

Aspects of dental health in children with asthma

Epidemiological studies of dental anxiety and caries among children in
North Jutland County, Denmark

PhD Thesis

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2004

This Ph.D. thesis is based on the following papers:

1. Wogelius P, Poulsen S, Sørensen HT. Prevalence of dental anxiety and behaviour management problems among six to eight years old Danish children. **Acta Odontol Scand** 2003; 61:178-83. (Study I)
2. Wogelius P, Poulsen S, Sørensen HT. Asthma, ear problems, and dental anxiety among 6- to 8-yr-olds in Denmark: A population-based cross-sectional study. **Eur J Oral Sci.** 2003; 111; 472-6. (Study II)
3. Wogelius P, Poulsen S, Sørensen HT. Use of asthma-drugs and risk of dental caries among 5 to 7 year old Danish children: a cohort study. **Community Dent Health** Submitted. (Study III)

Preface

This thesis is based on studies carried out during my employment at The Department of Community Oral Health and Pediatric Dentistry, Dental School, Faculty of Health Sciences, University of Aarhus, the Municipal Dental Service in Støvring-Nibe, and Department of Clinical Epidemiology, Aalborg Hospital during the period 1999-2003.

First of all, I want to thank my Principal Supervisor, Sven Poulsen who during the entire study period has been inspiringly engaged in my work and have spent time on my supervision in a humorous and patient manner. Also, I want to thank Henrik Toft Sørensen who has delivered valuable feedback to my writings and made it possible to continue my studies at the Department of Clinical Epidemiology in Aalborg at the time when my employment at Aarhus University ran out. I also want to thank my Project Supervisor Jørn Henriksen who helped me with important insights in asthma.

My special thanks go to Gerd Bangsbo who inspired me to initiate the training as a Ph.D.-student, introduced me to my Supervisor, and always underlined and understood the importance of research for the daily clinical work.

Also thanks to all employed in the Municipal Dental Services in Støvring, Nibe, Sejlflod, Skørping, and Brovst where large parts of the data were collected. And thanks to the employees at Department of Clinical Epidemiology in Aalborg who have become nice and inspiring friends. Thank you to Lis Jørgensen and Ulla Hassager at Department of Community Oral Health and Pediatric Dentistry for technical and secretarial assistance.

Finally my largest thanks go to my family: my husband Peter, and our three children.

The studies received financial support from: The Danish Dental Association, The Dentists New Association, The Research Foundation of the University of Aarhus, Danish Lung Association, The Asthma and Allergy Association, Denmark, The Western Danish Research Forum for Health Sciences, and Aalborg Hospital.

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Introduction

The aim of this Ph.D. project was to examine the prevalence of dental anxiety in Danish children between the ages of 6 and 8 years (Study I), and examine if an association between asthma, ear problems and dental anxiety exists (Study II). Further, we examined if there was an association between use of asthma medicine and risk of caries in children between five and seven years (Study III).

During my more than 10 years as dentist in the public dental health service for children, routinely collected information on the children's general health status has included information about asthma. The relevance of this was easy to accept as a clinician, since many children actually had asthma and both clinical observations and conversation with parents of asthmatic children seemed to suggest that use of asthma-drugs had caused caries in many children. In addition, chronic diseases are often mentioned as one of the risk factors of decreased dental health in children (1). However, few epidemiological studies exist on this topic, and the evidence of an association is sparse.

The overall dental health among Danish children has improved during the past decades, although a small proportion of the children still have a high level of dental caries. Thus, in 2002, 70% of the 5-year-old children had no caries in the deciduous dentition, while approximately 10% had more than five decayed tooth surfaces (2). Further, a population based epidemiological study from Sweden has shown that the prevalence of dental anxiety among children between the ages of 4 and 11 years was 6.7%, and that dental anxiety was associated with decreased acceptance of dental treatment (3;4). Consequently, a sufficient analysis of the asthmatic child's dental health should also imply examination of the association between asthma and dental anxiety.

Asthma is a chronic bronchial disease characterized by local inflammation, reversible obstruction of the bronchial airways, and bronchial hyper-reactivity. The local inflammation and the mucous secretions reduce the bronchial lumen as a chronic condition. Additionally, the lumen decreases in an acute asthma attack because of contraction of the smooth muscles in the bronchial airways. The severity of the disease varies by exposure to provoking factors and by general health constitution. The disease exists in two types: with and without an immunological component (5;6).

Asthma in children: prevalence and risk factors

A study conducted in 1992 and 1993 among 774 Danish children between the ages of 8 and 10 years found a prevalence of asthma of 6.6% using interviews, clinical examinations, spirometry, and exercise tests in diagnosing asthma (7). Among the 774 children, a proportion of 2.6% had no previous asthma diagnosis. In agreement with these findings, another Danish study among children between the ages of 7 and 10 years found that 4.3% had had received at least one prescription for inhaled beta2-agonists during 1997, and that 3.7% had received at least one prescription for inhaled corticosteroids (8). A recent Swedish study based on parental reporting of 7- and 8-year-old children's asthma-status in 1996 found that 6 % had physician-diagnosed asthma, while 7% of the children had used asthma-drugs during the past 12 months (9). In Norway in 1994, the prevalence of physician-diagnosed asthma according to parental reporting was almost 5 % in 8-year-old children (10). Before puberty, the prevalence of asthma is higher in boys (9).

Both genetic factors and lifestyle factors play a role for development of asthma. Twin studies have shown higher concordance between asthma in monozygote twins

than in dizygote twins, which indicates a genetic component as causal factor (11-13). If asthma had only genetic causes, the prevalence of asthma should be fairly constant over time; but studies from all over the world indicate an increasing prevalence (14). In part, changes in lifestyle factors may explain the increasing asthma prevalence; lifestyle factors may also explain the lower prevalence of asthma in Eastern Germany than in Western Germany before unification (6;14). There is increasing evidence that prenatal factors and asthma are associated (15;16). Other known risk factors for developing asthma include allergy, atopic dermatitis, humid indoor climate and exposure to dust mites. Early exposure to animals and infection seem to protect against asthma, probably due to an appropriate development of immunity (6).

The factors that commonly provoke asthma are upper respiratory tract infection, exercise, perfume, fumes, and changes in temperature and humidity (6).

Asthma: diagnosis and treatment

The diagnosis of asthma is based on clinical symptoms, tests of lung function, and response to medicament treatment. Diagnosing asthma in children can be difficult and lung function is not measured in children before the age of five. Typical symptoms of asthma in children are repeated episodes of coughing and wheezing, coughing at night and during physical exercise. From school age reliable lung function measurements are possible. A fall in Peak Expiratory Flow (PEF)/ Forced Expiratory Flow in the first second (FEV_1) following exercise or a significant increase in PEF/ FEV_1 after inhaled beta2-agonists will nearly confirm the diagnosis. In small children the diagnosis of asthma is based on history and response to anti-asthmatic therapy.

Treatment of asthma is based on two principles: 1) avoiding of allergic and non-specific precipitating factors and 2) pharmacological treatment. The drug of choice today is inhaled corticosteroids and inhaled beta2-agonists on demand (5;6).

Asthma and dental anxiety

Dental fear and dental anxiety are two concepts commonly used to understand children's behaviour in the dental treatment situation (17). It is difficult, however, to distinguish between these two concepts in the clinical situation. In the present thesis, only the term dental anxiety will be used to describe children's emotional reactions in the dental treatment situation. A more severe type of dental anxiety is odontophobia, which results in avoidance of dental treatment and interferes with daily routines. Dental behaviour management problems are defined as uncooperative and disruptive behaviours resulting in delay of treatment or rendering treatment impossible.

A well-known and accepted method of measuring dental anxiety in children is questionnaire-based parental reporting. The Children's Fear Survey Schedule-Dental Subscale (CFSS-DS) is widely used and has been validated in populations comparable to the Danish children (18-21). These validation studies showed high agreement between scores on the CFSS-DS scale and acceptance of dental treatment as rated by dentists. The scale consists of 15 items, and the possible score lies between 15 and 75.

Most studies on dental anxiety measured by the CFSS-DS score have reported mean CFSS-DS scores and shown scores between 22.1 and 35.7 (3;18;22-28). Some of these also reported prevalence of dental anxiety using different cut-off scores, as will appear from the following review on studies reporting prevalence of dental anxiety among children.

The studies comprised between 169 and 3,204 children between the ages of 4 and 13 years. The CFSS-DS scale was answered by either the child or the parents on behalf their child. One of the studies was population based (3). In two studies, self-reported data on CFSS-DS were used (22;29) and in others, parental reporting data were used (3;24;26;27). Different cut-off points have been used in previous studies in defining dental anxiety. In studies using a CFSS-DS score of 38 or above, the prevalence estimates were 6.7% among Swedish children aged of 4-11 years (3), 9.2% in Danish children aged 12-13 years (29), 21.4% among Chinese children living in Canada aged 5-15 years, and 43.4% among Chinese children living in the Chinese Republic aged 2-7 years (24). Two studies defined dental anxiety as the mean CFSS-DS score +1 standard deviation (SD); these studies found a prevalence of dental anxiety of 12% in Norwegian children aged 10 years and of 13.5% in children from Singapore aged of 10-14 years (22;27). In another study, dental anxiety was defined by two different CFSS-DS scores (26). Fourteen percent of the children scored above 32 - defined as borderline anxious children, and 6% of the children scored above 38-defined as dentally anxious children (Table 1).

Table 1. Summary of studies on prevalence of dental anxiety in different populations measured by Children's Fear Survey Schedule-Dental Subscale (CFSS-DS)

Authors year	Country	Number of children	Age in years	Reporting	Cut-off point	Prevalence (%)
Chellappah <i>et al</i> 1990 (22)	Singapore	505	10-14	Self	Mean+1 SD (≥ 42)	13.5
Milgrom <i>et al</i> 1993 (24)	Canada	70	5-15	Mother	≥ 38	21.4
	Republic of China	99	2-7			43.4
Klingberg <i>et al</i> 1994 (3)	Sweden	3,204	4-11	Parental	≥ 38	6.7%
ten Berge <i>et al</i> 2002 (26)	Netherlands	2,144	4-11	Parental	Borderline: ≥ 32 Anxious: ≥ 39	Borderline: 14% Anxious: 6%
Raadal <i>et al</i> 2002 (27)	Norway	180	10	Parental	Mean+1 SD (≥ 29)	12%
Andersen 2002 (29)	Denmark	478	12-13 years	Self	≥ 38	9.2%

From the studies including a broad age range, the mean CFSS-DS values decreased by increasing age according to parental reporting (3;26). When comparing parental-reported dental anxiety in younger children with self-reported dental anxiety in older children, the prevalence seemed to increase with increasing age, which may be interpreted as a cumulative problem.

Data on Danish children's acceptance of dental treatment have been collected in the early 1970s (30;31), but recent data on childhood dental anxiety only exist for 13-year-old children (29). Thus, there is a need to estimate the prevalence of dental anxiety and behaviour management problems in younger Danish children.

Most children with chronic diseases have experienced medical treatments at hospitals or by general medical practitioners, and it is often stated that medical fear is associated with dental fear (17). However, little is known about the association between past experience of medical treatment in children and dental anxiety.

The possible causal explanation of an association between medical treatment and dental anxiety could be recall of pain in connection with medical treatments when visiting the dentist. In particular in young children, the appearance of a dental clinic and

a hospital clinic might appear similar; and among dentists it is well known that children with previous ear problems are often very unhappy at their first dental visit. A literature search at “PubMed”, however, did not result in any relevant references. Thus, the following review is based on hand-searching the literature.

Table 2. Associations between medical experiences and dental anxiety in children

Author year	Number of children	Age Years	Data on medical history	Data on dental anxiety
Sermet 1974 (32)	200	5-12	Parental reporting	Visual Analogue Scales
Liddell 1990 (33)	179	12	Parental reporting	Corah Dental Anxiety Scale and the Revised Fear Survey Schedule
Holst <i>et al</i> 1993 (34)	273	3	Parental reporting	Rating of the accept
Majstorovic <i>et al</i> 2001 (35)	89	5-12	Broomes Child Medical Fear Questionnaire	Corahs Dental Anxiety Scale
ten Berge <i>et al</i> 2001 (36)	67	4-9	Parental reporting	CFSS-DS

In a Dutch cross-sectional study from 2001, 19 % of the parents of 67 highly dentally fearful children between the ages of 4 and 9 years reported that the most important reason for dental anxiety in their child was hospitalisation and a history of medical problems (36). The first study, reporting an association between hospital stays, asthma, and dental anxiety, was published in 1974 in England and showed that among 100 referred dentally fearful children between the age of 5 and 12 years, nine had asthma and six had asthma in combination with other diseases (32). In comparison, two out of 100 children in the control-group had asthma or asthma in combination with other diseases. Further, the study showed that 25% of the anxious children had had hospital treatments, compared with 9% in the control group. A Canadian cross-sectional study including 179 12-year-old children, found that parental reporting of medical fear

and number of hospital visits was associated with dental fear as rated by the Corah Dental Anxiety Scale and the Revised Fear Survey Schedule (33).

A cross-sectional study from Sweden investigated the same question in 1989 by examining the variables predicting negative acceptance of dental visits in 273 3-year-old children, but this study failed to find an association between health status and acceptance of dental visits as rated by the dental team using the method of Holst & Crossner (34;37). Finally, in 2001, a cross-sectional study from Croatia including 89 children between 5 and 12 years showed an association between high medical fear scores and high dental anxiety scores (35).

The reviewed studies showed large variations in medical conditions studied as well as definitions of dental anxiety. Further, the studies have been conducted in different countries, most likely with large cultural variations in handling children in medical and dental treatment situations.

Asthma and caries

The biological explanation, often mentioned for the higher caries risk in asthmatics, is a decreased salivary rate immediately after inhalation of beta2-agonists (38-40). Further some studies have found a general decreased salivary rate in asthmatics (41;42). In addition to the decreased salivary rate, an altered salivary composition in asthmatics found in some studies could also contribute to an increased caries risk in asthmatics (38-40;43). Other suggestions mentioned in the literature include the content of lactose in some inhaler drugs, or a higher intake of sweetened drinks in children with asthma due to more thirst or a desire to wash away the bad taste from the asthma-drugs (44).

A literature search was performed in PubMed in 2002 by combining the search words “asthma” AND “dental caries”. The literature search resulted in 33 references. English-language literature was reviewed. The computerised search was supplemented by hand-searching the reference lists in the relevant references. We included both references on the association between asthma and caries, and on the association between asthma-drugs and caries. Case-reports and reviews were not included. This search resulted in 12 references, listed in Table 3.

All studies were conducted in children or adolescents. In three of the studies, the outcome was dental caries in the deciduous dentition (45-47); in four studies, the outcome was dental caries in the permanent dentition (38;40;48;49); and in the remaining five studies, the outcome was dental caries in both the deciduous dentition and the permanent dentition (44;50-53).

We identified three follow-up studies, including between 21 and 56 asthmatics (40;49;51). One of the follow-up studies used questionnaire-based data on use of asthma-drugs (49), another used data from medical records on asthma-drug use (51), while in another study it was not clearly described how data on asthma-drug use was collected (40). The use of asthma-drugs differed among the three follow-up studies: in one study, all used inhaled beta2-agonists (40); in another, all used inhaled corticosteroids and beta2-agonists according to need (51); in the third study, a portion of the asthmatics used asthma-drugs, but information on drug type was not given (49). In one of the follow-up studies, Cox’s proportional hazard model was used for the analyses of the proportional effect of asthma (51); while in the others, mean values of caries-incidence were compared (40;49). Kankaala *et al.* and Ryberg *et al.* concluded that asthma-drug users had a higher caries risk; whereas Meldrum *et al.* concluded that the

mean caries incidence in asthmatics did not differ from the mean caries incidence in the controls.

We identified nine cross-sectional studies including one study delivering baseline data to one of the follow-up studies mentioned above (38). Between 21 and 1,129 children with asthma were included in the cross-sectional studies. In one of the studies, the asthmatics were included as a part of children using either asthma-drugs or antibiotics (46). A single of the cross-sectional studies was population-based (53). One of the cross-sectional studies included only hospitalised children (47), and another included only children attending a national centre for disabled children (45). In three of the cross-sectional studies questionnaire-based or interview-based data on asthma status and medication were used (46;50;53); while in the others, the way of collecting data on asthma status and drug-use was not clearly described. The use of asthma-drugs differed among the studies: in one, all the asthmatics used inhaled beta2-agonists (38); in two, all the asthmatics used “asthma-drugs”, but the type was not described (44;52); in three, some of the asthmatics used asthma-drugs (48;50;53); finally, in two of the cross-sectional studies, there was no information on use of asthma-drugs (45;47). In all cross-sectional studies, DMF-index was used to describe dental caries in the deciduous and permanent dentition.

In five of the studies asthma was found to be associated with higher mean values of decayed tooth or tooth surfaces (44-47;52); in three of the studies, no difference in mean values between asthmatics and controls was found (38;48;50); and in one of the studies, asthma was found to be associated with lower mean values of caries (53). One of the studies in which caries in both deciduous and permanent teeth was used as

outcome found no difference in caries in the deciduous dentition, while the difference in the permanent dentition was statistically significant (44).

The literature review shows, that the previous studies vary considerable according to number of study members, age groups studied, sources of asthma data, and use of asthma-drugs. Only a single population-based study on the association between asthma and caries existed; however this study was cross-sectional and based on parental reporting of exposure. Further, very few of the asthmatics in this population used corticosteroids. Moreover, the results of the previous studies are inconsistent, and allow no clear conclusion as to the association between asthma and caries.

Table 3. Summary of studies on the associations between asthma and dental caries in children.

Authors year	Number with asthma Not asthma	Study-design	Age in years	Sources of asthma data	Asthma-drugs	Results	P-value
Hyyppa & Paunio 1979 (48)	A: 30 N: 30	Cross-sectional	10-12	Hospital records	Cromoglicate: 15 Corticosteroid: 6	A: DMFS=10.0 ¹ N: DMFS=9.3	?
Storhaug 1985 (45)	A: 47 N: 386	Cross-sectional	1-6	Health center records Interview	75% of the exposed children used "saliva reducing drugs"	A: dmft=10.2 ¹ N: dmft=5.4	No test
Bjerkeborn <i>et al.</i> 1987 (50)	A: 61 N: 55	Cross-sectional	5-18	Interview	Asthma-drugs in different combinations	A: DFS=7.8 N: DFS=6.9 A: dfs=3.8 N: dfs= 4.1	P>0.05
Ryberg <i>et al.</i> 1987 (38)	A: 24 N: 24	Cross-sectional	10-20	Not described	Beta2-agonists	A: DFS=14.3 N: DFS=10.6	P=0.07
Holbrook <i>et al.</i> 1989 (46)	A ² : 49 N: 109	Cross-sectional	4	Questionnaire		A: dmft=3.0 N: dmft=2.1	P<0.05
Ryberg <i>et al.</i> 1991 (40)	A: 21 N: 21	Follow-up	14-24	Not described	Beta2-agonists	A: DMFS=17.6 ³ N: DMFS=11.9	P<0.01
Arnrup <i>et al.</i> 1993 (47)	A: 25 N: 244	Cross-sectional	0-19	Medical records	?	A: dmfs=3.5 N: dmfs=1.3	P<0.01
McDerra <i>et al.</i> 1998 (44)	A: 100 N: 149	Cross-sectional	4-16	Medical records	"all were currently using an inhaler"	A: dmfs=6.32 N: dmfs=2.97 A: DMFS=1.37 N: DMFS=0.37	P>0.05 P<0.05
Kankaala <i>et al.</i> 1998 (51)	A: 51 N: 102	Follow-up	> 3	Medical records	Corticosteroids Beta2-agonists as needed	RR=2.6 ⁴ 95% CI: 1.3-4.9	
Milano 1999 (52)	A: 179 N ⁵ : 165	Cross-sectional	2-12	Dental records	"Continuous use of asthma-drugs"	A: dmfs=15.5 N: dmfs=11.7 A: DMFS=1.3 N: DMFS=0.6	P<0.05 P<0.05
Shulman <i>et al.</i> 2001 (53)	A: 1129 N: 5809	Cross-sectional	4-16	Questionnaire	⁶	A: dfs=4.9 N: dfs=4.5 A: DMFS=0.24 N: DMFS=0.62	P>0.05 P=0.01
Meldrum <i>et al.</i> 2001 (49)	A: 92 N: 206	Follow-up	⁷	Questionnaire	42.4% of the exposed children used "anti-asthmatic" drugs	A: DFS=2.6 N: DFS=2.1	P>0.05

¹ Estimates based on authors own estimates

² The exposed children were children with parental-reported use of asthma-drugs or antibiotics

³ Initial lesions included

⁴ Upper primary first molar only

⁵ The children in the control-group were siblings to the exposed

⁶ Among the exposed children, 106 had severe asthma. Among the severe asthmatics, 34% used beta2-agonists and 1.9% used cortico-steroids

⁷ Data on exposure collected between the age of 9 and 15 years, and data on caries as caries increment between 15 and 18 years

Aims

The aims of this thesis were:

- to estimate the prevalence of dental anxiety and dental behaviour management problems in young Danish children;
- to estimate the association between medical problems as asthma and ear problems and the prevalence of dental anxiety; and
- to estimate the risk of dental caries in young children using asthma-drugs.

Materials and methods

All the data on which this Ph.D. thesis is based are collected in the County of North Jutland, which is located in the most northern part of Denmark. This county makes up 14.3 % of the area of Denmark and 9.3% of the population, with 495,625 inhabitants (54). The County has a mixed urban and rural composition.

Datasources

Questionnaire data

A questionnaire designed for research purposes was posted to the parents of the study members. The parents were asked to answer the questionnaire on behalf of their child. Further, they were asked for consent permitting us to obtain data from their children's dental records. The questionnaire was introduced by a covering letter that included: (1) information on the purpose of the study and instructions; (2) a Danish version of the Children's Fear Survey Schedule-Dental Subscale (CFSS-DS) (Appendix I); (3) questions on asthma symptoms and use of asthma-drugs; and (4) questions on ear problems. The CFSS-DS questionnaire was developed in 1967 in USA (55) and measures dental anxiety in children.

Dental records

In the Danish municipal dental service, dental records of all treatment performed are kept in an individual file for the child. The attendance rate is close to 100 %. Each child's dental file also contains a copy of the formula used for reporting to the Danish National Board of Health (56-58).

We obtained the following data from the dental records of those children with consent from their parents: (1) number of decayed deciduous teeth (codes 1, 2, 4, 5, and 6); (2) number of decayed permanent teeth (codes 1, 2, 4, 5, and 6); (3) number of appointments; (4) number of cancelled appointments; (5) number of missed appointments; (6) number of treatment sessions; (7) number of emergency sessions due to toothache; and (8) number of treatment séances where the child had exhibited dental behaviour management problems.

We defined behaviour management problems as report of pain felt during treatment, or insufficient fillings due to lack of cooperation, expression of anxiety during treatment, dental treatment under restraint, verbal or physical protest from the child during treatment, or cessation of treatment due to lack of cooperation from the child. The data on number of decayed teeth in (1) and (2) were collected from the last dental registration preceding the posting of the questionnaire. The data from (3) to (8) were collected from the first appointment in the municipal dental health service and onwards to the last appointment proceeding posting the questionnaire.

The Pharmacoepidemiological Prescription Database

All pharmacies in The County of North Jutland are equipped with a computerized accounting system by which the data are sent to the Danish National Health Service as a part of a national tax-supported health program. The program refunds a part of the costs associated with the purchases of the prescribed drugs. In The County of North Jutland, the accounting system also provides key data on prescriptions for refundable drugs to the Pharmacological Prescription Database (59). This database includes: (1) information on type of drug according to the Anatomical-Therapeutic-Chemical (ATC)

classification system (60); (2) dispensing of the drug; (3) municipality codes; (4) date of purchasing the prescription; (5) and patients' civil registry number that is assigned to all Danish residents since 1968, and which encodes gender and date of birth. The Pharmacological Prescription Database was founded in 1991. From 1991 to 1996, children's prescriptions were registered by their parent's civil registry number, while from 1 April 1996 they were registered in the child's own civil registry number. We extracted data on the following prescriptions on asthma-drugs: perorale beta2-agonists (ATC code: R03C); inhaled beta2-agonists (ATC code: R03A); inhaled corticosteroids (ATC code: R03BA); combined inhaled beta2-agonist and corticosteroids (ATC code: R03A K06).

The Danish SCOR-Database

The SCOR-database includes dental data based on registrations from local municipal dental clinics in Denmark since 1972 (56;57). It is mandatory for the municipalities to report all children at ages 5, 7, 12, and 15 years to this database, which is maintained by the Danish National Board of Health. The following data are reported for each tooth or tooth surface: identification of the tooth, initial caries (code 0); primary decay with cavitations (code 1); secondary decay or defective fillings (code 2); trauma (code 3); fillings (code 4); pulp treatment (code 5); extractions due to caries (code 6); teeth lost for other reasons than caries (code 7); sealant (code 8); and arrested initial caries (code 9). Also, data on gingival status and malocclusion traits are reported. We extracted the following data from the SCOR-database: number of deciduous and permanent tooth surfaces with the codes 1, 2, 4, 5, and 6.

Study populations and design

Study I and II: Prevalence of dental anxiety and behaviour management problems among six to eight years old Danish children, and Asthma, ear problems, and dental anxiety among 6- to 8-yr-olds in Denmark: A population-based cross-sectional study

Study I and II were performed in the municipalities of Nibe, Stoevring, Sejlflod, and Skoerping, which are located in the North Jutland County. These municipalities comprise a total of 40,003 inhabitants, which is 8.1% of the population in the North Jutland County.

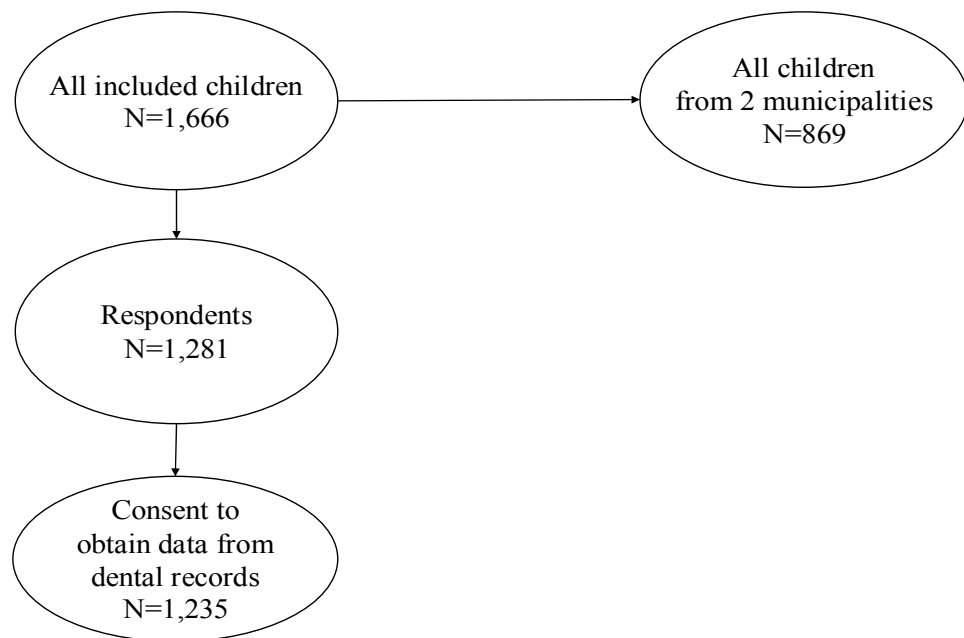
Study I and II were cross-sectional studies including all children in the study area between the age of 6 and 8 years in year 2001. From each of the four municipal administrations, we received a list of all children fulfilling these criteria, a total of 1,707 children. A number of 41 children were excluded by different reasons, thus a total of 1,666 children were included.

The questionnaire, including the CFSS-DS questionnaire, was posted to the parents of the children and, if necessary, two reminders were sent. Questionnaires with more than four missing CFSS-DS items were excluded from the analysis. The analysis in Study I and II were based on the following groups of children (Fig. 1):

- 1) All included children
 - a. Analysis of non-response in Study I and II
- 2) All included children in two of the municipalities
 - a. Additional analysis of non-response in Study I
- 3) All respondents
 - a. Estimate of prevalence of dental anxiety in Study I
- 4) Respondents with consent to obtain data from their dental records

- a. Estimate of prevalence of a history of behaviour management problems in Study I
- b. Association between asthma, ear problems, and dental anxiety in Study II

Figure 1. Flow-chart of the study population in Study I and II



In Study II, children with prescriptions for both inhaled beta2-agonists and inhaled corticosteroids during the past year were defined as the exposed group. The un-exposed group was defined as the children with no prescriptions for either perorale or inhaled beta2-agonists, or inhaled corticosteroids during the past 5 years.

Study III: Use of asthma-drugs and risk of dental caries among 5 to 7 year old Danish children: a cohort study

All children born in North Jutland County in 1993 and who were still living in the county at the end of 2000 were enrolled in this study ($N= 5,759$). The study was designed as a follow-up study. We extracted information on prescriptions on asthma-drugs from the age of 3 years until the age of 7 years (from 1 April 1996 to 31 December 2000). Children with prescriptions for both inhaled beta2-agonists and inhaled corticosteroids from the age of 3 to 7 years and from the age of 5 to 7 years were defined as the two exposed groups. The unexposed group was defined as the children with any prescriptions for either perorale or inhaled beta2-agonists, or inhaled corticosteroids. Since perorale β 2-agonists are used in the treatment of several different conditions, including asthmatic bronchitis, children receiving this type of medication either alone or in combination with one single other type of drug were not included as exposed in our analyses. Further, children who received only one single type of drug were also not included as exposed in the analyses, as they were not considered to have asthma.

We extracted information on dental caries in deciduous canines and molars and permanent teeth at age 5 years (1998) and at age 7 years (2000), and measured the incident caries between the age of 5 and 7 years of age in the two exposure groups and in the non-exposed group.

Statistics

Associations were examined by calculating prevalence odds ratios (OR) with their 95% confidence intervals (CI) (Study II) and relative risks (RR) with their 95% confidence

intervals (Study III). Multiple logistic regression analysis was used to adjust for potential confounders as age, gender, dental treatment sessions and toothache episodes (Study II).

Analysis of non-response

In Study I, we compared the non-respondents and the respondents with respect to age, gender, and municipality. Further, in two of the municipalities, the head of the public dental health provided us with the population data for dental caries, number of appointments, and number of treatment sessions. These data are collected as part of the administrative routines in the dental service. We therefore calculated the mean of decayed teeth, number of appointments, and number of treatment-sessions in the group of non-respondents. In Study II, we compared the proportion of children with asthma-drug use among respondents and non-respondents.

Results

Study I

A total of 73 children scored 38 or above on the CFSS-DS scale, resulting in a prevalence of 5.7% (95% CI: 4.6%-7.1%). The overall median CFSS-DS score was 22 (1st quartile 19; 3rd quartile 27), and the overall mean value of the CFSS-DS score was 23.8 (1 SD=7.1). We found a similar overall prevalence of dental anxiety among boys and girls. Among the 6-year-olds the prevalence was higher in girls; and among the 7-year-olds, the prevalence was higher among the boys. The prevalence was higher in the youngest children compared with the oldest children (Table 4).

A total of 1,235 children had data from both questionnaires and dental records. Of those, 584 had had dental treatments. Among these children the prevalence of a history of behaviour management problems was 37.2% (95% CI: 33.3%-41.1%). The prevalence of behaviour management problems increased from 25.8% in children with low CFSS-DS scores to 76.7% in children with high CFSS-DS scores.

Comparisons between respondents and non-respondents showed, that the mean number of appointments, missed appointments and decayed teeth were higher in the non-respondents.

Table 4. Descriptive statistics and the prevalence of the CFSS-DS scores according to age and gender.

Age and gender	Number	Median	1. quartile	3. quartile	Mean	SD	Per cent with CFSS-DS \geq 38	C.I. (95%)
6 years	Boys	204	23	19	24.4	7.3	5.4 %	(3.0-9.4)
	Girls	208	23	19	25.0	7.6	8.7 %	(5.5-13.3)
	Total	412	23	19	24.7	7.4	7.0 %	(4.9-9.9)
7 years	Boys	241	22	18	23.9	7.8	7.5%	(4.8-11.5)
	Girls	196	22	19	24.0	6.5	3.6 %	(1.7-7.2)
	Total	437	22	19	24.0	7.3	5.7 %	(3.9-8.3)
8 years	Boys	220	21	18	23.0	6.3	4.1 %	(2.2-7.6)
	Girls	212	21	18	22.8	6.6	4.7 %	(2.6-8.5)
	Total	432	21	18	22.9	6.5	4.4 %	(2.8-6.8)
Total	Boys	665	22	18	23.8	7.2	5.7 %	(4.2-7.7)
	Girls	616	22	19	23.9	7.0	5.7%	(4.1-7.8)
	Total	1281	22	19	23.8	7.1	5.7%	(4.6-7.1)

Study II

To obtain sufficient individuals with asthma, we used the CFSS-DS score of 31 as cut-off point. This cut-off point corresponded to the mean CFSS-DS score + 1 SD.

We identified 195 (15.8%) children with a CFSS-DS score of 31 or above 31. Nearly 5 % of them had had prescriptions for both inhaled beta2-agonists and inhaled corticosteroids during the past year, whereas 83.6% had had no prescriptions during the last 5 years. Approximately 20 % of the children had often had ear problems. Almost half of the children had experienced dental treatment, while about 7 % had had toothache.

Compared with children without asthma, we found an increased prevalence of dental anxiety in children with asthma (OR = 1.70; 95% CI: 0.90-3.22). We also found an increased prevalence of dental anxiety in children with frequent ear problems compared with children without ear problems (OR = 1.83; 95% CI: 1.20-2.80). Further, children who had experienced dental treatments had a decreased prevalence of dental anxiety compared with children who had never had dental treatments (OR = 0.67; 95% CI: 0.47-0.95), while children who had experienced toothache had a markedly increased prevalence of dental anxiety compared with children who had never had toothache (OR = 2.93; 95% CI: 1.69-5.03).

Comparisons between non-respondents and respondents showed that the prevalence of asthma-drug use was lower among the non-respondents.

Study III

Among the 5,759 children enrolled in the study, 4,920 had their dental data reported to the SCOR-database at both 5 and 7 years of age, and were defined as the cohort.

Between the age of 3 and 7 years, 3.4% of the children received prescriptions for both inhaled steroids and inhaled β_2 -agonists; between the age of 5 and 7 years, 6.0% received prescriptions for both inhaled steroids and inhaled β_2 -agonists.

Between the age of 3 and 7 years, 64.2% had not received any prescriptions of asthma-drugs. The corresponding figure between the age of 3 and 5 years was 69.6%, and between the age of 5 and 7 years was 81.2%.

One-third of the children (27.9%) had dental caries in the primary molars and canines at the age of 5 years and at the age of 7 years; half of the children (49.4%) had dental caries in the primary molars and canines. At the age of 7 years, 80.0% of the 1st permanent molars were reported as erupted. The proportion of erupted 1st permanent molars was the same, irrespective of the use of asthma-drugs. At the age of 5 years, only six children were reported to have caries in the permanent teeth. At the age of 7 years, 6.6% of the children had dental caries in permanent teeth.

We found no increased risk of dental caries in the deciduous dentition in children with asthma-drug use, irrespective of whether they had been exposed from 3 to 7 years (RR = 0.96; 95% CI: 0.80-1.15) or from 5 to 7 years (RR = 1.01; 95% CI: 0.89-1.16). The risk of dental caries in the permanent dentition was, on the other hand, increased in children with asthma-drug use both after exposure from 3 to 7 years (RR = 1.62; 95% CI: 1.03-2.56) and after exposure between 5 and 7 years (RR = 1.45; 95% CI: 0.99-2.11).

Discussion

Our studies showed that the prevalence of dental anxiety in children between the age of six and eight years was 5.7%, and that asthma and ear problems were associated with an increased prevalence of dental anxiety. Furthermore, in children with asthma-drug use between the age of three and seven years and between the age of five and seven years, we found an increased risk of caries in the permanent dentition while in the primary dentition, the risk was not increased.

The interpretation of the results will start with a discussion of the possible sources of bias in the studies followed by a discussion of our findings compared with other studies. The bias types discussed are selection bias, information bias, and confounding (61).

Study I

Methodological considerations

Table 5. Possible sources of bias in Study I

Selection bias	Information bias
Non response	Validity of the CFSS-DS Validity of data from dental records

Selection bias

In Study I and II, approximately one-fourth of the population was non-respondents. In Study I, our non-response analysis showed that the non-respondents had more missed dental appointments than the respondents, which could indicate that there were more children with dental anxiety among the non-respondents (4). This bias almost certainly caused an underestimation of the prevalence estimates of dental anxiety in Study I.

However a part of the non-response could be due to the recommendations from the Ethical Committee, which implied information on the purpose of the study and could have caused parents to children with healthy children not to return the questionnaire.

Information bias

The CFSS-DS scale is a short questionnaire; supposedly easy to understand and complete. For that reason it seemed unlikely that parents misunderstanding the questionnaire could be an important source of bias in this study. Prior to our study, the scale had been validated showing good agreement between the scale and acceptance of dental visits rated by dentists (19;20). Also our findings of agreement between a history of dental behaviour management problems and scores at the CFSS-DS scale supported the above-mentioned validity studies.

The data on behaviour management problems were obtained from dental records handwritten by several dentists, but very few problems were observed in reading the records. The review of the dental records showed that there was no consensus among the dentists of how and when to report dental behaviour management problems and there were great variations in the reporting. This resulted in a need for interpretation of some coded or short messages in the records. The data from the records were obtained without any knowledge of the child's CFSS-DS score.

Comparison with other studies

Our result on the prevalence of dental fear agreed well with previous findings from two populations, which are similar to the population in our study (3;26). Actually, our prevalence estimates were similar with the two others. In comparison with the studies

on children from Singapore and the Republic of China, the prevalence of dental anxiety in our study was lower, especially considering the higher cut-off point used in the study by Chellappah *et al.* (22). The reason for this could be cultural differences but probably also differences in dental health and experiences with painful treatments.

In another study from Denmark on older children, the prevalence of dental anxiety was higher (29). There is no obvious explanation for this disagreement, but one could be that the prevalence increases by age. If dental anxiety is a condition of long duration, incident cases may increase the prevalence by age. However, in studies including children of different ages (including our own), the mean CFSS-DS score according to parental reporting decreased by age (3;18;25). As the above-mentioned studies were based on parental reporting, there could be a discrepancy between parental reporting and self-reporting of CFSS-DS scores in older children. As mentioned earlier, the validity of parental-reported CFSS-DS scores on children between 4 and 12 years were compared with dentists' ratings of the behaviour of the children and were found to be valid (19;20). Parental rating of child dental anxiety is probably to a large extent based on the child's behaviour during previous dental visits. Therefore a high agreement should be expected between CFSS-DS and dentists' rating of the child's acceptance. ten Berge *et al.* also showed a declining trend in the association between parental CFSS-DS scores and dentist's rating with increasing age, indicating that older children tend to show cooperative behaviour although being dentally anxious (26). Probably some older children are able to hide their dental anxiety for both parents and dentists, and gradually the behavioural response to dental anxiety could be avoidance of dental visits. Consequently, in older children, further validation studies on both parental reporting and self-reporting of dental anxiety by the CFSS-DS scale are needed.

We found the same prevalence of dental anxiety in boys and girls, although some differences appeared between boys and girls at ages 6 and 7 years. Among the 6-year-olds, the girls had the highest prevalence, while the opposite was seen among the 7-year-olds. Other studies' references to the prevalence of dental anxiety revealed no specific prevalence estimates according to gender in the three age groups studied here; however the reason could be differences in psychological maturity between boys and girls.

Our study showed an association between high dental anxiety and a history of dental behaviour management problems among children having experienced dental treatment sessions, but this finding was not comparable to any other studies. On the other hand, it was not in disagreement with findings by ten Berge *et al.* and Klingberg *et al.*, who both found high agreements between prevalence of dental anxiety and prevalence of behaviour management problems (4;62).

Conclusion

Our study showed that parental-reported dental anxiety is a common condition in Danish children aged 6 to 8 years. However, the prevalence of children with CFSS-DS scores exceeding 38 seems to decline by age. The main limitation in Study I was the risk of an underestimation of the prevalence of dental anxiety as demonstrated by the non-response analysis.

Study II

Methodological considerations

A weakness of a cross-sectional study is the difficulty in establishing the causality.

However, if assuming that the risk factors came before the disease, the prevalence odds ratio could be a good approximation of the relative risk (63). A more appropriate design to examine the risk of dental anxiety in children with asthma and ear problems could be a follow-up study; however, this design would be very time consuming. And since asthma and ear problems in most children commence before the child's first dental visit it might be difficult to establish baseline data according to dental anxiety. For the same reason a case-control study would be complicated.

Table 6. Possible sources of bias in Study II

Selection bias	Information bias	Confounding
Non-response	Validity of data from the Pharmacoepidemiological Prescription Database	Socio economic factors
Completeness of the Pharmacoepidemiological Prescription Database	Validity of the CFSS-DS	Parental anxiety
	Validity of data on ear problems	
	Validity of data on confounders	

Selection bias

In Study II, the non-response analysis showed fewer children with prescriptions for asthma-drugs among the non-respondents, although the difference was small. There might be a higher prevalence of dental anxiety in children with asthma among the non-respondents, but our findings would probably not be seriously biased unless asthma-

drugs users among the non-respondents differed very much from the respondents in terms of level of dental anxiety. As far as ear problems are concerned, it is most likely that ear problems and dental anxiety are more frequent among the non-respondents. In that case our measure of association between ear problems and dental anxiety was probably biased toward a lower association. The Pharmacoepidemiological Prescription Database used in study II has been proved to be both complete and valid (59).

Information bias

Information bias could arise if children were misclassified according to asthma status. However, a validation study has shown that among people- who according to a prescription database- had received both inhaled beta2-agonists and inhaled corticosteroids, 80% had a definite asthma diagnosis, and 100% had symptoms of asthma according to their medical records (64). Therefore we assumed that children who received prescriptions for asthma-drugs actually had asthma.

In Study II, information bias might originate from misclassification of ear problems. We have no knowledge of the validity of parental reporting of ear problems, but the validity of parental reporting of treatment of ear diseases has proven to be high (65); therefore misclassification of ear problems were considered to be limited.

We also obtained information on some of the possible confounding variables from the dental records, but these data were of a more objective character as number of treatment sessions and number of decayed teeth; most likely unbiased.

Confounding

We evaluated a number of confounders, but there might still remain some others.

Comparison with other studies

We found an association between having had medical problems as asthma and ear problems and parental-reported dental anxiety scored by the CFSS-DS scale. This finding agrees well with previous findings (32;33;35;36;66).

Several explanations are possible. As general anxiety is associated with dental anxiety (4;22), the explanation for dental anxiety in asthmatic children could probably be the increased general anxiety found in asthmatics (67). Asthma attacks cause difficulties in breathing and it is reasonable to assume that asthmatics are more nervous in connection with dental treatments, which by nature can be considered as interfering with the respiration (68). When considering that cold air is a common asthma trigger (69), some asthmatics could fear cold air from the turbines used in preparation of a caries cavity. Another possible reason could be an increased prevalence of permanent molars with severe hypomineralisations in asthmatics, which may result in repeated painful treatment and subsequently a higher prevalence of dental anxiety (70). Most likely, and probably in particular relevant in the case of ear problems, many of the medical treatments that children have undergone have been painful; this could be another explanation for our findings. Since anxiety decreases the pain threshold, pain and anxiety often go hand-in-hand in a vicious circle (71). Therefore, it could be speculated that children with previous experiences of pain in connection with any medical or dental treatment have a decreased pain threshold when presenting for dental treatment, which could cause failure of the local analgesia. Children with ear problems, in particular, might have experienced physical restraint in connection with medical treatments.

The association between parental dental anxiety and children's dental anxiety has been demonstrated in several studies (4;66;72-74). Thus, maybe our findings may be explained, in part, by parents conveying their own anxiety to the child.

Young children who present with toothache often have extensive loss of tooth substance due to caries, pulpal infection, and periradicular infection of the tooth. The appropriate treatment is often extraction; however, due to the local infection, incomplete pain control could have caused pain during treatment, which is a well-known cause of dental anxiety (31;75-79). Our findings of the association between having had toothache and dental anxiety agreed well with others (73;80). However due to the cross-sectional design in our study, the association could be interpreted as if dental anxiety were the indirect cause of toothache because necessary dental visits have been postponed until toothache has forced the child and the parents to seek treatment.

Our findings of decreased risk of dental anxiety in the group of children who had had dental treatments agreed well with other findings. This may be interpreted by means of the "latent inhibition theory", *i.e.* if previous treatment experiences have been positive, it may protect against dental anxiety as proposed (70;76;81).

Conclusion

This study has shown, that children with medical diseases as asthma and ear problems have an increased risk of parental-reported dental anxiety. The main limitation is most probably that non-response could have caused selection bias. Further the cross sectional design prevents conclusions about the causality.

Study III

Methodological considerations

Table 7. Possible sources of bias in Study III

Selection bias	Information bias	Confounding
Completeness of the Pharmacoepidemiological Prescription Database	Validity of data from the Prescription Database	Eating habits Body Mass Index
Completeness of the SCOR database (15% were not reported to the SCOR-database at both 5 and 7 year of age)	Validity of data from the SCOR-database	Tooth brushing habits
	Misclassification of caries due to code 4 (fillings)	Mouth breathing
	Compliance	SES Eruption time of deciduous teeth Dental anxiety

Selection bias

As mentioned before, the Pharmacoepidemiological Prescription Database used in Study III has been proved to be both complete and valid (59). There was not complete follow-up because a small proportion of the included children were not reported to the SCOR-database both at the age of 5 and the age of 7 years. The reason is unknown, but most likely the dropout was unrelated to asthma-drug use and caries, and therefore would not cause selection bias.

Information bias

Information bias could arise if children were misclassified according to asthma-drug use, due to non-compliance or coding-failures in the Pharmacoepidemiological Prescription Database (82). In children with prescriptions for asthma-drugs, there might be non-compliance. However, as earlier mentioned, among people who according to a prescription database had received both inhaled beta2-agonists and inhaled

corticosteroids, between 80% and 100% had asthma (64). Therefore we can assume that children who reimbursed prescriptions of asthma-drugs actually have asthma. It is known that asthmatics improve their health by using asthma-drugs (83), which could indicate that the compliance is high. Further it is unlikely, that parents pay for asthma-drugs during two years or more if their child is not using the drugs. Children without prescriptions for asthma-drugs could have been drug-users by having the drugs delivered from relatives or friends. In the study on validity of parental-reported asthma-drug use (Appendix II), we found high validity values of parental-reporting of asthma-drug use during the past year, by comparing with prescriptions from the Pharmacoepidemiological Prescription Database, which could also be interpreted as a decreased risk of misclassification of asthma-drug users in this study.

Information bias in Study III could also arise from misclassification of caries. The SCOR-database has proved to be of high quality (84) and data on dental caries collected for public dental health purposes have been shown to compare well with data collected for research purposes, at least at an aggregated level (85). However, code 4 in the SCOR-database simply implies dental fillings, while the reason for placement of the filling is not specified. Fillings are sometimes made for reasons other than dental caries; one obvious reason is enamel mineralisation defects, which cannot be distinguished from fillings made due to caries. According to Jälevik *et al.*, the prevalence of severe enamel mineralisation defects due to hypomineralisation and possibly subsequent post-eruptive breakdown in permanent first molars requiring dental fillings was 6.5% in Swedish children (86). This could indicate that misclassification of caries might have influenced our estimates in Study III. If the prevalence of severe enamel defects is associated with asthma as indicated by a finding from Jälevik *et al.* (87), this

misclassification could have caused an overestimation of the association between asthma and dental caries in the permanent dentition.

Confounding

We have no information on confounding factors in this study. Since asthma-drugs are assumed among dentists, medical doctors and parents to increase the risk of caries, children with asthma-drug use might have received more intensive preventive services and might have brushed their teeth better and more frequently than non-asthmatics. On the other hand, the different results in terms of caries risk in the deciduous and permanent dentitions argue against this type of confounding. The same argument applies against other confounders such as eating habits, socio-economic variables, or dental anxiety.

The time of eruption of the permanent teeth might have been a confounder. We were unable to estimate the eruption time of the permanent teeth, but at the age of 7 years, the same proportion of the permanent teeth was erupted, irrespective of use of asthma-drugs. Further, in another study on the association between asthma and dental caries, no difference between the asthmatics and healthy controls was found in the timing of eruption (51), which also speaks against eruption time as confounder.

Comparisons with other studies

Our study was the only population-based follow-up study and we had valid exposure data for both the exposure group and the control group. Further, the study comprised the highest number of children exposed to both inhaled corticosteroids and inhaled beta2-

agonists, and the outcome data were obtained independently from exposure measurement.

For the period of the last 25 years since publication of the first study on the association between asthma and caries, treatment guidelines have changed from use of dinatriumcromoglicates and beta2-agonists (88), to where, at present, the guidelines recommend inhaled corticosteroids as the basic treatment and inhaled beta2-agonists as needed (6). Consequently, our choice of exposure definition reflected the present guidelines.

The analysis of caries in the permanent teeth in our study reflected no more than the period shortly after the teeth had erupted. This can be considered as an advantage in that it elucidated a short period of increased risk. Yet no other studies have examined the risk in newly erupted teeth, and therefore only our results according to the deciduous teeth were comparable to previous studies.

Our results were in agreement with findings of Hyyppa *et al.*, Bjerkeborn *et al.*, Ryberg *et al.* from 1987, Shulman *et al.*, and Meldrum *et al.* (38;48-50;53). However, our findings were in disagreement with most of the other studies (40;44-47;51;52). In none of these studies was a population-based study design used, and in two of the studies, only hospitalised children or children attended a centre for disabled children were studied (45;47). In the study by Holbrook *et al.*, the exposed children were those with use of antibiotics or asthma-drugs and it could not be rejected that the children with use of antibiotics could have contributed the largest part of the effect. In the study by Ryberg *et al.* from 1991, the mean number of decayed tooth surfaces in 21 children with asthma was compared with the mean number of decayed tooth surfaces in 21 children without asthma. One of the asthmatics in the study failed to secrete saliva, and

this individual was excluded from the analysis in the study concerning saliva, while the same individual was included in the analysis of caries. Because of the low number of study participants this individual had probably contributed very much to the mean number of decayed surfaces in the children with asthma. The studies by McDerra *et al.* and by Milano M were fairly similar concerning methods and results, and both studies disagreed with ours. They both delivered imprecise information on use of asthma-drugs; still the disagreement between their studies and ours is difficult to explain. In terms of information on drug-use, our study had similarities with the study by Kankaala *et al.*; yet in their study the mean length of drug-use was 14.4 months, whereas the follow-up period was 10 years. Consequently not all asthmatics could have been exposed to asthma-drug during the entire observation period, and probably therefore our findings were not in agreement with their findings of higher risk in the deciduous dentition and no risk in the permanent dentition.

The proposed biological explanations often mentioned in connection with higher caries risk in asthmatics seemed to have small clinical effect only (38-44).

In recent years, much attention had been paid to the higher risk of caries in the early eruption stage (89-91). Our findings of a higher caries risk in newly erupted permanent teeth could be in agreement with a higher caries risk in the early eruption stage if sufficient tooth brushing of the erupting molars is more difficult in asthmatics than in non-asthmatics. However, a more apparent explanation could be that long-term use of asthma-drugs during the time of tooth formation has influenced the mineralisation of the permanent teeth, as it is known that corticosteroids influence the calcium metabolism of bones (92). Further, use of inhaled corticosteroids in recommended doses in asthma treatment causes initial growth retardation, but no

decrease in adult height (93). This could lead to the speculation that inhaled corticosteroids can cause disturbances in tooth development, e.g. hypomineralisations, which in contrast to the effect on bone demineralisation are irreversible disturbances. Supporting this speculation is the findings by Jälevik *et al.*, who showed an association between asthma and hypomineralised first permanent molars (87). Their sample of exposed children was however very small. Whether our findings should be explained by primary caries lesions, by caries in hypomineralised teeth, or by misclassification of fillings made due to hypomineralisation and not caries, requires further studies to elucidate.

Conclusion

Our study could not find an increased risk of dental caries in the deciduous dentition after long-term asthma-drug use, while it indicated an increased risk of caries in the newly erupted permanent dentition during the period shortly after eruption. A limitation in Study III was the risk of information bias due to misclassification of dental caries in the permanent teeth. Further we have no data on confounding factors in this study.

Conclusions

The main conclusions of the work are

- in Danish children between the age of 6 and 8 years the prevalence of parental-reported child dental anxiety is 5.7 %;
- asthma, and ear problems seem to be associated with dental anxiety;
- use of asthma-drugs could not be shown to increase the risk of dental caries in the deciduous dentition, but seems to result in an increased risk of decayed or filled surfaces in the newly erupted permanent teeth.

Perspectives

The results presented in this thesis have both clinical and research perspectives. Among the clinical perspectives, it has been for the first time shown that dental anxiety is a common condition among young Danish children. Further, it has been shown that frequent health problems like asthma and ear problems seem to be risk factors for dental anxiety. This emphasise routinely collected information about the child's previous medical history for efficient planning of behaviour management in the dental services for children. Toothache-and possibly any other pain-provoking experience during dental treatment- is a risk factor for dental anxiety, too. Therefore attempts to avoid toothache as well as any other painful experiences in children are important *e.g.* early prevention, early diagnosis, and good pain control. Furthermore, children with previous experiences of toothache might benefit from a treatment programme that includes a number of dental treatment sessions where only simple non-invasive procedures like prophylaxis are carried out.

In order to further determine risk factors for dental anxiety or the prognosis of different treatment strategies for dental anxiety, repeated measurements of dental anxiety in children are needed. The Children's Fear Survey Schedule-Dental Subscale (CFSS-DS) is an important and valuable instrument to measure dental anxiety in children. However the association between the children's age and the validity of parental reporting on the CFSS-DS scale should be further investigated. Another valuable source of data on dental anxiety is the dental records. It should therefore be underlined that ratings of the children's acceptance of dental care in connection with each dental visit would provide very useful data for research purposes, in particular considering the relatively low response rate in questionnaire-based surveys.

Children with long-term asthma-drug use seem to have an increased risk of dental caries in the permanent teeth shortly after eruption, which should be considered in planning the recall intervals between the dental examinations in the age groups when permanent teeth erupt. Further studies are needed to examine whether asthma-drug use and disturbances of the mineralisation processes in the permanent teeth are associated.

Summary

The aims of this thesis were to examine the prevalence of dental anxiety in children (Study I), and the association between asthma and ear problems and prevalence of dental anxiety (Study II), and to examine the risk of dental caries in children with asthma-drug use (Study III).

Study I and II were based on all children at ages 6, 7, and 8 years, living in four municipalities in the North Jutland County in year 2001. Data on the children's dental anxiety was compiled as parental reporting on the Children's Fear Survey Schedule-Dental Subscale. We found that 5.7% of the children were dentally anxious according to our definition. The main limitation of Study I was the possibility of underestimation of the prevalence of dental anxiety, since the response rate was only 76.9%.

In Study II, besides the data on dental anxiety, we extracted data on asthma-drug use from the Pharmacoepidemiological Prescription Database, data on ear problems from parental answered questionnaires, and data on confounders from the children's dental records. We found that use of asthma-drugs and a history of frequent ear problems were associated with dental anxiety.

Study III was based on all children born in 1993 in North Jutland County, Denmark, who were still alive in the County in 2000 and who had dental reporting at age 5 years and 7 seven years to the SCOR-database maintained by the Danish National Board of Health. Data on asthma-drug use between the age of 3 and 7 years were extracted from the Pharmacoepidemiological Prescription Database in North Jutland. Data on dental caries in deciduous and permanent teeth were extracted from the SCOR-database. When comparing children with asthma-drug use with children without asthma-drug use, we found no increased risk of dental caries in the deciduous teeth,

while in the newly erupted permanent teeth, the risk was increased. The limitations of Study III were the possibility of misclassification of dental fillings due to other reasons than caries, and the lack of confounding information. Therefore, further studies are needed to address these limitations.

Dansk resumé

Formålene med afhandlingen var

- at estimere prævalensen af tandlægeangst blandt børn (Studie I),
- at estimere associationen mellem astma, øreproblemer og tandlægeangst (Studie II), samt
- at estimere risikoen for caries blandt børn, der brugte astma medicin (Studie III).

Studie I og II blev baseret på alle seks-, syv- og otteårige børn, bosiddende i fire kommuner i Nordjyllands Amt i 2001. Forældrene til disse børn besvarede på børnenes vegne spørgeskemaet ”Children’s Fear Survey Schedule-Dental Subscale”, hvorved vi fik data vedrørende børnenes tandlægeangst. Studiet viste, at 5.7 % af børnene havde tandlægeangst. Den væsentligste begrænsning i dette studie var den lave svardeltagelse (76.9 %), som kan have betydet en underestimation af prævalensen.

I studie II anvendte vi data vedrørende astma medicin fra den Farmakoepidemiologiske Receptdatabase i Nordjyllands Amt, data vedrørende confoundere fra børnenes tandlægejournal, samt data vedrørende tandlægeangst og øreproblemer fra det forældrebesvarede spørgeskema. Studiet viste at astma og øreproblemer var associerede med tandlægeangst.

Studie III blev baseret på alle børn født i Nordjyllands Amt i 1993, som stadig var bosiddende i amtet i 2000 og som havde fået foretaget caries indberetninger til Sundhedsstyrelsens SCOR-database både som femårige og som syvårige. Vi anvendte data vedrørende børnenes brug af astma medicin i perioden fra de var tre år til de var syv år. Disse data blev udtrukket fra den Farmakoepidemiologiske Receptdatabase i Nordjyllands Amt. Desuden fik vi udtrukket caries data fra SCOR databasen på både de primære og de permanente tænder. Sammenlignet med børn uden brug af astma medicin

fandt vi ingen øget risiko for caries i de primære tænder blandt børn med brug af astma medicin, hvorimod risikoen var forøget i de nyligt frembrudte permanente tænder. Den væsentligste begrænsning i Studie III kan have været muligheden for misklassifikation af tandfyldninger, der er blevet lagt af andre årsager end caries. Desuden var det en begrænsning, at vi i dette studie ikke havde mulighed for at kontrollere for confoundere. Det er nødvendigt med yderligere studier for at undersøge betydningen af disse begrænsninger.

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Appendix I

Nedenfor er beskrevet en række situationer.

Prøv at angive, hvor bange dit barn ville blive i den enkelte situation. Gå ud fra den alder, dit barn har nu. Hvis dit barn ikke har prøvet alle de situationer, der står på listen, så prøv at forestille dig, hvordan barnet ville reagere, hvis det blev udsat for situationen.

Hvor bange er dit barn for?:

	Slet ikke bange	En lille smule bange	Bange	Temmelig bange	Meget bange
1. Tandlæger	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Læger	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Indsprøjtning (stik)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. At få munden undersøgt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. At skulle åbne munden hos tandlægen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. At et fremmed menneske rører ved hende/ham	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. At en anden person ser på hende/ham	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. At tandlægen borer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. At se på, at en anden får boret i tænderne	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Lyden af tandlægens boremaskine	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. At nogen putter instrumenter i munden på hende/ham	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. At få noget galt i halsen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. At skulle på sygehuset	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. Folk i hvide kitler	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. At få pudset tænderne hos tandlægen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Appendix II

Validity of parental-reported questionnaire data on Danish children's use of asthma-drugs: comparison with a population-based prescription database

Pia Wogelius, Sven Poulsen, Henrik Toft Sørensen

Introduction The background of this study is the frequent use of parental reporting of children's asthma-drug use in both medical and dental epidemiological literature.

Although important for the validity and interpretation of these studies we are unaware of any validation studies on parental reporting of children's asthma-drug use.

Aim To examine the validity estimated as the sensitivity, the specificity and the predictive values of questionnaire-based parental reporting on Danish children's use of asthma-drugs.

Design Within a population-based cross-sectional study we compared parental reporting on their children's asthma-drug use with Health Insurance data on prescriptions on inhaled beta2-agonists, inhaled corticosteroids, or both.

Setting Four municipalities in North Jutland County, Denmark.

Participants At the end of 2001, parents of 1,273 children between the age of 6 and 8 years completed a questionnaire about their children's asthma-drug use during the past 12 months.

Results Table 1 shows the number of children with inhaled asthma-drugs according to the Pharmacoepidemiological Prescription Database in different categories of questionnaire answers on the question on asthma-drug use. Ninety-five (7.5%) children had received prescriptions for either inhaled beta2-agonists, or inhaled corticosteroids, or both during the past 14 months.

Table 1. Distribution of 1,273 children according to parental-reported information on asthma-drug use during the past 12 months and database information on prescriptions during the past 14 months.

Parental-reported asthma-drug use	Database information of inhaled beta2-agonists or corticosteroids		Total
	Yes	No	
”Every day”	55	3	58
”Often”	9	2	11
”Sometimes”	23	43	66
”Never”	8	1,130	1,138
Total	95	1,178	1,278

The sensitivity increased from 57.9% for the answer “Every day” to 91.6% when the answers “Every day,” “Often,” and “”Sometimes” were combined (Table 2). The positive predictive value increased from 64.4% according to the combined answer “Every day, often, and sometimes” to 94.8% according to the answer “Every day.” The specificity and the negative predictive values both exceeded 95% for all answers.

Table 2. The sensitivity, the specificity, and the predictive values of parental reporting on asthma-drug use in previous 12 months with database information on inhaled corticosteroids, or inhaled beta2-agonists, or both in previous 14 months as reference standard.

Parents-reported asthma-drug use	Sensitivity (%) (95% C.I.)	Specificity (%) (95% C.I.)	Positive Predictive Value (%) (95% C.I.)	Negative Predictive Value (%) (95% C.I.)
Every day	57.9 (47.8-67.3)	99.7 (99.3-99.9)	94.8 (85.9-98.2)	96.7 (95.5-97.6)
Every day and Often	67.4 (57.4-76.0)	99.6 (99.0-99.8)	92.8 (84.1-96.9)	97.4 (96.4-98.2)
Every day, Often and Sometimes	91.6 (84.3-95.7)	95.9 (94.6-96.9)	64.4 (56.1-72.0)	99.3 (98.6-99.6)

Conclusions Questionnaire-based parental reporting on children’s one-year asthma-drug use seems to be valid in epidemiological research.