CALD status			-0.36 (-0.52, -0.21)	0.02
No	393 (51.7)	16.95 (8.3)		
Yes	290 (38.2)	19.78 (7.2)		
Missing	77 (10.1)			
Do you have siblings?			0.15 (-0.06, 0.35)	1.00
No	121 (15.9)	19.15 (7.5)		
Yes	436 (57.4)	18.02 (7.8)		
Missing	203 (26.7)			
Sibling with ASD			0.31 (0.12, 0.49)	0.02
No	315 (41.4)	18.77 (8.1)		
Yes	181 (23.8)	16.35 (7.5)		
Missing	264 (34.8)			
Firstborn child			-0.18 (-0.33, -0.03)	0.44
No	360 (47.4)	17.54 (7.6)		
Yes	348 (45.8)	18.93 (8.3)		
Missing	52 (6.8)			
Type of concern				
Speech/Language delay	442 (58.2)	19.55 (7.4)	-0.47 (-0.63, -0.32)	0.02
Unresponsiveness	159 (20.9)	17.28 (6.9)	0.15 (-0.03, 0.32)	1.00
Motor signs	101 (13.3)	16.71 (6.5)	0.22 (0.01, 0.43)	0.92
Restrictive and Repetitive Behaviour	178 (23.4)	17.43 (8.1)	0.13 (-0.04, 0.30)	1.00
Eye contact	191 (25.1)	18.09 (7.1)	0.12 (-0.15, 0.18)	1.00
Sensory changes	79 (10.4)	16.64 (7.8)	0.22 (-0.02, 0.45)	1.00
Limited social interaction	211 (27.8)	19.00 (8.0)	-0.15 (-0.31, 0.01)	1.00
Hyperactivity/behavioural changes	192 (25.3)	18.43 (8.1)	-0.04 (-0.21, 0.12)	1.00
Developmental delay	114 (15.0)	14.66 (7.9)	0.53 (0.33, 0.74)	0.02
Parent/Carer-level characteristics				
Education level of Primary carer			-0.07 (-0.24, 0.10)	1.00
Primary/secondary education	198 (26.1)	17.75 (8.7)		
Tertiary/postgraduate education	483 (63.6)	18.32 (7.7)		
Missing	79 (10.3)			
Education level of Secondary carer			-0.06 (-0.23, 0.11)	1.00
Primary/secondary education	200 (26.3)	17.72 (8.6)		
Tertiary/postgraduate education	397 (52.2)	18.18 (7.5)		
Missing	163 (21.5)			
Occupation of Primary carer			0.15 (-0.02, 0.32)	1.00
Professional/paraprofessional	188 (24.7)	18.99 (7.8)		
Other	471 (62.0)	17.78 (8.1)		
Missing	101 (13.3)			
Occupation of Secondary carer			0.08 (-0.09, 0.24)	1.00
Professional/paraprofessional	290 (38.2)	18.31 (7.6)		
Other	299 (39.3)	17.71 (8.1)		
Missing	171 (22.5)			

Table 1 (continued)

Variables	N (%)	Mean AOC (SD)	Effect size (95% CI)	Adjusted p-value*
Annual Family Income			0.05 (0.02, 0.09)	0.02
Less than \$40,000	147 (19.3)	17.74 (8.0)		
\$40,001-\$85,000	162 (21.3)	20.83 (9.0)		
\$85,001-\$115,000	99 (13.0)	16.78 (6.8)		
More than \$115,000	119 (15.7)	16.56 (6.9)		
Missing	233 (30.7)			

*Adjusted p-value obtained using Bonferroni’s correction for multiple comparison

Table 2 Average age of concern and scores of ADOS-2 domains

Clinical measures	Mean (SD)
Age of concern (months)	18.18 (7.99)
ADOS-2 Social Affect score	14.36 (3.59)
ADOS-2 Restrictive and Repetitive Behaviour score	4.68 (1.97)
ADOS-2 Calibrated Severity Scores	7.16 (1.67)

parental AOC. Additionally, we also found that increase in child’s age and CALD status to be significant predictors of autism trait (RRB) and severity measured in terms of the CSS score and females to have higher difficulties with social communication and interaction skills as measured by ADOS-SA domain.

In this study, we found significant association between CALD status and delayed age of concern as well as higher severity of autism traits (RRB domain and CSS scores). The main findings are in keeping with our previous research and other Australian study that found evidence for an ‘inverse care law’ in that, children from more

disadvantaged backgrounds, including those from CALD background, who are at highest developmental risk, are least likely to access prevention and health promotion programs such as developmental surveillance, and they are late in seeking help for developmental issues [48, 49]. As a result, there is a delay in initiation of intervention due to late diagnosis and thereby missed opportunities to maximise the plasticity of the developing brain [50]. In line with this theory, the delayed AOC and the delay in help seeking behaviour may also have contributed to those with higher severity seeking intervention, in general. This is also reflected in the higher ADOS-2 scores, and specifically higher scores in the RRB domain and the overall severity of autism as measured by the CSS score.

This study also found that a positive diagnosis of autism among siblings can influence parents’ sensitivity to departures from typical development and lead to an earlier age of concern. This is consistent with the findings from previous literature [51, 52] where parents of

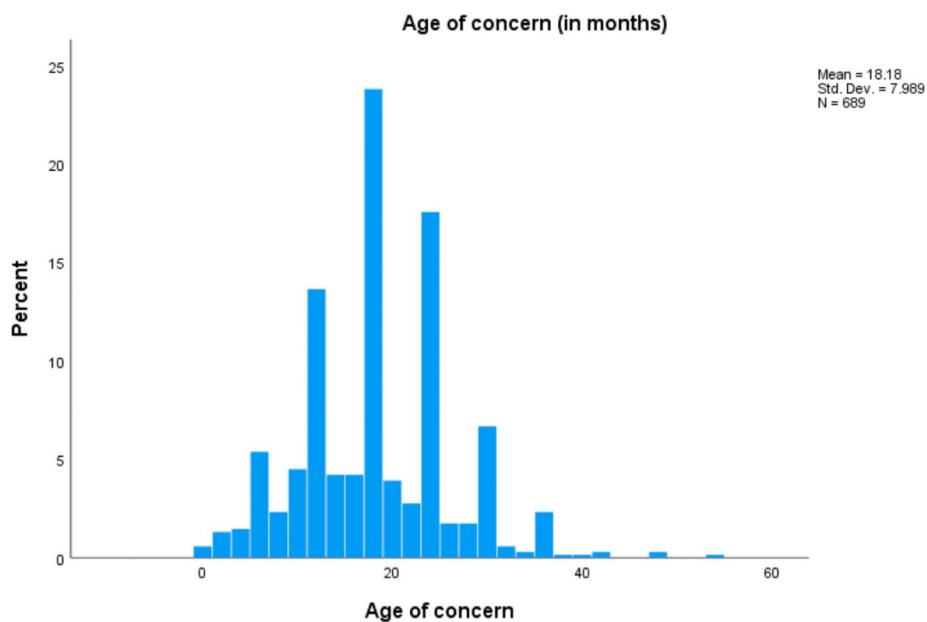


Fig. 1 Histogram of age of first concern

Table 3 Multivariable linear regression analyses with AOC, SA, RRB, and CSS as dependent variables

Predictors	Outcome variables			
	Age of concern (AOC) B (95%CI) [p-value] (Model 1)	Social affect (SA) B (95%CI) [p-value] (Model 2)	Restrictive and Repetitive Behaviour (RRB) B (95%CI) [p-value] (Model 3)	Calibrated Severity Scores (CSS) B (95%CI) [p-value] (Model 4)
Intercept	10.45	14.12	6.35	7.42
Age (years)	1.02 (0.54, 1.50) [< 0.001]	NS	-0.45 (-0.64, -0.27) [< 0.001]	-0.24 (-0.40, -0.08) [0.05]
Gender - Females	NS	1.29 (0.43, 2.16) [0.004]	NS	NS
CALD background - Yes	2.15 (0.56, 3.75) [0.008]	NS	0.60 (0.02, 1.17) [0.011]	0.55 (0.40, 1.07) [0.008]
Annual income	-0.94 (-1.63, 0.25) [0.008]	NS	NS	NS
Sibling's ASD diagnosis – Yes	-1.66 (-3.25, -0.07) [0.041]	NS	NS	NS
Speech/Language delay – Yes	3.21 (1.57, 4.85) [< 0.001]	NS	NS	NS
Developmental delay - Yes	-3.32 (-5.50, -1.13) [0.003]	NS	NS	NS

Primary Outcome (AOC – Model 1) – Cohen's $f^2=0.41$; adjusted $R^2=0.29$; $F=11.62$ on 8 and 352 DF; overall p -value <0.001 ; BIC of final model=2509.65 (compared to baseline model=4623.34 and baseline model + sociodemographic variables=2528.18)

B – unstandardized b coefficient (slope)

NS – not significant in the final model

an older autistic child have increased awareness of early signs and are more likely to scrutinize the younger child's development. Whilst gender was not a significant predictor of AOC, we found that females (compared to males) were associated with higher scores in the social affect domain. Although in contrary with previous literature which suggest that females have a later age of diagnosis, this seem to suggest that parents of those with more severe clinical features, particularly girls with prominent impairment in social communication and interaction skills may have been the ones who sought intervention from the ASLECCs.

With regards to the initial type of concern, speech/language delay, although reported to be the most common concern (58%), it was found to be associated with delayed AOC by 3.21 months. There is substantial evidence that speech/language delay is often the most commonly reported concerns for early identification of autism [18, 51, 53]. However, the conflicting evidence from this study could be due to the reason that, since speech and language delays are not specific to autism, it could be more easily underestimated by parents with respect to more evident motor impairments [17]. Another plausible reason for the delayed timing of concern related to speech/language delay could be due to cultural beliefs of parents where speech delays are often normalised or overlooked [54, 55].

This study also found that children who initially presented with general developmental delay had an AOC more than three months earlier than average. This finding is consistent with previous evidence [56, 57] and could be due to better parental awareness about general development and related delays and better understanding of expected developmental milestones [58]. Further,

general physical symptoms such as a motor skill deficit or feeding difficulty may also be more recognisable by parents as opposed to delays in receptive or expressive communication [17]. Thus, it is essential that screening tools that are sensitive to all aspects of development along with culturally sensitive awareness programs implemented within the health care setting to increase early identification of autism.

High income was also found to be associated with earlier AOC and autism diagnosis within this study. Both high and low prevalence rates of autism diagnosis have been identified based on socioeconomic group status [59–61]. However, the higher documented rates of autism amongst families from higher socioeconomic background may be due to delayed identification or lack of identification of autism in lower socioeconomic communities [59, 61, 62]. Guthrie et al. found autism prevalence rates to be 2–3 times higher in non-Caucasian children and lower-income households compared to Caucasian and higher-income families [60]. However, it has been reported that non-Caucasian children, from lower-income households, who received public insurance and were exposed to a language other than English were less likely to be screened for autism [63]. Therefore, the rates of autism amongst disadvantaged groups have been greatly underrepresented due to the lack of screening. The International Classification of Functioning, Disability and Health indicate that environmental factors contributing to health equity not only includes the attitudes and relationships of those immediately involved in the care of an individual, but also the services, systems, and government policy contributing towards their health [64]. For this reason, it is essential that government funded services increase the available screening and therapeutic

opportunities for autism with a focus on minority populations, in order to reduce the current inequity of services available within Australia and expand culturally sensitive programs.

This study has several strengths and limitations. The validity of relationships depicted within this study was strengthened by the size of the ASELCC dataset of 760 children across Australia and this sample size was a notable strength of this study. However, there may have been sampling bias given that the data was collected from children attending specialised autism early intervention centres. It is possible that the children attending the ASELCCs by and large had higher severity of autism. Hence, children continuing to go undiagnosed during the preschool years, or children who were not accessing this specific type of intervention centre were not represented. The generalisability of the finding, then, may be limited. Another limitation of this study was the subjective nature of broadly categorising the initial parental concerns into types of concerns which could have been influenced by observer bias. Further, while this paper primarily focussed on the sociocultural factors, it is possible that other factors including developmental/cognitive level and co-morbidities may have had an impact on the age and type of first concern. Thus, further studies must be conducted to address these limitations for increased clinical significance.

Conclusion

Identifying early features of autism is critical for providing early intervention as this offers better outcomes. Understanding factors that contribute to early identification of autism can help tailor awareness programs for parents and caregivers, whilst also informing the development of services focused on serving all ethnically diverse communities. The finding that first born children, children born overseas, and children from a CALD background had delayed AOC is indicative of the need for targeted community programs for priority and minority populations about the early signs of autism. These results have international significance in that identifying and addressing contextual and sociocultural factors that influence age and types of first concerns can help tailor community awareness campaigns and population health programs to facilitate early detection and address barriers to early intervention for autism.

Abbreviations

ADOS	Autism Diagnostic Observation Schedule
ADHD	attention deficit/ hyperactivity disorder
ANOVA	Analysis of variance
AOC	age of first concern/ age of concern
ASD	autism spectrum disorder
ASELCC	Autism Specific Early Learning and Care Centres
CALD	culturally and linguistically diverse
CSS	calibrated severity scores

DSM	Diagnostic and Statistical Manual of Mental Disorders
REDCap	Research Electronic Data Capture
RRB	restricted and repetitive behaviour
SA	social affect
SPSS	Statistical Package for the Social Sciences

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Authors' contributions

JRJ, LK, and VE assisted in conceptualization of the research question and design of the study; JRJ and AH conducted data analysis; AH drafted the manuscript under the supervision of VE, JRJ, and LK. All authors (AH, JRJ, CD, GF, SG, LK, AM, TA, VE) reviewed and approved the final manuscript.

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Data Availability

The datasets generated and/or analysed during the current study are not publicly available due to its sensitive nature. However, aggregate data may be available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All methods were carried out in accordance with relevant guidelines and regulations. Ethics approval was attained from the University of New South Wales Institutional Human Research Ethics Committee (HC14267). Informed consent was obtained from all subjects and/or their legal guardian(s) enrolled in early intensive intervention programs at each of the six ASELCCs.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- Diagnostic and Statistical manual of mental disorders: DSM-5™. 5th ed. Arlington, VA, US: American Psychiatric Publishing, Inc.; 2013.
- Maenner MJ, Shaw KA, Bakian AV, Bilder DA, Durkin MS, Esler A, Furnier SM, Hallas L, Hall-Lande J, Hudson A et al. Prevalence and characteristics of Autism Spectrum Disorder among Children aged 8 Years - Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2018. *MMWR Surveill Summ*. 2021;70(11).
- Corsello CM. Early intervention in Autism. *Infants & Young Children*. 2005;18(2):74–85.
- Dawson G, Rogers S, Munson J, Smith M, Winter J, Greenson J, Donaldson A, Varley J. Randomized, controlled trial of an intervention for toddlers with autism: the early start Denver Model. *Pediatrics*. 2010;125(1):e17–23.
- Emerson ND, Morrell HE, Neece C. Predictors of age of diagnosis for children with autism spectrum disorder: the role of a consistent source of medical care, race, and condition severity. *J Autism Dev Disord*. 2016;46(1):127–38.
- Fuller EA, Kaiser AP. The Effects of early intervention on Social Communication Outcomes for children with Autism Spectrum disorder: a Meta-analysis. *J Autism Dev Disord*. 2020;50(5):1683–700.
- Hyman SL, Levy SE, Myers SM, Council on Children With Disabilities, Kuo DZ, Apkon S, Davidson LF, Ellerbeck KA, Foster JEA et al. Identification, evaluation, and management of children with Autism Spectrum Disorder. *Pediatrics*. 2020, 145(1).
- Zwaigenbaum L, Bauman ML, Choueiri R, Kasari C, Carter A, Granpeesheh D, Mailloux Z, Smith Roley S, Wagner S, Fein D, et al. Early intervention for children with Autism Spectrum Disorder under 3 years of age: recommendations for practice and research. *Pediatrics*. 2015;136(Supplement1):60–S81.
- Sandbank M, Bottema-Beutel K, Crowley S, Cassidy M, Dunham K, Feldman JJ, Crank J, Albarran SA, Raj S, Mahub P. Project AIM: autism intervention meta-analysis for studies of young children. *Psychol Bull*. 2020;146(1):1.
- Landa RJ, Gross AL, Stuart EA, Faherty A. Developmental trajectories in children with and without autism spectrum disorders: the first 3 years. *Child Dev*. 2013;84(2):429–42.
- Ozonoff S, Iosif AM, Baguio F, Cook IC, Hill MM, Hutman T, Rogers SJ, Rozga A, Sangha S, Sigman M, et al. A prospective study of the emergence of early behavioral signs of autism. *J Am Acad Child Adolesc Psychiatry*. 2010;49(3):256–266e251.
- Zwaigenbaum L, Bryson S, Rogers T, Roberts W, Brian J, Szatmari P. Behavioral manifestations of autism in the first year of life. *Int J Dev Neurosci*. 2005;23(2–3):143–52.
- Rogers SJ. Neuropsychology of autism in young children and its implications for early intervention. *Ment Retard Dev Disabil Res Rev*. 1998;4(2):104–12.
- Sullivan K, Stone WL, Dawson G. Potential neural mechanisms underlying the effectiveness of early intervention for children with autism spectrum disorder. *Res Dev Disabil*. 2014;35(11):2921–32.
- Chawarska K, Shic F, Macari S, Campbell DJ, Brian J, Landa R, Hutman T, Nelson CA, Ozonoff S, Tager-Flusberg H. 18-month predictors of later outcomes in younger siblings of children with autism spectrum disorder: a baby siblings research consortium study. *J Am Acad Child Adolesc Psychiatry*. 2014;53(12):1317–27. e1311.
- van 't Hof M, Tisseur C, van Berckelaer-Onnes I, van Nieuwenhuyzen A, Daniels AM, Deen M, Hoek HW, Ester WA. Age at autism spectrum disorder diagnosis: a systematic review and meta-analysis from 2012 to 2019. *Autism*. 2020;25(4):862–73.
- Matheis M, Matson JL, Burns CO, Jiang X, Peters WJ, Moore M, de Back KA, Estabillio J. Factors related to parental age of first concern in toddlers with autism spectrum disorder. *Dev Neurorehabil*. 2017;20(4):228–35.
- Kozłowski AM, Matson JL, Horovitz M, Worley JA, Neal D. Parents' first concerns of their child's development in toddlers with autism spectrum disorders. *Dev Neurorehabil*. 2011;14(2):72–8.
- de Leeuw A, Happé F, Hoekstra RA. A conceptual framework for understanding the cultural and contextual factors on autism across the globe. *Autism Res*. 2020;13(7):1029–50.
- Liu F, Scheeren AM, Grove R, Hoekstra RA, Wang K, Guo D, Wang C, Beeger S. Exploring cultural differences in autistic traits: a factor analytic study of children with autism in China and the Netherlands. *J Autism Dev Disord*. 2022;52(11):4750–62.
- Alarcón RD. Culture, cultural factors and psychiatric diagnosis: review and projections. *World Psychiatry*. 2009;8(3):131.
- McDermott R, Varenne H. Culture as disability. *Anthropol Educ Q*. 1995;26(3):324–48.
- Carruthers S, Kinnaird E, Rudra A, Smith P, Allison C, Auyeung B, Chakrabarti B, Wakabayashi A, Baron-Cohen S, Bakolis I, et al. A cross-cultural study of autistic traits across India, Japan and the UK. *Mol Autism*. 2018;9(1):52.
- Daley TC. From symptom recognition to diagnosis: children with autism in urban India. *Soc Sci Med*. 2004;58(7):1323–35.
- Shochet IM, Orr JA, Kelly RL, Wurfl AM, Saggars BR, Carrington SB. Psychosocial resources developed and trialled for indigenous people with autism spectrum disorder and their caregivers: a systematic review and catalogue. *Int J Equity Health*. 2020, 19(1).
- Uono S, Hietanen JK. Eye contact perception in the West and East: a cross-cultural study. *PLoS ONE*. 2015;10(2):e0118094–4.
- Maenner MJ, Schieve LA, Rice CE, Cunniff C, Giarelli E, Kirby RS, Lee L-C, Nicholas JS, Wingate MS, Durkin MS. Frequency and pattern of documented diagnostic features and the age of autism identification. *J Am Acad Child Adolesc Psychiatry*. 2013;52(4):401–413e408.
- Montiel-Nava C, Chacín JA, González-Ávila Z. Age of diagnosis of autism spectrum disorder in latino children: the case of venezuelan children. *Autism*. 2017;21(5):573–80.
- Ravindran S, Brentnall J, Gilroy J. Conceptualising disability: a critical comparison between indigenous people in Australia and New South Wales disability service agencies. *Aust J Soc Issues*. 2017;52(4):367–87.
- Alegría M, Pescosolido BA, Williams S, Canino G. Culture, Race/Ethnicity and Disparities: Fleshing Out the Socio-Cultural Framework for Health Services Disparities. In: *Handbook of the Sociology of Health, Illness, and Healing: A Blueprint for the 21st Century*. edn. Edited by Pescosolido BA, Martin JK, McLeod JD, Rogers A. New York, NY: Springer New York; 2011: 363–382.
- Azzopardi PS, Sawyer SM, Carlin JB, Degenhardt L, Brown N, Brown AD, Patton GC. Health and wellbeing of indigenous adolescents in Australia: a systematic synthesis of population data. *Lancet*. 2018;391(10122):766–82.
- Matson J, Matheis M, Burns C, Esposito G, Venuti P, Pisula E, Misiak A, Kalyva E, Tsakiris V, Kamio Y. Examining cross-cultural differences in autism spectrum disorder: a multinational comparison from Greece, Italy, Japan, Poland, and the United States. *Eur Psychiatry*. 2017;42:70–6.
- Kelly B, Williams S, Collins S, Mushtaq F, Mon-Williams M, Wright B, Mason D, Wright J. The association between socioeconomic status and autism diagnosis in the United Kingdom for children aged 5–8 years of age: findings from the born in Bradford cohort. *Autism*. 2017;23(1):131–40.
- Liptak GS, Benzoni LB, Mruzek DW, Nolan KW, Thingvoll MA, Wade CM, Fryer GE. Disparities in diagnosis and access to health services for children with autism: data from the National Survey of Children's Health. *J Dev Behav Pediatr*. 2008;29(3):152–60.
- Ou L, Chen J, Hillman K, Eastwood J. The comparison of health status and health services utilisation between indigenous and non-indigenous infants in Australia. *ANZJP*. 2010;34(1):50–6.
- Khatri RB, Assefa Y. Access to health services among culturally and linguistically diverse populations in the Australian universal health care system: issues and challenges. *BMC Public Health*. 2022, 22(1).
- Thomas P, Zahorodny W, Peng B, Kim S, Jani N, Halperin W, Brimacombe M. The association of autism diagnosis with socioeconomic status. *Autism*. 2012;16(2):201–13.
- Masi A, Eapen V, Lane A, Simpson K, Roberts J. Sensory subtypes in children on the autism spectrum: Final Report. *Brisbane: Autism CRC* [Available at: https://www.autismcrc.com.au/sites/default/files/reports/1.075RU_Sensory-subtypes_Final_Report.pdf].
- Lord C, Risi S, Lambrecht L, Cook EH, Leventhal BL, DiLavore PC, Pickles A, Rutter M. The Autism Diagnostic Observation Schedule—Generic: a standard measure of Social and Communication Deficits Associated with the Spectrum of Autism. *J Autism Dev Disord*. 2000;30(3):205–23.

40. Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O'Neal L, McLeod L, Delacqua G, Delacqua F, Kirby J. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform.* 2019;95:103208.
41. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JGJBI. A metadata-driven methodology and workflow process for providing translational research informatics support. 2009, 42(2):377–81.
42. Gotham K, Pickles A, Lord C. Standardizing ADOS scores for a measure of severity in autism spectrum disorders. *J Autism Dev Disord.* 2009;39(5):693–705.
43. Hus V, Gotham K, Lord C. Standardizing ADOS domain scores: separating severity of social affect and restricted and repetitive behaviors. *J Autism Dev Disord.* 2014;44(10):2400–12.
44. Gagnon D, Zeribi A, Douard É, Courchesne V, Huguet G, Jacquemont S, Loum MA, Mottron L. Using developmental regression to reorganize the clinical importance of autistic atypicalities. *Transl Psychiatry.* 2022;12(1):498.
45. Garrido D, Carballo G, Artis J, Garcia-Retamero R. Timing of parents' concerns related to Autism Spectrum Disorder and its diagnosis: a mediation analysis. *Span J Psychol.* 2018;21:E59.
46. Smith-Young J, Chafe R, Audas R. Managing the Wait[®]: parents' Experiences in Accessing Diagnostic and Treatment Services for children and adolescents diagnosed with Autism Spectrum Disorder. *Health Serv Insights.* 2020;13:1178632920902141.
47. Zuckerman K, Lindly OJ, Chavez AE. Timeliness of Autism Spectrum Disorder diagnosis and use of services among U.S. Elementary School-Aged children. *Psychiatr Serv.* 2017;68(1):33–40.
48. Woolfenden S, Galea C, Badland H, Sheedy HS, Williams K, Kavanagh AM, Reddihough D, Goldfeld S, Lingam R, Badawi N. Use of health services by preschool-aged children who are developmentally vulnerable and socioeconomically disadvantaged: testing the inverse care law. *J Epidemiol Community Health.* 2020;74(6):495–501.
49. Lewis AK. Cultural and linguistic diversity among children and families referred for diagnostic evaluation of developmental delay and disability: implications for service delivery. *J Pol Pract Intel Disabil.* 2021;18(2):113–9.
50. Woolfenden S, Posada N, Krchnakova R, Crawford J, Gilbert J, Jursik B, Sarkozy V, Perkins D, Kemp L. Equitable access to developmental surveillance and early intervention—understanding the barriers for children from culturally and linguistically diverse (CALD) backgrounds. *Health Expect.* 2015;18(6):3286–301.
51. Hess CR, Landa RJ. Predictive and concurrent validity of parent concern about young children at risk for autism. *J Autism Dev Disord.* 2012;42(4):575–84.
52. Ozonoff S, Young GS, Steinfeld MB, Hill MM, Cook I, Hutman T, Macari S, Rogers SJ, Sigman M. How early do parent concerns predict later autism diagnosis? *J Dev Behav Pediatr.* 2009;30(5):367.
53. Chawarska K, Paul R, Klin A, Hannigen S, Dichtel LE, Volkmar F. Parental recognition of developmental problems in toddlers with autism spectrum disorders. *J Autism Dev Disord.* 2007;37(1):62–72.
54. Ndung'u R, Kinyua M. Cultural perspectives in language and speech disorders. *Disabil Stud Q.* 2009, 29(4).
55. Stahmer AC, Vejnaska S, Iadarola S, Straiton D, Segovia FR, Luelmo P, Morgan EH, Lee HS, Javed A, Bronstein B. Caregiver voices: cross-cultural input on improving access to autism services. *J Racial Ethn Health Disparities.* 2019;6:752–73.
56. Bhat A, Galloway J, Landa R. Relation between early motor delay and later communication delay in infants at risk for autism. *Infant Behav Dev.* 2012;35(4):838–46.
57. Leonard HC, Bedford R, Charman T, Elsabbagh M, Johnson MH, Hill EL, team B. Motor development in children at risk of autism: a follow-up study of infant siblings. *Autism.* 2014;18(3):281–91.
58. Gentles SJ, Nicholas DB, Jack SM, McKibbin KA, Szatmari P. Coming to understand the child has autism: a process illustrating parents' evolving readiness for engaging in care. *Autism.* 2019;24(2):470–83.
59. Dickerson AS, Rahbar MH, Pearson DA, Kirby RS, Bakian AV, Bilder DA, Harrington RA, Pettygrove S, Zahorodny WM, Moyé LA, et al. Autism spectrum disorder reporting in lower socioeconomic neighborhoods. *Autism.* 2016;21(4):470–80.
60. Guthrie W, Wallis K, Bennett A, Brooks E, Dudley J, Gerdes M, Pandey J, Levy SE, Schultz RT, Miller JS. Accuracy of Autism Screening in a large Pediatric Network. *Pediatrics.* 2019;144(4):e20183963.
61. Mandell DS, Novak MM, Zubritsky CD. Factors associated with age of diagnosis among children with autism spectrum disorders. *Pediatrics.* 2005;116(6):1480–6.
62. Daniels AM, Mandell DS. Explaining differences in age at autism spectrum disorder diagnosis: a critical review. *Autism.* 2014;18(5):583–97.
63. Aylward BS, Gal-Szabo DE, Taraman S. Racial, ethnic, and Sociodemographic Disparities in diagnosis of children with Autism Spectrum Disorder. *J Dev Behav Pediatr.* 2021;42(8):682–9.
64. World Health Organisation. International classification of functioning, disability and health: ICF. In. Geneva: World Health Organization; 2001.

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