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DENTAL HEALTH IN PRESCHOOL AND SCHOOLCHILDREN IN RELATION TO DENTAL FEAR AND FEAR-RELATED FACTORS, AND THE OUTCOME OF A CARIES PREVENTION PROGRAM IN OFFSPRING OF FEARFUL MOTHERS

by

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ABSTRACT

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Dental Health in Preschool and Schoolchildren in Relation to Dental Fear and Some Fear-Related Factors, and the Outcome of a Caries Prevention Program in Offspring of Fearful Mothers

Community Dentistry, Institute of Dentistry, University of Turku and the Department of Stomatology, University of Tartu. Annales Universitatis Turkuensis, Turku, Finland, 2013

Dental caries and dental fear and anxiety (DFA) are common interrelated problems but so far little is known about these problems in Estonia.

The aim was to study dental health in relation to DFA, some fear-related factors, and to study the effect of a caries prevention program in children of fearful mothers.

Dental health and DFA were assessed in two Estonian [2-4-year-olds (n=472) and 8-10-year-olds (n=344)], and the effect of some medical conditions on DFA in one Finnish child group [3-year-olds (n=148)]. 120 mother-child-pairs participated in the xylitol-based prevention program. Dental health was examined using the WHO or the ICDAS criteria and expressed as dmft/DMFT-indices. The modified children's fear survey schedule dental subscale (MCFSS-DS) was used to assess DFA of schoolchildren, one single question to assess parental DFA, and the Corah's dental anxiety scale (DAS) to assess DFA of mothers in the prevention study.

Dentine caries was diagnosed in 42% of the 2-4-year-old and in 93% of the 8-10-year-old Estonian children. DFA of 8-10-year-olds (17%) was associated with experience of dental treatment, and maternal and paternal DFA. Dental apprehension at 9 years of age was associated with frequent exposure to invasive medical care. The xylitol-based prevention was successful irrespective of poor dental hygiene habits and maternal severe DFA.

In conclusion, experience of operative dental treatment and DFA of Estonian children were closely associated. Invasive medical care and parental DFA were also linked to children's DFA. Habitual use of xylitol by mothers was effective in preventing caries even in children of severely fearful mothers.

Key words: children, mothers, dental fear and anxiety, dental health, prevention

TIIVISTELMÄ

Jana Olak

Esikouluikäisten ja kouluikäisten lasten hammasterveyden yhteys hammashoitopelkoon ja joihinkin pelkoon liittyviin tekijöihin, sekä kariesprevention onnistuminen lapsilla, joiden äidit kärsivät hammashoitopelosta

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Hammaskaries ja hammashoitopelko ovat yleisiä, toisiinsa liittyviä ongelmia, mutta toistaiseksi on hyvin vähän tietoa kummastakaan ongelmasta virolaisilla lapsilla. Tavoitteena oli selvittää hammaskarieksen ja hammashoitopelon ja joidenkin hammashoitopelkoon liittyvien tekijöiden yleisyys ja keskinäinen yhteys esikoululaisilla ja kouluikäisillä lapsilla. Lisäksi haluttiin tutkia mahdollisuuksia ehkäistä hammaskarieksen kehittyminen hammashoitopelkoisten äitien lapsilla. Hammaskarieksen esiintyvyyttä, korjaavan hammashoidon määrää ja hammashoitopelon yleisyyttä tutkittiin kahdessa virolaisessa [2-4-vuoden ikäisiä (n=472) ja 8-10-vuoden ikäisiä (n=344)] ja invasiivista hoitoa vaatineiden sairauksien vaikutusta hammashoitopelkoon yhdessä suomalaisessa lapsiryhmässä [3-vuoden ikäisiä (n=148)]. Ksylitoliperusteiseen kariespreventiotutkimukseen osallistui 120 virolaista äiti-lapsiparia. Hammasterveys tutkittiin kliinisesti ja tulokset ilmaistiin joko WHO:n tai ICDAS menetelmän mukaan dmft/DMFT-indekseinä. Koululaisten hammashoitopelon mittaamiseen käytettiin lapsille räätälöityä pelkokyselyä (MCFSS-DS), koululaisten vanhemmille yhtä pelkokysymystä ja preventiotutkimuksen äideille Corahin kehittämää pelkokyselyä (DAS). Dentiinikariesta todettiin 42% 2-4-vuotiaista ja 93% 8-10-vuotiaista virolaislapsista. Kohtalainen tai voimakas hammashoitopelko liittyi 8-10-vuotiailla (17%) lapsilla aikaisempiin hammashoitokokemuksiin, äidin ja isän hammashoitopelkoon sekä varhaislapsuudessa koettuihin invasiivisiin, lääkärikäynteihin. Vaikka hammashoitopelkoisten virolaisäitien hammashoitotottumukset olivat puutteelliset äitien käyttämä ksylitoli vähensi merkittävästi lasten kariesta äidin hammashoitopelosta riippumatta.

Yhteenvetona voitiin todeta, että lasten korjaavan hammashoidon ja hammashoitopelon välillä oli selkeä yhteys. Lasten hammashoitopelko liittyi myös varhaislapsuuden invasiivisiin hoitokokemuksiin ja vanhempien hammashoitopelkoon, mutta lasten hammaskarieksen kehittyminen voitiin estää äitien ksylitolin käytöllä silloinkin kun äidit kärsivät vakava-asteisesta hammashoitopelosta.

Avainsanat: lapset, äidit, hammashoitopelko, hammasterveys, karieksen ehkäisy

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ABBREVIATIONS

CFU	Colony forming units
DAS	Corah's dental anxiety scale
DFA	Dental fear and anxiety; dental apprehension
dmft	Decayed, missing and filled teeth in primary dentition
DMFT	Decayed, missing and filled teeth in permanent dentition
ECC	Early childhood caries
ICDAS	International caries detection and assessment system index
MCFSS-DS	Modified children's fear survey schedule - dental subscale
MS	Mutans streptococci
OH	Oral health
OHH	Oral health habits
STRIP	Special Turku coronary risk factor intervention project
WHO	World Health Organization
X-	Control group, mothers who did not use xylitol lozenges
X +	Intervention group, mothers who used xylitol lozenges

LIST OF ORIGINAL PUBLICATIONS

The thesis is based on the following original publications, which are cited in the text by the Roman numerals I-IV. The original publications are reproduced with the permission of the copyright holders.

I Olak J, Mandar R, Karjalainen S, Söderling E, Saag M. Dental health and oral mutans streptococci in 2-4-year-old Estonian children. Int J Paediatr Dent 2007, 17: 92-97.

II Olak J, Saag M, Honkala S, Nommela R, Runnel R, Honkala E, Karjalainen S. Children's dental fear in relation to dental health and parental fear. Stomatologija (The Baltic Dental and Maxillofacial Journal) 2013, 15: 26-31.

III Karjalainen S, Olak J, Söderling E, Pienihäkkinen K, Simell O. Frequent exposure to invasive medical care in early childhood and operative dental treatment is associated with apprehension and negative perception of dental treatment in 9-year-old children. Eur J Paed Dent 2003, 4: 186-190.

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1. INTRODUCTION

Dental fear is a specific type of fear, an individual emotional reaction to threatening stimuli, and is common among children and adults. Despite innovations in dental equipment and treatment procedures, part of the population experiences dental fear that can be problematic and may have adverse impact on dental treatment outcome.

Anxiety is a response to a situation in which the source of the threat is not well defined, is ambiguous or not immediately present, and is also known as anticipatory anxiety. Dental anxiety in adults is associated with poor health, poor oral health habits, irregular dental attendance, increased incidence of caries and dental fear in their offspring. Poor parental oral health habits may militate against good oral health in children. If children continue to neglect to care for their teeth at home they are likely to suffer negative effects on their dental health.

Dental fear/anxiety of mothers may influence the behaviour of their children and earlier studies show a clear relationship between dental fear/anxiety of children and parents (Arnrup et al 2002, Okada et al 2002). Non-dental factors such as personality traits, low social status, and low education level of parents have also been connected to dental fear/anxiety in children.

The most important factor regarding risks of behavioural problems at dental visits are negative experiences of dental treatment, but for children, negative experiences of medical treatment may also be involved. Child and adolescent dental fear or dental anxiety has been related to increased caries experience. Until now, no studies have been available on dental fear and anxiety of Estonian children or adults.

In addition to dental fear and anxiety, other important factors may determine dental health in young children. Highly acidogenic mutans streptococci (MS) are the primary pathogens in the aetiology of caries of children and young adults. Early colonization of MS on teeth is known to be significant for rapid caries development (Thibodeau and O'Sullivan 1996, Berkowitz 2003). Frequent salivary contact with the mother is known to be the main source of MS in children and programs reducing MS transmission from mother to child have been tested to prevent caries occurrence in children. Among the tested means, xylitol has been found to decrease the mother-child transmission of MS and consequently the child's caries experience in Belize, Estonia, Finland, and Sweden (Mäkinen et al. 1995, Alanen et al. 2000, Isokangas et al. 2000 and Holgerson et al. 2007, respectively). Given the occurrence of dental caries among children aged 2–4 years in Estonia is high; a program targeted for mothers could be useful in preventing caries among small children.

In conclusion, the problem of childhood caries is probably more complex than believed: apart from the primary MS infection, use of fluorides, toothbrushing, eating and drinking habits, parental health habits, social class and education, dental fear and anxiety of parents and/or the child may further affect the child's dental health.

2. REVIEW OF LITERATURE

2.1 Dental caries with special reference to early childhood caries

Dental caries has several etiological factors. As early as the nineteenth century, Miller described the activity of micro-organisms in the caries process. The disease is seldom self-limiting and in the absence of treatment, caries progresses until the tooth has been destroyed. The localized destruction of the hard tissues, often referred to as a lesion, is a sign or symptom of the disease (Fejerskov and Kidd 2008). Loesche (1986) defined dental caries as a common chronic transmissible disease, resulting from tooth adherent specific bacteria, primarily MS that metabolize sugars to produce acid that, over time, demineralises tooth structure. Dental caries has been described as microorganism-bound infectious disease, which is considered an ecological destruction process on a tooth surface with visible results (Marsh and Nyvad 2008).

The presence of dental biofilm is regarded as a prerequisite for the carious process. The supragingival dental biofilm constitutes an ecosystem of bacteria that exhibits a variety of physiological characteristics. In particular, the acid production resulting from carbohydrate metabolism by these bacteria and the subsequent decrease in environmental pH are responsible for the demineralization of tooth surfaces (Marsh and Nyvad 2008). The pH fluctuates continuously and if minerals during the acidic periods are cumulatively lost (mineral loss), the surface of enamel becomes porous, and the effect can be observed as a white spot carious lesion. The carious process usually progresses rather slowly because of the alternating de- and re-mineralization episodes in the biofilm. However, if the local environment changes – for example in response to frequent sugar intake combined with inadequate oral hygiene – the equilibrium between the de- and re-mineralization episodes may destabilize. Then an acidic environment is established and promotes lesion development.

This may lead to rampant caries, of which early childhood caries (ECC) is a classic example (Milgrom et al. 2000, Ge et al. 2008). ECC is a form of severe dental decay that affects primary teeth of infants and toddlers. ECC is influenced by various etiologic factors like cariogenic micro-organisms, fermentable carbohydrates, susceptible tooth and host (Seow 1998, Bowen 1998). Plaque amount and adherence play an important role in the colonization of cariogenic microbes. Frequent sugar consumption, particularly in between meals, has been reported to be associated with caries development in preschool children (Stecksen-Blicks and Holm 1995, Karjalainen et al. 2001, Vadiakas 2008).

The location of decay, and the number of teeth affected by ECC, varies between studies (Ramos-Gomez 1996). According to Ismail (1998), ECC should be defined as an

occurrence of any sign of dental caries on any tooth surface during the first years of life, and be considered a serious health problem. In 2008, the European Academy of Paediatric Dentistry (EAPD) approved the definition of Ismail.

The American Academy of Paediatric Dentistry (AAPD, 2011) has defined ECC as the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child under the age of six years.

ECC usually begins with the maxillary primary incisors initially developing a dull, chalky white demineralised band along the gingival margin. In advanced situations, the crowns of all upper incisors may be destroyed, leaving only root stumps. Other primary tooth surfaces may decay, depending on the duration of the harmful and frequent feeding habit.

2.1.1 Microbial ecology of dental caries and transmission of mutans streptococci

The role of mutans streptococci (MS) is indisputable in the initiation of coronal and root surface caries. A systematic review has confirmed that the presence of MS, both in plaque and saliva of young children, is associated with considerable increase in ECC risk (Alaluusua and Renkonen 1983, Thenish et al. 2006, Parisotto et al. 2010).

Children whose teeth are not colonized with MS by two years of age remain caries-free longer than children whose teeth are colonized by the age of two years (Alaluusua and Renkonen 1983, Köhler et al. 1988), and children whose teeth are not colonized by the age of three display significantly better health of permanent dentition compared to their counterparts (Köhler and Andréen 2010, Alaluusua et al. 1987, Pienihäkkinen et al. 2005, Skeie et al. 2006). The caries-free time for MS-colonized children is 4.6 years in comparison with 8.0 years for children who had not been colonized with MS by the age of two (Laitala et al. 2012). The mother is the primary source of MS infection for her child, saliva being the principle vehicle of transfer (Li and Caufield 1995, Law et al. 2007). Factors related to infant feeding practices such as frequent exposure to sugar, frequent snacking, having sweetened drinks in bed, sharing foods with adults, as well as poor maternal dental health, oral hygiene and dietary habits predispose to early MS colonization and establishment of high MS counts.

2.2 Dental fear and anxiety

2.2.1 Definitions, aetiology and prevalence

Fear is an emotional response to internal danger or an external realistic danger. Dental fear is a reaction to threatening stimuli in the dental situation. Anxiety is a response to a situation in which the source of the threat is not well defined, is ambiguous or not immediately present.

Dental anxiety is an anticipatory emotion which is associated with internal danger. It denotes that something dreadful is going to happen in relation to dental treatment (Milgrom et al. 1995, Klingberg and Broberg 2007). Dental anxiety is a multidimensional entity consisting somatic (tachycardia, hyperventilation muscle tension, and gastrointestinal discomfort), cognitive (a feeling that something terrible is going to happen), and emotional elements (shaking, pacing, and attempt to escape) (Kendall 2006). Phobia is an intense form of fear related to a specific object that usually provokes avoidance (Stein and Hollander 2002). Dental phobia is a severe type of dental fear and is characterized by marked and persistent anxiety in relation either to clearly discernible situations/objects (e.g. drilling, injections) or to dental situation in general (Klingberg and Broberg 2007, Freeman 2007).

Traumatic experiences in association with medical and/or dental treatment are known to be important factors for the development of extreme dental fear and anxiety (Moore et al. 1991, Raadal et al. 2002), and even a single negative experience may lead to later avoidance of dental procedures (Skaret et al. 1999). Dental fear and anxiety is a problem for dentists, parents and patients alike. About one third of the population in New Zealand experience dental fear and anxiety during childhood or early adolescence, one third during late adolescence and one third during early adulthood (Locker et al. 2001a). Direct and indirect experience and personality traits may lead to the acquisition of dental anxiety in childhood and adolescence (Poulton et al. 2001). Dental fear is likely to be a significant predictor of dental caries (Klingberg et al. 1995 Milgrom, 1995, Milsom et al. 2003). In conclusion, the aetiology of dental anxiety is multifactorial (Freeman 1985) and can be considered to be learnt – from traumatic experiences, family and peer-group influences but also as a result of personality and demography.

Numerous scales and questionnaires have been developed to assess dental fear and anxiety. The dental anxiety scale (DAS) (Corah 1969), the modified dental anxiety scale (MDAS) (Humphris et al. 1995), the dental fear survey (DFS), the dental fear survey schedule for children (DFSS-C) (Cuthbert and Melamed 1982) and the dental anxiety inventory (DAI) (Stouthard et al. 1995) are used most often. Alvesalo et al. (1993) and Rantavuori et al. (2004) have modified the dental fear survey schedule for children (MDFSS-C). Dental fear can be also assessed using one single question (Viinikangas et al. 2007, Pohjola et al. 2009). The abundance of measures applied to assess dental fear and anxiety and different cut-points used to indicate significant fear may partly explain the relatively large variations in prevalence rates published on children (Table 1). The prevalence of children's dental fear and/or anxiety ranges between 3% and 20%, and has a mean value of 9% (for review, see Klingberg and Broberg 2007).

Despite variations in prevalence rates, other findings related to dental fear and anxiety are mostly in line with each other: dental fear is more common among younger than

among older children (Holst et al. 1987, Wogelius et al. 2003), and more common among girls and women than among boys and men (Rantavuori et al. 2004, Bedi et al. 1992, Locker et al. 2001b). In addition, dental fear and anxiety is usually acquired in childhood or in adolescence (Berggren and Meynert 1984, Bedi et al. 1992).

The concepts of dental fear and dental anxiety are often used interchangeably within the dental literature and anxiety is often used as a synonym for dental fear. However, the term 'anxiety' should not be used among children younger than 12 years of age, as in these children "anxiety" is difficult to separate from 'fear', (Erikson 1950). Therefore, the terms 'dental fear' and 'dental anxiety' are combined 'dental fear and anxiety (DFA), and used from this point forward to indicate unpleasant or negative emotions associated with dental visits and dental treatment.

Table 1. Prevalence of dental fear and anxiety among children in different countries

Country	Author	Age (years)	Dental fear and anxiety (%)
Denmark	Wogelius et al. (2003)	6–8	16
Finland	Rantavuori et al. (2004)	3	32
		6	14
		9	6
Sweden	Klingberg (1995)	4–11	7
England	Milsom (2003)	5	11
Lithuania	Brukiene (2006)	15–16	11

2.2.2 Dental fear and anxiety in relation to dental health

Severe dental fear and anxiety (DFA) is associated with poor oral health, poor oral health habits, and irregular dental attendance (Berggren and Meynert 1984, Sohn and Ismail 2005, Pohjola et al. 2008). Adults with high DFA are likely to have poorer oral health habits and oral health problems more often than adults with low dental fear (Pohjola et al. 2008). Though generally women have better tooth brushing habits compared to men, the oral health habits of fearful women and men are equally poor (Pohjola et al. 2008). It has been shown that patients with high DFA have more decayed teeth than people with low DFA do (Milgrom et al. 1988, Schuller et al. 2003, Ng and Leung 2008). Usually, no differences in DMFT index are found between age-matched adults with high and low DFA, contrary to differences in numbers of decayed, missing and filled teeth (Locker and Liddell 1992, Schuller et al. 2003). Themessel-Huber et al. (2010) have shown that high DFA is associated with poor dental health and increased incidence of caries. DFA-patients have usually more missing teeth and fewer restored teeth than their counterparts with no DFA (Schuller et al. 2003, Ng and Leung 2008).

Earlier studies show that the stronger is the DFA the longer is the interval between dental visits, and the higher is the frequency of emergency care visits (Milgrom et al. 1988, Abrahamsson et al. 2001). There is strong evidence that people with greater DFA attend the dentist less regularly than those with less DFA (Schuller et al. 2003, Wigen et al. 2009, Armfield 2013). Negative experiences of dental treatment are important factors among children with regard to behaviour problems in the dental office (Majstorović et al. 2001, Abrahamsson et al. 2002, Raadal et al. 2002, Milsom et al. 2003, Oliveira and Colares 2009 Stenebrand 2012). Painful and threatening experiences such as injections administered prior to treatment provoke fearful reactions regardless of pain aetiology (Milgrom et al. 1997). Children with previous aversive dental experience are more likely to be fearful and avoidant than children who do not have such experiences (Klingberg et al. 1995, Milsom et al. 2003). Milgrom (1992) found that adolescents, who reported painful treatment during their last dental visit, were less likely to be willing to return to the dentist than those who reported no pain. The effect of dental extractions is a predictor of DFA in children (Milgrom et al. 1995, Raadal et al. 2002, Carillo-Diaz et al. 2012). Interestingly, Rantavuori et al. (2009) found that treatments experienced in previous years were only weak predictors of DFA, while parents' or siblings' levels of fear offered greater predictive power.

2.2.3 Dental fear and anxiety related to some medical conditions

Invasive procedures of general medical care have a significant influence on dental fear. Within the multifactorial aetiology of DFA, direct conditioning through past medical experience is shown to be one of the most prominent of factors (Locker 1996). A recent study supports the hypothesis that DFA is related to frequent exposure to medical interventions at a young age (Vogels et al. 2011). Children with asthma or with a history of ear problems may be more anxious than healthy children of the same age (Kvaernen 2002). Peak incidence of recurrent otitis media is usually prior to two years of age (Sipilä et al. 1987). Hospital stays and history of medical problems are associated with DFA among children, and though contrary reports also occur (Suprabha 2011), these are regarded as risk factors for behaviour management problems in the dental office (Wogelius et al. 2003).

2.2.4 The role of parents in children's dental fear and anxiety

Associations have been found between DFA of children and parents (Tuutti and Lahti 1987, Klingberg and Berggren 1992, Klingberg et al. 1995, Milgrom et al. 1994, Arnrup et al. 2002). In particular, mothers with a high level of DFA have a negative effect on their children in the dental operatory (Lahti et al. 1989, Goettems et al. 2012). The behaviour of the child in a dental setting is largely influenced by parental attitudes: positive oral health habits and parental support are of great importance to oral health (Kinirons and

McCabe 1995, Goettems et al. 2011). Most authors emphasize the role of the mother in promoting oral health of their children (Poutanen et al. 2007). In the attempt to model parental behaviour, the role of fathers who seem to influence children's oral health in positive ways was found important (Vanobbergen et al. 2001). Parental and other family characteristics influence children's health-related behaviour and their health itself, as do parents' health-related behaviours, attitudes, knowledge and oral health status (Mattila et al. 2000 and 2005, Okada et al. 2002 and 2008).

Children with poor dental attendance and poor dental health have a parent with DFA more often than children with better dental health (Tuutti and Lahti 1987, Lahti et al. 1992, Kinirons and McCabe 1995, Arnrup et al. 2002). Parents or caretakers suffering from DFA may have serious avoidance habits, and thus the oral hygiene habits of their children at home remain inadequate (Schuller et al. 2003, Pohjola et al. 2008, Wigen et al. 2009). Children of anxious mothers are more likely to present with untreated caries than their age-matched controls of non-anxious mothers (Goettems et al. 2012).

Arnrup et al. (2002) found that parents of uncooperative children had poorer dental knowledge and took less responsibility for their children's dental care than parents of their cooperative counterparts.

2.3 Prevention of dental caries, and dental fear and anxiety

2.3.1 Caries prevention in general with special reference to xylitol

During their whole lifespan teeth are under the risk of caries. The cornerstones of caries prevention are: avoiding transmission of MS from parents to child avoiding frequent intake of sweet drinks and frequent use of nursing bottle especially at night-time The cornerstones further include daily toothbrushing twice a day with fluoridated toothpaste; a visit to the dentist during the first year of life and professional applications of fluoride varnish in case of obvious caries risk. All these factors should be looked at together as they are highly interactive (Koch and Poulsen 2009), and the modifying factor of host- and family-related factors should be considered individually (Vadiakas 2008).

An oral health promotion program based on repeated preventive guidance, initiated during the mothers' pregnancy has been shown to reduce the incidence of severe ECC in young children (Ramos-Gomez et al. 2012). Information provided to pregnant women or mothers with babies about the risks of caries helps to reduce caries among their children (Gomez and Weber 2001, Mohebbi 2009). Parents and their preschool children should receive oral health education from the dental team (Weinstein et al. 2006, Kidd 2011) as parents of caries-active 5-year-olds have irregular toothbrushing and flossing habits (Mattila et al. 2000).

Home visits and information-based intervention by dental-health-educated non-professionals are effective in reducing caries in children (Kowash et al. 2000, Feldens et al. 2007). Moreover, the information-based intervention is cost-effective as compared to other preventive methods like fluoride devices, water fluoridation or sealant application (Kowash et al. 2006). Discussions with mothers about caries risks is called motivational interviewing (Weinstein et al. 2004, 2006), and dental health of children is better in the motivational interview group than in the control group. Counselling of pregnant women and young mothers is usually combined with preventive methods like fluoride varnish applications, professional tooth-cleanings, fluoride tablets, and advice to use fluoridated toothpastes (Tenovuo et al. 1992, Köhler and Andréen 1994, Gomez and Weber 2001, Weintraub et al. 2006, Davies et al. 2002, Espelid 2009).

The evidence that sugar intake (both amount and frequency) has a central role in the development of dental caries is overwhelming (for review, see Fejerskov and Kidd 2008). Milk has a neutral effect on the development of dental caries but yoghurt and desserts have added sugar, which is a substrate for oral bacteria. Bottle-feeding with sucrose containing fluid, especially at night time is a high caries creates a high risk for the infant (Mattila et al. 1998, Mohebbi et al. 2008).

Strong evidence between oral cleanliness and dental health has been demonstrated (Chestnutt et al. 1998, Hietasalo et al. 2008). Mechanical cleaning of teeth helps to decrease dmft in children (Macpherson et al. 2013). The probability to remain caries free is higher for those who start tooth brushing before three years of age compared to children who start tooth brushing later (Vanobbergren et al. 2001). Wong et al. (2012) found that children whose teeth parents start to brush before 12 months of age have more healthy teeth compared to children whose tooth-brushing starts later. Caries level of 6-10-year-old children who brush their teeth only occasionally is 40-45% higher than that of children of similar age range who brush at least twice a day (Maserejian et al. 2009).

Daily use of fluoride prevents caries by enhancing remineralisation and by inhibiting demineralisation. Caries prophylactic effect of daily use of fluoride toothpaste is found in all age groups (Marinho et al. 2004), and the effect increases with increasing fluoride concentrations (Walsh et al. 2010). However, daily frequency of its use is more important than the concentration (ten Cate 2013).

Reduction of MS with chlorhexidine applications in mothers during the emergence of the child's primary teeth has long-term influence on MS-colonization and caries experience in the child (Köhler and Andréen 1994). Since the early 1990ies, however, more agreeable methods than chlorhexidine have been introduced to reduce MS transmission from mother to child. Xylitol, a five-carbon sugar alcohol, is believed to possess anticaries properties, which may render it superior to other sugar alcohols

(Söderling 2009). Several studies have reported that caries occurrence significantly decreases as a result of daily use of xylitol-containing chewing gum (Scheinin et al. 1985, Isokangas et al. 1988, Trahan 1995, Mäkinen et al. 1995). Xylitol is not fermented by oral micro-organisms and it inhibits the growth of MS (Vadeboncoeur et al. 1983, Mäkinen 2010). Frequent consumption of xylitol-sweetened chewing gum results in a reduction of dental plaque and in a suppression of MS in the oral cavity (Söderling et al. 1989, 1991). This effect seems to depend on the frequency of chewing and on the initial level of MS (Mäkinen et al. 1989). Regular use of xylitol chewing gum three or more times a day about 6 g a day has caries preventive effects (Holgerson et al. 2007, Milgrom et al. 2006). It has been shown that xylitol not only in chewing gum but also in lozenge form is effective in caries prevention (Alanen et al. 2000). Honkala et al. (2006) suggested that xylitol candies have strong preventive and re-mineralizing effect on caries. Cosequently, the need of restorative treatment among 5-year-old children is 70% lower in the xylitol group as compared to the chlorhexidine-, or the fluoride varnish group (Isokangas et al. 2000). Reduction in transmission of MS from mother to child is explained by a reduced adhesiveness of maternal mutans streptococci during habitual xylitol consumption (Söderling et al.1991, Söderling et al. 2000 Alamoudi et al. 2012). Maternal xylitol consumption is more effective in reducing the prevalence of MS in children and the risk of dental caries of the offspring than fluoride or chlorhexidine applications (Thorild et al. 2003, 2006, Laitala 2012).

To conclude, three important stages are needed to prevent and manage dental caries in children (Innes and Evans 2009): the first is changing parental attitudes and priorities by providing relevant information, the second is to ensure maximal caries prevention including toothbrushing twice a day, fluoride varnish applications and using fissure sealants; the third is biological caries management with a child-friendly approach.

2.3.2 Prevention of dental fear and anxiety

Early detection of DFA can improve the quality of dental service at patient-dentist level (Eitner et al. 2006). Competence and knowledge of medical and dental personnel may prevent DFA in children and adolescents. For better results in dental treatment, a good collaboration between parents, the dental team and the child is needed (Freeman 2007). Dentists can help patients to establish realistic expectations of pain and minimize actual pain associated with dental treatment (Meng et al. 2007).

Child patients want explanations about the forthcoming and on-going procedures, and they like to be involved in the discussions (Welly et al. 2012). Uncooperative children evaluate the atmosphere in the dental office more thoroughly than their co-operative counterparts, and they do not like their dentist to appear in coloured uniforms, as they feel that white is the proper colour for the doctor's uniform (Welly et al. 2012, Armfield

et al. 2006). Children's DFA can be reduced by a reassuring touch accompanied by verbal explanation of the ongoing procedure and delivered in a firm tone of voice (Greenbaum et al. 1990, Zhou et al. 2011) and an appropriate working contact (ter Horst et al. 1987, Greenbaum et al. 1993), while verbal criticism leads to uncooperativeness. In addition, De Menezes et al. (2011) concluded that a gradual, step-wise exposure of children to the dental environment decreases their level of DFA. Negative behaviour decreases as children become familiarized with the dental environment and treatment provided (Venham and Quatrocelli 1977). Moreover, with small children, the dentist can use alternative, minimally invasive preparation and excavation techniques and stabilise the carious process (Foley 2006).

2.4 Conclusions

Fear-related research has increased more than tenfold during the past four decades. The findings so far show that dental fear and anxiety of adult age causes numerous, usually worsening problems not only to the person suffering from DFA him- or herself but to the offspring as well. The negative impact of DFA on dental health can be presented as a vicious circle (Figure 1). The model describes the circular relationship among fear and anxiety, avoidance, deterioration of dental status, and feelings of shame and inferiority.

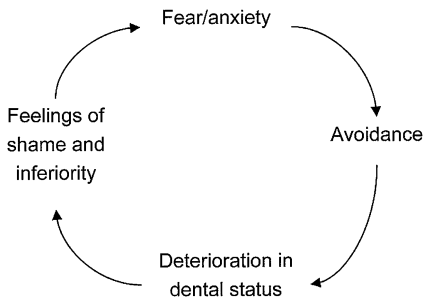

Figure 1. Berggren's model describing the 'vicious' circular connection maintaining and enforcing dental fear and avoidance (from Carlsson et al. 2013 with permission of the senior author, prof. Magnus Hakeberg)

In spite of the intense research it is still not known if the vicious circle of DFA and its deteriorating consequences on dental health can be prevented from transmitting from parent with DFA to offspring. Therefore, the main question of this thesis was whether a caries prevention program, found successful in other setups, is effective among toddlers of mothers with severe DFA.

In addition, until now no information is available about the prevalence of dental caries among Estonian preschool and schoolchildren, or about DFA among Estonian children or parents, all known etiologic factors of children's DFA. Moreover, little prospective information exists about the impact of medical conditions of early childhood on the development of DFA later in the child's life.

3. AIMS OF THE STUDY

The aims of this study were to assess the prevalence of dental caries in toddlers and schoolchildren, and to study associations between children's dental health and dental fear and anxiety (DFA), and fear-related factors. The ultimate goal was to study if a known caries prevention program is effective in offspring of fearful mothers.

Specific objectives

1. To assess the proportion of Estonian 2-4-year-old children with dental caries and colonization by mutans streptococci (MS), and to study the association with dental health. The hypothesis was that about half of this age group is colonized with MS, and that a strong association exists between dental caries and colonization of MS.

2. To assess DFA in Estonian 8-10-year-old children in relation to dental health. It was hypothesized that children with DFA had more past caries experience and higher exposure to operative dental care than their counterparts lacking DFA.

3. To study children's DFA in relation to parental general dental fear. The hypothesis was that there would be strong associations in the level of DFA among family members of children aged between eight and eleven.

4. To study if invasive medical treatment episodes experienced in early childhood are associated with DFA in later childhood. It was hypothesized that frequent exposure to invasive medical and dental care in early childhood would be associated with dental apprehension in later childhood.

5. To assess the level of dental health and health habits of dentally anxious mothers. The hypothesis was that the dental health and dental health habits of dentally anxious mothers would prove inferior to those of non-anxious mothers.

6. To study prospectively if the anticipated negative impact of maternal DFA on child's dental health is preventable. The hypothesis was that the prevention program is successful among children of non-anxious mothers but unsuccessful among their counterparts with anxious mothers.

4. SUBJECTS AND METHODS

4.1 Subjects and study designs

The age range, number of participants and type of study of the four original reports are summarized in Table 2.

Table 2. Subjects of the four original studies of the thesis

Age of participants	Number of participants	Type of study	No. of study
2–4 years	472	Cross-sectional	I
8–10 years	344	Cross-sectional	II
From 3 to 9 years	148	Follow-up	III
Mother-child pairs Children: 3 months of age at baseline 3 years of age at follow-up	120	Follow-up	IV

4.1.1 Preschool children (Study I)

A cluster sample of children aged between two and four years old were recruited in 2002 from 14 communal day-care centres throughout the country (Study I). In the year 2002 the number of day-care centres for preschool-aged children in Estonia was 518 (Statistical Year Book of Estonia 2005). The number of children representative of Estonian preschool-aged children was calculated according to the WHO instructions (World Health Organization 1997). Fourteen day-care centres throughout the country were selected to represent the age cohort of 2-4-year-old children. In most day-care centres, especially in rural areas, the number of children was lower than required by the WHO (1997), i.e. 25 children per age group. Thus the number of eligible day-care centres reduced in number. Finally four day-care centres from the capital city and others from major city of the region from different parts of Estonia were invited. All invited day-care centres (n=13) agreed to take part and a total of 472 children from 30 to 54 months of age participated. Informed consent was obtained from all parents. 5% of parents did not allow their children to be examined.

4.1.2 Schoolchildren (Studies II and III)

The total number of schools in Estonia in 2008 was 566, and the number of first grade Estonian speaking children was 9687 (Statistical Year Book of Estonia 2010). The selected schools were geographically dispersed around the South-Eastern region of Estonia and representative of all elementary schools of the region. The size of school (small, average

or large) was taken into account. Sampling was based on the proportional distribution of schools in each county: one urban school (from the major city of the region), four regional center schools, four rural schools and one where the day-care centre and the elementary school were combined.

An invitation to take part in the survey was sent to the management of schools in the stratified sample. If a school declined to participate (one school) or did not respond (10 schools), another school with similar size from the same region was selected. Reasons for refusal were not requested. When the school agreed to participate in the survey all children of that age were involved. The initial number of children would have been 522. A total of 485 second and third-grade schoolchildren from ten different schools participated in the dental examination. According to the teachers, the main reason for refusals was illness on the day of the examination. From among the 485 schoolchildren 71% (n=344) returned the fear questionnaires. Therefore, 344 pupils from 8 to10 years of age were included in this study. The subjects represented 9.8% of all schoolchildren in the area.

Figure 2. Flow chart of children participating in the oral sub-study of the Special Turku Coronary Risk Factor Intervention Project, the STRIP-project.

The children of study III were participants of a long-term, prospective randomized Special Turku Coronary Risk Factor Intervention Project (STRIP). From 1990 to 1992, 1062 infants (56% of the eligible cohort) had been recruited to the STRIP-project at the age of 5 months by nurses at well-baby clinics of the city of Turku, Finland (Lapinleimu et al. 1995). The sample size was determined according to the expected difference between the intervention and control groups and according to the anticipated dropouts during the

follow-up (Simell et al. 2009). The infants were randomized to receive individualized counseling aimed at controlling coronary heart disease risk factors (n=540) or to a control group (n=522). At 3 years of age, every fifth child of the main study was invited to an oral sub-study (Figure 2). At this point 83% (n=883) of those who had been recruited continued in the main trial. Eighty-three percent (n=148, 78 boys and 70 girls; 80 from the intervention and 68 from the control group) of the invited children (n=178) attended. A total of 135 and 126 children participated in the follow-up examinations at six (years 1996-1998) and at nine years of age (years 1999-2001), respectively (Figure 2). Information on children's general health was requested from parents at each dental visit and double-checked using the database of the main STRIP-study. Based on the results, the children in study III were devided into three categories according to general health: healthy; children with non-invasive medical conditions (e.g. allergy and asthma), and children with invasive medical conditions (e.g. middle ear infections, pharyngitis, sinusitis and juvenile diabetes).

4.1.3 Mother-child pairs (Study IV)

Young mothers in maternity clinics were informed about a caries prevention program According to the Estonian Medical Birth Registry the number of births at Tartu University Clinic is approximately 2100-2200 annually, in 2004 it was 2216 (Allvee and Karro 2009). Four hundred and eighty young mothers were interested and they were screened for salivary levels of MS and for the level of dental anxiety. In 2001 a total of 360 mothers with either low salivary levels of MS (CFU < 10^5/ml) or a DAS-score between 9 and 14, indicating mild or moderate dental anxiety, or both, were excluded from the subjects initially screened (Figure 3). Altogether 120 mothers volunteered. A total of 30 mothers from the high and another 30 mothers from the low-DAS score group started to use xylitol lozenges three months after delivery (X+ groups) and continued until the child was three years old. For comparison, 30 mothers from the high and 30 mothers from the low-DAS score group did not use xylitol, and formed the control group (X- groups, Figure 3).

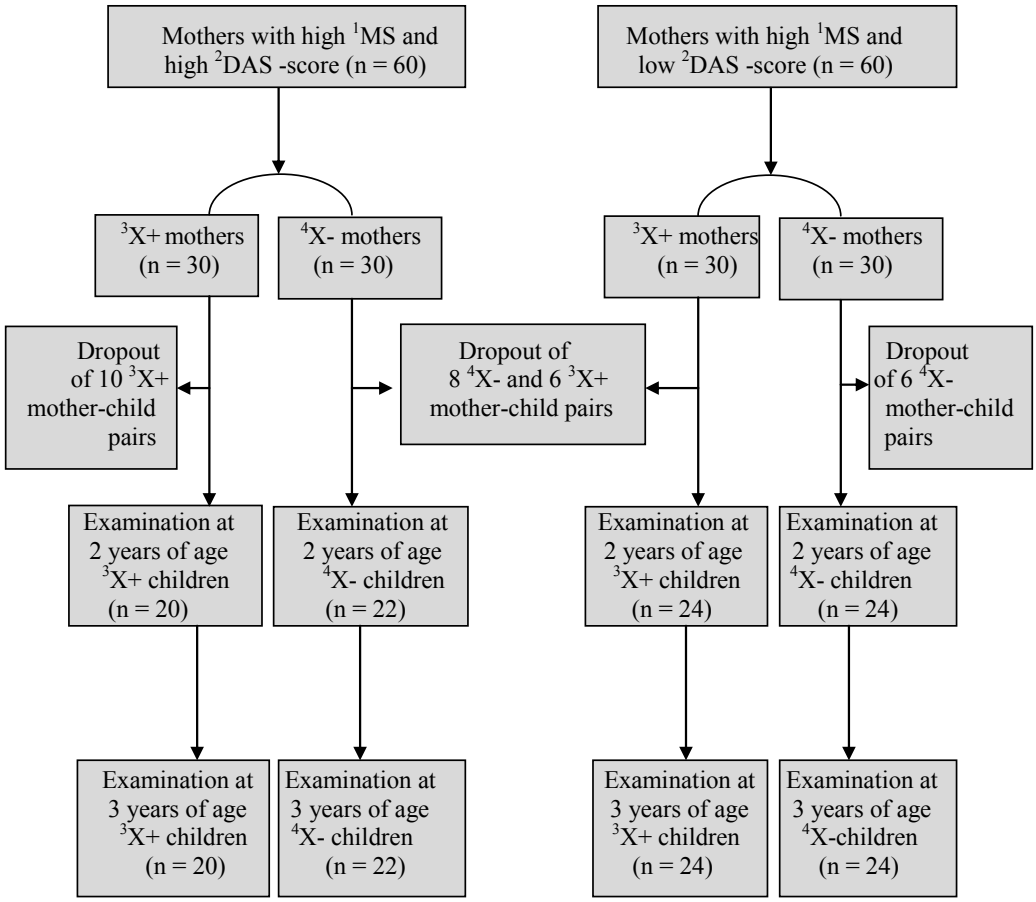

Figure 3. Flow chart of participants in Study IV. [1]Salivary level of mutans streptococci; [2] Dental anxiety scale, [3]Mothers using xylitol, [4]Mothers not using xylitol

The sizes of the study groups were partly based on earlier findings showing that 37 % of children aged between three and four in Estonia had manifest dentine caries. The drop-out rate was 25% and the main reasons for discontinuation were moving residential area or losing interest in the study. The difference between the dropout rates of the high- (18/60), and the low-DAS (12/60) groups was not significant (p=0.40, Chi-square).

4.2 Dental examination

4.2.1 Preschool children

The group of children aged between two and four years (Study I) was examined at day-care centres. Visual examination was performed in sitting position in a standard chair, using a mirror and a penlight (Halogen 76600 Penlight, Welch Allyn, Skaneateles, NY, USA). The numbers of decayed, missing and filled teeth were recorded. The incidence

of caries was recorded according to the criteria of the World Health Organization (WHO, 1997). Early stages of caries were excluded because they could not be reliably diagnosed. White and chalky, non-cavitated spots were recorded as sound. The examinations were carried out together with a dental assistant.

Children of the second follow-up study (Study IV) were examined twice, at two and at three years of age. The incidence of caries was recorded according to the criteria of the World Health Organization (WHO, 1997) as described above. The examination was carried out at the child's home in the knee-to-knee position,, using a mirror and a penlight .

The reproducibility (kappa 0.89) of the examiner was determined by repeated examination of a separate group (n=25) of 2-4-year-old children.

Children who required dental treatment were advised to visit their private or public health dentist.

4.2.2 Schoolchildren

Examination of the 8-10-year-old children (Study II) was conducted in January 2009 in dental units at the Department of Stomatology of the University of Tartu. The children were transported by bus from their schools to the examination site. A visual examination was carried out by four trained and calibrated examiners. All examiners were senior academic staff with long clinical experience. The training and calibration were carried out before the examinations. The ICDAS criteria were discussed together with all examiners and the calibration was arranged during a two days period prior to the commencement of the study. On the first day, eight children not involved in the study, were examined by all the examiners. The findings were discussed and disagreements were resolved by further discussion after re-assessment of the same child. On the second day about 5% of the children were studied twice. Each examiner (Numbers 2, 3 and 4) examined the same ten children with examiner 1, and ten children were examined twice by all four examiners to estimate the inter- and intra-examiner errors. All re-examinations were made on the same day, because there were no resources for recall visits. The intra- and inter-examiner weighted kappa values of the four examiners, ranging between 0.983 and 0.995 and between 0.989 and 0.991, respectively (Runnel et al. 2013), were determined according to Cicchetti and Allison (1971). Children were distributed at random among the four examiners.

The children were given a toothbrush and toothpaste and requested to brush their teeth before the examination. The cleaned dentition was assessed using the International Caries Detection and Assessment System (ICDAS) index. Two digit ICDAS codes were determined for each tooth surface of the mixed dentition. In further analyses, ICDAS codes 1, 2 and 3 were counted together as a measure of enamel caries and 4, 5 and 6 as dentine caries. Caries experience (dmft/DMFT) was calculated as the total number of

teeth with dentine caries, treated caries and missing teeth, extracted because of caries in the primary and permanent dentitions. Correspondence between the traditional dmft/DMFT-recordings of WHO (1997) and the new ICDAS-recordings is described in Table 4.

No treatment procedures were carried out during the examination. After the examination the children were given a written information sheet for their parents, indicating whether they needed restorative or orthodontic treatment. Those children requiring treatment were advised to visit their family or school dentist.

Table 4. Correspondence between the traditional dmft/DMFT-recordings of WHO (1997) and the new ICDAS-recordings

WHO		ICDAS	
Code	Definition	Code	Definition
Sound crown	No evidence of treated or untreated clinical caries, the stages, preceding cavitation are excluded because they cannot be reliably diagnosed: white and chalky spots; discoloured rough spots; dark, shiny, hard, pitted areas of enamel. Teeth with partial or sound fissure sealants	0	Sound, intact or unsealed teeth
		1	First visual change in enamel
		2	Distinct visual change in enamel
		3	Localized enamel breakdown, sized smaller than 0.5 mm around restorations
D/d	A lesion in a pit or fissure, or on a smooth tooth surface, has an unmistakable cavity with undermined enamel, or detectably softened floor or wall. A tooth with a temporary filling.	4	Underlying dentine shadow with or without enamel breakdown
		5	A distinct cavity with visible dentine. Cavity around restoration or sealant, not larger than 0.5 mm
		6	Extensive distinct cavity with visible dentine
M/m	Missing tooth, extracted because of caries. In case of normal exfoliation of primary teeth. Teeth, extracted for orthodontic reasons or trauma were excluded.	97	The tooth is lost due to caries
		98	The tooth is lost due to reasons other than caries
		99	Unerupted tooth
F/f	Restored crowns without decay Sealants are not marked as fillings	1	Partial sealant
		2	Sealant applied in all pits and fissures
		3	Tooth-colour resin or glass-ionomer restoration
		4	Stainless steel crown
		5	Amalgam restoration
		6	Veneer crown, porcelain- or porcelain fused to metal crown
		7	Lost or fractured restoration

In study III, visual assessment of dental health was carried out blinded to group assignment by one experienced paediatric dentist according to the WHO criteria (World Health Organization, 1979) as described (Karjalainen et al. 2001). Caries was recorded at the level of cavitation and expressed as the sum of decayed, missing and filled teeth in the primary (dmft), mixed (dmft/DMFT) and permanent dentition (DMFT). The intra-examiner reproducibility ratio of the examiner (r=0.08) was assessed according to Shaw and Murray (1975). This ratio is given as the number of disagreements of diagnosis to the number of consistent diagnoses on two successive examinations. Ideally, the ratio should be zero or as low a value as possible (Shaw and Murray 1975).

4.2.3 Mothers

Mothers' dental health was assessed at the dental clinic in a dental chair when their child was three months old, using the criteria of WHO (1997). The number of decayed, filled and missing teeth was recorded.

4.3 Sampling of mutans streptococci

4.3.1 Plaque sampling of preschool children

Plaque samples were collected from the children aged between two and four with a dental floss pick from the interproximal spaces of maxillary central incisors and lower molars (Study I). If the second molar had not erupted, the interdental space between the canine and the first mandibular molar was used for sampling. The commercial chair-side test, Dentocult-MS strip mutans test (Orion Diagnostica Espoo, Finland), was used to assess the amount of mutans streptococci (MS) in plaque. The plaque on the floss was gently spread on the test strip. The inoculated strips were immediately immersed in selective *Mitis salivarius* bacitracin broth and incubated at 37ºC for 48 hours. After incubation the strips were allowed to dry at room temperature and the strips were examined by naked eye. Blue staining with a spherical appearance and with an upward growing pattern was considered to be true bacterial growth. The following categories were used: strips with no colonies were classified as MS=0, and strips with one or more colonies were classified as MS>0.

4.3.2 Salivary sampling of mothers

Mothers were screened for their salivary level of mutans streptococci (MS, Study IV) in the maternity clinic a few days after delivery. The chair-side Dentocult-MS strip mutans test (Orion Diagnostica Espoo, Finland), was used to assess MS of paraffin-stimulation saliva. Stimulatsion was performed as follows: the mothers were advised to chew on a piece of paraffin (1.0 g) for 1 min and to swallow the secreted saliva. Then the roughened

side of the strip was gently pressed against against the mother's tongue, turned ten times around and drawn out through lightly closed lips. The inoculated test strips were immersed into liquid broth medium and incubated at 37ºC for 48 hours. The density of the colony forming units (CFU) in saliva was assessed the density chart provided by the manufacturer. Four categories, i.e. 0, 1, 2, and 3 were used to evaluate the density CFU. Categories "0–1", "2" and "3" correspond to$<10^5$, 10^5-10^6, $>10^6$ CFU/ml of saliva, respectively. MS-categories "2" and "3" were considered "high" representing high caries risk for the new-born child.

4.4 Dental fear and anxiety, and dental apprehension

4.4.1 Schoolchildren (Studies II and III)

Dental fear and anxiety of children and parents (Study II) was measured using the modified dental subscale of the children's fear survey schedule (MCFSS-DS) (Table 5. Appendix 1a). Children filled out the questionnaire mostly by themselves expect the question about general dental fear of parents. The respondents rated their fear using a 5-point Likert-scale: not afraid (1), a little afraid (2), afraid to some degree (3), quite afraid (4), and very afraid (5). The questionnaire had the following ten 5-point Likert-scale questions related to dental treatment: fear of having to open the mouth; fear of the dentist; fear of professional cleaning of teeth; fear of the sound of the dental drill; fear of being unable to breath; fear of having instruments in the mouth; fear of saliva suction; fear of pain caused by the dental treatment; fear of tooth drilling and fear of dental injection.

The modifications made to the original CFSS-DS were that three of the fifteen questions were omitted ('fear of someone looking at you', 'having a stranger touching you' and 'seeing people in white uniforms'), and questions about 'fear of dental treatment causing pain' and 'fear of suction' were added as described (Rantavuori et al. 2004). In this study, general dental fear was measured with a single question 'Are you afraid of dentistry in general?' as used earlier (Viinikangas et al. 2007, Rantavuori et al. 2004).

Dental apprehension of children in response to past medical conditions (Study III) was assessed among the STRIP-children at nine years of age. A questionnaire with eight multiple-choice questions designed for the purpose was used. One of the questions was related to dental apprehension and the rest to past operative treatment, general health, tooth-brushing habits, use of fluoridated toothpaste, oral hygiene advice received, frequency of consuming sweets, sweet juices, soft drinks and xylitol products. The question related to children's dental apprehension had four levels: 'not apprehensive'; 'slightly apprehensive'; 'moderately apprehensive'; and 'severely apprehensive' (Table 5). To evaluate the designed questions every other child with parental assistance

responded to the Dental Anxiety Scale questionnaire (DAS, Corah 1969). A positive correlation was found between the DAS-scores and the present classification ($r=0.326$, $p<0.05$).

4.4.2 Parents

The questionnaire described above (MCFSS-DS), designed primarily for children had a single question dedicated to parental dental fear (one for paternal and another for maternal dental fear) as described by Rantavuori et al. (2004). The question was addressed to the child but the children were instructed to ask help from their parents if they had difficulties responding to this or some other questions. This single question was also rated using the 5-point Likert-scale as described above (Table 5).

4.4.3 Mothers (Study IV)

All mothers were screened for dental anxiety using the Corah's Dental Anxiety Scale (DAS) as described by Corah (1969). Mothers with low-DAS scores (≤ 8) were categorized as having 'no or low dental anxiety', and those with DAS scores of 15 and higher were categorized as having 'high dental anxiety' according to Moore and Brødsgaard (1995) and both categories were included in the study (Table 5. Appendix 2a).

Table 5. Dental fear and anxiety scales used in the subject groups of the thesis

Study groups	Dental fear and anxiety (DFA) measure scales
3-year-olds (Study III)	First dental examination Problem-free or time-consuming
8-10-year-olds (Study II)	MCFSS-DS with eleven questions
9 year-olds (Study III)	One question on dental apprehension
Parents (Study II)	One question on general fear of dentistry added to the MCFSS-DS questionnaire
Mothers (Study IV)	DAS

4.5 Health behaviour and education of mothers

Mothers in the caries prevention study (Study IV) filled in a questionnaire about education, sugar intake, smoking habits and oral health habits (Appendix 3a). Their level of education was assessed in four categories: 'university', 'vocational', 'secondary' and 'basic education'. Daily sugar intake frequency was calculated by adding up all intakes of sweetened coffee or tea, sweetened juices or yoghurt, sweets and chocolate, cookies, desserts and bakery products. The question on smoking had four categories: 'non-

smoking'; '1–5 cigarettes a day'; '6–10 cigarettes a day' and 'more than 10 cigarettes a day'. Tooth-brushing frequency had two categories: '≥ twice a day' and '≤ once a day'. The mothers also responded to questions about time elapsed since their last dental visit which had the following three categories: 'less than 1 year ago'; '1–2 years-ago' and 'over 3 years-ago'.

4.6 Mother-focused caries prevention program (Study IV)

4.6.1 Individually tailored information

At child's age of three months, all consenting mothers with high levels of MS and a DAS-score of ≤8 or ≥15 were invited to an individual baseline visit. Information was given on good dental hygiene habits, cleaning the mother's and the baby's teeth and how to prevent dental caries in the future. It was explained what MS is and how important it was to avoid transmission of MS from mother to child. Special attention was paid to sugary food products, juices and feeding frequency of the babies. Mothers were shown pictures of ECC and informed of the options available to prevent it. Mothers received information about the effect of xylitol, and were encouraged to ask questions at the time or later. The discussion lasted about 45–60 minutes. The above information and the intervention program were described to all consenting mothers.

4.6.2 Xylitol intervention

Mothers of the xylitol group used the commercially available xylitol lozenges (Läkerol Dents, Leaf, Turku Finland) containing xylitol and maltitol (1:1) four times a day (approx. 5.8 g xylitol a day) two pieces at a time until their child became 36 month old. A supply of lozenges enough for a period of three months was provided for the intervention group every third month. The possibility of some side-effects deriving from regular xylitol consumption such as loose stools or diarrhoea was described. The control group did not use any placebo products.

4.6.3 Allocation to study groups

Anxious (DAS≥15, n=60) and non-anxious mothers (DAS≤8, n=60) were allocated to intervention [xylitol (X+, n=30) and control [no xylitol (X-, n=30)] groups according to mothers' choice. Mothers' own choice was used to improve compliance and adherence. Traditional randomization especially among the high-anxiety mothers was not possible, as the current prevention program required extra effort and commitment from the intervention mothers compared to the control mothers. Recruiting was easiest to the low-anxiety group, and hardest to the high-anxiety group, both scheduled to use xylitol during

the next 33 months. Reasons for choosing the intervention group were understanding benefits of xylitol for the child's oral health, and a chance to get the product free of charge. The most common reason for refusing the xylitol group was a general distrust in new products, fear of side effects, being deterred by getting a new supply of lozenges every third month, and doubts about being able to comply. In other words, the present study design was used to ensure enough participants in each subgroup.

4.7 Statistical analysis

Fisher's exact test was used to compare the proportions of children with and without caries, between boys and girls, and to compare MS colonization percentages between children with and without caries. The Chi-square test was used for estimating differences in proportions of children with and without MS with respect to caries and age (Study I).

The arithmetical sum of fear scores of non-invasive and invasive procedures, were tallied separately (Study II). Mann-Whitney U-test was used to analyse differences of fear scores between age groups, sex, and dental health (Study II).

Spearman's correlation and the Mann-Whitney U-test were used when applicable, and a logistic regression model for ordinal response variable was used estimate the significance of invasive medical procedures of early childhood for the development of dental apprehension. Dental apprehension was the dependent variable while cumulative general health and operative treatment were the independent variables (Study III).

In Study IV differences in age, DMFT scores and sugar intake frequencies between intervention and control mothers, and between mothers with high and low levels of dental anxiety were analysed using two-way analysis of variance. Children's dental health at two and three years of age, with respect to maternal background factors and the prevention program, were analysed using a logistic model (Study IV).

5. RESULTS

5.1 Dental caries

5.1.1 Preschool children

Caries was diagnosed in 41.6% of the 2-4-year-old children (Table 6), and the proportion of children with carious teeth ranged from 30.3% to 56.2%. (Study I). The proportion of children with ECC was 18.9% of the total examined material. The mean (SD) value of dmft was 1.6 (2.5), and ranged from 1.1± 1.2 to 2.4 ± 3.1. The proportion of caries-free was higher (37%) among the younger age group (24-35-months-old) than among the older (36-47-months-old) age (18.0%), (p=0.005). Evaluating the level of colonization with mutans streptococci, it was found that 58% of the 2-4-year-old children were colonized by MS. Colonization was detected more frequently among children with caries (80%) than among children with no caries (51%) (p=0.001).

Proportions of children with caries in the control group at two and at three years of age were 32.6% and 56.0% respectively (Table 6. Study IV),.

5.1.2 Schoolchildren

The proportion of children aged between 8 and 10 with dental caries (dmft/DMFT>0) in Estonia was 93.0% (Table 6). The proportion increased from 91.7% at eight years of age to 94.5% at ten (Study II). At nine years of age, 60.0% of the Finnish schoolchildren had developed dentine caries (Study III) (Table 6).

Table 6. Proportions of children with caries among Estonian and Finnish children

Age of children (years)	Children dmft/DMFT>0 (%)	No. of study
2[1]	32.6	IV
2–4[2]	42.0	I
3[1]	56.0	IV
8–10[3]	93.0	II
9[4]	60.0	III

[1]Estonian preschool children of control group participating in the follow-up study
[2]Estonian preschool children participating in the cross-sectional study
[3]Estonian schoolchildren participating in the cross-sectional study
[4]Finnish schoolchildren participating in the STRIP-study

5.2 Dental fear and anxiety

5.2.1 Preschool children

Behaviour of the 3-year-olds in Study III, observed at the first dental examination in the dental chair, was assessed time-consuming for 26% of the three-year-old children (Table 7).

5.2.2 Schoolchildren

Using the single question, 6.1 % of children aged between eight and ten reported that they were afraid of dentistry in general (Study II, Table 7). The proportions of children with non-invasive fears varied from 0.6% for fear of having to open the mouth to 4.5% for fear of not being able to breathe. Invasive fears ranged between 3.1% and 38.1%. The most feared dental procedures were tooth drilling (26.4%) and dental injections (38.1%). 3.1% of the schoolchildren reported fear of having instruments in the mouth. Proportions of children with fear of non-invasive items were 11.4%, with fear of invasive items 14.6 %, and with a fear of all 11 fear items 16.5%. Girls were more afraid of non-invasive procedures than boys. The highest frequency of zero-scores (no experience of the procedure questioned) was related to injections (n=62) and pain during dental treatment (n=36). The highest frequency of missing scores was related to fear of being unable to breath (n=32). The child's general fear of dentistry correlated with his/her fears of non-invasive and invasive procedures (r=0.42, p=0.000 and r=0.59, p=0.000).

Table 7. Proportions of schoolchildren and parents with general dental fear of dentistry obtained by one single question. The proportion of 3-year-olds with general dental fear was obtained by rating their behaviour using the dichotomized terms of 'time-consuming' or 'problem-free' during the first dental examination in the dental chair.

Study groups	Proportion of subjects with general dental fear (%)
3 year-olds	26.0
8–10 year-olds	6.1
9 year-olds	11.0
Mothers	16.8
Fathers	15.7

A total of 62.0% of the 9-year-old children reported being apprehensive when visiting the dentist – 51.0% slightly, 6.0% moderately and 5.0% severely (Study III). In other words, at nine years of age 11.0% of the Finnish schoolchildren reported moderate or severe dental apprehension (Table 7).

5.2.3 Parents

Compared to children, parents were more fearful of dentistry in general, than their own 8-10 year- old children. Prevalence of dental fear and anxiety among mothers and fathers was 16.8% and 15.7%, respectively (Study II, Table 7). The child's general fear of dentistry correlated with maternal (r=0.16, p=0.004) and paternal (r=0.16, p=0.005) dental fear and anxiety. Fathers' fear and anxiety of dentistry correlated significantly with that of the mothers (r=0.27, p=0.01).

5.3 Dental fear and anxiety in relation to dental health

5.3.1 Schoolchildren

Comparing children's dental health to their own level of dental fear and anxiety revealed that the mean rank of fear-scores of children with past or present caries (dmft/DMFT>0) (Study II) was significantly higher ($p<0.01$) than that of caries-free children (dmft/DMFT=0).

There were minor differences in dental health between 9-year-olds with different levels of apprehension (Study III). The mean scores (SD) of dmft/DMFT in relation to dental apprehension were as follows: children with no apprehension 1.75 (2.38); those with slight apprehension 2.11 (2.93); those with moderate apprehension 1.63 (1.99); and those with severe apprehension 4.00 (5.06). The differences were not significant ($p>0.05$). Only 40% of the nine-year-old children had experienced restorative treatment or extractions.

5.3.2 Mothers

The age of mothers varied between 15 and 40 years and did not differ between the intervention and control groups (Study IV). Mothers with high dental anxiety (DAS-score≥15) had more untreated carious lesions [Mean (SD) 2.7 (0.4) vs. 1.2 (0.3)] and fewer filled teeth [5.2 (0.5) vs. 7.6 (0.7)] than their low-anxiety (DAS-score≤8) counterparts (p=0.0007, p=0.006, respectively). No differences were found between the two groups in the numbers of missing teeth [0.9 (0.2) vs. 0.7 (0.1)] or between the DMFT [9.0 (0.6) vs. 9.5 (0.7)]-scores (p=0.402 and p= 0.549, respectively).

5.4 Dental apprehension in relation to some medical conditions

Invasive medical procedures were associated with dental apprehension at the age of nine years (Study III). Continuous monitoring of the children's general health up to the age of nine years revealed that 42.0% of children had been completely healthy, 20.0% had

asthma or allergy problems with non-invasive procedures and 38.0% had experienced invasive medical procedures. One in three children had experienced invasive medical procedures before the age of three; in most cases because of recurrent middle ear infections. The highest frequency of invasive medical procedure occurred prior to three years of age (33%) and the lowest at the age of nine (7%). Exposure to experiences of invasive medical care, and tooth extractions were associated with dental apprehension at nine years of age ($p<0.002$). The child's behaviour at three years of age was not associated with dental apprehension at the age of nine years.

5.5 Health behaviour and education of mothers

There were more smokers among the high-anxiety mothers than among the low-anxiety group ($p= 0.053$, OR 3.2; 95% CI 1.0-1.2). The low-anxiety mothers brushed their teeth twice a day, and had visited the dentist during the past year more often than was the case with the high-anxiety mothers ($p=0.014$, OR 3.6; 95% CI 1.3-9.9 and $p<0.0001$, OR 5.6; 95% CI 2.4-13.2, respectively). The proportion of mothers with a university education was higher in the low-anxiety group than in the high-anxiety group (OR 6.8; 95% CI 2.8-16.6).

5.6 Outcome of the mother-focused xylitol-based caries prevention program

Among the combined study groups the proportions of caries-free children (dmft=0) were 80.0% (72/90) at two and 64.0% (58/90) at three years of age. The proportions of caries-free children of the high-anxiety mothers and those of the low-anxiety mothers were 77.0% and 83.5% at the age of 2 years, and 60.5% and 68.5% at 3 years of age, respectively. The differences between the high-anxiety and the low-anxiety groups were not significant, not at two nor at three years of age ($p=0.417$; OR 1.6; 95% CI 0.5-4.7 and $p=0.377$, OR1.5; 95% CI 0.6-3.8, respectively).

The proportions of caries-free children were significantly higher in the intervention (X+) group (86.0%) than in the control group (X-) (58.8%). The difference was evident both at two (93.0%) and at three (79.0%) years of age ($p= 0.005$, and $p= 0.004$, respectively). The odds of having caries was higher among the X- children as compared to the X+ children both at two (OR 6.6; 95% CI 1.8-25.0), and at three years of age (OR 3.9; 95% CI 1.5-10.0).

6. DISCUSSION

6.1 Methodology

6.1.1 Study samples and study designs

From among the four study populations of this thesis, two (Study I and IV) were collected for the current purpose, one was part (Study II) of a follow-up study designed to monitor the level of dental health of Estonian schoolchildren (Runnel et al. 2013), and the fourth was part (Study III) of a randomized controlled intervention study on Finnish children (Simell et al. 2009). Cross-sectional findings are reported about three of the populations (Studies I, II and III), while follow-up findings are provided from two of the study samples (Study III and IV).

The day-care centres approached (Study I) were designed to represent 2-4-year-olds in major and minor communities in Estonia. All 13 day-care centres invited agreed to participate. Thanks to good co-operation of teachers of the day-care centers, the children and parents were well informed in advance, and examination of teeth was conducted smoothly. There were few refusals (5%) resulting in a high level of participation (95%). Children were interested and co-operative. For assessment of MS colonization of children a convenience sample of day-care centres of the city of Tartu was chosen because of the mean socioeconomic status of its citizens, the normal level of fluoride (0.7 mg/L) in drinking water, and for the readiness of facilities to organize the study.

A representative sample of 8-10-year-old Estonian schoolchildren from a random sample of schools was drawn (Study II). The participation rates were 71% for Estonian 8-10-year-old schoolchildren (Study II), 83% at 3 and 71% at 9 years of age for the Finnish children (Study III).

In conclusion, the participation rates of the younger age groups both in Estonia (95%) and in Finland (83%) were higher than those of the older age groups (71%). Participation rate of the Estonian follow-up study representing Estonian mother-child-pairs (Study IV) was 75% at children's age of 3 years.

A major limitation of study IV is that allocation of mothers was not random as described in the paragraph 4.6.3. Initially, participants were allocated randomly to the study groups but several high-anxiety mothers did not agree with the allocation and refused to participate. According to the initial screening, we estimated the proportion of Estonian mothers with high dental anxiety to be low, less than 10%, and as we expected this group of mothers to be exceptionally prone to discontinue participation, we decided to allow mothers with high DAS-scores (≥15) to choose between study groups providing that

they otherwise met the inclusion criteria of high salivary mutans counts (>10^5 CFU/ml). In order to treat participants equally, similar rights to choose between groups were given also for mothers with a DAS-score of ≤8. It is hard to estimate the bias of the current study design. However, it is most likely, that a greater number of highly anxious mothers would have discontinued if not given the chance to choose between the groups which again might have led to difficulties in statistical analyses.

6.1.2 Measures of dental fear and anxiety

Estonian schoolchildren: The modified children's fear survey schedule (MCFSS-DS) was used to assess the level of dental fear of different dental procedures among schoolchildren (Study II). The measure was designed to assess dental fear and anxiety in children up to 14 years of age (Alvesalo et al. 1993, Milgrom et al. 1995, ten Berge 2002b, Wogelius et al. 2003, Nakai et al. 2005, Klingberg and Broberg 2007). As in Estonia no information is available on children's fears related to various dental treatment procedures it was rational to use this particular questionnaire. At the same time the single question of 'Are you afraid of dentistry in general?' embedded in the MCFSS-DS questionnaire was used to assess the proportion of children afraid of dentistry in general. Children completed the MCFSS-DS questionnaire mostly by themselves and were advised to ask for parental help only if needed. In spite of the instructions the responses do not indicate who provided the information; the child, the parent or both.

Finnish preschool and schoolchildren: At 3 years of age children's behaviour was assessed at their first dental examination in the dental chair (Study III). The child whose dentition was examined easily was classified "problem free" and those whose examination required extra time or effort were classified as "time-consuming".

To assess dental apprehension of 9-year-olds Finnish schoolchildren (Study III), one simple question "Do you feel fear or anxiety when visiting the dentist for examination or for operative treatment?" was used with four alternatives (not-, slightly-, moderately or severely apprehensive). The question was very close to the single question used by Viinikangas et al. (2007) "Is a visit to the dentist?" with three options "not scary at all", "scary to some extent" and "very scary". This single question has proved to be valid in assessing dental fear in conditions where multi-item dental anxiety questionnaire is not realistic or feasible (Viinikangas et al. 2007). To evaluate the current single question on dental apprehension every other child responded to the dental anxiety scale (DAS, Corah 1969) with parental assistance. A positive correlation was found between the DAS-score and the present classification of dental apprehension ($r=0.326$, $p<0.05$).

Parents of schoolchildren and mothers of the 2-3-year-olds: One single question on general dental fear of mothers and fathers, embedded in the children's MCFSS-DS questionnaire was used to assess parental dental anxiety. The question with the 5-point

Likert-scale was addressed to the child but the children were instructed to ask help from their parents when responding to this question.

Though newer methods like the modified dental anxiety scale (Humphris et al. 1995) have been developed to modernize the scale for measuring dental anxiety, the traditional Corah's dental anxiety scale (DAS) was used to assess the level of dental anxiety in mothers (Study IV). Correlation between the two scales is high (Freeman et al. 2007), and even today they are the most popular instruments for measuring dental anxiety.

To conclude, to date there is no single scale which can be considered as a gold standard, and there may be a need to further simplify and/or calibrate scales of dental fear and anxiety for children and adolescents.

6.1.3 Clinical examinations

Dental examinations of Estonian preschool children were carried out either at the day-care centres in different parts of Estonia (Study I), or at home (Study IV). Dental health of children in both studies (Study I and Study IV), including mothers of Study IV were assessed using the criteria of WHO (1997) by one calibrated examiner whose intra-examiner reproducibility expressed as kappa value (0.89) was determined by duplicate examination of a separate group (n=25) of 2-4-year-olds. Dental examination of the Finnish 3- and 9-year-olds (Study III) were carried out also using the criteria of WHO (1997), by one examiner whose intra-examiner reproducibility ratio (r=0.08) was determined according to Shaw and Murray (1975).

The dental health of the Estonian schoolchildren was assessed by four calibrated dentists at the Institute of Stomatology, University of Tartu. The dentists examined the children's teeth using the new caries detection index, the international caries detection and assessment system criteria (ICDAS) as described by Ismail et al. (2007). The inter- and intra-examiner reliability of the four examiners was determined according to Cicchetti and Allison (1971) and the kappa-values ranged from 0.989 to 0.991, and 0.983 to 0.995, respectively (Runnel et al. 2013).

In conclusion, the reliable methods of WHO (1997) and ICDAS (Ismail et al. 2007) were used to assess dental health of preschool and schoolchildren, and mothers alike.

6.2 Results

6.2.1 Dental health of children

Caries prevalence of children of two and three years of age in Estonia was 42 % and the proportion of children with caries doubled during one year. The Estonian caries

prevalence is quite similar to that of its neighbour, Latvia, which has 37% but at the same time the Estonian rate is higher than is found in the Nordic countries. In Finland, the proportion of children with dental caries among 3-year-olds was 16% in 2000 (Nordblad et al. 2004), and 6% in Sweden in 2001 (Malmö University Oral Health Database). Differences found in the proportion of children with caries in different towns in the current study can be explained by the level of fluoride in drinking water, which is low (<0.5 mg/L) in southern Estonia (Valga and Võru) as compared to western area (Pärnu) with higher fluoride concentrations (>1.0mg/L) in tap water (Indermitte et al. 2005).

In accordance with earlier studies (Rodrigues and Sheiham 2000, Karjalainen et al. 2001, Alm 2008, Fontana et al. 2011) it was thought that frequent eating and using baby-bottle at night-time could have been the reason for the exceptionally high level of ECC in Tallinn, even higher than in low-fluoride south-eastern areas of Estonia. Speed of life in Tallinn is faster and caretakers are more nervous than in smaller, more peaceful towns, and prefer to comfort the crying child with a nursing-bottle.

In the current study (Study I), MS was detected in 58% of children representing Tartu area, where the proportion of children with caries (34%) was slightly below the national average (42%). Our study further showed that the proportion of children with MS was higher in the group with dental caries than among children without caries. This is in line with earlier studies (O´Sullivan and Thibodeau 1996, Milgrom et al. 2000) which showed that children with high levels of MS are at greater risk to develop new caries lesions compared to children with low levels of MS. In accordance with earlier reports (Takahashi and Nyvad 2008) our results confirm that a high level of MS in oral microflora may be a biomarker of rapid caries progression.

As the results of Study I showed that the prevalence of dental caries and the levels of MS among children between two and four years of age were high, a decision was made to assess dental health of 8-10-year-old children and to rate their dental fear at the same time (Study II). Only 7% of the schoolchildren examined were caries-free. Interestingly, the number of caries-free children increased from eight to ten years of age. This, we believe, was due to the fact that children in this age range represented a transitional phase, where primary teeth both decayed and healthy are exfoliating to become replaced by healthy permanent teeth. In Lithuania, the prevalence of dental caries of 7-10-year-old children varied between 86% and 89% in 2009 (Saldūnaite et al. 2009). In Finland, the proportion of caries-free 9-year-olds was 40% in 2000 (Nordblad et al. 2004), which is exactly the same as the size of our caries-free group at 9 years of age (Study III).

6.2.2 Dental fear and anxiety of children in relation to operative treatment and dental health

Children completed the MCFSS-DS questionnaire mostly by themselves and they were advised to ask for parental help only if needed (Study II). This way parental influence was tried to limit to the two questions where maternal and paternal dental fear was questioned. Parental influence, if not controlled properly, may lead to serious biases as cultural factors or associated stigmas may prompt parents to label girls more fearful than boys (ten Berge et al. 2002a, Ferrari et al. 1986). Some parents tend to overestimate their children's dental fear, while others underestimate it (Gustafsson et al. 2010). Moreover, fearful parents assess their child to be fearful regardless of the child's actual fear more often than non-fearful parents do and vice versa, fearful children do not really know about the dental fear of their parents (Luoto et al. 2010). In spite of the given instructions our questionnaire does not indicate who provided the information; the child, the parent or both.

Each single fear question was analysed against the child's general fear of dentistry. Children, who left any one of the questions without response, were considered not having dental fear and anxiety in line with earlier studies (ten Berge et al. 1998, Rantavuori et al. 2005, Rantavuori 2012).

The proportion of children, who in the current study assessed their general dental fear as moderate or severe (6%), was the same as that of Rantavuori et al. (2004).

As expected, the most frightening procedures in our study were drilling and injections. These are the two procedures feared most by respondents all over the world (Rantavuori et al. 2004, Nakai et al. 2005, Oba et al. 2009). According to results of Study III, the third most feared item was pain during dental treatment. Fear of choking and having instruments in the mouth ranked high among Turkish children (Oba et al. 2009). In study III, fear of not being able to breathe i.e. fear of choking ranked highest in the group of non-invasive items, despite that this item had the most missing scores. Fear of having instruments in the mouth, ranked fourth of all fear items.

In line with earlier reports (Nakai et al. 2005, Klingberg and Broberg 2007) we found that dental fear among girls was higher than among boys. Our results also showed that girls were afraid of non-invasive procedures more than boys. It has been suggested that girls are more open, they express their feelings and admit their fears more freely than boys as a result of cultural factors or associated stigmas (Schuller et al. 2003).

Though contrary opinions occur (Alvesalo et al. 1993, Yamad et al. 2002, Rantavuori et al. 2004), most studies show that DFA decreases with age (LeBaron and Zeltzer 1984, Wogelius et al. 2003). LeBaron and Zeltzer (1984) explained that children may learn to control the way of expressing fear as they grow older.

Several authors have reported a significant association between children's dental fear and oral health (Bedi et al. 1992, Kruger et al. 1998). Rantavuori et al. (2004) found a strong association between dental fear and untreated caries. In his study, schoolchildren's general fear of dentistry and fear of invasive procedures was strongly associated with the dental health indices dmft/DMFT and numbers of decayed teeth. The current finding of a positive correlation between the number of teeth needing treatment and fear of non-invasive procedures are in line with earlier results (Bedi et al. 1992, Kruger et al. 1998, Rantavuori et al. 2004).

Few studies have been able to show significant differences between DMFT-scores of adults with low and high dental anxiety, contrary to separate numbers of decayed, missing and filled teeth. (Thomson et al. 2000, Schuller et al. 2003, Ng and Leung 2008). Adults with high dental fear have more missing teeth and fewer restored teeth as compared to adults with no or low level of dental fear (Schuller et al. 2003, Ng and Leung 2008). In accordance with other reports on children's dental fear (Milgrom et al. 1992, Veerkamp et al. 1992, Raadal et al. 2002, Skaret 2000, Suprabha et al. 2011. Krikken et al. 2012) we found that children with past experience of tooth extractions were more apprehensive than children with experience of restorative treatment alone.

6.2.3 Dental fear and anxiety of children in relation to some medical conditions

Asthma and middle ear infections are the most common medical conditions suffered in early childhood. Asthma is diagnosed in approximately 20% of Swedish children with 7% needing asthma medication (Bråbäck 2012). In Estonia 8% of children are affected by asthma (Genuneit et al 2009) but no information is available on the prevalence of middle-ear infections in Estonia. It is known that 44% of Estonian children are colonized by *Streptococcus pneumonia* (Tamm et al 2007), which can cause different diseases like acute middle-ear infections, sinusitis, meningitis, and lung infections. Usually, 15% of children colonized by *S. pneumonia* will develop infection (Grey et al 1980) and in most cases in the nasopharyngeal region (Jacobs 1998). In line with other studies (Wogelius et al. 2003, ten Berge et al. 2001, Liddell et al. 1990) our results showed that invasive medical conditions, mainly recurrent middle-ear infections, experienced in early childhood were linked to dental apprehension at 9 years of age (Study III). Interestingly, also contrary findings have been reported: according to the study of ten Berge et al. (2002c) children who have experienced invasive medical treatment are less likely to develop high dental fear as compared to other children without similar experiences. In our follow-up study (Study III) none of the children had been exposed to operative dental treatment by 3 years of age. Parents of children who agreed to participate in this dental study were very co-operative and interested in the child's dental health. Collaboration with them was easy. Yet one quarter of the 3-year examinations appeared to be time-consuming, which, however, was not related to past episodes of middle ear infections. In line with earlier

findings (Klingberg et al. 1995), we thought that children's behaviour at the very first dental examination whether time-consuming or not was probably due to maternal factors like age, emotional status and maternal dental anxiety.

Though medical conditions *per se* do not cause caries, sick children are known to consume more sugary drinks, and are more often mouth-breathers compared to healthy children (Nascimento et al. 2004, Stensson et al. 2010). These factors may increase the caries risk of children. The dental health of severely apprehensive children in the current follow-up study (Study III) was inferior compared to that of the non-apprehensive children but the difference was statistically not significant.

6.2.4 Oral health role model of severely fearful mothers

Mothers with low or high levels of dental anxiety were recruited to the second follow-up study (Study IV). In accordance with earlier findings on young women (Pohjola et al. 2008, 2012) more smokers were found among fearful mothers than among mothers with no- or mild dental fear. In agreement with Pohjola et al. (2008) it was concluded that the number of smokers is higher among fearful than among non-fearful adults. It was further found that the number of mothers with university education was higher in the low anxiety group. As the level of education and the level of socioeconomic status are linked to each other, it is safe to say in line with earlier findings (Armfield et al. 2006) that people with lower socioeconomic status are generally more fearful of dental treatment. The current findings of less frequent toothbrushing events and longer intervals between dental visits among fearful mothers as compared to their non-anxious counterparts are also in agreement with earlier results (Pohjola et al. 2008).

Maternal dental anxiety is associated with poor oral health habits, and neglecting regular dental visits (Schuller et al. 2003). In the current study, the oral health behaviour of mothers with high level of dental anxiety was similar to those described above. They tended to postpone visits to the dentist, as exemplified by the number of participants who had visited their dentist during the previous year, being lower than was the case amongst less anxious mothers.

Dental examination of anxious mothers revealed more decayed and fewer filled teeth than those of their non-anxious counterparts. However, no differences were found between DMFT-scores of the two groups. Hence these findings are well in line with earlier studies (McGrath and Bedi 2004, Mehrstedt et al. 2004).

We found no significant differences between the dental health of 2-3-year-old children of anxious and non-anxious mothers. The lack of difference between the two groups of children was thought to be either due to a positive change in the oral health behaviour of severely anxious mothers, or due to the possibility that high salivary levels of MS,

common inclusion criterion for both groups of mothers, masked the more subtle effects of dental fear. The former explanation was thought to be due to the thorough individually tailored information of 45 minutes on factors affecting the child's dental health provided for all mothers anxious and non-anxious alike. This may indicate that the expected difference in dental health of children of anxious and non-anxious mothers can be prevented by individually tailored counselling sessions. These ideas, however, need further investigation. Dental anxiety in adults has been proven to restrict prophylactic measures and is associated with impaired oral health status (Mehrstedt et al. 2004). Changing the mother's own oral health behaviour is thought to be especially important (Okada et al. 2008). Added benefit was achieved by xylitol-intervention as discussed in the next section.

6.2.5 Outcome of the mother-focused xylitol-based caries prevention program

The overall proportion of 2-3-year-old children with caries was high. However, it should be remembered that in the second follow-up study (Study IV), all mothers had high salivary MS, unlike in the first cross-sectional study representing a random sample of Estonian preschool children (Study I). It seems likely that without an effective prevention program, every other child of mothers with high levels of MS will present with manifest dentine caries by the time they turn three years of age.

The hypothesis was that a xylitol-based program would benefit children whose mothers used xylitol lozenges (Study IV). The proportion of caries-free children was highest in the group of children with non-anxious mothers using xylitol lozenges. Xylitol lozenges are comparable with xylitol chewing gum in caries prevention (Alanen et al. 2000). Sucking and chewing are known to stimulate salivary flow. However, a considerable part of preventive effect can be attributed to the polyol itself (Ribelles Llop et al. 2010, Alanen et al. 2000, Mäkinen et al. 1989). Xylitol concentrates in saliva after consuming xylitol-containing products like chewing gum, sucking tablets, candies and rinses (Holgerson et al. 2006). In accordance with earlier studies (Isokangas et al. 2000, Thorild et al. 2006, Alamoudi et al. 2012), our results showed a clear caries preventive effect in high-risk children whose mothers had been using xylitol. Therefore, the finding that there were fewer children with caries in the xylitol groups was probably due to reduced early MS-colonization of children's teeth. It seems that xylitol, if used daily at an adequate frequency, in adequate quantity and for an adequate length of time during the eruption of primary teeth reduces the level of transmission (Söderling et al. 2000, Nakai et al 2010). The reduced transmission level of MS then manifests as an improved dental health of the child (Isokangas et al. 2000, Thorild et al. 2006). Most xylitol studies show that a daily dose of at least 5–6 g of xylitol is needed to reduce the level of MS and prevent the occurrence of caries (Mäkinen et al. 1995, Alanen et al. 2000). The lozenges used in our study have been shown to prevent caries in schoolchildren as effectively as xylitol

chewing gum (Alanen et al. 2000, Honkala et al. 2006). In view of our current findings, the effect of maternal consumption of xylitol lozenges in preventing ECC seems to be similar to that of xylitol chewing gum demonstrated previously (Isokangas et al. 2000, Thorild et al. 2006).

Communication with the non-anxious mothers was easy, but quite challenging with the severely anxious mothers who initially were reluctant to commit to any program connected with dentistry and tried to avoid meetings with the dentist. While communication with the very anxious mothers who did not wish to use xylitol was difficult, the anxious mothers who agreed to use xylitol expressed their hope that interaction with the dentist would help them conquer their anxiety problems. Infant-onset health education programs and one 15-minutes' dental health education session followed by reinforcement of the message every third month appears to be effective in preventing ECC in a low socioeconomic/high caries suburb (Kowash et al. 2000). In line with these findings of Kowash et al. (2000) we believe that the behaviour of our highly anxious mothers was positively influenced by the 10-15 minutes' counselling after every three months. As was mentioned earlier collaboration with extremely anxious mothers was problematic but they did not discontinue participation and tried to give their best to conquer their fearful behaviour. It has been shown that children whose mothers have their own dentist, whom they can visit regularly, and from whom they receive information about avoiding dental caries, have healthier teeth than those without regular support of a dental team (Grembowski et al. 2009). For this reason, this study was organized so that the primary researcher met each mother of the intervention group after every three-month period. These meetings provided an opportunity to reinforce the importance of cleaning the child's teeth, and for mothers to raise any dentistry-related questions they had.

Based on the current findings and study design it is hard to say which of the two, the regular encounter with the dentist, or the polyol itself was the reason for the successful outcome. It seems likely that the combination of the two i.e. the polyol and the three-monthly encounter with the dental professional is needed to achieve meaningful success among families with small children.

7. CONCLUSIONS

1. Nearly 60 % of all children in the group aged between two and four years old were colonized with mutans streptococci (MS), and the proportion was clearly higher among children who had caries than among those who had no past or present caries. A total of 42% of Estonian children between two and four years of age had past or present caries lesions extending to the dentine.

2. A total of 16 % of the Estonian children aged between eight and ten year-old reported fair, moderate or severe dental fear and anxiety (DFA). Children, with past or present caries (93%), had higher fear scores than their counterparts with no caries. Children's DFA was associated with prior experience of dental treatment.

3. The proportion of Estonian parents with DFA was 16–17%. Strong correlations were found between DFA of children and parents.

4. Schoolchildren exposed to frequent medical treatment episodes in early childhood (≤ 3 years of age) reported higher level of dental apprehension at nine years of age as compared to their counterparts without general health problems.

5. Mothers suffering from severe dental anxiety were poor role models of oral health habits for their offspring: highly-anxious mothers brushed less frequently, left it longer between dental visits, had more untreated carious teeth, fewer filled teeth, and a lower level of education than their non-anxious counterparts.

6. The xylitol-based prevention program focused on mothers was successful in preventing/postponing manifestation of dentine caries in their children irrespective of maternal dental anxiety. An infancy-onset caries prevention program including maternal use of xylitol lozenges seems to carry the potential to postpone caries-related problems in children for at least two years, even in unfavourable circumstances.

In conclusion, it is important to improve mothers' knowledge about general and dental health and basic rules of caries prevention, like oral hygiene, healthy diet and adequate health behaviour. It is important to explain how parental fear influences the child's health behaviour, especially the child's dental fear and consequently dental health as well. Frequent, three-monthly reinforcement of the information above during the first three years of the child's life combined with daily use of xylitol of mothers may result in successful caries prevention among children of severely fearful parents.

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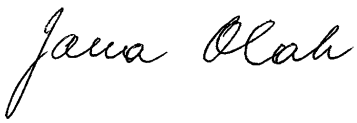

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APPENDICES

Appendix 1a. The Modified Children's Fear Survey Schedule-Dental Subscale (MCFSS-DS) questionnaire. Paper II.

Items	**0** No experience	**1** Not afraid at all	**2** A little afraid	**3** Moderately afraid	**4** Quite afraid	**5** Very afraid
1. Fear in general						
2. Having to open the mouth						
3. Fear of the dentist						
4. Fear of professional tooth cleaning						
5. Fear of drilling						
6. Fear of injections/ needles						
7. Fear of the sound of drilling						
8. Fear of choking						
9. Fear of somebody putting instruments in your mouth						
10. Fear of suction						
11. Fear of pain during the treatment						
12. Mother						
13. Father						
14. Siblings						
15. Someone else. Who?						

Appendix 1b. The Modified Children's Fear Survey Schedule-Dental Subscale (MCFSS-DS) questionnaire in Estonian. Paper II.

Laste ja noorte küsimustik hirmust hambaravis (MCFSS-DS)

Kardan:	**0** Ei ole kogenud	**1** Ei karda üldse	**2** Kardan natukene	**3** Kardan	**4** Kardan väga	**5** Kardan väga palju
1. Üldiselt kogu hambaravi						
2. Kui pean suu avama						
3. Hambaarsti						
4. Kui hambaarst puhastab mu hambaid						
5.Hammaste puurimist						
6. Süstimist (tuimastust)						
7. Hambapuuri häält						
8. Kardan, et ei saa hingata						
9. Instrumendi suhu panemist						
10. Suust sülje imemist						
11.Hammaste raviga seotud valu						
12. Ema						
13. Isa						
14. Õed, vennad						
15. Keegi teine. Kes?						

Appendix 2a. Corah's Dental Anxiety Scale. Paper III-IV.

1. If you had to go to the dentist tomorrow for a check-up, how would you feel about it?
    a. I would look forward to it as a reasonably enjoyable experience.
    b. I wouldn't care one way or the other.
    c. I would be a little uneasy about it.
    d. I would be afraid that it would be unpleasant and painful.
    e. I would be very frightened of what the dentist would do.

2. When you are waiting in the dentist's office for your turn in the chair, how do you feel?
    a. Relaxed.
    b. A little uneasy.
    c. Tense.
    d. Anxious.
    e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

3. When you are in the dentist's chair waiting while the dentist gets the drill ready to begin working on your teeth, how do you feel?
    a. Relaxed.
    b. A little uneasy.
    c. Tense.
    d. Anxious.
    e. So anxious that I sometimes break out in a sweat or almost feel physically sick.
4. Imagine you are in the dentist's chair to have your teeth cleaned. While you are waiting and the dentist or hygienist is getting out the instruments which will be used to scrape your teeth around the gums, how do you feel?
    a. Relaxed.
    b. A little uneasy.
    c. Tense.
    d. Anxious.
    e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

Appendix 2b. Corah's Dental Anxiety Scale in Estonian. Papre III-IV.

1. Peate homme minema hambaarsti juurde. Kuidas te ennast tunnete?
    a. Mõtlen, et see on meeldiv
    b. Suhtun ükskõikselt
    c. Mõtlen sellele kerge murega
    d. Mõtlen, et see on ebameeldiv ja valus
    e. Kardan väga ja mõtlen, mida hambaarst võib minuga teha

2. Istute hambaarsti ooteruumis. Kuidas te ennast tunnete?
    a. Mugavalt ja muretult
    b. Natuke murelikult
    c. Närviliselt
    d. Hirmunult
    e. Olen nii hirmul, et higistan ja/või tunnen ennast psüühiliselt haigena

3. Istute hambaravi toolis ja hambaarst seab instrumente, et hakata teie hammast puurima. Kuidas te ennast tunnete?
    a. Mugavalt ja muretult
    b. Natuke murelikult
    c. Närviliselt
    d. Hirmunult
    e. Olen nii hirmul, et higistan ja/või tunnen ennast psüühiliselt haigena

4. Istute hambaravi toolis ja hambaarst valib instrumente, et hakata teie hammastelt hambakivi puhastama. Kuidas te ennast tunnete?
    a. Mugavalt ja muretult
    b. Natuke murelikult
    c. Närviliselt
    d. Hirmunult
    e. Olen nii hirmul, et higistan ja/või tunnen ennast psüühiliselt haigena

Appendix 3a. Questionnaire for assesment of mothers' oral health habits. Paper IV.

1. ID code……..
2. Mothers age……
3. Date of birth of the child……
4. Sex of the child…….
5. When was your last dental visit.
   …….. months ago
   …… years ago
6. How often you usually eat sweets (candies, cookies, coffee with sugar)
   Consumption times ……... per week
   ..…….per day
7. How often you usually drink soft drinks
   Consumption times …… per week
   …… per day
8. How often do you brush your teeth
   - Once a day
   - Twice a day
   - The other possibilities…….
9. Do you use tootpaste with fluorides
   - Yes
   - No
10. Do you use dental floss
    - Yes
    - No
11. Do you use fluoride rinses
    - Yes
    - No
12. Do you smoke
    - Yes If yes, then how many sigarettes per day……..
    - No
13. Have you used xylitol-products (chewing-gums) before the study…….
    If yes, then how many times per day…….
14. Your nationality…….
15. Your education
    - Primary
    - Secondary
    - Vocational
    - University

Appendix 3b. Questionnaire for assesment of mothers'oral health habits in Estonian. Paper IV.

Küsimustik emadele

1. ID kood……..
2. Ema vanus……...
3. Lapse sünniaeg…….
4. Lapse sugu……
5. Millal viimati külastasite hambaarsti
   ……. kuud tagasi
   …… aastat tagasi
6. Kui sageli sööte magusat (komme, kooke, kohvi suhkruga)
   ……korda nädalas
   ……korda päevas
7. Kui sageli joote magusaid gaseeritud jooke
   ……korda nädalas
   ……korda päevas
8. Kui sageli pesete hambaid
   - Üks kord päevas
   - Kaks korda päevas
   - Muu……
9. Kas kasutate fluoriga hambapastat
   - Jah
   - Ei
10. Kas kasutate hambaniiti
    - Jah
    - Ei
11. Kas kasutate suuvett
    - Jah
    - Ei
12. Kas suitsetate
    - Jah Kui jah, siis mitu suitsu päevas või nädalas……
    - Ei
13. Kas olete varem kasutanud ksülitooli siasldavaid tooteid (nätsu)
    - Jah
    - Ei
14. Teie rahvus……
15. Teie haridus
    - Algharidus
    - Keskharidus
    - Keskeri
    - Kõrgharidus