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Assessment of Dental Status and Oral Health Status in Children with Congenital Heart Diseases

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Abstract

Purpose: This study aims to identify the dental caries, decayed, missing, and filled teeth index (dmft/DMFT) scores amongst children with cyanotic, and acyanotic congenital heart diseases (CHD), compare with healthy controls and identify the risk factors for poor dental health.

Methods: Between January 2016 and June 2017, 236 children aged 2 to 15 years (mean±SD=7.61±3.88 yrs, median 7 yrs) with CHD and 951 healthy children aged 2 to 15 years (mean±SD=8.83±7.34 yrs, median 9 yrs) were evaluated.

Results: Children with CHD had more caries in their primary and permanent dentition (mean dmft: 2.42±3.82, cardiac group vs. 2.32±6.68, control group; p<0·05; mean DMFT: 2.15±3.38, cardiac group vs. 1.27±1.89, control group; p=0.002).

The DMFT scores for children with CHD were higher in the rural areas. Children frequently consuming biscuits, confectionary and sugared milk had higher dmft±SD scores. The possibility of caries in permanent dentition was more in children with cyanotic CHD compared to acyanotic. Caries in primary dentition showed positive correlation with age.

Conclusions: CHD is associated with poorer dental health in children. Close cooperation between pediatric cardiologists and pediatric dentists is warranted to raise awareness, prevent and institute early treatment for dental ailments.

Keywords: Cyanotic congenital heart diseases; Acyanotic congenital heart diseases; Dental caries; Oral health

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Introduction

The prevalence of caries in children with congenital heart disease (CHD) in India, where children are not offered organised dental care from an early age is unknown. Developmental enamel defects, inadequate oral hygiene and unawareness of dental diseases among parents make them prone for dental caries. Bacteraemia induced by dental caries and dental procedures predispose these children to life threatening infective endocarditis [1,2]. Various haematological, respiratory, and immunological morbidities associated with CHD and drug interactions associated with cardiac medications should be considered while managing the dental pathology [1] Moreover, the affected children have a reduced tolerance to stress induced by dental treatment [3]. Therefore early/preventive dental care of children with CHD is vital. The incidence of CHD across the world is approximately 8-10 cases per 1000 live births [4,5]. The prevalence of CHD in India is 19.2 per 1000 individuals and CHD alone accounts for 10% of the total infant mortality in India. According to the 2001 census data, there are 28 million live births per year in India. Going by the incidence of 8/1000 live births, 60,000-90,000 in a total of 1,80,000 children have CHD in India.4 With advances in medical and surgical management, most of the children with CHD survive into adulthood resulting in the introduction of a new group of patients in dentistry. Despite advances in cardiac management, there is a lack of information regarding the dental health and treatment requirements of these patients [4,5]. With this background, we conducted this study with the primary objective to compare the prevalence of dental caries and dmft/DMFT scores amongst children with CHD and healthy controls. The secondary objective was to investigate the dental health practices and the risk factors for dental caries in the children with CHD.

Methods

This study conforms to the principles outlined in the declaration of Helsinki and approved by the Institutional Ethics Committee. The study included surviving children with CHD aged between 2 to 5 and 12 to 15 years. These two age groups were selected as per the recommendation of WHO Oral Health Survey 2013 that laid down 5 years as the index age group for primary dentition and 12 years as the index age for permanent dentition [6]. Children aged between 6 and 11 years (the mixed dentition group), children with concomitant severe congenital non-cardiac diseases like congenital nephrotic syndrome, exomphalos, tracheoesophageal atresia, tracheoesophageal fistula, anal atresia, Hirschsprung's disease, thalassemia, vonWillebrand disease, idiopathic thrombocytopenic purpura, children with learning difficulties and cerebral palsy, and those who did not have the consent to participate were excluded from the study.

The present study has a descriptive cross-sectional design. The sample size was calculated to estimate the true prevalence of the disease with 95% confidence level, α=0.05, $Z\alpha$=1.96 (value of Z from probability tables), prevalence= 20% (calculated from the pilot study), and precision of the estimate (d)=10 (taking relative precision of 20%). The minimum sample size calculated for the study was 200. The null hypothesis (H0) of this study was 'the dmft/ DMFT index scores are equal

amongst children with CHD and healthy controls.' In the present study, the null hypothesis was tested and rejected for the primary outcome measure of caries experience (dmft/ DMFT) for the primary and permanent dentition. Between January 2016 and June 2017, 236 children (183 males), aged between 2 to 15 years with CHD under treatment at the department of cardiothoracic vascular surgery, All India Institute of Medical Sciences, New Delhi and division of paediatric cardiology, Dr. RML Hospital, Delhi were included in this study. Data for the control group were collected from school health surveys for caries prevalence in healthy children conducted by the Department of Paediatric Dentistry, Santosh Dental College and Hospital. The control group comprised 951 healthy children (609 males) aged 2 to 15 years.

Based on age at presentation, the patients were allocated to two groups: Group I: primary dentition (age 2-5 years; CHD, n=150; control, n=423) and Group II: permanent dentition (age 12-15 years; CHD, n=86; control, n=528). The children with CHD had a migratory background and hence were further subdivided according to the location into urban, peri-urban and rural.

Two examiners examined each child and recorded dmft/ DMFT. The methods for clinical examination were adapted from the World Health Organization's guidelines for basic oral health surveys, 2013 [6]. An inter-examiner kappa value of >0.8 (almost perfect agreement) was achieved amongst all examiners including the gold standard examiner (BS). The Intragroup comparison was done for the variables namely age, sex, location and status of Congenital Heart Disease (CHD) for the prevalence of dental caries (dmft/DMFT). Intergroup comparison was made for caries prevalence (dmft/DMFT) in healthy children and children with CHD according to the age groups.

Statistical Analysis

Stata Statistical Software: Release 12 College Station, TX: StataCorp LP was used for statistical analysis. Descriptive statistics were expressed as Mean±Standard Deviation (SD) and Median with Range for quantitative, dependent variable dmft/DMFT. 95% confidence levels (C.L.) were calculated and presented. Analytical statistics were employed for intergroup and intragroup comparisons by Mann-Whitney U test, Kruskal-Wallis equality of population rank test, Pearson's Chi-Square test and Fisher's exact test. The P value <0.05 was considered statistically significant. The inter-examiner and intra-examiner variation were calculated using Kappa statistics, >0.8 being 'almost perfect agreement'. Logistic regression analysis was applied to the quantitative dependent variables.

Results

The distribution of the samples in the CHD group according to age, gender, and geographical location is depicted in Table E1. Patients' age at evaluation ranged from 2 to 5 years (mean 3.5±1.1, median 4 years) among those with primary dentition (group I) and 12 to 15 years (mean 13.3±1.05, median 13.5 years) among those with permanent dentition (group II). Both the groups had male preponderance (group I: 75.3% and group II: 81.4%). The mean dmft±SD and mean DMFT±SD scores for dental caries were higher in the study group than in the control (group I: study vs. control: mean dmft±SD=2.42±3.81 vs. 0.009±0.13, p<0.001; group II: study vs. control: mean DMFT±SD=2.15±3.37 vs. 0.14±0.09, p<0.001) (Table E2). The mean dmft±SD scores were similar in both genders in the primary dentition group. The mean DMFT±SD scores were significantly higher among males with CHD (mean DMFT±SD=1.06±2.04 vs. 0.13±0.8, p=0.01) (Tables E3A, E3B).

In the permanent dentition group, the mean DMFT±SD score was higher in children with

CHD coming from rural areas than in those from urban and peri-urban areas (p=0.001). However, such difference was absent in the primary dentition group (p=0.2) (Table E3C). The primary dentition group did not exhibit any significant difference between cyanotic and acyanotic congenital heart disease for dmft scores. In the permanent dentition group, cyanotic patients had a higher DMFT±SD than did acyanotic patients (mean DMFT±SD=3.04±4.2 vs 1.12±1.5, p=0.006) (Table E4). The dmft/DMFT scores were significantly higher in children who perceived their health of teeth as poor, followed by average and good in both the age groups (Table E5A). The dmft scores were significantly higher in children who perceived their health of gums as poor, followed by average and good in group I (Table E5B). The gum health did not affect the DMFT scores in group II according to the perceived health of gums (Table E5B). In group I, dmft indices were significantly higher in children visiting the dentist than in children who never visited the dentist (Table E5C). There was no significant difference in the dental caries index among children of both groups according to the frequency of cleaning teeth and usage of toothbrush and toothpaste (Table E5D, E5E). A majority of subjects brushed their teeth once a day.

In group I, dmft scores were significantly higher in children frequently consuming biscuits and confectionary (2.10 ± 3.33; p=0.01) and milk with sugar (2.14 ± 3.37; p=0.008) (Table E6). In group II, DMFT scores were significantly higher in children frequently consuming tea with sugar (1.06 ± 1.72; p<0.001). There was no statistically significant difference in the dental caries index of children with CHD in both the groups according to the parents' level of education (Table E7). In group I, dmft scores were significantly higher in children who missed school due to toothache. The mean dmft scores were 7.21 ± 5.03 (n=24), (missed school) versus 1.52 ± 2.74 (n=126), (did not miss school), (p<0.0001) (Table E8). Intervention urgency in children with CHD was grouped into four categories (Table E9). The majority of the children needed either preventive (n=81) or routine (n=55) treatment; only six children in group I needed urgent treatment. The mean dmft scores were significantly high in the children requiring routine (5.02 ± 3.44) or urgent (10.83 ± 7.49) treatment, compared to children requiring only preventive treatment (0.27±0.65). As the severity of caries increased, there was a greater need for routine or urgent treatment intervention in primary dentition (Table E9). All the children in group II required either preventive (n=37) or routine (n=49) treatment. The mean DMFT scores were significantly high in children requiring routine treatment (3.35 ± 3.98) compared to those requiring preventive treatment (0.54±1.10) in group II (Table E9).

In the acyanotic CHD group of 142 children, 7 subjects (4.9%) required no treatment, 78 subjects (54.9%) required preventive treatment, 53 subjects (37.3%) required routine treatment, and 4 subjects (2.8%) required urgent treatment. In the cyanotic CHD group of 93 children, 7 subjects (2.9%) required no treatment, 40 subjects (43%) required preventive treatment, 51 subjects (54.8%) required routine treatment, and 2 subjects (2.1%) required urgent treatment. The need for routine treatment was significantly high in the cyanotic CHD group (54.8%), compared to acyanotic CHD group (37.3%); p=0.01 (Table E10).

In the present study, when bivariate logistic regression analysis was applied (Table E11, E12), the possibility of caries in permanent dentition was high in children with cyanotic CHD compared to acyanotic CHD (OR=3.46; 95% CI=1.24 - 9.64). Cyanotic CHD was positively associated with caries experience in permanent dentition (p=0.01).

Table E1: Demographic details of the study group of patients with congenital heart diseases and the control group.

Distribution of samples according to age								
Group	**Primary dentition**				**Permanent dentition**			
	Number	**Age (Mean±SD)**	**Median**	**Range**	**Number**	**Age (Mean±SD)**	**Median**	**Range**
CHD	150	3.5±1.09	4.0	2.0-5.0	86	13.3±1.05	13.5	12.0 - 15.0
Control	423	3.9±0.85	4.0	3.0-5.0	528	13.1±0.99	13.0	13.0-15.0

Distribution of samples according to gender				
	Primary dentition		**Permanent dentition**	
Group	**CHD, n (%)**	**Control, n (%)**	**CHD, n (%)**	**Control, n (%)**
Males	113 (75.33%)	227 (53.66%)	70 (81.40%)	362 (68.56%)
Females	37 (24.67%)	196 (46.37%)	16 (18.60%)	166 (31.44%)

Distribution of samples in CHD group according to geographical location				
Location	**Primary dentition**		**Permanent dentition**	
	Number	**Frequency**	**Number**	**Frequency**
Urban	86	57.33%	30	34.88%
Semi-Urban	40	26.67%	38	44.19%
Rural	24	16.00%	18	20.93%

Table E2: Comparison of dental caries index of the patients with congenital heart diseases in the study and the control group.

Groups	**Primary Dentition**			**Permanent Dentition**		
	n	**dmft (Mean±SD)**	**Range (Min-Max)**	**n**	**DMFT (Mean±SD)**	**Range (Min-Max)**
Control group	423	0.009±0.13	0.00-2.00	528	0.13±0.92	0.00-14.00
CHD group	150	2.42±3.81	0.00-20.00	86	2.15±3.37	0.00-27.00
p value+	p-value<0.001*			p-value<0.001*		

Table E3A: Comparison of dental caries index of children with congenital heart diseases (primary teeth) according to gender.

Groups	**Male**			**Female**			**P value**
	n	**dmft (Mean±SD)**	**Range (Min-Max)**	**n**	**DMFT (Mean±SD)**	**Range (Min-Max)**	
Control group	227	0.01±0.18	0.00-2.00	196	0.00	0.00	0.18
CHD group	113	2.41±3.84	0.00-20.00	37	2.43±3.76	0.00-14.00	0.93

Table E3B: Comparison of dental caries index of children with congenital heart diseases (permanent teeth) according to gender.							
Groups	**Male**			**Female**			**P value**
	n	**dmft (Mean±SD)**	**Range (Min-Max)**	**n**	**DMFT (Mean±SD)**	**Range (Min-Max)**	
Control group	362	0.14±0.95	0.00-14.00	166	0.12±0.85	0.00-10.00	0.91
CHD group	70	2.40±3.57	0.00-27.00	16	1.06±2.04	0.00-8.00	**0.01***

Table E3C: Comparison of dental caries index of children with congenital heart diseases according to geographical location.						
Groups	**Primary Dentition**			**Permanent Dentition**		
	n	**dmft (Mean±SD)**	**Range (Min-Max)**	**n**	**DMFT (Mean±SD)**	**Range (Min-Max)**
Urban	86	2.63±4.07	0.00-20.00	30	1.53±1.97	0.00-8.00
Peri-urban	40	1.85±3.42	0.00-13.00	38	1.84±1.91	0.00-8.00
Rural	24	2.58±3.52	0.00-14.00	18	3.83±6.20	0.00-27.00
p value++	p-value=0.29			p-value=**0.0001***		

Table E4: Comparison of dental caries index in primary and permanent teeth according to type of congenital heart diseases.						
Groups	**Primary Dentition**			**Permanent Dentition**		
	n	**dmft (Mean±SD)**	**Range (Min-Max)**	**n**	**DMFT (Mean±SD)**	**Range (Min-Max)**
Acyanotic group	102	2.27±3.82	0.00-20.00	40	1.12±1.55	0.00-6.00
Cyanotic group	48	2.72±3.83	0.00-18.00	46	3.04±4.20	0.00-27.00
p value+	p-value=0.28			p-value=**0.0006***		
+Mann-Whitney/Wilcoxon Two sample test ++ Kruskal-Wallis equality-of-population rank test *Statistically significant						

Table E5A: Comparison of dental caries index in children with congenital heart disease according to perceived health of teeth.				
Group	**Primary Dentition**		**Permanent dentition**	
	n	**dmft (Mean±SD)**	**n**	**DMFT (Mean±SD)**
Good	89	0.26±0.73	47	1.28±4.01
Average	12	1.92±1.56	25	2.88±2.00
Poor	49	6.47±4.27	14	3.79±1.85
p value+	p=0.0001*		p=0.0001*	
+Mann-Whitney / Wilcoxon Two sample test ++Kruskal-Wallis equality-of-population rank test *Statistically significant				

Table E5B: Comparison of dental caries index in children with congenital heart disease according to perceived health of gums.

Group	Primary Dentition		Permanent dentition	
	n	dmft (Mean±SD)	n	DMFT (Mean±SD)
Good	92	0.47±1.57	24	2.33±5.51
Average	6	5.17±3.87	26	1.88±2.05
Poor	9	8.22±6.06	24	2.38±2.36
Don't know	43	5.00±3.76	12	1.92±1.78
p value+	p=0.0001*		p=0.5041	

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E5C: Comparison of dental caries index in children with congenital heart disease according to visit to a dentist.

Group	Primary Dentition		Permanent dentition	
	n	dmft (Mean±SD)	n	DMFT (Mean±SD)
Once a year	4	10±8.49	5	3.2±1.10
Twice or more	2	9.5±4.95	-	-
Never	144	2.11±3.33	81	2.09±3.46
p value+	p=0.0001*		p=0.05*	

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E5D: Comparison of dental caries index in children with congenital heart disease according to frequency of cleaning teeth.

Group	Primary Dentition		Permanent dentition	
	n	dmft (Mean±SD)	n	DMFT (Mean±SD)
Never	29	2.86±4.98	-	-
Weekly	10	3.9±5.70	3	0.33±0.58
Daily once	97	2.27±3.29	78	1.99±2.05
Daily twice	14	1.5±2.79	5	5.6±11.97
p value+	p=0.58		p=0.27	

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E5E: Comparison of dental caries index in children with congenital heart disease according to tooth brush and tooth paste usage.

Age group	Yes		No		p value+
	n	Dmft/DMFT (Mean±SD)	n	Dmft/DMFT (Mean±SD)	
Primary dentition	120	2.33±3.51	30	2.77±4.92	p=0.64
Permanent dentition	86	2.15±3.38	0	0	-

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E6: Comparison of dental caries index in children with congenital heart disease according to type of food.

Food type	Less frequent/Never		Frequent		p value+
Primary teeth	**n**	**dmft (Mean±SD)**	**n**	**dmft (Mean±SD)**	
Fresh fruits	81	1.58±3.06	330	2.06±3.25	p=0.11
Biscuits & confectionary	56	1.07±2.14	355	2.10±3.33	**p=0.01***
Soft drinks	391	2.01±3.25	20	1.25±2.20	p=0.37
Sweet candies	301	1.85±3.12	110	2.3±3.44	p=0.22
Milk with sugar	57	0.86±1.55	354	2.14±3.37	**p=0.001***
Tea with sugar	233	2.32±3.59	178	1.51±2.58	**p=0.02***
Coffee with sugar	406	1.95±3.22	5	2.8±2.95	p=0.35
Permanent teeth	**n**	**DMFT (Mean±SD)**	**n**	**DMFT (Mean±SD)**	**p value+**
Fresh fruits	81	0.57±1.15	330	0.84±2.08	p=0.49
Biscuits & confectionary	56	0.63±1.09	355	0.81±2.04	p=0.64
Soft drinks	391	0.81±1.96	20	0.45±1.23	p=0.25
Sweet candies	301	0.84±2.08	110	0.65±1.46	p=0.22
Milk with sugar	57	1.49±3.78	354	0.67±1.41	**p=0.001***
Tea with sugar	233	0.58±2.07	178	1.06±1.72	**P<0.001***
Coffee with sugar	406	0.79±1.94	5	0.6±1.34	p=0.78

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E7: Comparison of dental caries index in children with congenital heart disease according to parent's education level.

Primary teeth	**Father**		**Mother**	
	n	**dmft (Mean±SD)**	**n**	**dmft (Mean±SD)**
No schooling(G1)	29	2.55±3.40	32	3.06±3.89
Lower than primary school(G2)	6	0.00	4	5.00±10.00
Primary school(G3)	36	2.94±4.60	38	3.07±4.08
Secondary school(G4)	44	2.54±3.92	49	1.69±3.05
High school(G5)	17	1.58±2.47	13	1.92±3.75
College(G6)	18	2.44±4.09	13	1.53±2.33
p value+	p=0.28		p=0.15	
Permanent teeth	**n**	**DMFT (Mean±SD)**	**n**	**DMFT (Mean±SD)**
No schooling(G1)	25	3.08±5.35	40	3.0±1.41
Lower than primary school(G2)	4	2.50±1.91	2	1.3±0.9
Primary school(G3)	21	1.71±2.10	19	1.3±0.8
Secondary school(G4)	20	2.05±2.39	20	1.1±0.5
High school(G5)	7	1.57±2.14	2	0.80±0.37
College(G6)	9	1.11±0.92	3	0.66±0.57
p value+	p=0.71		p=0.3	

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E8: Comparison of dental caries index in children with congenital heart disease according to missed school due to tooth ache.

	Primary Dentition		**Permanent dentition**	
	n	**dmft (Mean±SD)**	**n**	**DMFT (Mean±SD)**
Yes	24	7.21±5.03	10	2.7±1.64
No	126	1.52±2.74	76	2.08±3.54
p value+	P<0.001*		p=0.07	

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E9: Comparison of dental caries index in children with congenital heart disease according to intervention urgency.

	Primary Dentition		Permanent dentition	
	n	dmft (Mean±SD)	n	DMFT (Mean±SD)
No treatment(G1)	8	0.00	0	0.00
Preventive treatment(G2)	81	0.27±0.65	37	0.54±1.10
Routine treatment(G3)	55	5.02±3.44	49	3.35±3.98
Urgent treatment(G4)	6	10.83±7.49	0	0.00
p value+	p=0.0001*		p=0. 0001*	

+Mann-Whitney / Wilcoxon Two sample test
++Kruskal-Wallis equality-of-population rank test
*Statistically significant

Table E10: Intervention urgency according to type of CHD.

Intervention urgency	Acyanotic CHD		Cyanotic CHD		Total	
	n	Percentage	n	Percentage	n	Percentage
No treatment	7	4.93%	0	0.00%	7	2.98%
Preventive treatment	78	54.93%	40	43.01%	118	50.21%
Routine treatment	53	37.32%	51	54.84%	104	44.26%
Urgent treatment	4	2.82%	2	2.15%	6	2.55%
Total	142	100%	94	100%	235	100%
p value=0.01*						

Pearson's chi-squared test ($\chi 2$) and Fisher's exact test
*Statistically significant

Table E11: Bivariate logistic regression analysis on caries prevalence in permanent dentition applied to all patients in the study group (n=86).

Variables	Odds Ratio	95% confidence interval	Coefficient	S.E.	Z-Statistic	P-Value
Cyanotic CHD	3.99	1.30-12.18	1.38	0.56	2.43	**0.01**
Age	0.71	0.36-1.38	-0.33	0.33	-0.99	0.31
Gender	0.47	0.09-2.29	-0.75	0.80	-0.93	0.35
Location	1.84	0.80-4.22	0.61	0.42	1.45	0.14
Biscuits/confectionary	1.16	0.76-1.77	0.15	0.21	0.70	0.47
Chewing gum/sugar	2.16	0.63-7.35	0.77	0.62	1.23	0.21
Fresh fruits	0.79	0.41-1.54	-0.22	0.33	-0.66	0.50

Jam/honey	1.99	0.70-5.62	0.69	0.52	1.30	0.19
Milk with sugar	0.96	0.65-1.42	-0.03	0.19	-0.17	0.86
Sweet/candies	1.06	0.60-1.86	0.06	0.28	0.22	0.82
Soft drinks	0.81	0.28-2.31	-0.20	0.53	-0.38	0.69
Tea with sugar	0.76	0.53-1.10	-0.26	0.18	-1.41	0.15
Coffee with sugar	0.00	0.08-1	-11.39	285.88	-0.03	0.96
Father education	1.19	0.78-1.81	0.17	0.21	0.82	0.41
Mother education	0.82	0.49-1.36	-0.19	0.26	-0.75	0.45

Table E12: Bivariate logistic regression analysis on caries prevalence in primary dentition applied to all patients in the study group (n=86).

Term	Odds Ratio	95%	C.I.	Coefficient	S.E.	Z-Statistic	P-Value
Cyanotic CHD	1.12	0.45	2.76	0.12	0.45	0.26	0.79
Age	2.66	1.73	4.08	0.97	0.21	4.49	**<0.001**
Gender	1.36	0.53	3.43	0.30	0.47	0.65	0.51
Location	0.59	0.33	1.04	-0.52	0.29	-1.80	0.07
Biscuits/confectionary	0.96	0.73	1.27	-0.03	0.14	-0.24	0.81
Chewing gum/sugar	0.78	0.46	1.34	-0.23	0.27	-0.86	0.38
Fresh fruits	1.33	0.91	1.95	0.29	0.19	1.49	0.13
Jam/honey	0.89	0.44	1.78	-0.10	0.35	-0.31	0.75
Milk with sugar	0.96	0.65	1.40	-0.03	0.19	-0.19	0.84
Sweet/candies	0.95	0.72	1.25	-0.04	0.13	-0.34	0.73
Soft drinks	0.99	0.59	1.64	-0.00	0.25	-0.03	0.96
Tea with sugar	0.89	0.68	1.17	-0.11	0.13	-0.81	0.41
Father education	1.11	0.77	1.60	0.11	0.18	0.59	0.55
Mother education	0.71	0.48	1.04	-0.33	0.19	-1.72	0.08

Discussion

The limited studies in the literature addressing the oral health status and prevalence of dental caries in children with CHD reflects the possibility of higher risk to these patients in developing countries (Table E13) [1, 7-16]. Hoffman and associates demonstrated that countries with high fertility rates tend to be those with lower per capita income and more births per unit of population [9]. They have a disproportionate number of children born with congenital heart disease; this imposes an added burden. Poverty compounded by limited education forms a high barrier to successful treatment of CHD [17]. With the advent of paediatric cardiac surgery in 1938 along with modern diagnostic tools; most of these children survive into adulthood [18]. However, the burden of a severe medical condition, multiple medications and long periods of hospitalisation

in these children lead to neglect of oral health and of its effect on their general health over time [1,7,19,20].

For both group of patients with primary and permanent dentition, the dental caries index scores were high in the study group compared to healthy control (Table E2). The results of the present study corroborate the findings of other studies [1, 16, 21, 23-27]. This could be due to decreased dental intervention in the cardiac group compared to the control group, high complexity of CHD disease and increased health demands made by their medical condition. Children who experience extensive decay in the primary dentition group are at risk for future proximal molar decay despite implementing preventive measures [21,22]. Our findings are at variance with Tasioula and associates who found that children with CHD had similar levels of dental disease compared to children without this congenital anomaly [7]. This could be attributed to the intervention in, and successful management of, these patients at an early age [7]. The results of our study were statistically significant for the CHD group in the permanent dentition group, with higher caries index in males than females (Table E3A, E3B). This finding conforms with a study by Joshi and associates who found that overindulgence and frequent feeding of males over females prevail in India regardless of the socio-economic class [23]. In this study, mean DMFT score was high in permanent dentition in rural areas (Table E3C). This may be attributed to factors like family income, parental education, parents' dental knowledge, attitude and behaviour, the child's dietary and oral hygiene habits, and place of residence [24]. Further support regarding the positive correlation of dental caries with the above factors comes from studies conducted in Greece [25], Hong Kong [26] the UAE [27] and China [28]. Studies conducted on caries in rural areas of Uganda [29] and Southwestern China [30] showed that decayed teeth accounted for the greatest percentage of total dmft/ DMFT. Similar findings on caries experience were reported in rural areas of Maharashtra [31], Karnataka [32] and Punjab [24] in India. Although higher than the WHO target, there was no statistically significant difference between the cyanotic and acyanotic groups for dmft scores in the primary dentition group (Table E4). In the permanent dentition group, DMFT scores in the cyanotic group were significantly higher than in the acyanotic group. Berger and associates demonstrated that cyanotic children had more active carious teeth, received fewer reminders to brush from their mothers, had more cariogenic food at home, and lowest levels of dental treatment [15]. Seymour and associates also demonstrated that bleeding gums with anticoagulants and gingival hyperplasia due to calcium channel blockers compromised the oral health conditions in these children [33]. Furthermore, Stecksen-Blicks and associates showed the association of digoxin and dental caries in children with CHD because of its availability in sucrose-based suspension (Lanoxin) [20]. In addition, studies by Linda Rose [34] and Stecksen-Blicks [10] reported that diuretics increase the risk of caries and hyposalivation. Owing to the compounded chair-side risks of medical emergencies dental care is often of low priority in this group as in agreement with Franco and associates [8]. Thus, children with cyanotic heart disease are at increased risk of developing dental and gingival diseases.

Table E13: Published studies on caries in children with heart disease.

Author	Year	Country	Sample size	Age group	Caries experience / prevalence
Berger ENH[15]	1978	Australia	n=57	8-10 years	Cyanotic CHD had higher dt, DT and MT.
Hallett KB et al[1]	1992	Australia	n=39	2-15 years	dmft=4.2
Pollard MA and Curzon ME[14]	1992	UK	n=100	2-16 years	dmft=1.8 (2-4 years) dmft=4.3 (5-9 years) DMFT=0.6 (5-9 years) DMFT=1.8 (10-16 years)
Franco E et al[8]	1996	UK	n=60	2-16 years	dmft=3.9 DMFT=2.7
Balmer R and Bu'Lock FA[16]	2003	UK	n=38	2-16 years	Dental caries experience=58% Untreated dental caries=39%
Stecksen-Blicks C et al[10]	2004	Sweden	n=41	6.5 years	dmfs=5.2 +/-7.0 DMFS=0.9 +/-1.9
Tasioula V et al[7]	2008	UK	n=176	2-16 years	dmft=1.57 +/-3.01 DMFT=0.77 +/-1.42
Rai K et al[9]	2009	India	n=170	1-16 years	Dental caries experience=42.4%
Panggabean EP et al[11]	2011	Indonesia	n=35	2-15 years	Dental caries experience=97.1%
Pimental ELC et al[12]	2013	Brazil	n=144	3-5 years	dmft=5.4 +/-4.9 Dental caries experience=80.5%
Ali HM et al[13]	2017	Sudan	n=111	3-12 years	dmft/DMFT=3.7 (3-7 years) dmft/DMFT=1.3 (8-12 years)

The dmft/DMFT scores were significantly higher in children who perceived their health of teeth as poor in both the age groups (Table E5A). Therefore, it appears that children with CHD were able to identify the problem and could be symptomatic due to the high caries tendency. This finding corresponds with Stecksen-Blicks, and was applicable to both the dentitions. However, their visit to a dentist was deferred until a caries problem was evident [20]. In the primary dentition group, dmft indices were significantly higher in children who perceived their health of gums as poor (Table E5B). This could be due to lack of supervised tooth-brushing and inability to take good oral care independently in children of this age group [8]. Primary teeth are also more predisposed to demineralization than mature permanent teeth due to the thinner and immature enamel, as stated by Franco and associates [8]. In the primary dentition group, dmft indices were significantly higher in children visiting the dentist compared to children who never visited the dentist (Table E5C). Several children with CHD experience long hospital stays because of surgery or illness. Many of them never visit a dentist until a caries problem is evident [20]. Their burdens of financial and medical concerns make dental needs a lesser priority [2,16].

In the present study, a majority of subjects brushed their teeth only once a day. There was no statistically significant difference in mean dmft/DMFT scores in primary and permanent dentition on intra-group comparison according to frequency of cleaning teeth (Table E5D). But the scores were higher than the WHO target. Lockhart and associates [35] recommended more attention to avoidance of dental disease in patients susceptible to endocarditis. Daily supervised tooth brushing has been shown to reduce dental caries in children [35]. In the primary dentition group the dmft scores amongst those who practiced tooth brushing were not significantly different from those who did not use a toothbrush (Table E5E). All the children in the permanent dentition group used a toothbrush and toothpaste for cleaning their teeth. However, the caries prevalence in both the study groups was above the WHO target (DMFT/dmft1.5) [6]. This showed the need for better oral hygiene practices to reduce caries experience. In our study, the mean dmft scores for children frequently consuming biscuits, confectionary and milk with sugar in the primary dentition group (>2.10) was higher than the WHO target [6]. The mean DMFT score in the permanent dentition group for children frequently consuming tea with sugar was 1.06 ± 1.72, which was within the WHO target (Table E6). This could be because biscuits, confectionary and milk with sugar are fermentable carbohydrates, whose frequent consumption may cause a fall in the pH leading to a constant acidic environment in the oral cavity. In a systematic review conducted in 2001 by Burt and colleagues, it was stated that sugar consumption in high frequency and amounts appear to be a risk factor for caries among some children, but not all [36]. Further research is needed to identify the factors that render some children more likely than others to develop caries in the presence of a high sugar diet. Studies have shown that parents of chronically sick children (like CHD) tend to overprotect and overindulge their child. Because of the reduced appetite of these children, parents often let their child eat and drink what they prefer (mostly sugar-containing beverages and cariogenic snacks), whenever they want (between main meals, at night), putting oral health at risk [23]. Also, children with CHD often need dietary modifications which may have damaging effects on their oral health. In the present study, there was no statistically significant difference in the mean dmft/DMFT scores of children with CHD in both the groups according to the parents' level of education (Table E7). Rai and associates stated that parents' awareness of the importance of maintaining good oral hygiene was very poor in India [9]. da Fonseca and associates reported that one-fifth of the parents of children with CHD did not know that oral health was important for their children's heart [37]. In the primary dentition group, the dmft indices were significantly higher in children who missed school due to toothache (Table E8). Jackson and associates have also shown a positive association between irregularity in school and dental problems [38]. The prevailing cardiac condition together with poor oral condition compounded the difficulties of the child and affected their regular attendance and education.

In the present study, the majority of the children needed either preventive or routine treatment; only six children in the primary dentition group needed urgent treatment. The mean dmft scores were significantly high in the children needing routine or urgent treatment than in children needing only preventive treatment (Table E9). As the severity of caries increased, there was a greater need for routine or urgent treatment intervention. This concurs with a study by Franco and associates [8]. Among the children with CHD, the need for routine treatment intervention was significantly higher in the cyanotic group compared to the acyanotic group (Table E10). When bivariate logistic regression analysis was applied (Table E11, E12); the possibility of caries in permanent dentition was 3.46 times more in children with cyanotic CHD than in acyanotic CHD (Odds ratio 3.46, 95% CI: 1.24-9.64, p=0.01). This was in concurrence with Stecksen-Blicks and

associates [20]. In the present study over 68% of the cyanotic CHD children required some type of dental treatment.

Congenital heart diseases- a potential risk factor for poor oral health or vice versa?

There have been several studies in the literature addressing poor oral health and its association with infective endocarditis in patients with CHD. However, the dynamicity of their inter-relation has been inadequately explored. Ironically, CHD by itself could be a cause for the manifestation of the oral disease as stated by various authors. Cyanotic heart disease leads to altered structure of enamel and dentin with a significantly decreased calcium and phosphorus content in the saliva [39]. This is attributed to altered haemodynamics, chronic malnutrition, medication and hypoxia. Furthermore, Hansson and associates found cariogenic microflora like mutans streptococci at higher levels in CHD than case matched controls in infants at 12 months of age [34,40]. In addition, oral conditions like stomatitis, cyanotic oral mucous membrane, gingiva and tongue together with chronic malnutrition predispose these children to a higher incidence of enamel hypoplasia and periodontal disease [3].

Study Limitations

In this study, the control group was taken from school health surveys. We could take the control group from non-cardiac healthy patients reporting to the respective hospitals.

Conclusions

We conclude that children with CHD have poor oral health, and are prone to dental caries, compared to healthy children. Cyanotic heart disease patients have a higher caries experience than acyanotic patients. These patients should be given more attention due to their susceptibility to infective endocarditis. Mothers, being the primary caregivers, should be aware about oral health care and nutritional needs of children with complex CHD. Hence, their education level has a close association with their child's well-being. Children with complex CHD often miss school due to toothache and debilitated health conditions. Lactose in milk together with sucrose in sugar and frequent food intake are contributory to the caries formation in the primary dentition group. Dental care is often a low priority in children with CHD, and is addressed only on occurrence of a problem. Closer collaboration amongst all medical professionals including cardiologists, dentists and nutritionists is needed in order to identify the children at high-risk and provide preventive oral care, awareness of oral hygiene, diet, and the benefits of fluoride supplements. Children with CHD should have their first dental check-up as the first tooth erupts, with follow up every 6 months. Dental surgeons should be appointed in Primary Health Centres (PHCs) to provide oral care in Rural India.

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