Dental caries and background factors in children with heart disease

Linda Rosén
If you want to study yourself — look into the hearts of other people.

If you want to study other people — look into your own heart.

Quote from Friedrich von Schiller
Abstract

Congenital heart disease (CHD) is one of the most common congenital anomalies with an incidence of approximately 8–10 cases per 1000 live births. Technical development and continuing improvement in surgical methods have led to early interventions and an increased survival and consequently also a new group of patients in dentistry. The general aim of this thesis was to study the caries prevalence and some possible background factors in children with complex CHD.

Paper I examined the caries prevalence in 41 children with complex CHD and 41 healthy age- and gender-matched controls. CHD children had higher dmfs-values 5.2 ± 7.0 vs. 2.2 ± 3.5 in the controls (p < 0.05). CHD children on digoxin medication had higher dmfs values 10.1 ± 8.5 vs. 3.7 ± 5.3 in the other CHD children (p < 0.05). CHD children had received more fluoride varnish treatments and fluoride tablets (p < 0.01).

Paper II investigated attitudes and experiences of dental health information and advice, dental care, and service in 33 parents of children with complex CHD and 33 parents of age- and gender-matched controls. Differences were displayed in the professional group that provided the parents with dental health information and advice, attitudes to reception at the dental clinic, and experience of sedation before operative dental treatment (p < 0.05).

Paper III examined 183 Swedish general dentists’ experiences of and attitudes to dental care for children with CHD. Eighteen % of the dentists had received special education or information to treat children with CHD, while almost half of the dentists had one or more patients with CHD and a majority of them stated that their CHD patients had a caries problem. The dentists had a different opinion regarding the provision of dental treatment for children with CHD compared to the current situation (p < 0.001).

Paper IV studied salivary secretion, salivary buffering capacity, viable count of bacteria (TVC), mutans streptococci (MS) and lactobacilli (LBC), calcium, chloride, magnesium, potassium, sodium, and IgA in 24 children on heart failure medication and 24 healthy controls. Seven children (29 %) had stimulated secretions below 0.5 ml/min compared to no child among the controls (p < 0.01). TVC were $1.4 \times 10^6 \pm 1.2 \times 10^7$ in the cardiac group vs. $2.7 \times 10^6 \pm 2.9 \times 10^7$ in the control group (p < 0.05). MS ratio of TVC constituted 0.11 ± 0.35 % vs. 0.01 ± 0.02 % for the controls (p > 0.05).

Paper V studied the endogenous pH and titratable acidity and dissolution of calcium and phosphate from dental hard tissues by 13 pharmaceutical preparations used in paediatric cardiology. Six of the preparations had an endogenous pH below the critical value for enamel dissolution.

It is concluded that (i) children with complex CHD had a higher caries experience in the primary dentition than healthy matched controls, (ii) children on digoxin medication had a higher caries experience than other children with complex CHD.
complex CHD, (iii) children with complex CHD had received more caries prevention than healthy controls, (iv) parents of children with complex CHD were less satisfied with the reception and care they received than parents of healthy children, (v) general dentists had a different opinion regarding the provision of dental treatment to children with CHD compared to the current situation (vi) children on heart failure medication can have a low saliva secretion, (vii) pharmaceutical preparations used on long-term basis in paediatric cardiology may pose a hazardous threat to dental hard tissues due to their acidity.

Key words: attitudes, caries, children, dental care, heart disease, medication, saliva
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Papers

This thesis is based on the following original papers, which will be referred to by their Roman numerals:


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**Thesis at a glance**

<table>
<thead>
<tr>
<th>Aims</th>
<th>Material and Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I</strong> To study the caries prevalence in children with complex CHD and compare with a healthy age- and gender-matched control group.</td>
<td>Each group comprised 41 children. Data were collected from medical and dental records.</td>
</tr>
<tr>
<td><strong>II</strong> To study attitudes and experiences of parents of children with complex CHD with respect to dental health information and advice, dental care, and service and compare with data from a healthy age- and gender-matched control group.</td>
<td>Each group comprised parents of 33 children. Data were collected with a questionnaire.</td>
</tr>
<tr>
<td><strong>III</strong> To study experiences of and attitudes to dental care for children with CHD among Swedish general dentists.</td>
<td>General dentists from 2 Swedish counties participated (n = 183). Data were collected with a questionnaire.</td>
</tr>
<tr>
<td><strong>IV</strong> To study saliva profiles in children on heart failure medication and compare them with healthy age- and gender-matched controls.</td>
<td>Each group comprised 24 children. Stimulated saliva was collected. Salivary secretion rate, buffering capacity, total viable count (TVC), mutans streptococci (MS), lactobacilli (LBC), calcium, chloride, magnesium, potassium, sodium, and salivary IgA were determined.</td>
</tr>
<tr>
<td><strong>V</strong> To study the endogenous pH, titratable acidity, and dissolution of calcium and phosphate from dental hard tissues by pharmaceutical preparations used regularly and on long-term basis in paediatric cardiology.</td>
<td>Thirteen pharmaceutical preparations were selected and the titratable acidity and the dissolution of calcium and phosphate after immersion of tooth specimens were quantified for medicines with an endogenous pH below 5.5.</td>
</tr>
</tbody>
</table>
Results

The dmfs-values were higher in the CHD group (5.2 ± 7.0 vs. 2.2 ± 3.5, p < 0.05) while DMFS-values not were different 0.9 ± 1.9 vs. 0.3 ± 0.6 (p > 0.05). Children on digoxin medication had higher dmfs values 10.1 ± 8.5 vs. 3.7 ± 5.3 (p < 0.05). CHD children had received more fluoride varnish treatments and fluoride tablets (p < 0.01).

Conclusions

Swedish children with complex CHD had more caries in the primary dentition than healthy age- and gender-matched controls in spite of intensive preventive efforts. A closer cooperation between paediatric cardiology and paediatric dentistry is needed.

Differences were displayed in the professional group that provided the parents with dental health information and advice (p < 0.01) and attitudes to reception at the dental clinic (p < 0.05). Parents of children who were patients at a specialist clinic for paediatric dentistry were more satisfied with the reception compared to those who were patients in the general dental practice (p < 0.01).

Parental attitudes to reception in the dental service differed, and parents of healthy children scored the reception at the dental clinic better than parents of children with complex CHD. It is suggested that children with complex CHD should receive dental care in clinics for paediatric dentistry particularly at early ages.

A minority of the dentists had received special education to treat children with CHD. Almost half of them had one or more patients with CHD. A majority stated that their CHD patients had a caries problem. The dentists had a different opinion regarding the provision of dental treatment to children with CHD compared to the current situation (p < 0.001).

Data indicates that the Swedish dentists are unsettled and insecure in the dental treatment of children with CHD. Close cooperation between specialists in paediatric dentistry, dentists with special training, and general dentists is essential.

Twenty-nine % of the children on heart failure medication had secretions below 0.5 ml/min compared to no child in the control group (p < 0.01). TVC were lower in the cardiac group compared to the control group (p < 0.05). MS ratio of TVC constituted 0.11 ± 0.35 % vs. 0.01 ± 0.02 % for the controls (p > 0.05).

Children on heart failure medication can have a low saliva secretion.

The pH of the pharmaceutical preparations varied between 3.03 and 9.02 and 6 had an endogenous pH below 5.5. The highest dissolved calcium and phosphate from the tooth specimens was displayed by captopril (12.5 mg) tablet water solution and by the acetylsalicylic acid (75 mg) tablet water solution.

Some pharmaceutical preparations used on a long-term basis in paediatric cardiology may pose a hazardous threat to dental hard tissues due to their acidity.
Abbreviations

ACE  Angiotensin-converting enzyme
ANOVA Analysis of variance
AS  Aortic stenosis
ASD Atrial septal defect
BAO Blood agar oral plates
CFU Colony forming units
CHD Congenital heart disease
CoA Coarctation of the aorta
DCM Dilated cardiomyopathy
dmfs/DMFS Decayed, missed, filled surfaces for primary/permanent teeth
ECC Early childhood caries
LBC Lactobacilli
LCC Late childhood caries
MS Mutans streptococci
PDA Patent ductus arteriosus
PDS Public dental service
PS Pulmonary stenosis
SWS Stimulated whole saliva
TGA Transposition of the great arteries
TOF Tetralogy of Fallot
TVC Total viable count
UWS Unstimulated whole saliva
VSD Ventricle septal defect
Introduction

The human heart develops between the 8th and the 12th gestational week. A disturbance in this process may result in an anomaly—a congenital heart disease (CHD). CHD is one of the most common congenital anomalies in children, with a mean incidence of approximately 8–10 cases per 1000 live births (1-4). Children with complex anomalies constitute approximately one-third of all children with CHD (3). Technical development and continuing improvement in surgical methods have led to early interventions and an increased survival of children with CHD (5). A majority of children with significant heart disease are today subjected to successful surgery, but those children with very complex heart diseases are often surgically palliated and not completely corrected (6, 7). The aetiology behind cardiac developmental disturbances are in a majority of cases unknown, but risk factors like maternal diseases and infections like diabetes, rubella, HIV, and alcoholism have been suggested (4, 8). Many CHDs result from genetic and environmental interactions rather than mendelian inheritance (9). The CHD may occur individually as a single diagnosis, which is seen in a majority of cases, or as a part of a syndrome or genetic malformation, e.g. Down’s syndrome, Noonan’s syndrome, Turner’s syndrome, 22q11, and trisomy 18. Approximately 40% of children with Down’s syndrome and a majority of children with Noonan’s syndrome and trisomy 18 are affected with CHD (10, 11). Besides the group of congenital anomalies, heart disease in childhood may also be caused by various kinds of cardiomyopathies leading to heart failure and the need of anti-congestive medication (12).

CHD is the comprehensive term for congenital cardiac anomalies. The most common anomalies can be divided into the sub-groups: left-right shunts, obstructive heart diseases, and cyanotic congenital anomalies. The most common diagnoses are listed in Table 1, and the frequency distributions of the most common congenital cardiac diagnoses in live births are listed in Table 2.
Table 1. The most common cardiac diagnoses divided in sub-groups.

<table>
<thead>
<tr>
<th>Left-right shunt</th>
<th>Ventricular septal defect (VSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Atrial septal defect (ASD)</td>
</tr>
<tr>
<td></td>
<td>Patent ductus arteriosus (PDA)</td>
</tr>
<tr>
<td></td>
<td>Atrioventricular septal defect (AVSD)</td>
</tr>
<tr>
<td>Obstructive heart disease</td>
<td>Coarctation of the aorta (CoA)</td>
</tr>
<tr>
<td></td>
<td>Aortic stenosis (AS)</td>
</tr>
<tr>
<td></td>
<td>Pulmonary stenosis (PS)</td>
</tr>
<tr>
<td>Cyanotic vitia</td>
<td>Transposition of the great arteries (TGA)</td>
</tr>
<tr>
<td></td>
<td>Tetralogy of Fallot (TOF)</td>
</tr>
</tbody>
</table>

Table 2. Distribution of the most common congenital cardiac diagnoses in live births according to the National Board of Health and Welfare (1).

<table>
<thead>
<tr>
<th>Cardiac anomaly</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular septal defect (VSD)</td>
<td>20–30</td>
</tr>
<tr>
<td>Patent ductus arteriosus (PDA)</td>
<td>10–12</td>
</tr>
<tr>
<td>Atrial septal defect (ASD)</td>
<td>8–10</td>
</tr>
<tr>
<td>Pulmonary stenosis (PS)</td>
<td>8–10</td>
</tr>
<tr>
<td>Tetralogy of Fallot (TOF)</td>
<td>5–10</td>
</tr>
<tr>
<td>Coarctation of the aorta (CoA)</td>
<td>5–8</td>
</tr>
<tr>
<td>Atrioventricular septal defect (AVSD)</td>
<td>4–5</td>
</tr>
<tr>
<td>Transposition of the great arteries (TGA)</td>
<td>3–7</td>
</tr>
<tr>
<td>Aortic stenosis (AS)</td>
<td>3–5</td>
</tr>
<tr>
<td>Hypoplastic left heart syndrome (HLHS)</td>
<td>2–5</td>
</tr>
</tbody>
</table>
**Signs and symptoms of heart disease**

The main symptoms of CHD are cyanosis and/or heart failure. In cyanosis, de-oxygenated blood is mixed with oxygenated blood or an increased amount of blood goes to the pulmonary circulation. Low saturation in tissues and organs may lead to acidosis, and this may cause an impaired heart function and heart failure (4, 9).

Heart failure occurs either due to an increased blood flow to the pulmonary circulation or due to a deteriorated ventricle, which fails to keep the pumping function. Blood will accumulate in the lungs, and breathing will be affected. The clinical signs are rapid breathing and an increased heart rate (tachypnea and tachycardia), feeding problems, and inadequate weight gain. The first signs of heart failure are often observed during the child’s first 3 months of life.

**Treatment of CHD**

*Pharmacological treatment*

If left untreated, CHD is the single greatest cause of death during the neonatal period after full-time pregnancies in the industrialized part of the world (4,9). The medication is often complex in children with complex CHD, and the most common pharmaceutical preparations used in paediatric cardiology can be found in Table 3. Diuretics are the first treatment of choice in heart failure, decreasing total blood volume and thereby diminishing the volume load of the heart. In heart failure, medical treatment with angiotensin-converting enzyme (ACE) inhibitors and/or cardiac glycosides, such as digitalis, can also be indicated. ACE inhibitors inhibit the formation of angiotensin II, and as a result of this, the peripheral resistance is decreasing both preload and afterload. Digitalis preparations reduce the heart rate and increase the contractility of the heart. Beta-blockers are used in management of cardiac arrhythmias and may be indicated as adjuncts to standard therapy in heart failure. Anticoagulants, as warfarin,
stops blood from clotting and antiplatelet drugs, such as acetylsalicylic acid, decrease platelet aggregation formation. They are used in prevention of thrombotic events in cardiovascular disease.

In duct-dependent anomalies, like in pulmonary atresia or hypoplastic left heart syndrome, it is of decisive importance that the ductus arteriosus remains open, otherwise the child will die. In the late 1970’s, it was found that prostaglandin keeps the ductus arteriosus open, and this finding has a key role in the dramatically improved results of paediatric heart surgery. By giving prostaglandin infusions, the child can be stabilized and transported to surgery under considerably better circumstances.

**Table 3.** Pharmaceutical preparations used in paediatric cardiology.

<table>
<thead>
<tr>
<th>Medicine</th>
<th>Generic substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE inhibitors</td>
<td>enalapril</td>
</tr>
<tr>
<td></td>
<td>captopril</td>
</tr>
<tr>
<td>Diuretics</td>
<td>spironolactone</td>
</tr>
<tr>
<td></td>
<td>furosemide</td>
</tr>
<tr>
<td>Beta-blockers</td>
<td>metoprolol</td>
</tr>
<tr>
<td></td>
<td>propranolol</td>
</tr>
<tr>
<td>Cardiac glycosides</td>
<td>digoxin</td>
</tr>
<tr>
<td>Anti-coagulants</td>
<td>warfarin</td>
</tr>
<tr>
<td>Anti-platelet drugs</td>
<td>acetylsalicylic acid</td>
</tr>
</tbody>
</table>
**Surgical treatment**

In 1938, the first paediatric heart surgery was performed. In 1953, the heart-lung machine was used for the first time, and during 1970, the pacemaker and heart transplantations on newborns were introduced in paediatric cardiology. In the 1980’s, catheter treatments of several CHD became possible. The use of prostaglandin on duct dependent anomalies, as described earlier, taken together with the development of the diagnostic instrument echocardiography, contributed to an increased survival rate of children subjected to paediatric heart surgery. Figure 1 shows that the mortality rate decreased in children subjected to open heart surgery in Sweden. Today surgery is successful for the majority of children born with complex CHD (9). The median age of children subjected to heart surgery is today below 2 years of age (4).

**Fig. 1.** Thirty-day mortality rate in children subjected to open heart surgery, 1988–2006 (data received from the National Board of Health and Welfare).

**Saliva**

To maintain a normal physiology in the oral cavity, an adequate salivary production is of great importance. Saliva is produced by the 3 major pairs of
salivary glands, namely, parotid, submandibular, and sublingual as well as by numerous minor salivary glands, namely, buccal, lingual, labial, and palatinal, in a total volume of 0.5–1.0 litre per day. The salivary glands seem to be fully developed at the age of 15, and the salivary flow rate increases with age and girls have lower rates than boys (13). The saliva produced by the different gland types has a characteristic composition, and the composition of the saliva has a diurnal variation (14) and is affected by input stimuli (15). Saliva contains inorganic components like calcium and phosphate and organic components like proteins, carbohydrates, immunoglobulins, and enzymes. In the oral cavity, the saliva from the salivary glands mixes with mucus from the nasal cavity and pharynx, epithelial cells, and millions of microorganisms, and this mix is in the literature referred to as whole saliva (14).

The salivary glands have a dual innervation with nerve fibres from both sympathetic and parasympathetic nervous system. In general, parasympathetic stimulation increases salivation, while sympathetic stimulation produces more viscous saliva and therefore appears to depress salivation (14). Pharmacotherapy is probably the most common cause of impaired salivary secretion.

The saliva plays an important role in the complex oral ecosystem, and several factors of great importance for maintaining oral health are present in the saliva (16). One important objective of saliva in the defence against caries is to neutralize acids in plaque, and an impaired salivary flow will result in an increased risk of developing caries. Saliva acts as a lubricant for the oral tissues and it facilitates swallowing and speech. Further, saliva contributes in the initial step of digestive break down (14, 17). With its buffering capacity, saliva protects the oral cavity against damaging pH changes. By several anti-microbial components, such as immunoglobulins, the saliva also constitutes a barrier for bacteria and viruses not to permeate the mucous membrane. Several types of immunoglobulins are present in saliva, such as IgG, IgM, and IgA, of which the
secretory IgA (sIgA) is predominant (18). sIgA is produced by plasma cells located in the connective tissues and is translocated through the duct cells of the major and minor salivary glands (19, 20). Salivary IgA against mutans streptococci (MS) can be found in a majority of children over 3 years of age and the amount increases with the length of exposure (18, 21).

**Dental caries**

Dental caries is defined as ‘a dynamic process taking place in the tooth bacterial biofilm (plaque), which results in a disturbance of equilibrium between tooth substance and the surrounding plaque fluid and finally results in a loss of minerals from the tooth surface’ (22). Dental caries is one of the most prevalent chronic and infectious diseases in man. Susceptibility to caries remains throughout life, and it is the primary cause of oral pain and tooth loss in both the primary and the permanent dentition. The disease may be reversed if arrested in time, but without proper care caries may progress until the tooth is destroyed (23). Caries in young children may be divided into early childhood caries (ECC) and late childhood caries (LCC) (24). Several studies have shown a close relationship between caries in the primary dentition and caries in the permanent dentition (25-28). The main assignment for paediatric dentistry is thus to endeavour that dental caries never get established in the primary dentition.

*Pathogenesis of dental caries*

Dental caries develops in the interplay between acid-producing bacteria, e.g. mutans streptococci (MS) and lactobacilli (LBC), dietary sugars that the bacteria can metabolise, and several host or personal factors like teeth and saliva (23, 29). The most cariogenic group of bacteria present in the oral cavity is MS (30). An increase in the proportion of acidogenic bacteria such as MS and LBC in the oral biofilm has been shown to be associated with dental caries (31). Cariogenic plaques normally contain high numbers of these bacteria and the acidogenic
potential is extensive. A shift in the composition of dental plaque towards acidogenic bacteria occurs as an effect of environmental changes. Such changes may occur due to reduced salivary flow, high and frequent intake of sucrose, impaired oral hygiene or combinations of these factors (32-35). The low pH generated from acids changes homeostasis in the microbial community in the dental plaque and a selection towards bacteria with a capacity to induce caries will take place. The acids produced by the cariogenic bacteria will cause a drop in pH below the critical value where demineralisation of enamel occurs (pH ≤ 5.5) (36). If the demineralization proceeds, cavitations in the tooth will be a fact. On the other hand, if minerals in the saliva, like fluoride, calcium, and phosphate diffuse into the tooth, remineralisation occurs and the enamel turns more acid-resistant. Remineralisation occurs frequently, especially when the biofilm pH is restored by saliva, which acts as a buffer (36).

Risk factors

A potential risk factor is a variable associated with an increased risk of disease or infection. The exposure must be established before the outcome and prospective studies are necessary to demonstrate risk factors, and they imply causality (37). Low salivary secretion and high numbers of acid producing oral bacteria are well-known risk factors for caries development. Risk factors for dental caries may vary over time and are strongly affected by lifestyle and behavioural factors that may expose the individual to risk factors. Poor oral hygiene habits, poor dietary habits, and frequent use of medicines that contain sugar, are acidic, and/or are xerogenic are examples of behavioural factors that may lead to an increased caries risk (23).
Epidemiology

Several studies have reported the caries prevalence in Swedish children. Two studies from 2006 and 2007 showed that 6–7% of 2-year-old children have caries (38, 39). Decreasing caries prevalence has been demonstrated in Swedish children (40, 41). Caries prevalence and background factors were studied in a series of cross-sectional studies from the northern part of Sweden in 4-year-olds from 1967 to 2007. These studies showed a decreasing caries frequency over the years, but it is also clear that caries is still a common problem in the primary dentition (42). Many chronic diseases in childhood have been associated with poor oral health (43). A number of studies have been carried out on the caries prevalence in children with CHD (44-53) of which only five have been controlled studies (44, 46-48, 52). Published studies on caries in children with heart disease are presented in Table 4. In the controlled studies published between 1978 and 2008 from Australia and UK the severity of CHD and outcome measures varies but the studies indicate more untreated caries, treatment need and/or a higher caries prevalence compared to healthy children.

In Sweden, the caries distribution in children today is skewed, and susceptible individuals like children with immigrant background (42) and some medically compromised children (54-56) have more caries than non-immigrants and healthy children. When this thesis was planned, little was known about the caries prevalence in the increasing group of children with CHD in Sweden where all children are offered organised dental care free of charge from an early age.
Table 4. Published studies on caries in children with heart disease. Reference number in parenthesis.

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Country</th>
<th>n</th>
<th>Age</th>
<th>Caries/age group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berger, 1978 (44)</td>
<td>Australia</td>
<td>CHD=57 Ctr=57</td>
<td>8-10</td>
<td>Cyanotic CHD had higher dt, DT and MT</td>
</tr>
<tr>
<td>Urquhart and Blinkhorn, 1990 (45)</td>
<td>UK</td>
<td>CHD=134</td>
<td>4-12</td>
<td>4-6 dmft 7-9 DMFT 10-12 DMFT</td>
</tr>
<tr>
<td>Pollard and Curzon, 1992 (46)</td>
<td>UK</td>
<td>Cardiac=100 Ctr=100</td>
<td>2-16</td>
<td>2-4 dmft 5-9 DMFT 10-16 DMFT</td>
</tr>
<tr>
<td>Hallett et al, 1992 (47)</td>
<td>Australia</td>
<td>CHD=39 Ctr=33</td>
<td>2-15</td>
<td>dmft 4.2 * DMFT 0.9</td>
</tr>
<tr>
<td>Franco et al, 1996 (48)</td>
<td>UK</td>
<td>CHD=60 Ctr=60</td>
<td>2-16</td>
<td>dmft 3.7±3.2 DMFT 2.7±3.4</td>
</tr>
<tr>
<td>Hayes and Fasules, 2001 (49)</td>
<td>USA</td>
<td>Children scheduled for cardiac surgery=209</td>
<td>≥ 6 months</td>
<td>29 % with caries</td>
</tr>
<tr>
<td>Da Silva et al, 2002 (50)</td>
<td>Brazil</td>
<td>Children with risk of IE=104</td>
<td>2-17</td>
<td>dmft 2.6±3.0 DMFT 4.0±4.1</td>
</tr>
<tr>
<td>Balmer and Bu’Lock, 2003 (51)</td>
<td>UK</td>
<td>Children with risk of IE=38</td>
<td>2-16</td>
<td>39 % with untreated caries</td>
</tr>
<tr>
<td>Tasioula et al, 2008 (52)</td>
<td>UK</td>
<td>CHD=76 Ctr=47</td>
<td>2-15</td>
<td>dmft 1.6±3.0 DMFT 0.8±1.4 Care index 10 % *</td>
</tr>
<tr>
<td>Rai et al, 2009 (53)</td>
<td>India</td>
<td>CHD=170</td>
<td>1-16</td>
<td>42 % with caries</td>
</tr>
</tbody>
</table>

* Statistically significant difference, IE=infective endocarditis
Caries prevention

The dental care for Swedish children has had a preventive approach for more than 40 years with start in an early age of the child. The concept with an early prevention start is based on the thought that initially children’s teeth are healthy and that the dental health of the preschool child is important since it has a strong influence on the future dental health (25-28). The beneficial development of the dental health of preschool children during the 1970’s has been ascribed to the introduction of early dental health information to parents and an increased use of fluorides (57). Fluoride plays an important role in caries prevention (58, 59) and stimulates self healing of minor cavities by reducing the demineralisation process and promoting the remineralisation process (60). Further, fluoride also affects the metabolism in caries-associated bacteria (61). The effect of fluoride strongly depends on the frequency of administration. Fluoride toothpaste is considered as the most cost-effective homecare measure (58), and semi-annual fluoride varnish applications, as the best professional method for infants at risk (62). In a group of special-needs children, the beneficial effect of daily fluorides was demonstrated, and it was shown that both fluoride tablets and fluoride liquid could prevent ECC in children with cleft lip and/or palate (63). In Sweden, basic caries prevention in healthy individuals consists of tooth brushing twice a day with fluoride toothpaste. In individuals with an increased risk for caries, like some medically compromised patients (43, 54-56), additional fluoride may be indicated and is suggested to be administered based on individual needs and compliance (24).

Oral effects of pharmacotherapy

It is known that children with very complex CHD frequently require regular long-term medication (7), but the knowledge of oral health effects caused by long-term medication in medically compromised children is sparse (64). Many pharmaceutical preparations used on a long-term basis may have a low pH, high
acidity, and contain sugar (65, 66). A strong correlation between xerostomia and pharmacological treatment has been shown (67), and a number of drugs have been listed as xerogenic (68). These drugs include those with a direct damage to salivary glands such as cytotoxic drugs, drugs with anticholinergic activity, drugs which deplete fluid as diuretics, and drugs acting on sympathetic system like antihypertensive drugs (69). Only a few clinical studies have been carried out on the outcome of salivary function with antihypertensive drugs, and the outcome is not clear-cut (70). In healthy men, the effects of β-adrenoceptor antagonists, such as atenolol and propranolol, on saliva flow and composition was tested and no effect on saliva secretion was found; however, there was a reduction in total salivary protein (71) and hypertensive patients increased their salivary secretion during withdrawal of β₁-selective drug metoprolol (72). Treatment with the ACE inhibitor captopril increased the secretion rates for unstimulated and paraffin-chewing stimulated whole saliva and for parotid secretion. No alterations in the composition of saliva were observed (73). Thiazide diuretics significantly reduced salivary secretion in 34 healthy adult volunteers (74).

To maintain chemical stability, control tonicity, and physiological compatibility in medicines, acids are frequently used as buffering agents (64). Fermentable sugars such as sucrose can also be added in paediatric medicines to disguise their unpleasant taste and thereby facilitate compliance. Sugars in medicines may, however, cause a pH drop in the oral biofilm as a result of their fermentation in acid-producing bacteria (23, 43), and acids in medicines may help to prolong the pH drop after a sugar challenge. Pharmacotherapy may therefore, beside the effects on salivary secretion, also act directly on the dental hard tissues with dental caries and/or erosive lesions as possible outcomes as a result of their content of acids and fermentable sugars (66, 68, 75, 76). Dental erosion is a multifactorial condition, defined as the ‘dissolution of the tooth by acids when the surrounding aqueous phase is unsaturated with respect to tooth mineral’ (77). Minerals in dental hard tissue are dominated by calcium and
phosphate mainly organised in hydroxyapatite crystals with a critical pH value of 5.5 (36). Any substance with an endogenous pH below this value may cause ionic dissolution of the hard tissue with caries and erosion as possible outcomes (78). The causes behind the development of dental erosion are often divided into either extrinsic or intrinsic factors. Extrinsic factors are factors like acidic foodstuffs and medications. Intrinsic factors may be diseases and consequences of diseases where acidic contents of the stomach reach the oral cavity and thereby pose a threat to the oral health (79).
Aims of the Thesis

General aim
The general aim of this thesis was to investigate the caries prevalence in children with complex CHD and potential background factors.

Specific aims
The specific aims of this thesis were to:

- Study the caries prevalence in children with complex CHD and compare with healthy age- and gender-matched children.
- Study the attitudes and experiences of parents whose children have complex CHD with respect to dental health information and advice, dental care and service, and to compare the results with data from a healthy age- and gender-matched control group.
- Study the experience of and attitudes to dental care for children with CHD among Swedish general dentists.
- Study the secretion and composition of saliva in children on heart failure medication, and to compare with saliva from healthy age- and gender-matched controls.
- Study the endogenous pH, titratable acidity, and dissolution of calcium and phosphate from dental hard tissue by medicines used regularly and on long-term basis in paediatric cardiology.
Materials

Study designs

- Study I, II and IV: Cross-sectional case-control design.
- Study III: Descriptive cohort study.
- Study V: *In vitro* study.

Study and control groups

Table 5. Number of invited, consented, gender distribution, and mean age.

Equal numbers and gender in study and control groups.

<table>
<thead>
<tr>
<th>Study</th>
<th>Invited</th>
<th>Consented</th>
<th>Boys</th>
<th>Girls</th>
<th>Mean age, range (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>43</td>
<td>41</td>
<td>25</td>
<td>16</td>
<td>6.5 (2–11)</td>
</tr>
<tr>
<td>II</td>
<td>38</td>
<td>33</td>
<td>20</td>
<td>13</td>
<td>9.4 (3–13)</td>
</tr>
<tr>
<td>IV</td>
<td>37</td>
<td>24</td>
<td>11</td>
<td>13</td>
<td>12.0 (6–19)</td>
</tr>
</tbody>
</table>

Paper I

All surviving children with CHD, complexity grading II and III, born between 1991 and 2000 and living in the county of Västerbotten were selected from the Paediatric Cardiology Outpatient Clinic at University Hospital in the city of Umeå, Sweden and invited to take part in the study (n = 43). Children with other serious medical diagnoses and children with learning difficulties were excluded. For each CHD, a healthy child with the same date of birth and gender was selected. The first child in the population register who met the inclusion criteria was included in the control group. Informed consent was received from the parents of 95% of the selected groups, which resulted in 41 children in each
The mean age of the children was 6.5 years, and there were 25 boys and 16 girls.

**Paper II**

Parents of all children with CHD between 3 and 13 years of age, complexity grading II and III, without other chronic diseases, learning difficulties, or syndromes registered in the Paediatric Cardiology Outpatient Clinic at University Hospital in the city of Umeå were invited (n = 38). The parents of 2 children with CHD did not consent. For each child in the study group, a child of the same gender and date of birth was selected from the population register for the county of Västerbotten. Approximately 50% of the parents replied to the first questionnaire. After reminders 10 participants did not reply, and they were exchanged with the parents of the next child with the same birth date and gender in the population register. In spite of this, there were 3 non-respondents. To match the controls, the parents of 3 children with CHD were excluded. The final material thus consisted of 33 pairs of parents.

**Paper III**

All general dentists employed in the Public Dental Health Service and all private dentists listed with dentistry for children in the county of Västerbotten (n = 145) in the north of Sweden and all general dentists employed in the Public Dental Health Service in the county of Uppsala (n = 100) in the middle of Sweden were invited to participate in the study. All specialists were excluded from the invitation. The final material consisted of 183 dentists (75%) of which 40% were males and 60% were females. Seventy-two percent of the dentists had their dental degree 16 years ago or earlier, and 10%, six years earlier or less.
**Paper IV**

All children with CHD complexity grading II and III, or dilated cardiomyopathies (DCM), 5 years or older, medicating with ACE inhibitors and/or diuretics, and attending the Paediatric Cardiology Clinics at the University Hospital in the city of Umeå or at the Karolinska University Hospital, Stockholm, Sweden, were invited to take part in the study (n = 37). Children with other chronic diseases, learning difficulties or syndromes were not invited. Each child in the study group who fulfilled the criteria for inclusion and consented to participate was asked to bring along a friend, healthy, with the same age and gender, to the saliva-sampling occasion. The final material consisted of pairs of 24 children (65%). Three cases were 1 year younger or older than their control.

**Paper V**

Thirteen medicines commonly used in paediatric cardiology were selected. For quantification of dissolution of calcium and phosphate, tooth specimens were prepared from the central corona of extracted primary canines with no cracks in enamel.
Methods

Diagnosis, medication, and blood pressure
Data on diagnosis, medication, and blood pressure in the study groups were extracted from the records at the Paediatric Cardiology Clinics at the University Hospital in Umeå and at the Karolinska University Hospital, Stockholm, Sweden. Data extraction was performed by an experienced paediatric cardiologist.

Caries registration (I)
For both groups of children, copies of their dental records and bitewing radiographs were collected from the dental clinic where the child received dental treatment. Data on decayed, missing, filled, and carious surfaces (dmfs/DMFS) were collected from the records, while data on posterior approximal caries were collected from bitewing radiographs. The examiner was blinded to group when reading the bitewing radiographs. All initial (in the enamel) and manifest (in the dentine) caries lesions on approximal surfaces in posterior teeth, i.e. primary molars in the primary dentition and first permanent molars, were included in the dmfs/DMFS values. A primary molar that had been extracted due to caries was counted as 3 missing surfaces in the dmfs values.

Caries prevention (I)
Data on the number of occasions the child had been treated with fluoride varnish and professional polishing was noted from the dental records, as well as the number of prescriptions of fluoride tablets.
Attitudes and experiences (II, III)

Paper II

A questionnaire with 20 questions was used for both groups of children. Thirteen of the questions concerned dental health information and dental care and service. Both groups were also asked 7 questions about dental health of the child and his/her parents, the children’s and parents’ expectations before visits to the dental clinic, and the educational level of the parents. In the questionnaire to the parents of the children with CHD, 4 specific questions were added, concerning if the child with CHD had siblings, the differences in dental health information compared to healthy siblings, parents’ knowledge about antibiotic prophylaxis, and where they had received this information.

Paper III

The invited dentists were sent written information about the purpose of the study and were asked to fill in a questionnaire. The questions were pre-tested in a group of experienced clinicians, and a few changes were performed in the questionnaire before data collection. The questionnaire had 18 questions concerning the dentists’ experiences and attitudes to dental care for children with CHD as well as the dentists’ age, gender, and year of graduation. Two reminders were sent out to non-responders.

Saliva (IV)

Saliva sampling

Stimulated whole saliva (SWS) was collected before lunchtime, and the participants were asked to refrain from all eating, drinking, and tooth brushing at least 1 hour before sampling. Age, general health, and medication were checked for the accompanying control.

SWS was collected by chewing on a standardised lump of paraffin. Instructions were given to chew for 1 minute and thereafter to spit out or
swallow any saliva produced. The subject was then asked to chew paraffin for 5 minutes and to collect all saliva that was produced in a test tube. The saliva samples were assessed for salivary secretion rate (ml/min), buffering capacity, electrolyte concentration, salivary IgA, total viable counts (TVC), and caries-associated bacteria, namely, MS and LBC. The secretion rate and buffering capacity were determined at the sampling occasion, and the samples were then transported to the laboratory at the department of Paediatric dentistry at Umeå University for cultivation of oral bacteria. Saliva for assessment of electrolyte concentrations and salivary IgA was stored frozen until the sampling was finalized.

**Assessment of stimulated saliva secretion rate and buffering capacity**

The volume of the produced saliva was immediately measured and the secretion rate was calculated (ml/min). A drop of saliva from the test tube was applied to a Dentobuff Strip test pad (Orion Diagnostica Oy, Espoo, Finland) and the colour of the pH pad was read and compared with the manufacturer’s colour chart.

**Cultivation of bacteria**

After sampling, the saliva samples were serially diluted in a potassium phosphate buffer with NaCl to obtain 0, 40, 800, and 8000 times dilutions. MS were cultivated on selective (MSB) agar (Difco Mitis Salivarius Agar, Becton, Dickinson and Company, USA) and LBC were cultivated on Man, Rogosa, Shape (MRS) agar (Merck, Germany). TVC were cultivated on blood agar oral plates (BAO). All plates were incubated aerobically in 37 °C in 5 % CO₂ for 48 hours and then examined under a light microscope to verify the colony forming units (CFU). The total number of CFU in saliva was calculated as CFU/ml of saliva.
Determination of the salivary composition of electrolytes

The saliva samples were diluted 1:1 with MQ-distillated water and centrifuged at 13200 rpm for 10 minutes and then stored frozen (-20 °C) until all samples were collected. All analyses of the electrolytes were performed in the same session. Calcium and magnesium were measured by atomic absorption with an acetylene flame, with a standard curve in the range of 0.8–1.5 mM total calcium and 0.05–0.21 mM total magnesium. Sodium and potassium concentrations were measured in the same way at 589.6 nm and 769.9 nm respectively, with a standard curve in the range of 4–40 mM total sodium and 14–26 mM total potassium. Chloride was measured indirectly by precipitation of silver at 328.1 nm, with a standard curve in the range of 9–34 mM total chloride. Phosphate was determined spectrophotometrically at 700 nm with a standard curve in the range of 2.2–5.7 mM total phosphate.

Determination of salivary IgA

The saliva for determination of salivary IgA was diluted, centrifuged, and stored frozen as saliva for determination of electrolytes. As a standard preparation, a purified human colostral IgA Sigma no 1-3755 was used. The salivary IgA concentrations were calculated by reference to this standard. As a primary antibody, an affinity purified anti-human IgA α (alpha chain specific) from goat was used, and as a secondary antibody, a peroxidased conjugated affinity purified goat anti-human IgA α (alpha chain specific) was used. The analyses were performed in triplets on Elisa plates, leaving the first wells as blanks. The IgA concentrations were determined spectrophotometrically at 490 nm, providing a mean value for the sample in mg/l.
Effects on dental hard tissues caused by medication (V)

Medicines, sample preparation, and pH measurement

Of the 13 selected medicines, there were solid tablets (n = 7), capsules (n = 2), and mixtures (n = 4). Citric acid (10 mM) was used as control. Tablets were crushed in a mortar and dissolved in 10 ml of distilled water. For liquid medicines, a 10 ml sample was taken. The endogenous pH values of the water solutions of tablets or liquid medicines were measured with a pH meter.

Titration

Each medicine sample was titrated by adding 0.01 ml aliquots of a NaOH solution (0.1 M) by using a titrator. The pH value achieved for each 0.01 ml NaOH added was read with the pH meter and recorded. The titration was performed until a pH value of 7.0 was reached. Samples with an endogenous pH value ≥ 5.5 were not titrated.

Loss of calcium and phosphate after immersion of dental hard tissue in medicines

For medicines with a pH below 5.5, the dissolution of calcium and phosphate after immersion of tooth specimens were quantified. Specimens were prepared from the central corona of extracted primary canines with no cracks in enamel. The teeth were embedded in Epofix (Struers, Ballerup, Denmark) and 3 horizontal slices (thickness 80 µm) were cut from each tooth under water-cooling. Prior to the experiment, the tooth specimens were pre-treated with immersion in 1 mM CaHPO₄ + 1 mM F overnight in room temperature. Tablets were crushed in a mortar, diluted in 2 ml MQ-water and rocked overnight in room temperature. Calcium and phosphate were analyzed as in Paper IV. First, the baseline calcium and phosphate content of medicine solutions were measured in 100 µl of each sample. Thereafter, 500 µl of each medicine solution was transferred into cell cultivation chambers, and 2 chambers were filled with each medicine.
One tooth disc was put into each chamber and the plate was placed in 37 °C. One hundred \( \mu l \) were collected from each chamber after 30 minutes of immersion and analysed. The mean of 2 samples for each medicine was calculated.

**Ethical approval**
The protocols of studies I and II were approved by the Research Ethics Committee of the Faculty of Medicine and Odontology at Umeå University and IV was approved by the Regional Ethical Review Board at Umeå University. For Paper V prior to the extractions for orthodontic reasons the patients and their parents were informed about that the teeth should be used for research purposes and consent were obtained. For paper III no ethical approval was applied for.

**Ethical considerations**
Informed consent from all the participating children and their parents was obtained before the start of clinical studies in Paper I, II, and IV. The parents were informed that participation was voluntarily, and any time the study could be terminated, and the CHD group termination could be performed without harm to the doctor-patient relation. As families with children with serious heart diseases face heavy demands due to their surgery, medication, recurrent illness, and occasional nutritional problems, the added burden the participation in these studies constituted were carefully considered when the studies were planned. As the caries problem constitute a considerably add to their burden the potential medical benefits of these studies were considered to outweigh encroach in their privacy.

**Statistical analyses**
All data were processed with the SPSS (versions 11.0-17.0, SPSS Inc., Chicago, IL, USA). The following statistical analyses were performed: Paper I—One-way
analysis of variance (ANOVA) was used to compare the differences between groups, and Spearman’s rank correlation was used to explore the relationship between dental caries and selected variables. Chi-Square test was used to test the differences between groups in the use of fluoride tablets. Paper II—Fischer’s exact test (2-sided) was used to test the differences in standardised answers between the 2 groups. Paper III—Chi-Square test was used to test the differences between groups. Paper IV—Continuous data were analysed by ANOVA, and categorical data, by chi-square test. In paper V, only descriptive data were presented. In all statistical analyses, a p-value of less than 0.05 was considered statistically significant.
Results

Paper I
Data for dmfs and DMFS are given in Table 6. All dmfs indices were statistically significantly higher in the CHD group (p < 0.05), while no statistically significant differences could be displayed for any of the DMFS indices (p > 0.05). The number of months the child had been on digoxin medication and the dmfs value had a statistically significant positive correlation (r = 0.368, p < 0.05). Ten of the children in the CHD group had been on digoxin medication between 6 and 87 months. This sub-group had a statistically significant higher mean dmfs value compared to those children in the CHD group who did not medicate with digoxin (10.1 ± 8.5 vs. 3.7 ± 5.3, p < 0.05). The children in the CHD group had achieved statistically significant more treatments with fluoride varnish and prescriptions of fluoride tablets compared to the control group. The mean number of treatments with fluoride varnish was 3.8 ± 4.0 for children in the CHD group compared to 1.8 ± 2.2 in the control group (p < 0.01). Fifty-two % of the children in the CHD group had been prescribed fluoride tablets on one or more occasions compared to 17 % in the control group (p < 0.01). There was a significant positive correlation between the numbers of fluoride varnish treatments and the dmfs value of the child (r = 0.411, p < 0.01).
### Table 6. dmfs and DMFS in the CHD group and the control group.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>CHD</th>
<th>Control</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>dmfs\textsuperscript{tot}</td>
<td>41</td>
<td>5.2 ± 7.0</td>
<td>2.2 ± 3.5</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>dmfs\textsuperscript{dentine}</td>
<td>41</td>
<td>4.7 ± 6.3</td>
<td>2.1 ± 3.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>dmfs\textsuperscript{approxtot}</td>
<td>41</td>
<td>3.4 ± 4.0</td>
<td>1.5 ± 2.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>dmfs\textsuperscript{approxint}</td>
<td>41</td>
<td>0.5 ± 1.0</td>
<td>0.1 ± 0.3</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>DMFS\textsuperscript{tot}</td>
<td>26</td>
<td>0.9 ± 1.9</td>
<td>0.3 ± 0.6</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>DMFS\textsuperscript{dentine}</td>
<td>26</td>
<td>0.6 ± 1.7</td>
<td>0.3 ± 0.6</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>DMFS\textsuperscript{approxtot}</td>
<td>26</td>
<td>0.1 ± 0.7</td>
<td>0.1 ± 0.2</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>DMFS\textsuperscript{approxint}</td>
<td>26</td>
<td>0.1 ± 0.7</td>
<td>0.0 ± 0.0</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

* approximal surfaces in canines, premolars, and molars

### Paper II

Statistically significant differences were displayed in the professional group that provided the parents with dental health information and advice, attitudes to reception at the dental clinic, and experience of sedation before operative dental treatment (p < 0.05). Parents of children with CHD who were patients at a specialist clinic for paediatric dentistry scored the reception at the dental clinic higher than those who were patients in general dental practice. This difference was statistically significant (p < 0.01). No statistically significant differences in educational level or parental experience of dental health were noted between the 2 groups (Table 7), (p > 0.05).
Table 7. Educational level and reported dental health in parents of the CHD children and controls.

<table>
<thead>
<tr>
<th></th>
<th>CHD %</th>
<th>Control %</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational level of the mother</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 9 years</td>
<td>12</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>• 12 years</td>
<td>52</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>• University/college</td>
<td>36</td>
<td>44</td>
<td>0.481</td>
</tr>
<tr>
<td>Educational level of the father</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 9 years</td>
<td>13</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>• 12 years</td>
<td>64</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>• University/college</td>
<td>23</td>
<td>40</td>
<td>0.223</td>
</tr>
<tr>
<td>Dental health of the mother</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No problems</td>
<td>61</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>• Some problems</td>
<td>30</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>• Large problems</td>
<td>9</td>
<td>12</td>
<td>0.872</td>
</tr>
<tr>
<td>Dental health of the father</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No problems</td>
<td>76</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>• Some problems</td>
<td>24</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>• Large problems</td>
<td>0</td>
<td>6</td>
<td>0.400</td>
</tr>
</tbody>
</table>

Paper III
One-fifth of the dentists stated that they had received special education or information, except the graduate training, to treat children with CHD. Almost half of the dentists had one or more patients with CHD, and a majority of these stated that their CHD patients had a caries problem. Only 34 % knew that some of the medicines used by CHD patients could increase the risk for caries. One-third of the dentists (33 %) reported that the level of dental care for children with CHD did not differ compared to healthy children at their clinic, and 42 % of the dentists reported that more caries prevention were given compared to healthy children. Seven % of the dentists reported that shorter recall intervals were given to children with CHD, while 16 % gave the answer that they did not know.
Statistically significant differences were displayed between the answers to the questions ‘who in the dental team perform the major part of dental care for children with CHD’ and ‘what is your opinion on who should perform the major part of the dental care for this group of children’ (p < 0.001). Among dentists whose clinical time mainly was used for dentistry for children, it was more common to treat children with CHD than for dentists with less time with dentistry for children (p < 0.001).

Paper IV
Seven of the children (29 %) on anti-congestive medication had secretion rates below 0.5 ml/min compared to no child in the control group (p < 0.01), (Fig 2). Four cases had the same secretion rate as a control with the same age. There were no statistically significant differences concerning mean salivary secretion rate, buffering capacity, calcium, chloride, magnesium, phosphate, potassium, sodium, or salivary IgA concentrations (p > 0.05). TVC differed statistically significantly between the 2 groups, \(1.4 \times 10^6 \pm 1.2 \times 10^7\) in the CHD group vs. \(2.7 \times 10^6 \pm 2.9 \times 10^7\) in the control group (p < 0.05). The MS levels were \(5.2 \times 10^4 \pm 1.5 \times 10^5\) in the cardiac group vs. \(8.1 \times 10^3 \pm 1.3 \times 10^4\) in the control group (p > 0.05), and the MS ratio of TVC constituted \(0.11 \pm 0.35\) % compared to \(0.01 \pm 0.02\) % for the control group (p > 0.05).
**Fig. 2.** Stimulated salivary secretion rate by age in children with heart disease on heart failure medication and healthy age- and gender-matched controls. Filled circles show cases, unfilled circles show controls.

**Paper V**

The endogenous pH values varied between 3.03 and 9.02 of the 13 medicines that were studied. Six of these (46 %) had an endogenous pH below the critical pH of 5.5. The lowest pH was recorded for the captopril 12.5 mg tablet water solution, while the propranolol hydrochloride mixture displayed the highest titratable acidity. The highest dissolved calcium and phosphate from the tooth specimens was displayed for the captopril (12.5 mg) tablet water solution 1.9 mM and 1.1 mM, respectively, and with the acetylsalicylic acid (75 mg) tablet water solution, 1.6 mM calcium and 0.7 mM phosphate were dissolved.
Discussion

Material and Methodological considerations

Study designs and study groups

For the studies in Paper I, II, and IV in this thesis, a case-control study design was chosen. Case-control studies can be used to study risk factors by comparisons of individuals who have a condition (the cases) with patients who do not have the condition but are otherwise similar (the controls) (80). Data for each case-control pair are assessed and are then aggregated. Case-control studies are relatively inexpensive and can be carried out by small teams or individual researchers in single facilities in a way that more structured experimental studies often cannot be. They have pointed to a number of important discoveries, but the hierarchical level of scientific evidence is considered to be relatively low because of the retrospective exposure, non-randomized nature, and often blinding not is possible. The shortcomings in the case-control design can be overcome by cohort study design were exposed and non-exposed are compared. Cohort studies are however often not possible for practical reasons when the disease is rare.

Study III examined the experience of dental care for children with CHD among Swedish general dentists using a descriptive cross-sectional design. Cross-sectional studies performed with convenience samples cannot be generalized to the entire population. However, they can identify risk indicators of those parameters that are significantly associated with the condition being investigated. One benefit of cross-sectional studies is that they are considered to be hypothesis-generating (80).

Using plaque pH measurements (81) in Paper V could have given information of the *in vivo* effects of medication. This experiment was considered, but due to the added burden, the participation would have implied for this medically comprised group, we decided to give up the idea. As the composition of teeth is variable, due to genetic influences, environmental conditions, and post-
eruptive maturation and dentin sclerosis, such differences may lead to large variations in their response under acidic challenges. The in vitro design that made it possible to pre-treat the tooth specimens, with immersion in a calcium phosphate medium, helped to increase the standardization of the specimens.

Clinical decision making should ideally be based on powered high-quality studies. Using a multicenter approach in Paper I could have made it possible to include more individuals. As the study group in Paper I included all children with complex CHD in the area who fulfilled the inclusion criteria, except 2 whose families did not give consent to their child to participate, a multicenter approach was not considered. It is possible however, that the caries experience in the permanent dentition also would have reached a statistically significant difference with increased numbers. In Paper II, among the 38 invited parents, there were only 2 who did not give consent. To match the controls, parents of 3 children with CHD were excluded. In Paper IV, a multicenter approach was used for increasing power and significance, as children who fulfilled inclusion criteria in the county of Västerbotten was limited. In Paper III, 75% of the invited dentists responded, and the non-responding rate is considered acceptable for a study based on a questionnaire (82).

Caries registration
Caries were assessed from recordings in dental records and bitewing radiographs in the Public Dental Service (PDS). Ideally, the same examiner would have examined all the children in both groups to remove the effects of variation in caries diagnosis between different examiners. As the children had many medical contacts already, it was considered unethical to add to their burden. The study was, therefore, performed on data that had already been collected at the dental clinics, despite the disadvantages of this procedure. Partly to reduce the effect of variation in caries diagnoses, all data on posterior approximal caries were collected by one of the authors from bitewing radiographs for both groups of
children. In order to increase the level of evidence, all reading of bitewing radiographs were performed blinded to the examiner, and initial caries were analysed separately.

**Saliva collection, cultivation of bacteria, and analysis of saliva**

Measurement and analysis of saliva is non-invasive, fast, and cost-effective diagnostic tool. The salivary secretion rate varies during the day and is affected by temperature, fluid balance, state of health, frame of mind, and medication. Hence, the collection of saliva should be standardized so that the results can be comparable with those from other clinical investigations (14, 20). To meet this, all saliva samples in study IV were collected before lunchtime and the participants were asked to refrain from eating, drinking, and tooth brushing 90 minutes before sampling.

Saliva may be collected as whole saliva or as selectively collected secretion from specific salivary glands. In the clinic, whole saliva secretion often is used to assess salivary flow rate, and buffer capacity. Whole saliva can be collected as unstimulated whole saliva (UWS) or stimulated whole saliva (SWS). The total volume of saliva collected is expressed as ml/min. An UWS rate less than 0.1 ml/min is considered a risk value (20). A SWS of 1–3 ml/min is considered normal and 0.7 ml/min and below is considered a risk value for caries (83). For schoolchildren, a cut-off of less than 0.5 ml/min is considered low with regard to caries risk (24).

**Questionnaires**

There are several methods available to collect qualitative data such as attitudes and experiences, for example, questionnaires and interviews. Both strategies for data collection have strengths and shortcomings. The questionnaire can be distributed in groups or geographic areas and the method is proportionately cost-effective. Standardized questions can be formulated, that is, all questions and
responding-alternatives are presented in the same way for every respondent. The strengths with interviews on the other hand are that the questions can be formulated in a more detailed way, there is a possibility to ask follow-up questions, and the non-responding rate is often lower in interviews compared to questionnaires.

When designing a questionnaire, great effort has to be made when formulating the questions. The questions should be unambiguous, not leading, and formulated in a language suited to the target group. The questionnaire should be followed by a prepaid envelope and a letter. Two reminders are considered normal (82, 84).

**Evaluation of results**

In Papers I, II and IV a null-hypothesis was tested and could be rejected for some of the primary outcome measures as caries experience, attitudes and experiences of dental care and saliva secretion.

Paper I shows that caries is a common oral health problem in Swedish children with complex CHD, especially at early ages, and it confirms findings from studies with different study designs, inclusion criteria, outcome measures and from countries with differing dental care system (44-53). The difference in caries prevalence between Swedish children with CHD and healthy controls was larger than that shown in a British study with a similar design as ours (48), which only showed more untreated caries in children with CHD. The high caries frequency is not acceptable and calls for strategies for disease control.

Due to the great progress in surgical techniques and intensive care for infants with CHD, the number of surviving children is increasing (1). Groups of medically compromised children such as immuno-compromised from disease and/or therapy and children with complex CHD have an increased risk of
developing systemic complications from dental infections, which may prove fatal (43). Poor dental health gives an increased risk of dental bacteraemia that may lead to infective endocarditis, and healthy teeth may decrease this risk. Dentists are advised to provide antibiotic prophylaxis against endocarditis in many of the children with complex CHD, before invasive dental procedures (1). Healthy teeth among CHD children may contribute to a decrease in the use of antibiotics for dental/oral infections. Healthy teeth also decrease the need of general anaesthesia and tooth extractions, which may be more complicated in complex CHD because of the increased medical risks with general anaesthesia and the risk of prolonged bleeding amongst children on anti-coagulants and anti-platelets. Siahi-Benlarbi et al (85) assumed that high levels of oral Candida, which are associated with caries (86-88), and its descending/resorption through the gastrointestinal tract may lead to serologic Candida accumulation or candidiasis. Therefore, a healthy oral cavity (especially before and after heart transplantation) is an important precondition to prevent Candida infections since these infections are opportunistic and when the immune system is depressed an acute infection may occur. Of major significance is also the fact that untreated caries can be a contraindication for heart surgery and as patients with more complex anomalies often require several surgical interventions, it is particularly important that scheduled surgery does not have to be postponed because of dental disease.

The dental care for children in Sweden is organized by the county councils and is free of charge. The parents can choose between dental care for their children organized within the PDS or by private clinics. Around 90 % of the dental care for children in Sweden is provided within the PDS. The dental care system offers all children a comprehensive dental care between the ages of 3 and 19 years. The care has a strong preventive approach from an early age, and all parents are offered dental health information when the child is between 1- and 2-years-old. A common clinical experience in children with CHD is that
their parents do not attend this early dental health information and, thus, they do not benefit from early oral health promotion to the same extent as most individuals. Paper I showed that children with complex CHD had received more caries prevention than the healthy controls, and there was a positive correlation between the caries prevalence and number of fluoride varnish treatments, but the care had been offered when caries already had become a problem.

Socio-economic factors of the family and the oral health of the caretaker are closely associated with the oral health and the oral health habits of the child (89). No differences in educational level of the parents or in their dental health could be detected between parents of the cases and their controls in Paper II. Based on this finding, there must be other reasons that explain the increased caries experience in children with complex CHD.

Saliva plays a key role in the biological interaction between many medical conditions and oral health related either directly, as in 22q11 and ectodermal dysplasia, with a reduced salivary secretion (90, 91) or due to effects of pharmacological treatment (92, 93). Medication-induced xerostomia has been considered as a caries-risk factor in CHD children (94). Paper IV showed that reduced salivary secretion could be a caries-risk factor in children on heart failure medication. It is therefore possible that some participants had a reduced salivary flow in Paper I and this may contribute to the explanation of the high caries experience in children with complex CHD. Use of antibiotics during early childhood has been associated with higher MS levels in children aged 5 to 12 years (95), and it is a clinical experience that antibiotics are used more frequently among children with heart disease than healthy children but higher MS levels has not been shown earlier (48, 96) or in Paper IV. Paper IV showed that MS constituted a non-significantly higher proportion of the TVC in the study group and this fit into the theory that a differentiation towards aciduric microorganisms in the oral ecology precedes dental caries (34).
A novel finding was the strong correlation between digoxin medication and caries experience in Paper I. Sucrose is added to the syrup to disguise unpleasant taste and thereby facilitate compliance. Sucrose-containing medicines are often given together with diuretics that can reduce salivary secretion (68), which add to the cariogenic challenge. Sugars in medicines cause a pH drop in the oral biofilm as a result of their fermentation in acid-producing bacteria (23, 43). Additionally, acids in medicines may help to prolong the pH drop after a sugar challenge. The clinical effects of the low pH, titratable acidity, and effect on dental hard tissues shown in Paper V can only be speculated on as data were obtained in vitro. It is, however, clear that some pharmaceutical preparations commonly used in paediatric cardiology in Sweden have a low endogenous pH and a potential to dissolve dental hard tissues. The erosive potential depends on the intimate interplay between chemical factors like endogenous pH and titratable acidity; biological factors such as the properties of the saliva; and behaviourally factors like oral hygiene, vomiting, and frequency of medication (97). If this finding is taken together with the fact that these medicines may be given together with Lanoxin® (digoxin), which contains sucrose and some of the patients suffer from medication-induced xerostomia, it is clear that medication may pose a hazardous threat to the oral health in children with complex CHD. These findings support the hypothesis that both caries and erosions are possible outcomes in connection with the regular use of pharmaceutical preparations (97). An assessment of the prevalence of erosions was not the within the aim of this thesis, however. In a study on the erosive potential of 97 medicines used regularly and long term by children, 57% had an endogenous pH below 5.5, and those used for the cardiovascular system had the lowest mean endogenous pH, and it was 4.05 (98). Further, Neves et al (75) concluded that several paediatric medicines showed high sugar concentration, pH values below the critical value, and high titratable acidity values, all of which increase the medicines’ cariogenic and erosive potentials.
Ersin et al (99) studied oral and dental manifestations of young asthmatics in relation to medication, severity, and duration of the condition. The results of their study supported the hypothesis that factors related to asthmatic condition and/or medication might increase the risk of caries due to the lower salivary flow rate and pH in asthmatics. In addition, the duration of medication and the duration of illness were shown to be risk factors for caries development in asthmatic children. The authors concluded that asthmatic patients especially in the younger age groups should receive intensive preventive care, including oral hygiene instruction, dietary advice, and regular topical fluoride treatments. Stensson et al (56) investigated preschool children with asthma and found a higher caries frequency among asthmatic children. They pointed to the importance of developing preventive dental programs for preschool children with asthma and of developing collaboration between dental and medical caregivers in relation to children with asthma. This is also applicable for children with complex CHD.

Being born with a heart anomaly may, depending on the severity of the CHD, cause a dramatic start in life for the affected child and the family. Surgery may be performed directly after birth or within the first year of life and be followed by several complementary surgeries. Multiple medications and long periods of hospitalisation with frequent contacts with medical staff become the part of everyday life to families with children affected with complex CHD. Feeding problems are often seen during the first years of life. Vomiting is common and to compensate for this, feeds are frequent and night meals are often necessary to maintain energy intake at an acceptable level. Infections often last for longer periods than in healthy children, with an increased need for drinking, sometimes at night, when salivary protection is low (4). Brain injury is the most significant complication of surgery for CHD (100). Neurodevelopmental outcome, however, is influenced mostly by genetic co-morbidity and preoperative neurological status (101). A systematic review of psychological adjustment and
quality of life after open-heart surgery for congenital heart disease concluded that children with more severe heart defects, or those in need of future surgical interventions and children with neurodevelopmental impairment are at particular risk for maladjustment (102). It is clear that children with complex CHD, particularly at early ages, should be considered as a group with special needs in dentistry (103-105).

Paper III showed that parents of children with complex CHD did not have the same satisfaction with the reception they received in dental care than the healthy controls. Children with CHD had received sedation before operative dental treatment significantly more often than healthy children, reflecting a higher need of operative dental treatment. The CHD group had also received more caries prevention (Paper I). Lowry et al (106) compared dental attitudes knowledge and health practice between a CHD group and a matched control group and found that 18% of the children with CHD had not received dental care. In a study on the provision of dental care for medically compromised children, it was shown that dental practitioners had treated patients with CHD in 0 to 5 sessions in the past 5 years with an average of 2 patients for each practitioner (107). Only 37% felt confident in providing dental treatment for children with cardiac disease, while 80% of the respondents stated they would benefit from further regular training. Jowet and Cabot (108) noted that many dentists were not confident in treating children with CHD, which is in coherence with data in Paper III that indicated that Swedish dentists are unsettled and insecure in the dental treatment of children with heart disease. As the PDS does not differ significantly from county to county, the results of the study are considered applicable to Sweden in general. The findings should, however, be generalized to the whole group of children with CHD as it was considered difficult for the dentists to classify their CHD patients due to limited information on medical background facts. This lack of experience regarding these children’s medical conditions and pharmacological regimes is a cause of concern and
suggests a need for specialist dental care for these children. These data also support the need for further education about dental treatment for groups of medically compromised children (109).

The transition into adulthood has been a significant clinical concern as the survival rate for adolescents with CHD increases. There is a continued need to support and counsel adolescents to maintain their health-promoting behaviour. Health promotion counselling for adolescents with CHD should encourage improving lifestyle habits, including adequate physical exercise and good oral hygiene (110).

**Clinical perspectives**

Except for the replacement of sucrose in Lanoxin® with a non-cariogenic sweetener, factors that can be changed in a more health-promoting direction in children with complex CHD are oral hygiene habits, fluoride exposure, and sugar consumption.

In the clinical management of children with complex CHD, high-caries-risk children should be identified as early as possible, which is possible if a close cooperation between the paediatric cardiologist and paediatric dentist is established. Early preventive care should be adjusted to the special needs of children with CHD and an individual preventive program should be implemented during the first year of life (49). This regime is supported by Gussy et al who in their review on caries in early childhood found evidence that potentially effective interventions should occur in the first 2 years of life of the child at risk (27). An interdisciplinary approach integrating the professional knowledge and skills may help to improve the results for the individual patient (43, 107, 111, 112).

The paediatrician should facilitate referral to dental services and emphasize the importance of good oral health. For high-caries-risk groups, it is recommended that regular dental care is offered within clinics for specialized
paediatric dentistry (103, 104). Together with parents, a plan for dental care should be established, and the responsibilities for dental care and for families should be made clear. Individual need of antibiotics for prophylaxis for infective endocarditis at invasive dental treatments should also be determined (1). Short recall intervals should be offered until the caries-risk factors are eliminated. Children on medication with sugar-containing syrups should be given extra attention, and salivary secretion should be assessed in children on heart failure medication. Tooth brushing using fluoridated toothpaste should be encouraged. Based on individual needs, additional fluoride may be indicated and is suggested to be administered based on caries risk and compliance (24). Parents should be advised to avoid added sugar at meals. Today, there is poor knowledge of the early feeding practice in children with CHD. We will obtain knowledge from a running prospective study of dietary habits and colonisation of the oral microflora from an early age in children with complex CHD.

A continuous issue for improving the oral health is the accomplishment of education and training for both dental and medical health care providers about oral health problems and their prevention in this new group of patients (109, 113).
Conclusions

- Children with complex CHD had a higher caries experience than healthy age- and gender-matched controls.
- Children with complex CHD on digoxin medication had a higher caries experience than other children with complex CHD.
- Children with complex CHD had received more caries prevention than healthy controls.
- Parents of children with complex CHD were less satisfied with the reception and care they received in the dental service compared with the parents of healthy children.
- Swedish dentists had a different opinion regarding the provision of dental treatment to children with CHD compared to the current situation.
- Children on heart failure medication can have a low saliva secretion.
- Some pharmaceutical preparations used on long-term basis in paediatric cardiology may pose a hazardous threat to dental hard tissues due to their acidity.
Populärvetenskaplig sammanfattning

Medfödda hjärtfel (CHD) är en av de vanligaste utvecklingsanomalierna hos barn och förekommer hos ca 8-10 per 1000 levande födda barn. Med anledning av stora framsteg inom barnkardiologin de senaste decennierna så överlever idag allt fler barn som föds med komplexa CHD. Detta har inneburit att barn med CHD blivit en ny och växande patientgrupp även inom tandvården. Den övergripande målsättningen med denna avhandling var att kartlägga kariesförekomsten och potentiella bakgrundsfaktorer hos barn med komplexa CHD.


I delarbete II studerade föräldrars attityder till och erfarenheter av omhändertagande av barn med CHD i tandvården. Trettiotre föräldrar till barn med komplexa CHD jämfördes mot en matchad grupp av föräldrar till friska barn. Föräldrar till friska barn var mer nöjda med omhändertagandet och bemötandet inom tandvården än föräldrar till barn med CHD. Studien rekommenderar att barn med komplexa CHD erhåller sin tandvård hos specialistkliniker för barntandvård särskilt de första levnadsåren.

I delarbete III studerade attityder till och erfarenheter av tandvård för barn med CHD bland 183 allmäntandläkare. En minoritet av de tillfrågade tandläkarna hade erhållit någon kompletterande utbildning av tandvård för barn med CHD. Cirka 50 % av tandläkarna hade en eller flera patienter med CHD och majoriteten av dessa hade noterat en ökad kariesförekomst hos dessa barn. Studien visade att tandvård för barn med CHD utförs till största del av tandköterskor, tandhygienister och allmäntandläkare vilket avvek från tandläkarnas önskemål om hur tandvården skall organiseras för barn med CHD.

Många barn med komplexa CHD måste medicinera över lång tid och vissa mediciner kan minska salivflödet och därigenom bidra till att karies utvecklas. Salivens egenskaper studerades hos 24 barn som hade hjärtsviktsmedicinering i delarbete IV och jämfördes mot saliv från en frisk kontrollgrupp. Salivens sekretionshastighet, buffringskapacitet, bakteriehalter samt elektrolytnivåer undersöktes. Tjugonio % av barnen med hjärtsviktsmedicinering hade låg salivsekretion jämfört med inget barn i kontrollgruppen. En slutsats är att barn med hjärtsviktsmedicinering kan ha låg salivsekretion och det kan vara en riskfaktor för att utveckla karies.

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References

APPENDIX I. Questionnaires Paper II

**CHD**

**Dental health information and advice**

<table>
<thead>
<tr>
<th>Description</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the dental health information and advice. The information has been</td>
<td>□ Very good</td>
</tr>
<tr>
<td></td>
<td>□ Good</td>
</tr>
<tr>
<td></td>
<td>□ Neither good nor poor</td>
</tr>
<tr>
<td></td>
<td>□ Poor</td>
</tr>
<tr>
<td></td>
<td>□ Very poor</td>
</tr>
<tr>
<td>The quantity of information has been</td>
<td>□ Sufficient</td>
</tr>
<tr>
<td></td>
<td>□ Neither sufficient nor</td>
</tr>
<tr>
<td></td>
<td>insufficient</td>
</tr>
<tr>
<td></td>
<td>□ Insufficient</td>
</tr>
<tr>
<td>Does your child have siblings?</td>
<td>□ Yes</td>
</tr>
<tr>
<td></td>
<td>□ No</td>
</tr>
<tr>
<td>Did you notice differences in dental health information compared to your</td>
<td>□ Yes, more extensive</td>
</tr>
<tr>
<td>child’s healthy siblings?</td>
<td>□ Yes, more adjusted to</td>
</tr>
<tr>
<td></td>
<td>existing needs</td>
</tr>
<tr>
<td></td>
<td>□ No</td>
</tr>
<tr>
<td></td>
<td>□ Don’t know</td>
</tr>
<tr>
<td>When did you receive information and advice on oral health? When the child</td>
<td>□ &lt; 6 months</td>
</tr>
<tr>
<td>was</td>
<td>□ 6 months – 1 year</td>
</tr>
<tr>
<td></td>
<td>□ 1-3 years</td>
</tr>
<tr>
<td></td>
<td>□ &gt; 3 years</td>
</tr>
<tr>
<td>From where did you receive the information and advice?</td>
<td>□ Physician</td>
</tr>
<tr>
<td></td>
<td>□ Dentist</td>
</tr>
<tr>
<td></td>
<td>□ Dental hygienist</td>
</tr>
<tr>
<td></td>
<td>□ Found information on my</td>
</tr>
<tr>
<td></td>
<td>own</td>
</tr>
<tr>
<td></td>
<td>□ Other source</td>
</tr>
<tr>
<td>Is it possible to follow the current advice?</td>
<td>□ Yes, completely</td>
</tr>
<tr>
<td></td>
<td>□ Yes, partly</td>
</tr>
<tr>
<td></td>
<td>□ No, I am doubtful</td>
</tr>
<tr>
<td></td>
<td>□ No, not at all</td>
</tr>
<tr>
<td>Have you been informed that your child needs antibiotic prophylaxis before</td>
<td>□ Yes</td>
</tr>
<tr>
<td>invasive dental treatment?</td>
<td>□ No</td>
</tr>
<tr>
<td>From where did you first receive information about antibiotic prophylaxis?</td>
<td>□ Physician</td>
</tr>
<tr>
<td></td>
<td>□ Dentist</td>
</tr>
<tr>
<td></td>
<td>□ Dental hygienist</td>
</tr>
<tr>
<td></td>
<td>□ Found information on my</td>
</tr>
<tr>
<td></td>
<td>own</td>
</tr>
<tr>
<td></td>
<td>□ Other source</td>
</tr>
<tr>
<td>Does the current dental health information need to be changed?</td>
<td>□ Yes, a lot</td>
</tr>
<tr>
<td></td>
<td>□ Yes, some</td>
</tr>
<tr>
<td></td>
<td>□ No, not in need of change</td>
</tr>
<tr>
<td></td>
<td>□ No opinion</td>
</tr>
</tbody>
</table>
## Dental care and service

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the reception at the dental clinic</td>
<td>□ Excellent □ Satisfactory □ Decent □ Poor □ Very poor □ Yes, definitely □ Yes, partially □ Probably not □ No, not at all</td>
</tr>
<tr>
<td>Are enough time provided during appointments at the dental clinic?</td>
<td>□ Yes, definitely □ Yes, partially □ Probably not □ No, not at all</td>
</tr>
<tr>
<td>Have sedatives or general anesthesia been used for your child?</td>
<td>□ Never □ 1-2 occasions □ 3-4 occasions □ &gt;4 occasions</td>
</tr>
<tr>
<td>What was your experience of sedatives or general anesthesia</td>
<td>□ Excellent □ Satisfactory □ Decent □ Poor □ Very poor</td>
</tr>
<tr>
<td>Was local anesthesia used when teeth were filled?</td>
<td>□ Always □ Often □ Sometimes □ Never □ Don’t know</td>
</tr>
<tr>
<td>What was your experience with respect to the competence of the dental staff</td>
<td>□ Very good □ Good □ Varying □ Bad □ Very bad</td>
</tr>
<tr>
<td>Do you believe the control intervals were adjusted to meet the needs of your child?</td>
<td>□ Gaps were to long □ Sufficient □ Too close □ Don’t know</td>
</tr>
</tbody>
</table>

## Children and parents

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would you describe your child’s dental health?</td>
<td>□ No problems □ Some problems □ Large problems</td>
</tr>
<tr>
<td>How do you experience your child’s expectations before a visit to the dental clinic?</td>
<td>□ Positive □ Neither positive nor negative □ Negative □ Don’t know</td>
</tr>
<tr>
<td>Does you or the other parent experience discomfort before your own visits at the dental clinic?</td>
<td>□ Always □ Sometimes □ Never □ Don’t know</td>
</tr>
<tr>
<td></td>
<td>□ No problems</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Dental health of mother</td>
<td></td>
</tr>
<tr>
<td>Educational level of mother</td>
<td>□ Nine years</td>
</tr>
<tr>
<td>Dental health of father</td>
<td></td>
</tr>
<tr>
<td>Educational level of father</td>
<td>□ Nine years</td>
</tr>
<tr>
<td>Your comments</td>
<td></td>
</tr>
</tbody>
</table>
### Controls

#### Dental health information and advice

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the information you received regarding oral health care. The information has been</td>
<td>□ Very good  &lt;br&gt; □ Good  &lt;br&gt; □ Neither good nor poor  &lt;br&gt; □ Poor  &lt;br&gt; □ Very poor</td>
</tr>
<tr>
<td>The quantity of information has been</td>
<td>□ Sufficient  &lt;br&gt; □ Neither sufficient nor insufficient  &lt;br&gt; □ Insufficient</td>
</tr>
<tr>
<td>When did you first receive information and advice on oral health? When the child was</td>
<td>□ &lt; 6 months  &lt;br&gt; □ 6 months – 1 year  &lt;br&gt; □ 1-3 years  &lt;br&gt; □ &gt; 3 years</td>
</tr>
<tr>
<td>From where did you receive the information and advice?</td>
<td>□ Physician  &lt;br&gt; □ Dentist  &lt;br&gt; □ Dental hygienist  &lt;br&gt; □ Found information on my own  &lt;br&gt; □ Other source</td>
</tr>
<tr>
<td>Is it possible to follow the current advice?</td>
<td>□ Yes, completely  &lt;br&gt; □ Yes, partly  &lt;br&gt; □ No, I am doubtful  &lt;br&gt; □ No, not at all</td>
</tr>
<tr>
<td>Does the current dental health information need to be changed?</td>
<td>□ Yes, a lot  &lt;br&gt; □ Yes, some  &lt;br&gt; □ No, not in need of change  &lt;br&gt; □ No opinion</td>
</tr>
</tbody>
</table>

#### Dental care and service

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the reception at the dental clinic</td>
<td>□ Excellent  &lt;br&gt; □ Satisfactory  &lt;br&gt; □ Decent  &lt;br&gt; □ Poor  &lt;br&gt; □ Very poor</td>
</tr>
<tr>
<td>Are enough time provided during the appointments at the dental clinic?</td>
<td>□ Yes, definitely  &lt;br&gt; □ Yes, partially  &lt;br&gt; □ Probably not  &lt;br&gt; □ No, not at all</td>
</tr>
<tr>
<td>Have sedatives or general anesthesia been used for your child?</td>
<td>□ Never  &lt;br&gt; □ 1-2 occasions  &lt;br&gt; □ 3-4 occasions  &lt;br&gt; □ &gt;4 occasions</td>
</tr>
<tr>
<td>What was your experience of sedatives or general anesthesia</td>
<td>□ Excellent  &lt;br&gt; □ Satisfactory  &lt;br&gt; □ Decent  &lt;br&gt; □ Poor  &lt;br&gt; □ Very poor</td>
</tr>
</tbody>
</table>
Was local anesthesia used when teeth were filled? □ Always  
□ Often  
□ Sometimes  
□ Never  
□ Don’t know  

What is your experience with respect to the competence of the dental staff? □ Very good  
□ Good  
□ Varying  
□ Bad  
□ Very bad  

Do you believe the control intervals were adjusted to meet the needs of your child? □ Gaps were to long  
□ Sufficient  
□ Too close  
□ Don’t know  

**Children and parents**  

| How would you describe your child’s dental health? | □ No problems  
□ Some problems  
□ Large problems  

| How do you experience your child’s expectations before a visit to the dental clinic? | □ Positive  
□ Neither positive nor negative  
□ Negative  
□ Don’t know  

| Does you or the other parent experience discomfort before your own visits at the dental clinic? | □ Always  
□ Sometimes  
□ Never  
□ Don’t know  

| Dental health of mother | □ No problems  
□ Some problems  
□ Large problems  

| Educational level of mother | □ Nine years  
□ 12 years  
□ University/college  

| Dental health of father | □ No problems  
□ Some problems  
□ Large problems  

| Educational level of father | □ Nine years  
□ 12 years  
□ University/college  

Your comments
APPENDIX II. Questionnaire Paper III

1. How much of your clinical time do you practice dentistry for children?

☐ 0 %
☐ 0-24 %
☐ 25-49 %
☐ 50-74 %
☐ 75-100 %

2. Have you received any education/information regarding dental care of children with heart disease except that during the graduate training?

☐ Yes
☐ No
☐ I don’t know

3. Has any of your child patients a heart disease?

☐ Yes, one or several
☐ No, no one
☐ I don’t know
☐ I don’t treat children

If response alternative 2-4 in question 3, please go to question 12

4. Do you know the child’s/children’s heart diagnosis?

☐ Yes
☐ No

5. Do you know if the any of the child/children has any heart medication?

☐ Yes
☐ No

6. Has your child patient/s with heart disease display a caries experience?

☐ Yes
☐ No
☐ I don’t know

7. Do you know the name/s of the child’s/children’s physician/s?

☐ Yes
☐ No
☐ I don’t know

8. Have you been in contact with the child’s/children’s physician/s?

☐ Yes
☐ No

If no please go to question 11

9. If yes in question 8, what was your opinion of the cooperation?

☐ Positive
☐ Negative
☐ Neither positive nor negative
☐ No special difficulties
☐ Odontological difficulties
☐ Medical difficulties
☐ Insecurity regarding the child’s medical condition
☐ The same as for healthy children
☐ More caries prevention
☐ Longer visits
☐ Shorter recall intervals
☐ No opinion

10. What is your experience on providing dental treatment for children with heart disease? More than one alternative may be chosen.

☐ No special difficulties
☐ Odontological difficulties
☐ Medical difficulties
☐ Insecurity regarding the child’s medical condition
☐ The same as for healthy children
☐ More caries prevention
☐ Longer visits
☐ Shorter recall intervals
☐ No opinion

11. How is the dental treatment and care of children with heart disease arranged in your clinic?

☐ The same as for healthy children
☐ More caries prevention
☐ Longer visits
☐ Shorter recall intervals
☐ No opinion

12. Do you know if any of the pharmaceutical preparations taken by children with heart disease can increase the caries risk?

☐ Yes
☐ No
☐ No opinion
13. Have you received clear cut information regarding which heart diagnoses that should be provided with antibiotic prophylaxis before invasive dental treatment?

☐ Yes
☐ No
☐ No opinion

14. Who in the dental team perform the major part of dental care for children with heart disease?

☐ Dental nurse
☐ Dental hygienist
☐ General dentists
☐ Dentists with special training
☐ Specialists in paediatric dentistry

15. What is your opinion on who in the dental team that should perform the major part of the dental care for this group of children?

☐ Dental nurse
☐ Dental hygienist
☐ General dentists
☐ Dentists with special training
☐ Specialists in paediatric dentistry

16. Your gender?

☐ Male
☐ Female

17. Year of your dental graduation?

18. University?

Your comments