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ABSTRACT

Background:

Poor oral health in children with cardiac conditions can have negative effects on quality of life and increased risk of infective endocarditis. The aim of this study was to investigate the caries experience in children with cardiac conditions attending the Royal Children's Hospital, Melbourne.

Methods:

Medical and dental records of 428 children aged <12 years were examined. Cardiac and other medical diagnoses, decayed, missing and filled surfaces/teeth were recorded and analysed. Children referred for reasons other than caries management (NRCM) was analysed separately to address confounding of referral reason on caries experience.

Results: Mean age of overall study population was 4.9 (SD2.4) years, caries prevalence 52.1%, mean dmft 3.65 (SD4.8), mean dmfs 6.19 (SD11.3), enamel defects prevalence 29.2%. Mean age of NRCM group was 4.6 (SD2.4) years, caries prevalence 37.5%, mean dmft 2.37 (SD4.2), mean dmfs 4.22 (SD9.4), enamel defects prevalence 23.0%. Untreated carious lesions accounted for 89.9% of caries experience. Caries experience was associated with low socio-economic status, absence of comorbidity and enamel defect presence.

Conclusions: High disease levels were observed. Age, socio-economic status, and enamel defects were associated with caries experience, not severity of cardiac diagnoses. Early referral for dental care and improved access should be facilitated.

Keywords: cardiac disease, congenital heart disease, Australian children, dental caries, enamel defects

Abbreviations and acronyms:

ASD = Atrial septal defect

AVSD = Atrioventricular septal defect
CI = 95% confidence interval
DDE = Developmental defects of enamel
dmft/DMFT = decayed, missing (due to caries), filled teeth (upper case denotes permanent teeth, lower case denotes primary teeth)
dmfs/DMFS = decayed, missing (due to caries), filled surfaces (upper case denotes permanent teeth, lower case denotes primary teeth)
DoD = Department of Dentistry
ICDAS II = International Caries Detection and Assessment System II
IRSD = Index of Relative Socio-Economic Disadvantage
MACPAS = Major aorto-pulmonary collateral arteries
NRCM = Subset of children not referred for caries management
OR = Odds ratio
RCH = The Royal Children's Hospital of Melbourne
SD = Standard deviation
SEIFA = Socio-Economic Indexes for Areas
SES = Socio-economic status
VSD = Ventricular septal defect
WHO = World Health Organisation

INTRODUCTION

Despite declining prevalence in the last 30 years, dental caries persists as one of the most prevalent chronic conditions affecting Australian children.[1,2] Untreated dental caries can result in pain and discomfort that can negatively impact a child's quality of life with difficulty chewing, gaining weight from adequate nutrition, growth, and sleep.[3] The impact of poor oral health may exacerbate other health problems for children with cardiac conditions including low weight gain, and difficulty with eating, in addition to increasing the risk of developing infective endocarditis.[4,5]

Children with cardiac conditions in developed countries such as the Netherlands, Sweden, Norway, United Kingdom, Australia and United States of America have been reported to have greater caries experience than healthy matched controls, that manifests as larger decayed missing and filled indices with significantly more untreated, advanced carious lesions in both primary and permanent teeth.[6-11] Additionally there are reports of difficultly accessing adequate dental care within the wider community and children that have received care have teeth extracted rather than restored.[10, 12, 13]

Little is known about the contemporary caries experience and related factors in Australian children with cardiac conditions. Only two reports have been published since the indexation of Medline in 1966, a descriptive study of children at the Royal Children's Hospital, Melbourne (RCH) in the 1970s[14] and a case-controlled study of a sample of Queensland children referred to a tertiary care facility published in 1992.[6] Children with acyanotic and cyanotic cardiac conditions in the Victorian study were reported as having significantly greater decayed, missing and filled teeth (dmft and DMFT) indices than healthy children.[14] In the Queensland study, despite a similar home environment, cardiac children had a similar prevalence of cavitated carious lesions, but almost double the number of affected teeth than their siblings, and a significantly greater prevalence of developmental enamel defects.[6]

The medical management for children with cardiac diagnoses, particularly complex cardiac conditions, has improved markedly since the last published Australian study, and the population of children with cardiac conditions has changed with an increased complexity of cardiac conditions.[15] Given the paucity of current information on the caries experience of Australian children with cardiac conditions and anecdotal reports of poor oral health necessitating cancellation of cardiac surgery, an understanding of the current caries experience of these children is needed.

The aim of this study was to i) evaluate the caries experience of children with cardiac conditions attending the Royal Children's Hospital of Melbourne Department of Dentistry (RCH DoD); and ii) the factors associated with the caries experience in these children.

METHODS

Ethical approval was obtained from The Royal Children's Hospital Human Research Ethics Committee (DAF #DA008-2015-01). A cross-sectional retrospective audit of the caries experience of all children diagnosed with a cardiac condition attending the RCH DoD between July 2007 and February 2016 was undertaken.

Australia-born children diagnosed with a cardiac condition who attended the RCH DoD were identified by searching the compulsory health condition and medical history fields of the electronic patient management database software (Titanium®, Spark Dental Technology, Auckland, New Zealand). Dental and medical records of the subjects were examined to assess cardiac diagnoses and eligibility for inclusion. Children with a confirmed cardiac diagnosis who were referred and presented to the Department during the specified time period were included. Children were excluded if they had a medical condition misclassified as a cardiac condition (i.e. haemolytic anaemia, pulmonary hypertension secondary to respiratory disease, hypertension secondary to renal disease), an innocent heart murmur without confirmed structural defects, attended for initial examination prior to the specified time period, or where cardiac diagnosis could not be confirmed through either dental or medical records. Where data were not readily available or verifiable, children were excluded from the analysis. A cohort of children existed who had a record of attendance prior to the inclusion of the electronic dental record in 2007. For this cohort, sourcing the original dental chart was attempted, however, it was not possible and children who had a first visit prior to July 2007 were excluded.

Data collected

Data collected included gender, date-of-birth, Australian postcode, date of first examination in the DoD, age at first examination, cardiac diagnosis, comorbid diagnosis, and referral reason. Socioeconomic status (SES) was estimated based on postcode using quintiles of the Index of Relative Socio-Economic Disadvantage (IRSD) from the Socio-Economic Indexes for Areas (SEIFA) from the Australian Bureau of Statistics.[16] The IRSD and SEIFA accounts for multiple factors that influence SES including education, employment, income, housing, health and geographic isolation.[16]

Dental charts from the first visit were examined and data collected on type of dentition, teeth and surfaces affected by advanced carious lesions (d_{3-6}/D_{3-6}: charted as “cavitated” or ICDAS II Codes 3-6) and early lesions (d_{1-2}/D_{1-2}: uncavitated carious lesions charted as “demineralised” or ICDAS II Codes 1, 2), restored teeth, and teeth missing or extracted due to dental caries. Decayed, missing and filled indices for primary (dmf) and permanent (DMF) teeth were calculated as a sum of the number of teeth and surfaces involved. Extracted teeth were counted as three surfaces as per WHO criteria.[17] The Significant Caries Indices (SiC) were calculated as the mean decayed, missing and filled teeth indices from the third of the population with the highest ranked decayed, missing and filled indices.[18] Enamel defects affecting teeth and surfaces on both primary and permanent teeth were recorded as charted in the dental record as present/absent and the type of defect as hypoplasia, hypomineralisation, or hypoplasia and hypomineralisation. Treatment of advanced carious lesions received prior to presentation was determined by the separate decayed, missing and filled portions of the d_{3-6}mft/D_{3-6}MFT. Prior treatment of early carious lesions could not be determined.

Grouping of heart conditions

Heart conditions were categorised into the following groups (Table 1): simple acyanotic, simple cyanotic, complex (acyanotic or cyanotic), acquired (e.g. pulmonary hypertension, myocarditis, cardiomyopathy, rheumatic heart disease and other acquired heart disease).

Comorbid diagnoses were recorded according to primary diagnosis and stratified for analysis as a non-cardiac comorbidity present or cardiac diagnosis only (absent).

Confounding factors

The effects of non-cardiac comorbidity and referral for dental caries were investigated as confounding factors. As the RCH DoD provides not only primary care for children with complex medical conditions but also tertiary care, data were stratified to account for the effect of confounding of caries experience for children referred specifically for management of dental caries. Children referred to the RCH DoD for reasons other than caries management (NRCM), including assessment prior to cardiac surgery, routine dental care, dental trauma and parent request were identified and analysed collectively, separate to the children referred for caries management.

A small number of children in the sample resided in other Australian states and territories. Children residing in towns in New South Wales or South Australia that bordered Victoria were considered as the equivalent of their Victorian counterparts if located within 25km of the Victorian border (i.e. Albury-Wodonga). The remainder (n=13) were assessed separately however included in the final analyses, as there was no significant difference in caries experience or mean age of presentation to the Victorian children.

Data analysis

Data were collected and stored in a secured database and de-identified prior to statistical analysis using IBM SPSS Statistics for Windows (Version 24.0; IBM Corp., NY, USA). Descriptive statistics were used to investigate demographic data and outcome variables including caries prevalence, caries severity and presence of enamel defects. Associations between caries experience and potential risk factors contributing to caries experience were explored and evaluated. Univariate analyses of the associations between caries prevalence (d_{1-6}mft/D_{1-6}MFT>0) and independent variables were explored using Chi squared analysis. Assessment of Gaussian normality of the distribution of dmft/DMFT scores was undertaken using Q–Q normality plots and the Shapiro–Wilk test (α=0.05). Univariate analyses of independent variables and caries severity were undertaken using non-parametric Mann Whitney U and Kruskal Wallis tests. Multivariate analysis of the association of caries prevalence and independent variables was explored using a stepwise logistic regression analysis. Independent variables identified during univariate analyses with a moderate association ($p<0.20$) with caries prevalence were included in the model construction with the presence/absence of caries (d_{1-6}mft/D_{1-6}MFT>0 = 1) established as the outcome variable. The threshold for statistical significance was set at $p < 0.05$.

RESULTS

A total of 776 children with a diagnosis of congenital or acquired heart disease attended the RCH DoD between July 2007 and February 2016. Of these children, 348 were excluded: 337 had had incomplete dental or medical records, and 11 did not have a cardiac diagnosis verified by their medical record. A total of 428 children had complete medical and dental records with 249 males and 179 females (1.4:1).

The mean age at first visit to the DoD was 4.9 years (SD 2.4; range 0.4 – 12.3). Three to five years (32.5%) was the most frequent age that children were referred to and examined in the DoD. One-in-four children (25.5%) were referred and examined before their third birthday, with three (0.7%) children referred and examined by their first birthday. For the NRCM, the mean age at first visit was 4.7 years (SD 2.4; range 0.4 – 11.5). Most children in both the overall population and the NRCM subset group (299 and 212 respectively) presented in the primary dentition stage of development with less than one-in-three of children presenting in the mixed dentition stage with both primary and permanent teeth (overall population – 129 children; subset – 84 children).

Medical diagnoses

A spectrum of cardiac diagnoses was observed in the study population, from relatively simple cardiac defects requiring minimal intervention through to complex conditions requiring transplantation or palliation. More than half of the children were diagnosed with a simple acyanotic cardiac condition (59.7%) with atrial or ventricular septal defects the most frequent diagnoses, accounting for 29.7% of all cardiac diagnoses. One-in-six children (17%) had a complex cyanotic cardiac condition, e.g. hypoplastic left heart syndrome, considered the most complex diagnoses at risk of infective endocarditis and carrying the greatest anaesthetic risk.

Just under half (49.3%) of the children had a comorbid condition identified in their medical record. The most common condition was Trisomy 21 accounting for 29.4% of children with a comorbid condition, followed by neurodevelopmental disorders such as cerebral palsy or epilepsy, and velo-cardio-facial syndrome/22.11q deletion syndrome, accounting for 15.2% and 9.5% of the cohort, respectively. Significantly more children with simple acyanotic or simple cyanotic conditions had a comorbid diagnosis compared to children with complex cardiac diagnoses (Table 1, $p < 0.0001$).

Caries experience: prevalence and severity

Caries data of both the overall population and subset group are presented in Tables 2 and 3. The total caries prevalence of the overall cardiac population studied was 52.1%, with cavitated carious lesions involving dentine on either primary or permanent teeth in 46.7% of children. In the NRCM group of children referred for reasons other than caries management, the caries prevalence was 37.5% with cavitated carious lesions into dentine on either primary or permanent teeth in 30.4% of children.

Caries experience in primary teeth increased with age of presentation for children in the primary dentition stage of development then decreased after age 8 years as children presented in the mixed dentition stage of development. In both the overall study population and NRCM group, the prevalence of caries affecting primary teeth was lowest in children who presented prior to their second birthday (overall 13.5%; NRCM group 9.1%), increasing by age 5 years (overall 65.4%; NRCM group 50.0%), peaking at age 8 years (overall 77.8%; subset 57.1%) and decreasing in children aged 9-12 years (overall 33-40%; subset 23.1-27.8%) with the exfoliation of primary teeth in the late mixed dentition. The caries experience in primary teeth of the overall population was accompanied by an increase in carious lesions in permanent teeth from age 8 years onwards (overall 17.1-31.8%). However, this was not observed in the NRCM group where carious lesions in permanent teeth affected only five children.

Carious lesion severity of the study population, expressed through decayed/missing/filled teeth or surface indices and the SiC index, is presented in Tables 2 and 3. The mean number of tooth surfaces affected was twice the number of teeth affected, implying multiple surfaces involved for both the overall and NRCM populations. Among children affected by caries, the burden of disease was high with a mean $d_{1\text{-}6}$mft of 7.44 (SD 4.8) for the overall study population and 6.24 (SD 4.6) for children in the NRCM group and mean $d_{1\text{-}6}$mfs indices of 14.88 (SD 13.8) and 11.36 (SD 12.5) respectively. Caries in the permanent dentition in the study population was uncommon with no child examined younger than age 8 years diagnosed with carious lesions in their permanent teeth and mean DMFT after 8 years-of-age of <1.0. Early carious lesions accounted for 18.9% and 24.3% of the decayed portion of the $d_{1\text{-}6}$mft indices for the overall and NRCM populations, 12.0% of the decayed portion of the $D_{1\text{-}6}$MFT and $D_{3\text{-}6}$MFT indices in the overall population, however, no early carious lesions were charted in the NRCM group.

Untreated carious lesions

Carious lesions in both primary and permanent teeth in children in both the overall population and subset were predominantly untreated as demonstrated by the decayed proportion (percentage dt/DT) of the dmft/DMFT indices (Tables 2, 3). Caries experience in children who presented younger than three years of age was exclusively untreated, with no filled or missing teeth. After three years of age the $d_{3\text{-}6}$/$d_{3\text{-}6}$mft ratio decreased from greater than 80% before age 10 to 62.6% overall by 10-12 years-of-age. Similar experience with untreated carious lesions was observed in permanent teeth with advanced carious lesions. At a child level, 4% of children overall with advanced caries experience (d_{3-6}mft>0 or D_{3-6}MFT>0) had no untreated carious teeth.

Enamel Defects

The prevalence of developmental defects of enamel (DDE) in either primary or permanent teeth was 29.2%; one-in-four (24.8%) of children in the primary dentition stage of development had DDE charted at their first examination. For children in the mixed dentition stage of development, 20.2% had DDE in at least one permanent tooth, 5.4% had DDE in both primary and permanent teeth and 9.3% had DDE affecting primary teeth but not permanent teeth. A total of 394 primary teeth and 87 permanent teeth had a DDE charted. The most common permanent tooth affected was the first permanent molar (71.3%), followed by the maxillary permanent central incisor tooth (16.1%). The most frequently affected primary tooth was the second molar (45.4%) followed by the first primary molar (23.9%). No permanent teeth had hypoplastic enamel defects charted, however, there was a hypoplastic component charted for 17.3% primary teeth with DDE. All permanent tooth DDE were hypomineralised, with 32.3% of affected molars also presenting with advanced carious lesions (D_{3-6}). Of the primary teeth charted with hypomineralised DDE, 34.0% also had carious lesions; including 41.9% of affected second primary molars and 31.9% of affected first primary molars (untabulated). There was no significant association of DDE in primary or permanent teeth with cardiac diagnosis severity (P>0.05).

Associations of caries experience with gender, socio-economic status, cardiac diagnosis, other comorbid diagnoses and enamel defects.

The association of caries experience with gender, SES, cardiac diagnosis, presence of comorbid conditions and enamel defects are presented in Tables 4-6. Caries experience was associated significantly with age at presentation, SES, the absence of comorbid diagnoses (non-cardiac) and enamel defects but was not associated with gender or type of cardiac diagnosis . Most differences observed in caries distribution were limited to overall prevalence and prevalence and severity of caries experience within primary teeth, with only the presence of enamel defects associated with permanent caries experience.

Children residing in postcodes areas with the lowest SES ranking had a significantly greater burden of caries experience, both prevalence and severity, than other children and this disparity increased as SES increased in both univariate and multivariate analyses. Children residing in locations with an IRSD quintile 1 ranking (greatest disadvantage) had 2.2-fold greater odds of presenting with carious lesions than children in quintile 2, increasing to 3.9-fold greater odds than children with the least disadvantage in quintile 5. Within the NRCM group the disparity was even more apparent, with children residing in locations in quintile 1 having 2.4-fold greater odds of presenting with carious lesions than children in quintile 2 and these odds increased to 6.7x greater when compared with children in quintile 5. This disparity in disease prevalence with SES was also evident with the severity of caries burden in the most disadvantaged children who had almost twice the number of teeth and surfaces affected than children with the least disadvantage ($P<0.05$).

There was a strong association between caries experience in both primary and permanent teeth and the presence of DDE. Children with DDE had more than 1.5-fold the prevalence of caries experience of children who were charted without any DDE with a similar increase in mean number of affected teeth and tooth surfaces. This association was observed in children both in the overall population and subset group and a child with DDE had significantly increased odds of presenting with carious lesions (Overall: OR 3.60, 95% CI 2.20-5.88, $p<0.0001$; NRCM subset: 2.79, 95% CI 1.51-5.18, $P=0.0001$).

The presence of a comorbid diagnosis was associated with decreased caries experience in both the overall and NRCM groups. These children presented for examination at a significantly earlier age. When adjusted for age at presentation, comorbidity was associated with significantly decreased prevalence and severity of caries experience between 4-9 years ($p<0.05$).

Older age at presentation was associated with increased caries prevalence and severity as described earlier. Multivariate analysis revealed that for each year later a child presented for initial consultation compared to children who presented prior to their first birthday the odds of presenting with caries experience increased 1.2-fold; i.e. a child presenting at age 5 had 4.9-fold increased odds (4.7-fold in the NRCM group) of presenting with caries than a child who presented before their first birthday.

DISCUSSION

This is the first Australian study in almost 30 years to examine the caries experience of children with cardiac conditions. It is disturbing that despite the obvious benefits of good oral health, a large proportion of these children presented with substantial caries experience that was largely untreated. Close to half of all children in the study population and almost one-third of children in the NRCM subset had experienced advanced dental caries affecting multiple teeth and surfaces. There was little difference in the caries experience between the 'cardiac' children in the present study and those reported in the previous Australian studies despite a decrease in the overall caries experience of Australian children.[1, 2, 6, 14]

The caries experience of the population examined at RCH was similar to children described in contemporary reports from similar populations and centres in other developed nations where children with cardiac conditions had substantial burden of disease, mostly untreated.[7, 11, 19, 20] Comparison of the caries experience of the present study population with children in the wider Victorian community was difficult due to the lack of accessible, contemporary data in Victoria and the inherent limitations of the population studied. However, despite these limitations, the caries prevalence appears to be considerably higher than the findings of a recent study of Victorian pre-schoolers of 36.4% ($d_{1\text{-}6}$mft>0)[21] but similar to the prevalence of advanced caries ($d_{3\text{-}6}$mft>0; 43.6%) reported in general population data in children from New South Wales, an Australian state with similar population size.[1] The severity of caries experience of 5-year-old children in both the overall population and the NRCM group was considerably greater than the dmft scores in Victorian pre-schoolers ($d_{1\text{-}6}$mft: 0.94 (SD 1.71)), 5-year-old children from NSW ($d_{3\text{-}6}$mft: 1.53, 95% CI: 1.36-1.70), and 5-year-old Australian children ($d_{3\text{-}6}$mft: 1.82; SiC: 9.78).[1, 21] Caries experience in the permanent dentition was low, with few children in the subset having carious lesions in their permanent teeth and the overall experience comparable with the Australian mean DMFT for 8-10 year old children (0.34-0.60). [1]

Traditionally, the motivation for good oral health in children with cardiac conditions has been for the prevention of infective endocarditis, infection of the lining of the heart that carries significant morbidity and mortality.[22] Whilst the overall risk for infective endocarditis in children is low, the presence of chronic, untreated dental disease has been implicated as a significant aetiological factor[5] and negatively impacts oral health-related quality-of-life for an already vulnerable population.[10] It was alarming that such a large proportion of children in the present study had active, advanced untreated carious lesions, considerably greater than that of healthy Australian children.[1, 21] The vast majority (96%) of children with advanced caries experience presented with untreated disease and overall, the proportion of treated lesions was disturbingly low. As the RCH DoD is a tertiary referral centre, the need for treatment may be skewed to the more severe caries experience, however, the proportion of untreated carious lesions in the NRCM subset was similar to the overall study population. The large proportion of children with no history of operative treatment of advanced dental caries suggests that even "asymptomatic" children have difficulty accessing or attaining adequate and timely oral healthcare or that oral health may not be perceived as a priority in the context of the child's health status.

Children who accessed operative treatment for advanced dental caries prior to referral and presentation predominantly received extractions rather than restorations when carious lesions involved primary teeth. There may be several explanations for this including 1) delay in access to adequate dental healthcare resulting in children presenting with more advanced disease, 2) pulpal involvement and a treatment philosophy to extract rather than provide pulp therapy as stated by treatment guidelines, 3) an aggressive approach to minimise the need for future surgical intervention.[23-24] The predilection for extraction rather than restoration has been observed in other cardiac populations and reflects treatment often received by children with medical complexity or special healthcare needs.[6, 8, 9, 12, 26]

Early establishment of a dental home, similar to a medical home, to provide education and preventive treatment has been advocated by key paediatric and dental bodies to facilitate the identification of at risk behaviours and children and provide education and preventive treatments.[24, 27, 28] Given the effect of age on caries experience it would be prudent to recommend that all children with cardiac conditions have a first visit to a dentist by the recommended age of 12 months. The mean age of presentation to the RCH DoD was almost 5 years in both the overall and subset populations and delayed age of presentation was associated with increased risk of presenting with caries and with increased caries experience. Only three children in the study were referred and examined by twelve months-of-age, however, this unfortunately is not dissimilar to the experience of children in the wider Australian community where early dental visits before two years-of-age are rare.[29] Whilst there was no measurement of whether children had a dental visit prior to referral, the high rate of untreated disease suggests that an early visit was unlikely.

The high frequency of children in the present study population charted as being affected by DDE may explain some of the caries experience observed. A high prevalence of DDE has been reported previously in cardiac children compared with healthy controls for both primary and permanent teeth that has been speculated to be the consequence of early hospitalisation in infancy.[6, 9, 11, 30] The prevalence of DDE observed in our study population was comparable with the prevalence of DDE in primary teeth of healthy Australian children residing in Queensland[31] and similar to the reported prevalence of molar incisor hypomineralisation in Western Australian children (22%)[32] and DDE in permanent teeth of Queensland children.[32] Whilst the prevalence is comparable with healthy children it remained as a risk factor for caries experience in the study population with a strong association between DDE and caries experience in primary and permanent teeth was observed similar to the observations of an association reported in other studies. [21, 33, 34] In addition to the prevalence being comparable it was surprising that there was no apparent association between the prevalence of DDE in primary or permanent dentition and cardiac diagnosis severity. It is possible that the true prevalence of DDE may have been underestimated due to limitations in data collection and recording of DDE with concomitant carious lesions as only a carious lesion at the time of examination.

Surprisingly, unlike the previous study undertaken at the RCH DoD there were no significant differences in caries experience associated with the severity of cardiac diagnosis but the existence of concomitant disease or comorbidity was associated with decreased caries experience.[14] This could be attributed to the age of referral, as children with comorbidity, despite the simpler cardiac diagnoses, were referred and examined significantly younger than children with only cardiac diagnoses. The medical complexity of the children with comorbidity means that referral may be facilitated directly at an earlier stage or as a planned part of a complex care plan rather than in an *ad hoc* nature. The medical complexity of the population combined with the severity of caries experience may also partly explain the high proportion of untreated caries observed in our population and the lack of care received prior to referral. Treatment of advanced carious lesions in young children often necessitates the use of general anaesthesia that may have been contraindicated outside a tertiary paediatric hospital setting for this medically complex population.

As this was a retrospective audit there were several limitations of the dataset and interpretation. In particular multiple clinicians examined and charted the caries experience. However, despite multiple examiners, the RCH DoD has an ordered examination protocol and electronic information recording where most clinicians diagnose and record caries activity using departmental guidelines, and clinical findings that were completed by junior trainees were verified by supervising consultant dentists. The transition from paper to electronic records for both the RCH and DoD meant a large number of children had incomplete records, were excluded from analysis and potentially missed during the database search. Despite this, it is one of the largest datasets examining the caries experience of children with heart conditions. Whilst the recording of enamel defects in this study was done in a subjective manner without the use of a standardised index, there is a strong clinical research focus on enamel defects within both the RCH DoD and its partner the Melbourne Dental School (The University of Melbourne). Consequently, there is likely to be validity in the charting of DDE, however, these results should be viewed cautiously in the absence of verified examiner training and calibration. Additionally, as the RCH DoD is a tertiary centre for paediatric dental management whilst the data may not be representative of the caries experience of the wider cardiac population it is probably accurate for patients with complex cardiac conditions.

The present study has identified the need for future research investigating the caries experience in the wider paediatric cardiac population and the complex relationship between cardiac diagnosis and care and oral health determinants. Given the high rate of untreated carious lesions, issues surrounding access to care, particularly the facilitators and barriers from both parental and healthcare provider perspectives should be explored. A collaborative approach to research and management by medical, dental and other healthcare professionals is necessary to reduce this burden of oral disease within this vulnerable population.

CONCLUSION

Children with cardiac conditions attending the RCH DoD had a higher caries experience compared with the general paediatric population, with most lesions untreated. Delayed presentation was associated with greater caries experience. The high prevalence of untreated carious lesions, minimal dental treatment received prior to presentation and late age of referral suggests that better access for timely, appropriate preventive and operative care is needed.

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Table 1. Categorisation of primary cardiac diagnoses

Category	Cardiac condition	Cardiac diagnosis only N (%)	Children with comorbidity i.e. additional non-cardiac medical diagnosis N (%)
Simple acyanotic N=254	Atrial septal defect (ASD) Ventricular septal defect (VSD) Atrioventricular septal defect (AVSD) Patent ductus arteriosus Coarctation of the aorta Pulmonary stenosis	104 (40.9)	150 (59.1)

	Aortic stenosis Supraventricular tachycardia Electrophysiology diagnoses (e.g. atrial fibrillation)		
Simple cyanotic N= 61	Tetralogy of Fallot Transposition of the greater arteries/vessels Pulmonary atresia with VSD without pulmonary stenosis or MACPAS Truncus arteriosus	38 (62.3)	23 (37.7)
Complex (acyanotic and cyanotic) N=82	Congenitally corrected transposition of the greater arteries/vessels (acyanotic) Shone's complex (acyanotic) Hypoplastic left heart syndrome (cyanotic) Hypoplastic right heart syndrome (cyanotic) Single ventricle anatomy (cyanotic) Double inlet left ventricle (cyanotic) Double inlet right ventricle (cyanotic) Double outlet left ventricle (cyanotic) Double outlet right ventricle (cyanotic) Tricuspid atresia (cyanotic) Pulmonary atresia with VSD & MACPAS (cyanotic) Aortic atresia (cyanotic)	61 (74.4)	21 (25.6)
Acquired N=31	Cardiomyopathy Pulmonary hypertension Myocarditis Kawasaki disease Rheumatic heart disease	14 (45.2)	17 (54.8)

MACPAS - Major aorto-pulmonary collateral arteries

Note: Where multiple cardiac diagnoses co-exist the most severe structural defect was considered diagnosis was used for categorisation.

Table 2. Mean caries experience in primary and permanent teeth in overall study population and subset group

	Caries indices	Overall				Subset			
		Tooth level		Surface level		Tooth level		Surface level	
		All children N= 428 Mean (SD)	Children with caries N=221	All children	Children with caries	All children	Children with caries	All children	Children with caries
Primary teeth	d_{1-6}mf	3.65 (4.9)	7.44 (4.8)	7.14 (11.9)	14.88 (13.8)	2.34 (4.1)	6.24 (4.6)	4.26 (9.4)	11.36 (12.5)
	d_{3-6}mf	2.97 (4.4)	6.36 (4.4)	6.19 (11.3)	13.24 (13.5)	1.82 (3.7)	4.86 (4.6)	3.59 (8.9)	9.57 (12.5)
	d_{1-6}	3.34 (4.6)	6.77 (4.6)	6.39 (11.1)	13.28 (13.1)	2.10 (3.8)	5.61 (4.4)	3.49 (7.9)	9.30 (10.7)
	d_{3-6}	2.71 (4.1)	5.79 (4.3)	5.44 (10.5)	11.64 (12.8)	1.59 (3.3)	4.23 (4.3)	2.81 (7,4)	7.50 (10.5)
	m	0.09 (0.6)	0.18 (0.8)	0.43 (2.8)	0.93 (4.0)	0.09 (0.6)	0.25 (1.0)	0.47 (3.2)	1.26 (5.2)
	f	0.18 (0.8)	0.38 (1.2)	0.32 (1.6)	0.67 (2.3)	0.14 (0.8)	0.38 (1.2)	0.30 (1.8)	0.80 (2.8)
Permanent teeth	D_{1-6}MF	0.30 (0.8)	0.50 (1.0)	0.57 (1.4)	0.94 (1.7)	0.11 (0.5)	0.26 (0.8)	0.26 (1.1)	0.63 (1.6)
	D_{3-6}MF	0.28 (0.8)	0.46 (0.9)	0.51 (1.3)	0.85 (1.6)	0.11 (0.5)	0.26 (0.8)	0.19 (0.8)	0.46 (1.3)
	D_{1-6}	0.25 (0.7)	0.41 (0.9)	0.45 (1.2)	0.74 (1.4)	0.08 (0.4)	0.20 (0.4)	0.20 (0.9)	0.49 (1.4)
	D_{3-6}	0.22 (0.7)	0.37 (0.8)	0.40 (1.1)	0.65 (1.3)	0.08 (0.4)	0.20 (0.4)	0.12 (0.6)	0.29 (0.9)
	M	0	0	0	0	0	0	0	0
	F	0.05 (0.4)	0.09 (0.5)	0.12 (0.7)	0.19 (0.9)	0.02 (0.2)	0.06 (0.2)	0.02 (0.3)	0.17 (0.9)

Table 3. Caries experience in primary and permanent teeth by age (Overall and subset populations)

Age	N	d_{1-6}mft>0 N (%)	d_{3-6}mft>0 N (%)	d_{1-6}mft Mean (SD)	d_{3-6}mft Mean (SD)	% d_3	SiC d_{1-6}mft Mean (SD)	SiC d_{3-6}mft Mean (SD)	Age	N	D_{1-6}MFT>0 N (%)	D_{3-6}MFT>0 N (%)	D_{1-6}MFT Mean (SD)	D_{3-6}MFT Mean (SD)	%D_3	SiC D_{1-6}MFT Mean (SD)	SiC D_{3-6}MFT Mean (SD)

Ove	≤2	37	5 (13.5)	5 (13.5)	0.81 (2.2)	0.73 (2.0)	100	2.31 (3.3)	2.08 (2.9)	-	-	-	-	-	-	-	-	-
	3	72	26 (36.1)	17 (23.6)	2.56 (4.4)	1.85 (3.8)	100	6.46 (5.2)	5.54 (4.8)	-	-	-	-	-	-	-	-	-
				N (%)	**Mean age in**	**Primary or permanent teeth N (%)**					**In primary teeth N (%)**		**Mixed dent**	**In permanent teeth N (%)**				
	4	58	24 (41.4)	23 (39.7)	3.59 (5.7)	2.98 (5.0)	96.0	9.95 (5.4)	8.45 (5.1)	-	-	-	-	-	-	-	-	-
	5	81	53 (65.4)	48 (59.3)	5.10 (5.5)	4.37 (5.2)	97.5	11.52 (3.7)	10.70 (3.7)	-	-	-	-	-	-	-	-	-
	6	56	38 (67.9)	33 (58.9)	5.57 (5.5)	4.34 (4.6)	90.6	11.37 (3.2)	9.84 (2.6)	6	19	0	0	0	0	-	0	0
	7	49	31 (63.3)	28 (57.1)	4.16 (4.5)	3.53 (4.3)	82.2	9.29 (3.0)	8.59 (3.1)	7	35	0	0	0	0	-	0	0
	8	27	21 (77.8)	19 (70.4)	4.59 (4.0)	3.44 (3.6)	80.8	9.33 (2.3)	8.00 (1.7)	8	27	7 (31.8)	6 (28.6)	0.41 (0.8)	0.33 (0.7)	80.5	0.56 (1.0)	0.33 (0.7)
	9	18	6 (33.3)	6 (33.3)	1.33 (3.5)	1.11 (2.2)	80.2	4.00 (2.9)	3.33 (2.7)	9	18	4 (18.2)	4 (18.2)	0.50 (1.1)	0.50 (1.1)	56.0	1.17 (1.6)	1.17 (1.6)
	10-12	30	12 (40.0)	12 (40.0)	2.17 (3.6)	1.87 (3.3)	62.6	6.30 (3.7)	5.40 (3.7)	10-12	30	11 (17.8)	11 (17.8)	0.63 (1.1)	0.60 (1.1)	88.3	0.90 (1.3)	0.80 (1.2)
	Total	**428**	**216 (50.5)**	**191 (44.6)**	**3.65 (4.9)**	**2.97 (4.4)**	**91.2**	**9.66 (3.8)**	**7.96 (4.2)**	**Total**	**129**	**22 (17.1)**	**22 (17.1)**	**0.30 (0.8)**	**0.28 (0.8)**	**78.6**	**0.37 (0.8)**	**0.29 (0.7)**
Subset	≤2	33	3 (9.1)	3 (9.1)	0.64 (2.1)	0.55 (1.8)	100	1.91 (3.5)	1.64 (2.9)	-	-	-	-	-	-	-	-	-
	3	54	14 (25.9)	6 (11.1)	1.26 (3.0)	0.74 (2.5)	100	3.78 (4.3)	2.22 (3.9)	-	-	-	-	-	-	-	-	-
	4	43	13 (30.2)	12 (27.9)	2.63 (4.9)	2.05 (4.2)	94.1	7.53 (5.7)	5.87 (5.4)	-	-	-	-	-	-	-	-	-
	5	48	24 (50.0)	20 (41.7)	3.42 (4.9)	3.04 (4.8)	98.7	9.25 (4.2)	8.56 (4.8)	-	-	-	-	-	-	-	-	-
	6	37	20 (54.1)	15 (40.5)	3.84 (5.1)	2.84 (4.4)	79.9	9.85 (4.1)	7.38 (4.8)	6	14	0	0	0	0	-	0	0
	7	36	20 (55.6)	17 (47.2)	3.31 (4.0)	2.61 (3.6)	71.3	8.17 (2.8)	6.75 (3.4)	7	25	0	0	0	0	-	0	0
	8	14	8 (57.1)	8 (57.1)	2.71 (4.4)	1.93 (3.2)	59.1	6.80 (5.4)	4.80 (4.1)	8	14	1(7.1)	1(7.1)	0.07 (0.3)	0.07 (0.3)	100	0.20 (0.4)	0.20 (0.4)
	9	13	3 (23.1)	3 (23.1)	1.08 (2.4)	1.00 (2.4)	77.0	2.80 (3.3)	2.60 (3.4)	9	13	2 (15.4)	2 (15.4)	0.23 (0.6)	0.23 (0.6)	100	0.60 (0.9)	0.60 (0.9)
	10-12	18	5 (27.8)	5 (27.9)	0.78 (1.7)	0.50 (1.0)	88.0	2.33 (2.3)	1.50 (1.4)	10-12	18	2 (11.1)	2 (11.1)	0.28 (1.0)	0.28 (1.0)	60.7	0.67 (1.6)	0.67 (1.6)
	Total	**296**	**110 (37.2)**	**89 (30.1)**	**2.34 (4.1)**	**1.82 (3.7)**	**87.4**	**6.32 (5.0)**	**5.38 (4.6)**	**Total**	**84**	**5 (6.0)**	**5 (6.0)**	**0.11 (0.5)**	**0.11 (0.5)**	**72.7**	**0.27 (0.8)**	**0.27 (0.8)**

Table 4. Association of caries prevalence with gender, socio-economic status, cardiac diagnosis, comorbidity and present of enamel defects in overall population and subset group

			d(1-6)mft>0 + D(1-6)MFT>0	d(3-6)mft>0 + D(3-6)MFT>0	d(1-6)mft>0 N (%)	d(3-6)mft>0 N (%)		D(1-6)MFT>0 N (%)	D(3-6)MFT>0 N (%)
Overall	**428**	**4.9 (2.4)**	**223 (52.1)**	**200 (46.7)**	**216 (50.5)**	**191 (44.6)**	**129**	**22 (17.1)**	**21 (16.3)**
Gender		**NS**	**NS**	**NS**	**NS**	**NS**		**NS**	**NS**
Male	249 (58.2)	4.8 (2.3)	133 (53.4)	120 (48.2)	128 (51.4)	114 (45.8)	72 (55.8)	15 (20.8)	15 (20.8)
Female	179 (41.8)	4.9 (2.4)	90 (50.3)	80 (44.7)	88 (49.2)	77 (43.0)	57 (44.2)	7 (12.3)	6 (10.5)
IRSD Quintiles		**NS**	**P=0.010**	**P=0.019**	**P=0.003**	**P=0.004**		**NS**	**NS**
1 (highest disadvantage)	72 (16.8)	4.9 (2.2)	50 (69.4)	44 (61.1)	50 (69.4)	44 (61.1)	16 (12.4)	2 (12.5)	2 (12.5)
2	82 (19.2)	4.8 (2.4)	43 (52.4)	35 (42.7)	42 (51.2)	34 (41.5)	24 (18.6)	2 (8.3)	2 (8.3)
3	110 (25.7)	4.7 (2.3)	58 (52.7)	57 (51.8)	56 (50.9)	55 (50.0)	31 (24.0)	6 (19.4)	5 (16.1)
4	88 (20.6)	5.1 (2.4)	40 (45.5)	36 (40.9)	36 (40.9)	30 (34.1)	31 (24.0)	10 (32.3)	10 (32.3)
5	76 (17.8)	4.9 (2.5)	32 (42.1)	28 (36.8)	32 (42.1)	28 (36.8)	27 (20.9)	2 (7.4)	2 (7.4)
Cardiac condition		**NS**	**NS**	**NS**	**NS**	**NS**		**NS**	**NS**
Simple acyanotic	254 (59.3)	4.9 (2.3)	123 (48.4)	112 (44.1)	120 (47.2)	107 (42.1)	80 (62.0)	13 (16.3)	12 (15.0)
Simple cyanotic	61 (14.3)	4.6 (2.3)	39 (63.9)	31 (50.8)	37 (60.7)	29 (47.5)	15 (11.6)	4 (26.7)	4 (26.7)
Complex	82 (19.2)	4.8 (2.2)	45 (54.9)	42 (51.2)	45 (54.9)	42	23 (17.8)	2 (8.7)	2 (8.7)
PH/C/Myocarditis	31 (7.2)	5.4 (2.9)	16 (51.6)	15 (48.4)	14 (45.2)	13	11 (8.5)	3 (27.3)	3 (27.3)
Comorbidity		**P=0.006**	**P<0.0001**	**P<0.0001**	**P<0.0001**	**P<0.0001**		**NS**	**NS**
Cardiac only	217 (50.7)	5.1 (2.3)	137 (63.1)	127 (58.5)	133 (61.3)	122 (56.2)	74 (57.4)	14 (18.9)	13 (17.6)
Comorbid condition	211 (49.3)	4.6 (2.4)	86 (40.8)	73 (34.6)	83 (39.3)	69 (32.7)	55 (42.6)	8 (14.5)	8 (14.5)
Presence of enamel defects		**NS**	**P<0.0001**	**P<0.0001**	**P<0.0001**	**P<0.0001**		**P<0.0001**	**P<0.0001**
Present	126 (29.4)	5.0 (2.5)	84 (66.7)	89 (70.6)	78 (61.9)	84 (66.7)	38 (29.5)	14 (36.8)	14 (36.8)
Not present	302 (70.6)	4.8 (2.3)	116 (38.4)	134 (44.4)	113 (37.4)	132 (43.7)	91 (70.5)	7 (7.7)	8 (8.8)
Subset	**296**	**4.7 (2.4)**	**111 (37.5)**	**90 (30.4)**	**110 (37.2)**	**89 (30.1)**	**84**	**5 (6.0)**	**5 (6.0)**
Gender		**NS**	**NS**	**NS**	**NS**	**NS**		**NS**	**NS**
Male	167 (56.4)	4.6 (2.3)	63 (37.7)	52 (31.1)	62 (37.2)	51 (30.5)	43 (51.2)	5 (11.6)	5 (11.6)
Female	129 (43.6)	4.9 (2.5)	48 (37.2)	38 (29.5)	48 (37.1)	38 (29.5)	41 (48.8)	0	0
IRSD Quintiles		**NS**	**P=0.002**	**P=0.002**	**P=0.002**	**P=0.002**		**NS**	**NS**
1 (highest disadvantage)	50 (16.9)	4.9 (2.3)	29 (58.0)	23 (46.0)	29 (58.0)	23 (46.0)	11 (13.1)	1 (9.0)	1 (9.0)
2	59 (19.9)	4.8 (2.5)	23 (39.0)	16 (27.1)	23 (39.0)	16 (27.1)	16 (19.0)	1 (6.2)	1 (6.2)
3	74 (25.0)	4.4 (2.2)	29 (39.2)	28 (37.8)	29 (39.2)	28 (37.8)	20 (23.8)	1 (5.0)	1 (5.0)
4	62 (20.9)	4.8 (2.3)	20 (32.3)	17 (27.4)	19 (30.6)	16 (25.8)	19 (22.6)	2 (10.5)	2 (10.5)
5	51 (17.2)	4.8 (2.7)	10 (19.6)	6 (11.8)	10 (19.6)	6 (11.8)	18 (21.4)	0	0
Cardiac condition		**NS**	**NS**	**NS**	**NS**	**NS**		**NS**	**NS**

Simple acyanotic	178 (60.1)	4.7 (2.4)	59 (33.1)	49 (27.5)	59 (33.1)	49 (27.5)	52 (61.9)	2 (3.8)	2 (3.8)
Simple cyanotic	38 (12.8)	4.4 (2.3)	21 (55.3)	14 (36.8)	20 (52.6)	13 (34.2)	9 (10.7)	1 (11.1)	1 (11.1)
Complex	58 (19.6)	4.9 (2.2)	24 (41.4)	21 (36.2)	24 (41.4)	21 (36.2)	16 (19.0)	1 (6.2)	1 (6.2)
Acquired	22 (7.4)	5.1 (3.1)	7 (31.8)	6 (27.3)	7 (31.8)	6 (27.3)	7 (8.3)	1 (14.3)	1 (14.3)
Comorbidity		**P=0.028**	**P=0.006**	**P=0.002**	**P=0.009**	**P=0.004**		**NS**	**NS**
Cardiac only	135 (45.6)	5.0 (2.5)	62 (45.9)	53 (39.3)	61 (45.2)	52 (38.5)	46 (54.8)	4 (8.7)	4 (8.7)
Comorbid condition	161 (54.4)	4.4 (2.3)	49 (30.4)	37 (23.0)	49 (30.4)	37 (23.0)	38 (45.2)	1 (2.6)	1 (2.6)
Presence of enamel defects		NS	**P=0.003**	**P=0.002**	**P=0.003**	**P=0.001**		**NS**	**NS**
Present	68 (23.0)	4.8 (2.3)	36 (52.9)	31 (45.6)	36 (52.9)	31 (45.6)	20 (23.8)	2 (10.0)	2 (10.0)
Not present	228 (77.0)	4.7 (2.4)		59 (25.9)	74 (32.5)	58 (25.4)	64 (76.2)	3 (4.7)	3 (4.7)

	Primary teeth								Permanent teeth		
	N (%)	**Mean age in years (SD)**	**$d_{(1-6)}$mft Mean (SD)**	**$d_{(3-6)}$mft Mean (SD)**	**$d_{(3-6)}$t Mean (SD)**	**$d_{(3-6)}$t/ $d_{(3-6)}$mft**	**$d_{(1-6)}$mfs Mean (SD)**	**$d_{(3-6)}$mfs Mean (SD)**	**N (%)**	**$D_{(1-6)}$MFT Mean (SD)**	**$D_{(3-6)}$MFT Mean (SD)**
Overall	**428**	**4.9 (2.4)**	**3.65 (4.9)**	**2.97(4.4)**	**2.71 (4.1)**	**91.2**	**7.14 (11.9)**	**6.19 (11.3)**	**129**	**0.30 (0.8)**	**0.28 (0.8)**
Gender		P=0.677	P=0.210	P=0.260	P=0.355		P=0.288	P=0.282		P=0.181	P=0.100
Male	249 (58.2)	4.8 (2.3)	4.02 (5.2)	3.28 (4.7)	2.98 (4.5)	90.9	8.25 (13.7)	7.21 (13.2)	72 (55.8)	0.39 (0.9)	0.38 (0.9)
Female	179 (41.8)	4.9 (2.4)	3.15 (4.4)	2.55 (3.9)	2.34 (3.5)	91.8	5.59 (8.8)	4.77 (8.0)	57 (44.2)	0.19 (0.6)	0.16 (0.6)
IRSD Quintiles		P=0.775	**P=0.010***	**P=0.005***	**P=0.001***		**P=0.005***	**P=0.004***		P=0.081	P=0.087
1 (highest disadvantage)	72 (16.8)	4.9 (2.2)	5.01 (5.3)	4.35 (4.8)	4.14 (4.5)	95.2	9.93 (12.2)	8.89 (11.4)	16 (12.4)	0.31 (0.9)	0.25 (0.7)
2	82 (19.2)	4.8 (2.4)	3.45 (4.8)	2.87 (4.5)	2.54 (4.3)	88.5	7.43 (14.4)	6.65 (14.2)	24 (18.6)	0.08 (0.3)	0.08 (0.3)
3	110 (25.7)	4.7 (2.3)	3.89 (5.0)	3.05 (4.1)	2.89 (4.0)	94.8	7.46 (11.3)	6.15 (10.1)	31 (24.0)	0.48 (1.2)	0.45 (1.2)
4	88 (20.6)	5.1 (2.4)	3.11 (4.9)	2.47 (4.5)	1.98 (3.9)	80.2	5.82 (11.5)	5.08 (11.2)	31 (24.0)	0.48 (0.9)	0.45 (0.8)
5	76 (17.8)	4.9 (2.5)	2.87 (4.3)	2.26 (3.8)	2.12 (3.7)	93.5	5.22 (9.7)	4.46 (9.3)	27 (20.9)	0.07 (0.3)	0.07 (0.3)
Cardiac condition		P=0.477	P=0.123	P=0.449	P=0.464		P=0.169	P=0.506		P=0.428	P=0.367
Simple acyanotic	254 (59.3)	4.9 (2.3)	3.22 (4.5)	2.72 (4.1)	2.47 (3.9)	90.8	6.28 (11.2)	5.58 (10.8)	80 (62.0)	0.25 (0.7)	0.24 (0.7)
Simple cyanotic	61 (14.3)	4.6 (2.3)	5.36 (6.4)	4.18 (5.8)	3.74 (5.3)	89.5	10.74 (15.8)	9.18 (15.1)	15 (11.6)	0.60 (1.2)	0.53 (1.1)
Complex	82 (19.2)	4.8 (2.2)	3.66 (4.5)	3.00 (3.9)	2.77 (3.7)	92.3	6.88 (10.5)	5.85 (9.8)	23 (17.8)	0.26 (0.9)	0.22 (0.9)
Acquired	31 (7.2)	5.4 (2.9)	3.87 (5.5)	2.61 (4.1)	2.48 (4.0)	95.0	7.74 (12.1)	6.13 (10.8)	11 (8.5)	0.36 (0.7)	0.36 (0.7)
Comorbidity		**P=0.006***	**P<0.001***	**P<0.001***	**P<0.001***		**P<0.001***	**P<0.001***		P=0.456	P=0.593
Cardiac only	217 (50.7)	5.1 (2.3)	4.53 (5.1)	3.68 (4.5)	3.29 (4.2)	89.4	8.93 (11.9)	7.65 (11.2)	74 (57.4)	0.36 (0.9)	0.32 (0.8)
Comorbid condition	211 (49.3)	4.6 (2.4)	2.75 (4.5)	2.24 (4.1)	2.11 (4.0)	94.2	5.29 (11.7)	4.68 (11.3)	55 (42.6)	0.22 (0.7)	0.22 (0.7)
Presence of enamel defects		P=0.694	**P<0.001***	**P<0.001***	**P<0.001***		**P<0.001***	**P<0.001***		**P<0.001***	**P<0.001***
Present	126 (29.4)	5.0 (2.5)	4.79 (4.9)	4.02 (4.4)	3.66 (4.2)	91.0	9.03 (10.8)	7.94 (10.1)	38 (29.5)	0.63 (1.1)	0.63 (1.1)
Not present	302 (70.6)	4.8 (2.3)	3.18 (4.8)	2.54 (4.3)	2.31 (4.0)	90.9	6.34 (12.3)	5.45 (11.8)	91 (70.5)	0.16 (0.6)	0.13 (0.5)
Subset	**296**	**4.7 (2.4)**	**2.34 (4.1)**	**1.82 (3.7)**	**1.59 (3.3)**	**87.4**	**4.26 (9.4)**	**3.59 (8.9)**	**84**	**0.11 (0.5)**	**0.11 (0.5)**
Gender		P=0.299	P=0.506	P=0.510	P=0.672		P=0.546	P=0.539		**P=0.025**	**P=0.025**
Male	167 (56.4)	4.6 (2.3)	2.70 (4.6)	2.12 (4.1)	1.81 (3.8)	85.4	5.23 (11.3)	4.50 (10.8)	43 (51.2)	0.21 (0.7)	0.21 (0.70)
Female	129 (43.6)	4.9 (2.5)	1.88 (3.4)	1.44 (3.0)	1.30 (2.6)	90.3	3.00 (6.1)	2.40 (5.4)	41 (48.8)	0	0
IRSD Quintiles		P=0.894	**P=0.005**	**P=0.002**	**P<0.0001**		**P=0.004**	**P=0.004**		P=0.738	P=0.738
1 (highest disadvantage)	50 (16.9)	4.9 (2.3)	3.16 (4.3)	2.84 (4.2)	2.68 (4.0)	94.4	5.52 (9.0)	4.98 (8.7)	11 (13.1)	0.18 (0.6)	0.18 (0.6)
2	59 (19.9)	4.8 (2.5)	2.07 (3.7)	1.42 (3.1)	1.00 (2.5)	70.4	3.88 (8.8)	3.17 (8.5)	16 (19.0)	0.06 (0.2)	0.06 (0.2)
3	74 (25.0)	4.4 (2.2)	3.00 (4.6)	2.32 (3.9)	2.18 (3.7)	94.0	5.69 (10.7)	4.68 (9.6)	20 (23.8)	0.20 (0.9)	0.20 (0.9)
4	62 (20.9)	4.8 (2.3)	2.16 (4.5)	1.77 (4.2)	1.37 (3.6)	77.4	4.34 (11.6)	3.92 (11.4)	19 (22.6)	0.11 (0.3)	0.11 (0.3)
5	51 (17.2)	4.8 (2.7)	1.12 (2.8)	0.63 (2.1)	0.61 (2.1)	96.8	1.29 (3.3)	0.73 (2.4)	18 (21.4)	0	0

Cardiac condition		P=0.789	P=0.102	P=0.594	P=0.624		P=0.129	P=0.598		P=0.663	P=0.663
Simple acyanotic	178 (60.1)	4.7 (2.4)	2.07 (3.8)	1.66 (3.3)	1.43 (3.0)	86.1	3.70 (8.0)	3.14 (7.5)	52 (61.9)	0.06 (0.3)	0.06 (0.3)
Simple cyanotic	38 (12.8)	4.4 (2.3)	4.08 (5.9)	3.08 (5.6)	2.66 (5.1)	86.4	7.53 (15.0)	6.37 (14.6)	9 (10.7)	0.11 (0.3)	0.11 (0.3)
Complex	58 (19.6)	4.7 (2.2)	2.24 (3.7)	1.71 (3.1)	1.48 (2.9)	86.5	4.33 (9.5)	3.62 (9.1)	16 (19.0)	0.25 (1.0)	0.25 (1.0)
Acquired	22 (7.4)	5.1 (3.1)	1.82 (3.4)	1.32 (3.0)	1.27 (3.0)	96.2	2.95 (6.2)	2.32 (5.8)	7 (8.3)	0.14 (0.4)	0.14 (0.4)
Comorbidity		**P=0.028**	**P=0.010**	**P=0.005**	**P=0.036**		**P=0.006**	**P=0.004**		P=0.0237	P=0.237
Cardiac only	135 (45.6)	5.0 (2.5)	2.92 (4.5)	2.31 (4.0)	1.86 (3.5)	80.5	5.64 (10.7	4.82 (10.2)	46 (54.8)	0.17 (0.7)	0.17 (0.7)
Comorbid condition	161 (54.4)	4.4 (2.3)	1.86 (3.7)	1.42 (3.3)	1.36 (3.2)	95.8	3.10 (8.0)	2.55 (7.7)	38 (45.2)	0.03 (0.2)	0.03 (0.2)
Presence of enamel defects		P=0.575	**P=0.003**	**P=0.002**	**P=0.001**		**P=0.003**	**P=0.002**		P=0.370	P=0.370
Present	68 (23.0)	4.8 (2.3)	3.29 (4.4)	2.68 (3.9)	2.41 (3.7)	89.9	5.22 (8.1)	4.40 (7.4)	20 (23.8)	0.25 (0.9)	0.25 (0.9)
Not present	228 (77.0)	4.7 (2.4)	2.06 (4.0)	1.57 (3.5)	1.34 (3.2)	85.4	3.97 (9.8)	3.35 (9.3)	64 (76.2)	0.06 (0.3)	0.06 (0.3)

Table 5. Association of caries severity with gender, socio-economic status, cardiac diagnosis, comorbidity and present of enamel defects in overall population and subset group

Table 6. Multivariate analysis of factors associated with caries prevalence ($d_{1-6}mft>0 + D_{1-6}MFT>0$) in overall and subset groups – final model

Overall

Characteristics	Reference level	Baseline level	OR (95% CI)	P value*	P value overall
Age	Per year of life	Age 1	**1.23 (1.12-1.36)**	**P<0.001**	**P<0.001***
Socioeconomic status	Quintile 2	Quintile1 – Greatest disadvantage	**0.46 (0.22-0.96)**	**P=0.038***	**P=0.007***
	Quintile 3	Quintile1 – Greatest disadvantage	**0.43 (0.22-0.85)**	**P=0.015***	
	Quintile 4	Quintile1 – Greatest disadvantage	**0.34 (0.17-0.68)**	**P=0.002***	
	Quintile 5 – Least disadvantage	Quintile1 – Greatest disadvantage	**0.26 (0.13-0.55)**	**P<0.001***	
Cardiac Diagnosis	Simple cyanotic	Simple acyanotic	1.89 (0.99-3.61)	P=0.052	P=0.283
	Complex (acyanotic and cyanotic)	Simple acyanotic	1.11 (0.63-1.95)	P=0.726	
	Acquired	Simple acyanotic	1.20 (0.51-2.79)	P=0.678	
Comorbidity	Comorbidity	No comorbid diagnosis	**0.44 (0.28-0.69)**	**P<0.001***	**P<0.001***
Enamel defects	Enamel defect present	No enamel defects	**3.60 (2.20-5.88)**	**P<0.001***	**P<0.001***

Subset

Characteristics	Reference level	Baseline level	OR (95% CI)	P value	P value overall
Age	Per year of life	Age 1	**1.17 (1.05-1.31)**	**P=0.006***	**P=0.006***
Socioeconomic status	Quintile 2	Quintile1 – Greatest disadvantage	**0.41 (0.18-0.95)**	**P=0.036***	**P=0.002***
	Quintile 3	Quintile1 – Greatest disadvantage	**0.46 (0.21-0.99)**	**P=0.047***	
	Quintile 4	Quintile1 – Greatest disadvantage	**0.31 (0.14-0.71)**	**P=0.005***	
	Quintile 5 – Least disadvantage	Quintile1 – Greatest disadvantage	**0.15 (0.06-0.39)**	**P<0.0001***	
Cardiac Diagnosis	Simple cyanotic	Simple acyanotic	**2.82 (1.30-6.32)**	**P=0.009***	P=0.074
	Complex (acyanotic and cyanotic)	Simple acyanotic	1.35 (0.68-2.68)	P=0.396	
	Acquired	Simple acyanotic	1.02 (0.35-2.95)	P=0.956	
Comorbidity	Comorbidity	No comorbid diagnosis	0.62 (0.36-1.05)	P=0.076	P=0.076
Enamel defects	Enamel defect present	No enamel defects	**2.76 (1.49-5.09)**	**P=0.001***	**P=0.001***