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Original Article

Speech Disorders in Children with Congenital Heart Disease Attending a Tertiary Institution in South East Nigeria.

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Abstract

Background: Speech problems are neurodevelopmental disorders rarely reported in children with congenital heart defects (CHD). This study aimed to elicit various speech disorders in children with CHD compared to controls.
Methodology: This cross-sectional study involved 50 children with CHD and 50 children without CHD (control group).
Results: Children with heart defects had a higher mean score (1.02±0.16) for speech problems than the control (0.22±0.14), with a statistically significant p-value of <0.0001. Difficulty in understanding a child's speech was also more pronounced in children with heart defects (1.00±0.16) than in control (0.27±0.19), p=0.006. Understanding speech over the phone was significantly harder for children with heart defects (1.22±0.18) compared to control (1.93±1.83), p=0.003. The belief that a child might have a stutter was significantly higher in children with heart defects (0.65±0.14) versus (0.29±0.2), p=0.0001. Tourette's syndrome was reported more frequently in those with heart defects (1.14±0.18) than in those with heart defects (0.1±0.07; p=0.0001). Family history of speech or language disorder shows significant differences, with children with heart defects scoring 0.65±0.15 versus 0.01±0.001, p= 0.001. The prevalence of speech disorders was significantly higher in 36% of children with heart defects, which was significantly higher than 4% seen in controls. χ^2=14.18; p=0.0001, Regarding the age of the child, 36.8% of children under five years of age had a speech disorder compared to 33.3% of those aged five years and older. p= 0.825, OR= 1.1 (95% CI: 0.2 – 4.5).
Conclusion: Children with CHD presented with a higher prevalence of speech disorders compared with control. The prevalence of speech disorders among children with CHD was higher in children who were less than five years old. Furthermore, children with CHD had a significant family history of speech or language disorders than control.

Keywords: Speech Abnormalities; Controls; Subjects; Children; Congenital Heart Defect.

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Introduction

Congenital heart disease (CHD) accounts for approximately 28% of all congenital anomalies.[1] There are varying reports on the prevalence of congenital heart diseases. For instance, Chinawa et al [2], in a cross-sectional study, reported a prevalence of 0.22% in Enugu, among children with congenital heart disease, while Van der Linde et al [3], in their meta-analysis, noted a prevalence of 9.3 per 1000 live births among the Asian continent and Africa having a prevalence of 1.9 per 1000 live births. [1]

Speech disorders are the most common extra-cardiac complications seen in approximately one-third of children with congenital heart disease (CHD). [4] These disorders may result from cardiac defects, complications following open heart surgery delays in management, and poor referrals.[4-6] hypoxemia, pulmonary hypertension, genetic syndromes, hemodynamic instability, chromosomal abnormalities, cardiac arrest, and prolonged cardiopulmonary bypass are possible factors associated with speech disorders in children with CHD.[7,8] Children with congenital heart disease (CHD are known to be at risk of neurodevelopmental delays in language and speech acquisition.[9-11] These disorders include several domains such as impaired pronunciation and delayed onset of language.[11]

In health, children coo at three months, babble at six months, and babbling becomes mimicry at one year with the achievement of a monosyllabic word at that time. However, this cannot be said in children with CHD. For instance, children with CHD have lower scores (on average, 10–17 points lower) at 15 months of age. This worsens at 21 months of age when a language impairment rate of 15.5% is reported.[11] At the age of 2 years, more than a quarter of children with CHD present with lower communicative skills.[12]

Late diagnosis and interventions characterize childhood speech disorders in sub-Saharan Africa, despite the usual early parental concern about development. [13,14] In Nigeria, there is also poor awareness and health-seeking behaviour due to a lack of finance for health care, as health insurance as a means of health care financing is rudimentary.[15]

As a result of late interventions for children with speech disorders in the region, their optimal functioning is not achieved, as many of them do not have access to any form of education or impairment in expressive language ability. [13-15] Early and periodic neuro-developmental assessments in children with CHD may enhance the early identification of speech disorders among them. This allows for early intervention with appropriate therapies and special-needs services for these children. Early intervention leads to enhanced academic, behavioral, and adaptive functioning and a better quality of life. [16-19]
Studies on speech disorders in the study locality have been conducted in the general population, but studies on speech disorders on congenital heart defects are sparse.

This study explored the prevalence and patterns of speech disorders in children with CHD at the UNTH Enugu and compared them with those of controls.

Methods

Study Population

These include children with congenital heart diseases aged 3 months to 18 years who come for follow-up in the cardiology clinic of UNTH and their controls, which included children who are healthy and who were present for a follow-up for minor illnesses such as uncomplicated malaria.

Study Design:

This cross-sectional study was conducted at the cardiology clinic of UNTH, Enugu State.

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Study Period

The study was conducted over a 2 and half year period from 1st January 1, 2022, to 31st October 31, 2024.

Study area and site

This study was conducted in the cardiac clinic of the University of Nigeria Teaching Hospital Ituku-Ozalla Enugu.

Inclusion Criteria

The case subjects consisted of children with CHD who attended the consultant clinic of the study hospital. Children with other congenital anomalies that may affect speech and language, such as Down syndrome, other syndromes associated with cardiac defects, and congenital heart defects occurring with cerebral palsy were excluded from the study.

Sampling Method

Children with CHD and their controls were recruited consecutively until a minimum sample size was reached.

Anthropometry

Weight and height were measured using the stadiometer with a precision of 0.05 kilogramme.

Sample size estimation

The sample size in this study was determined using the formula.

$N = Z^2P (I – P)/ D^2$

Z = 1.96, i.e. the level of significance

P = Prevalence of children with CHD (0.022). [19]

D = Tolerable error (0.05)

Using the above formula, a minimum sample size of 34 was obtained; however, this was rounded off to 50 for the subjects and controls.

Diagnosis of congenital heart disease

Diagnosis of congenital heart disease was done with the aid of Echocardiography with the Hewlett-Packard (HP) model SONO 2000 in the University of Nigeria Teaching Hospital from 2016 to 2018.Both 2D ECHO and Doppler were used for the diagnosis of CHD with all cardiac measurements taken in diastole. Diagnosis of cardiac disease was also made following the standard definition.[19]

Questionnaire for Speech disorders

Speech disorder was assessed using the questionnaire by Earl O. Bergersen [20] It is made up of 23 variables on speech disorders, each measured on a five-point Likert scale ranging from 0 to 5. These variables include; Difficulty understanding your child's speech, Difficulty understanding speech over the phone, Use of grunts or screams more than words, Lisp, Hoarseness, Nasal speech, frustration when attempting to speak, Often using words with only 1 or 2 syllables, Seems winded when increasing volume, difficulty in swallowing, stutter, Tourette's syndrome, Family history of speech or language disorder, speech therapy instituted, difficulty in pronouncing words like- Hap, Wabbit, Tock, Sum, Gog, Ship, Pasghetti, Stuh-reet, Doat.

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The mean score for each variable for the respondents with heart defects and those without defects was compared using the Student's T-test. The outcome measure of the study, Speech disorders, was obtained by categorizing the average score as follows; a score of less than one is regarded as 'No Speech disorder' while scores greater than one are regarded as having 'Speech disorder'. A score of 1-2 stands for mild Speech disorder, 3 as moderate, and 4-5 is categorized as pronounced Speech disorder. [20]

Ethical Approval and Consent to Participate

This was obtained from the Research and Ethics Committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla Enugu, while verbal informed consent was obtained from the mothers who brought their children to the health facility. Informed consent was obtained from the parents and/or legal guardians for study participation. In addition, all methods were performed according to the relevant guidelines and regulations of the Declaration of Helsinki. The code of ethical clearance is UNTH/HREC/2025/01/012.

Data management

The statistical software, International Business Machine, Statistical Product and Service Solutions (IBM-SPSS) was used for data entry and analysis. Categorical variables were presented using frequencies and proportions while continuous variables were represented using mean, standard deviation, and median if the data is skewed. The chi-square test of statistical significance was used to compare the difference in proportions between two categorical variables. Logistic regression was used to assess the association of variables with the occurrence of Speech disorder. Student t-test was used to compare the difference in means between two samples. The level of statistical significance was determined by a p-value of <0.05.

Results

Table 1: Socio-demographic characteristics of the children

Variable	Heart Defect (n=50)	No Heart Defect (n=50)	χ^2 (p-value)
Age of child in years			
Mean±SD	4.5±3.6	4.7±2.5	0.669
Minimum	0.20	0.40	
Maximum	17	17	
Age of child in groups			
<1 year	3(6.0)	11(22.0)	7.21 (0.065)
1-4 years	29(58.0)	20(40.0)	
5-9 years	11(22.0)	8(16.0)	
≥10 years	7(14.0)	10(20.0)	
Age of Father in years Mean±SD	36.8±7.5	44.1±8.4	0.0001*
Age of Father in groups			
<40 years	30(60.0)	12(24.0)	16.53 (0.0001)*
40-49 years	8(16.0)	25(50.0)	
≥50 years	8(16.0)	9(18.0)	
Age of Mother in years Mean±SD	29.3±6.7	36.9±6.6	0.0001*

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Age of Mother in years			
<30 years	27(54.0)	4(8.0)	26.6 (0.0001)*
30-39 years	21(42.0)	43(86.0)	
≥40 years	0(0.0)	2(4.0)	
Educational attainment of Father			
Primary education	6(12.0)	3(6.0)	13.21 (0.004)*
Secondary education	28(56.0)	15(30.0)	
Tertiary education	13(26.0)	32(64.0)	
Educational attainment of Mother			
Primary education	2(4.0)	8(16.0)	18.61 (0.001)*
Secondary education	37(74.0)	19(38.0)	
Tertiary education	8(16.0)	22(44.0)	

Table 1 presents the sociodemographic characteristics of the children and their parents. The mean age of subjects 4.5±3.6 years was slightly lower than the control 4.7±2.5 years, but not statistically significant. P= 0.065.

Table 2: Assessment of Speech disorder among children with heart defects and those without

Speech variable	Heart Defect	No Heart Defect	t-test(p-value)
Speech problems	1.02±0.16	0.22±0.14	<0.0001*
Difficulty understanding your child's speech?	1.00±0.16	0.27±0.19	0.006*
Difficult to understand over the phone	1.22±0.18	1.93±1.83	0.003*
Uses grunts or screams more than words	0.64±0.15	0.13±0.1	0.62
Lisp	0.62±0.13	0.01±0.001	0.001*
Hoarseness	0.9±0.16	0.11±0.08	0.015*
Nasal speech	0.58±0.13	0.03±0.03	0.003*
Has frustration when attempting to speak	0.65±0.15	0.01±0.001	0.001*
Often uses words with only 1 or 2 syllables	1.04±0.18	0.27±0.19	0.022*
Seems winded when increasing the volume	1.12±0.17	0.1±0.07	0.001*
Any difficulty in swallowing	0.9±0.17	0.1±0.1	0.003*
do you think your child might have a stutter	0.65±0.14	0.29±0.2	0.0001*
Tourette's syndrome	1.14±0.18	0.1±0.07	0.0001*
Family history of speech or language disorder	0.65±0.15	0.01±0.001	0.001*
Any speech therapy	0.65±0.15	0.03±0.03	0.002*
Hap	1.04±0.18	0.27±0.19	0.012
Wabbit	1.1±0.2	0.27±0.19	0.0001
Tock	1.12±0.17	0.1±0.07	0.001
Sum	0.98±0.18	0.05±0.05	0.004
Gog	0.9±0.17	0.1±0.1	0.0001*
Ship	0.94±0.15	0.14±0.1	0.0001*
Pasghetti	0.65±0.14	0.29±0.2	0.143
Stuh-reet	1.12±0.17	0.29±0.2	0.005*
Doat	1.14±0.18	0.1±0.07	0.0001*

Table 2 shows that children with heart defects have a higher mean score (1.02±0.16) for speech problems compared to those without heart defects (0.22±0.14), with a statistically significant p-value of <0.0001. Difficulty understanding a child's speech is also more pronounced in children with heart defects (1.00±0.16) versus those without (0.27±0.19), with a p-value of 0.006. Understanding speech over the phone is significantly harder for children with heart defects (1.22±0.18) compared to those without (1.93±1.83), a p-value of 0.003.

Significant differences in other speech variables were noted: children with heart defects exhibit a higher prevalence of lisp (0.62±0.13) compared to those without (0.01±0.001), with a p-value of 0.001; hoarseness (0.9±0.16) versus (0.11±0.08), a p-value of 0.015; and nasal speech (0.58±0.13) versus (0.03±0.03), a p-value of 0.003.

Additionally, children with heart defects showed higher frustration when attempting to speak (0.65±0.15) compared to those without (0.01±0.001) (p = 0.001). They also often use words with only 1 or 2 syllables more frequently (1.04±0.18) than those without heart defects (0.27±0.19), p-value of 0.022, and seem winded when increasing volume (1.12±0.17) compared to (0.1±0.07), p-value of 0.001. Difficulty swallowing was also more common in children with heart defects (0.9±0.17) than in those without (0.1±0.1), with a p-value of 0.003.

The belief that a child might have a stutter was significantly higher in children with heart defects (0.65±0.14) versus (0.29±0.2), p < 0.0001. Tourette's syndrome was reported more frequently in those with heart defects (1.14±0.18) than in those without heart defects (0.1±0.07; p = 0.0001). Family history of speech or language disorder shows significant differences, with children with heart defects scoring 0.65±0.15 versus 0.01±0.001, a p-value of 0.001.

Table 3: Prevalence of Speech disorder among children with heart defect and those without defect

Variable	Heart Defect (n=50)	No Heart Defect (n=50)	χ^2 (p-value)
Speech disorder			
Yes	18(36.0)	2(4.0)	14.18 (0.0001)*
No	32(64.0)	43(86.0)	
Category of disorder			
None	32(64.0)	43(86.0)	14.82 (0.0001)*
Mild	15(30.0)	1(2.0)	
Pronounced	0(0.0)	1(2.0)	

The data in Table 3 present the prevalence of speech disorders among children with heart defects compared to those without heart defects. The analysis was based on 50 children each with and 50 children without heart defects.

In the presence of speech disorders, 36% of the children with heart defects (18 out of 50) had a speech disorder, whereas only 4% of those without heart defects (2 out of 50) had a speech disorder. The chi-squared test (χ^2) value was 14.18 with a p-value of 0.0001, indicating a statistically significant difference between the two groups. 30 % of the children with heart defects had mild speech disorders compared to 2% of the controls.

Table 4: Factors associated with Speech disorder among Heart Defect children

Variable	Speech disorder (n=50)		Total n, (%)	χ^2 p-value	OR (95% CI)
	Yes N (%)	No N (%)			
Age of child in years					
<5 years				0.040	1.1 (0.2 – 4.5)
	14(36.8)	24(63.2)	**38(100.0)**	(0.825)	
≥5 years	4(33.3)	8(66.7)	**12(100.0)**		
Age of father in years					
<40 years	12(40.0)	18(60.0)	**30(100.0)**	0.34 (0.558)	1.4 (0.4 – 5.3)
≥40 years	5(31.3)	11(68.8)	**16(100.0)**		
Age of mother in years					
<30 years				0.002	0.9 (0.2 – 3.9)
	4(36.4)	7(63.6)	**11(100.0)**	(0.963)	
≥30 years	13(37.1)	22(62.9)	**35(100.0)**		
Educational attainment of Mother					
Primary education				1.055	NA
	3(50.0)	3(50.0)	**6(100.0)**	(0.590)	
Secondary education	8(28.6)	20(71.4)	**28(100.0)**		
Tertiary education	4(30.8)	9(69.2)	**13(100.0)**		
Educational attainment of Father					
Primary education	1(50.0)	1(50.0)	**2(100.0)**	0.81 (0.847)	NA
Secondary education	12(32.4)	25(67.6)	**37(100.0)**		
Tertiary education	2(18.2)	9(81.8)	**11(100.0)**		

Table 4 shows the factors associated with speech disorders in children with heart defects.

Regarding the age of the child, 36.8% of children under five years of age had speech disorders compared to 33.3% of those aged five years and older. The p-value was 0.825, suggesting no significant difference, with an odds ratio (OR) of 1.1 (95% CI: 0.2 – 4.5).

Considering the age of fathers, 40.0% of children with fathers under 40 years of age had a speech disorder, whereas 31.3% of children with fathers aged 40 years or older had a speech disorder. The p-value was 0.558, and the OR was 1.4 (95% CI: 0.4 – 5.3), indicating no significant association.

Regarding the age of the mother, 36.4% of children with mothers under 30 years of age had a speech disorder, compared to 37.1% of those aged 30 years or older. The p-value was 0.963, and the OR was 0.9 (95% CI: 0.2 – 3.9)

The educational attainment of the mothers showed that 50.0% of children with mothers having primary education had a speech disorder, 28.6% of children with mothers having secondary education had a speech disorder, and 30.8% had a tertiary education. The p-value was 0.590.

In terms of fathers' educational attainment, 50.0% of children with fathers with primary education had a speech disorder compared to 32.4% with secondary education and 18.2% with tertiary education. The p-value was 0.847

Discussion

This study aimed to document the various forms of speech disorders in children with CHD. The prevalence of speech disorders in children with CHD was noted to be 36%, while that in controls was reported to be 4%.

Somefun et al. [21] in Lagos, Nigeria among 184 subjects, aged 6-47 months, noted a prevalence of 30.4% among children that presented in the audiology clinic of the hospital who had no CHD. This value is higher than 4% seen in the control of the current study. The large sample size used by the latter may explain these differences in prevalence values.

Almuzaini et al. [22], in Tabuk, Saudi Arabia, among 158 children with CHD and 145 controls aged 6 months to 15 years, reported a prevalence of 14.5% in children with CHD and 12.4% in controls. The lower prevalence value obtained by Almuzainiet al. [22] could be a result of the larger sample size, method of recruitment of their subjects, and racial differences. A synopsis of the genetic, environmental, and brain alterations that occur before and after birth could explain the impairment of speech among children with congenital heart disease. [23-26]

Similarly, Hövels-Gürichet al. [26], in Aachen, Germany, noted consistent impairments of speech function in children with CHD, with a prevalence rate of 29%. The prevalence was obtained among 35 children with CHD, comprising 19 children with TOF and 16 with VSD. The similar prevalence observed in both studies could be because they involved preoperative patients.

The current study revealed higher scores for speech and language disorders in children with CHD than in the controls. These speech disorders include difficulty in understanding a child's speech, higher frustration when attempting to speak, use of words with only one or two syllables more frequently, and compromised pronunciation. This finding was also in keeping with the study by Fourdain et al. [27], in Montréal, Canada, who also documented a reduction in the scores of both intellectual and language skills among 49 children with CHD. They noted a dissociation between intellectual and language outcomes at 21 months of age, with an average language composite score below 5 points lower than that obtained in the cognitive scores of Bayley-III. [27] The reason for the speech disorders seen in this study could be attributed to the complex interaction between environmental risk factors, brain alterations, and genetic alterations that occur both before and after conception. [28] A spurious rise in the prevalence of delayed brain development and white matter injury has been reported in previous studies. [29-32]

Tourette syndrome was reported more frequently in children with CHD than in controls in the current study. Previous studies have documented a strong association between Tourette's syndrome, hyperactivity, and cardiovascular disorders. [33]

There was a very high score for a family history of speech or language disorders among children with CHD compared to controls. Wernovsky et al. [34] noted a strong link between familial and genetic predispositions with speech disorders in children with CHD. This tends to arise from the complex interactions between brain alterations and genes.

Over a third of the children with CHD under the age of 5 years had a speech disorder compared to about a third of those aged > 5 years. One study noted that, among 194 subjects with congenital heart defects, older children showed more severe speech deficits. [23-25] It is crucial to note that developmental delay in children with congenital heart defects is age-dependent. In the first year of life, there are some delayed motor milestones, with reduced intelligence quotient (IQ) scores in preschool and school-age periods, while challenges in attaining executive function led to difficulties in academic performance. [35,36]

Fathers who were less than 40 years old and mothers who were more than 30 years old had a higher frequency of having children with speech disorders. Malaspina et al. [37] noted that paternal age was

related to the offspring's non-verbal intelligence. They opined that fathers younger than 25 years and older than 44 years produced offspring with lower neurodevelopment scores.

About half of the children with CHD whose mothers had primary education had speech disorder, while 28.6% of children whose mothers had secondary education had speech disorder, and 30.8% of children whose mothers had tertiary education had speech disorder. In the corollary, half of the children with CHD whose fathers had primary education had a speech disorder, while 32.4% of children with CHD whose fathers had secondary education had a speech disorder, and 18.2% had tertiary education. Fourdain et al. [21] found no predictive effect of a mother's education on both expressive and receptive speech development in children with CHD.

Limitation

A larger sample size of children with CHD who had speech disorders may have improved the study. Furthermore, it would have been valuable to compare the prevalence of speech disorder among children cyanotic vs acyanotic heart disease.

Conclusion

Children with CHD presented with a higher prevalence of speech disorders compared with the controls. The prevalence of speech disorders among children with CHD was higher in children who were less than five years old. Furthermore, children with CHD had a significant family history of speech or language disorders than control.

The findings of this study are crucial as they will help in institute an urgent speech therapy unit that will help in the management of children with CHD who have speech disorders. Furthermore, since hypoxemia and pulmonary hypertension are noted triggers of speech disorders in children with CHD, early referral and surgical intervention of children with CHD will also reduce the burden of speech disorders among children with CHD. This will improve quality of life and school performance in the long run.

References

1. van der Linde D, Konings EE, Slager MA, Witsenburg M, Helbing WA, Takkenberg JJ, Roos-Hesselink JW. Birth prevalence of congenital heart disease worldwide: a systematic review and meta-analysis. J Am Coll Cardiol. 2011 Nov 15;58(21):2241-7.
2. Chinawa AT, Chinawa JM. Compendium of cardiac diseases among children presenting in tertiary institutions in southern Nigeria: a rising trend. *Libyan J Med*. 2021 Dec;16(1):1966217. doi: 10.1080/19932820.2021.1966217.
3. Chinawa JM, Eze JC, Obi I, Arodiwe I, Ujunwa F, Adiele K Daberechi C, et al. Synopsis of congenital cardiac disease among children attending University of Nigeria Teaching Hospital Ituku Ozalla, Enugu. *BMC Res Notes* 2013; 6, 475 https://doi.org/10.1186/1756-0500-6-475
4. Sizarov A, Boudjemline Y. Novel materials and devices in the transcatheter management of congenital heart diseases—the future comes slowly (part 1). *Arch Cardiovasc Dis* 2016; 109:278–85.
5. Snookes SH, Gunn JK, Eldridge BJ, Donath SM, Hunt RW, Galea MP, Shekerdemian L. A systematic review of motor and cognitive outcomes after early surgery for congenital heart disease. Pediatrics 2010;125(4): 818-27. doi: 10.1542/peds.2009-1959.
6. Jones B, Muscara F, Lloyd O, McKinlay L, Justo R. Neurodevelopmental outcome following open heart surgery in infancy: 6-year follow-up. *Cardiol Young*. 2015 Jun;25(5):903-10. doi: 10.1017/S1047951114001140
7. Rollins CK. A mixed bag: Differential influences of oxygenation and perfusion on brain development in congenital heart disease. *J Thorac Cardiovasc Surg* 2016; 152:960–1.

8. Beca J, Gunn JK, Coleman L, Hope A, Reed PW, Hunt RW, Finucane K, Brizard C, Dance B, Shekerdemian LS. New white matter brain injury after infant heart surgery is associated with diagnostic group and the use of circulatory arrest. Circulation. 2013;127(9):971-9. doi: 10.1161/CIRCULATIONAHA.112.001089
9. Bellinger DC. Newburger JW. Neuropsychological, psychosocial, and quality-of-life outcomes in children and adolescents with congenital heart disease *Prog Pediatr Cardiol*. 2010; 29:87-92
10. Fourdain S, Vanasse CM, Poirier N, Carmant, L, Gallagher A. Congenital Heart Disease: Pathophysiology, Risk Factors and Neuropsychological Profiles. Quebec Journal of Psychology 2016;37; 3-20. https://doi.org/10.7202/1040035ar
11. Nattel SN, Adrianzen L, Kessler EC, Andelfinger G, Dehaes M, Côté-Corriveau G, et al. Congenital Heart Disease and Neurodevelopment: Clinical Manifestations, Genetics, Mechanisms, and Implications. *Can J Cardiol*. 2017 Dec;33(12):1543-55. doi: 10.1016/j.cjca.2017.09.020.
12. Squires J, Bricker D, Potter L. Revision of a parent-completed development screening tool: Ages and Stages Questionnaires. J Pediatr Psychol. 1997 Jun;22(3):313-28. doi: 10.1093/jpepsy/22.3.313.
13. Bouma BJ, Mulder BJ. Changing landscape of congenital heart disease. *Circ Res* 2017;120: 908–22.
14. Ali SS. A brief review of risk – factors for growth and developmental delay among preschool children in developing countries. Advanced biomedical research. 2013; 2.
15. Duru CO, Okpokowuruk FS, Adesina AD, Worgu GO, Adeniji FO, Chinawa JM, et al. Caring for Children with Congenital Heart Diseases:Economic Burden of Pre-Surgical Management on Nigerian Families. West Afr J Med. 2021 Feb;38(2):144-51.
16. Fisher VJ, Morris J, Martines J. Developmental screening tools: feasibility of use at primary healthcare level in low and middle–income settings. Journal of health, population, and nutrition. 2014; 32 (2): 314
17. Ford ND, Stein AD. Risk factors affecting child cognitive development: a summary of nutrition, environment. And maternal – child interaction indicators for Sub-saharan Africans. Journal of developmental origins of health and disease. 2016; 7(2): 197 -217.
18. Bakare MO, Munir KM, Bello–Mojeed MA. Public health and research funding for childhood neurodevelopmental disorders in Sub Saharan Africa: a time to balance priorities. Health care in low resource settings. 2014;2 (1).
19. Chinawa JM, Eze JC, Obi I, Ijeoma A, Ujunwa F, Adiele K, et al. Synopsis of congenital cardiac disease among children attending University of Nigeria Teaching Hospital Ituku Ozalla, Enugu. *BMC Res Notes* 2013; 6: 475. https://doi.org/10.1186/1756-0500-6-475
20. Sleep Disordered Breathing Questionnaire for Children Steveston Smiles. Obtainable from https://stevestonsmiles.com › uploads › 2020/05.accessed on 15/01/2025
21. Somefun OA, Lesi FE, Danfulani MA, Olusanya BO. Communication disorders in Nigerian children. Int J Pediatr Otorhinolaryngol. 2006 Apr;70(4):697-702. doi: 10.1016/j.ijporl.2005.09.003.
22. Almuzaini HI, Almuzaini I, Hassan MM. Parents reported language development and scholastic achievement in children with congenital heart diseases versus typically developed. Egypt J Otolaryngol 2024; 40: 66. https://doi.org/10.1186/s43163-024-00628-y

23. Limperopoulos C, Tworetzky W, McElhinney DB, Newburger JW, Brown DW, Robertson RL, et al. Fetuses with congenital heart disease: evaluation with quantitative magnetic resonance imaging and spectroscopy. Circulation 2010;121(1):26e33.
24. Brossard-Racine M, DuPlessis AJ, Vezina G, Robertson R, Bulas D, Evangelou IE, et al . Prevalence and spectrum of in uterostructural brain abnormalities in fetuses with complex congenital heart disease. Am J Neuroradiol 2014;35(8):1593e9
25. Solène F, Ariane St-Denis, Julien H, Ala B, Lionel C, Anne G, et al. Language development in children with congenital heart disease aged 12–24 months, European Journal of Paediatric Neurology 2019; 23: 491-9,
26. Hövels-Gürich HH, Bauer SB, Schnitker R, Willmes-von Hinckeldey K, Messmer BJ, Seghaye MC, et al. Long-term outcome of speech and language in children after corrective surgery for cyanotic or acyanotic cardiac defects in infancy. *Eur J PaediatrNeurol* 2008;12(5):378-86. doi: 10.1016/j.ejpn.2007.10.004.
27. Fourdain S, St-Denis A, Harvey J, Birca A, Carmant L, Gallagher A, et al. Language development in children with congenital heart disease aged 12-24 months. Eur J Paediatr Neurol. 2019 May;23(3):491-9. doi: 10.1016/j.ejpn.2019.03.002.
28. Wernovsky G, Licht DJ. Neurodevelopmental Outcomes in Children with Congenital Heart Disease-What Can We Impact? *Pediatr Crit Care Med*. 2016 ;17(8 Suppl 1):232-42. doi: 10.1097/PCC.0000000000000800.
29. Licht DJ, Shera DM, Clancy RR, Wernovsky G, Montenegro LM, Nicolson SC, et al. Brain maturation is delayed in infants with complex congenital heart defects. *J Thorac Cardiovasc Surg*. 2009 Mar;137(3):529-36; discussion 536-7. doi: 10.1016/j.jtcvs.2008.10.025
30. Warren DJ, Connolly DJ, Griffiths PD. Assessment of sulcation of the fetal brain in cases of isolated agenesis of the corpus callosum using in-utero MR imaging. *AJNR Am J Neuroradiol.* 2010 ;31(6):1085-90. doi: 10.3174/ajnr.A1982.
31. Marino BS, Lipkin PH. Newburger JW. Neurodevelopmental outcomes in children with congenital heart disease: evaluation and management: a scientific statement from the American Heart Association Circulation. 2012; 126:1143-72
32. Clouchoux C, du Plessis AJ, Bouyssi-Kobar M, Tworetzky W, McElhinney DB, Brown DW, et al. Delayed cortical development in fetuses with complex congenital heart disease. Cereb Cortex. 2013 Dec;23(12):2932-43. doi: 10.1093/cercor/bhs281.
33. Brander G, Isomura K, Chang Z, Kuja-Halkola R, Almqvist C, Larsson H, Mataix-Cols D, Fernández de la Cruz L. Association of Tourette Syndrome and Chronic Tic Disorder with Metabolic and Cardiovascular Disorders. *JAMA Neurol*. 2019 Apr 1;76(4):454-61. doi: 10.1001/jamaneurol.2018.4279.
34. Wernovsky G, Licht DJ. Neurodevelopmental outcomes in children with congenital heart disease-what can we impact? *Pediatr Crit Care Med*. 2016; 17:232-42
35. Schwab JF, Lew-Williams C. Language learning, socioeconomic status, and child-directed speech. Wiley Interdiscip *Rev Cogn Sci*. 2016 Jul;7(4):264-75. doi: 10.1002/wcs.1393.
36. Latal B. Neurodevelopmental outcomes of the child with congenital heart disease. *Clin Perinatol*2016; 43:173–85.
37. Malaspina D, Gilman C, Kranz TM. Paternal age and mental health of offspring. *Fertil Steril.* 2015;103(6):1392-6. doi: 10.1016/j.fertnstert.2015.04.015.