

Children and adolescents with externalizing behavior in dental care

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UNIVERSITY OF GOTHENBURG

Gothenburg 2017

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ISBN 978-91-629-0153-0

Printed in Gothenburg, Sweden 2017
Ineko AB, Gothenburg, Sweden

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ABSTRACT

Aim: To study children/adolescents with externalizing behavior and a subgroup diagnosed ADHD, regarding oral health, oral health behavior, and the parents' evaluation on their child's oral health and dental experience.

Patients and Methods: Study Groups 1 & 2 consisted of families of 228 children (10-13 years), who participated in a parental training program. The parents answered the *Strengths and Difficulties Questionnaire*, *Disruptive Behavior Disorder Rating Scale*, *Parental Knowledge and Monitoring Scale*, and *Family Warmth and Family Conflict*, and evaluated the child's oral health and dental care. The children estimated dental fear via CFSS-DS and indicated diet and tooth brushing habits. Data, from dental records concerning caries, caries risks, dental injuries, dental fear, and behavior management problems, were compared to a control group. The study group was divided into low and elevated caries risk. Behavioral characteristics and family structure were studied. Study Group 3 consisted of families of children/adolescents with ADHD, 5-19 years of age, from the Child Neuropsychiatric Clinic in Gothenburg. The parents filled out forms regarding dental care, oral hygiene, and dietary habits. Dental records on dental care, caries, and dental injuries were obtained.

Results: There was no difference in caries prevalence in children/adolescents with externalizing behavior, compared to controls. Children/adolescents with ADHD showed a high caries prevalence, compared with data from Region of Västra Götaland (RVG). There were more children with an elevated risk of caries among the children with externalizing behavior, compared to children in RVG. These children with an elevated caries risk showed higher levels of conduct problems, hyperactivity and impulsivity, compared to children with low caries risk. It was more common for children with externalizing behavior

and children with ADHD to brush their teeth less than twice a day. Both of these groups of children preferred sweet drinks when thirsty. Children with externalizing behavior and children with ADHD had a high prevalence of dental injuries. There were no differences regarding the parents' assessment of oral health in the children with externalizing behavior, compared to controls. There was no difference regarding the parents' evaluation of dental care for the children with externalizing behavior, compared to controls. These children with an elevated caries risk had a higher risk of developing dental fear. Few parents of children/adolescents with ADHD perceived their child as having dental fear. The parents of children/adolescents with ADHD experienced shortcomings regarding neuropsychiatric knowledge, treatment, and patience from dental staff.

Conclusions: Children with externalizing behavior, and children diagnosed ADHD, exhibited differences in oral health and had an increased risk behavior.

Keywords: ADHD, adolescents, behavioral characteristics, caries, children, dental care, dental trauma, externalizing behavior, oral health, neuropsychiatric disorders, parental attitudes, risk behavior.

ISBN: 978-91-629-0153-0

SAMMANFATTNING PÅ SVENSKA

Syfte: att studera barn och ungdomar med utagerande beteende och en subgrupp med diagnosticerad ADHD avseende oral hälsa, oralt hälsobeteende, föräldrars syn på barnets orala hälsa och tandvårdserfarenhet.

Patienter och metod: Studiegrupp 1 & 2 bestod av familjer till 228 barn (10-13 år) som deltog i ett familjestödsprogram. Föräldrarna fyllde i formulären *Strengths and Difficulties Questionnaire*, *Disruptive Behaviour Disorder rating scale*, *Parental Knowledge and Monitoring Scale*, *Family Warmth and Family Conflict* och värderade barnets munhälsa och tandvård. Barnet skattade tandvårdsrädsla via CFSS-DS samt angav kost- och tandborstvanor. Data från tandvårdsjournal gällande karies, kariesrisk, tandskador, tandvårdsrädsla och behandlingsproblem jämfördes med en kontrollgrupp. Studiegruppen delades i; låg och förhöjd kariesrisk. Beteendekarakteristika och familjestruktur studerades. Studiegrupp 3 bestod av familjer till barn/ungdomar med ADHD, 5-19 år från Barnneuropsykiatriska kliniken, Göteborg. Föräldrarna fyllde i formulär om tandvård, munhygien och kostvanor. Journaldata om tandvård, karies och tandskador inhämtades.

Resultat: Det var ingen skillnad i kariesprevalens hos barn/ungdomar med utagerande beteende jämfört med kontrollbarn. Barn/ungdomar med ADHD uppvisade en hög kariesprevalens jämfört med data från Västra Götalandsregionen (VGR). Det fanns fler barn med förhöjd kariesrisk bland utagerande barn jämfört med barn i VGR. Utagerande barn med förhöjd kariesrisk uppvisade högre grad av utagerande, hyperaktivitet och impulsivitet i jämförelse med barn med låg karies risk. Det var vanligare att barn med utagerande beteende och ADHD borstade tänderna mindre än 2ggr/dag. Både utagerande barn och barn med ADHD föredrog söt dryck vid törst. Barn med utagerande beteende och de med ADHD hade hög förekomst av tandskador. Det var inga skillnader gällande föräldrarnas värdering av orala hälsan hos utagerande barn i förhållande till kontrollbarn. Det fanns inga skillnader gällande föräldrarnas värdering av tandvården hos utagerande barn i förhållande till kontrollbarn. Utagerande barn med förhöjd kariesrisk hade högre risk att utveckla tandvårdsrädsla. Få föräldrar till barn/ungdomar med ADHD upplevde barnet som tandvårdsrädd. Föräldrarna till barn/ungdomar med ADHD upplevde brister i neuropsykiatrisk kunskap, bemötande och tålamod hos tandvårdspersonalen.

Konklusion: Barn/ungdomar med utagerande beteende och diagnosticerad ADHD uppvisade skillnader i oral hälsa och hade ett ökat riskbeteende.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

- I. Staberg M, Norén JG, Gahnberg L, Ghaderi A, Kadesjö C, Robertson A. Oral health and oral health risk behavior in children with and without externalizing behavior problems. Submitted for publication in *Eur Arch Paediatr Dent*.
- II. Staberg M, Norén JG, Gahnberg L, Ghaderi A, Kadesjö C, Robertson A. Behavioural characteristics in externalising children with low and elevated risk for caries. *Eur Arch Paediatr Dent*. 2016;17:475-484.
- III. Staberg M, Norén JG, Johnson M, Kopp S, Robertson A. Oral health and dental care among children and adolescents with ADHD - A retrospective and exploratory study. *JDOH* 2015;15:5-13.
- IV. Staberg M, Norén JG, Johnson M, Kopp S, Robertson A. Parental attitudes and experiences of dental care in children and adolescents with ADHD - a questionnaire study. *Swed Dent J*. 2014;38:93-100.

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ABBREVIATIONS

ADHD	Attention Deficit Hyperactivity Disorder (ADHD)
APA	American Psychiatric Association
ASD	Autism Spectrum Disorder
BH-c	Bonferroni-Holm correction
BNK	Gothenburg Child Neuropsychiatric Clinic
CA	Caries activity
CBT	Cognitive Behavioral Therapy
CD	Conduct Disorder
CDAS	Corah Dental Anxiety Scale
CFSS-DS	Children's Fear Survey Schedule-Dental Subscale
CI	Confidence Interval
Comet	COmmunication METHod
DBD	Disruptive Behavior Disorder
DBMP	Dental Behavior Management Problems
DCD	Developmental Coordination disorder
deft	decayed, extracted, filled - primary teeth
DFA	Dental Fear and Anxiety
DH	Dietary habits
DMFS	Decayed, Missing, Filled - permanent tooth surfaces
DMFT	Decayed, Missing, Filled - permanent teeth
DR	Dental records
DSM	Diagnostic and Statistical Manual of Mental Disorders
EAS	Emotionality, Activity, and Sociability
EASI	Emotionality, Activity, Sociability and Impulsivity
EBP	Externalizing behavior problems
ER	Elevated risk
FCU	Family check-up

FDI	“Fédération dentaire internationale” World Dental Federation
FW/FC	Family Warmth and Family Conflict
GUI	General Unintentional Injuries
ICD	International Statistical Classification of Diseases and Related Health Problems
i-Comet	The online internet version of Comet
LA	Local anesthetics
LR	Low risk
MC-app	Missed and cancelled appointments
OCD	Obsessive Compulsive Disorder
ODD	Oppositional Defiant Disorder
OH	Oral hygiene
OR	Odds ratio
PAL 2	Project Alliance 2 (school-based prevention trials)
PDS	Public Dental Service
PKMS	Parental Knowledge and Monitoring Scale
PMT	Parent Management Training
R2	Computerized algorithm-based caries risk system
RVG	Region of Västra Götaland
SD	Standard Deviation
SDQ	Strengths and Difficulties Questionnaire
SiC	Significant Caries Index
TDI	Traumatic Dental Injuries
TNBHW	The National Board of Health and Welfare
TW-1a	Treatments without local anesthesia
VGR	Västra Götalandsregionen
WHO	World Health Organization

1 INTRODUCTION

1.1 Mental health

The Public Health Agency of Sweden has a particular mission to build, develop and coordinate national efforts, aiming to promote mental health and prevent mental illness, in the population [1]. Most children and adults state they have good or very good mental and physical health, although some have recurring mental and somatic complaints [2].

According to results of the Swedish survey, *Schoolchildren's health habits 2013/2014*, based on information from 11, 13 and 15-year-olds, the majority of the children consider themselves to have good health [3]. However, with increasing age, the self-rated reported health becomes lower, with more mental and somatic complaints. Moreover, the gap between boys and girls widens with increased age, the latter claiming to have poorer health and more somatic complaints. During the 1980s and 1990s, the self-reported psychological and somatic symptoms increased among the 15-year-olds, but have since decreased. Currently, the claims have increased, especially among 13 and 15-year-old girls. In Sweden, and 40 other participating countries, the survey is conducted every four years within the framework of the international research project, *Health Behavior in School-aged Children*, Nearly 8,000 Swedish students answered the survey in January 2014, representing a response rate of 69% [3].

1.2 Classification of mental disorders

For the classification of mental disorders, clinicians and researchers use the Diagnostic and Statistical Manual of Mental Disorders (DSM), published by the American Psychiatric Association (APA). Several revisions have been made since its first publication in 1952 (DSM-I). The DSM is now in its fifth edition, DSM-5, published in May 2013 [4]. An alternative is the International Statistical Classification of Diseases and Related Health Problems (ICD) [5], published by the World Health Organization (WHO), who is stricter in the case definition of Attention Deficit Hyperactivity Disorder (ADHD) than the DSM-IV [6].

A revision in the criteria for disruptive behavior disorders took place in the transition from DSM-IV (APA, 2000) to DSM-5 (APA, 2013). In DSM-5,

externalizing behavior problems in children include the diagnoses Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD), as well as other diagnoses that will not be further explored here. Attention Deficit Hyperactivity Disorder (ADHD) has shifted in DSM-5, from a disruptive, impulse-control and conduct disorder category, to a neurodevelopmental disorder, to reflect brain developmental correlates associated with ADHD [4].

1.3 Externalizing behavior

Externalizing Behavior Problems (EBP) is a wide spectrum or comprehensive concept with many dimensions [7]. EBP includes attention deficit hyperactivity disorder problems (hyperactivity/impulsivity, inattention), as well as disruptive, oppositional, aggressive, and conduct disorder behavior [8]. Subsequently, children with externalizing behavior problems constitute a heterogeneous group of children referred to having behavior problems manifested in the child's outward behavior, and reflected in the child's negative acting-out toward the external environment [8]. Externalizing behaviors can thus have a different expression throughout the child's developmental stages [9].

A common way to obtain an understanding of a child's problem is to use a categorical approach, as in diagnostic manuals, which identify categories such as Attention Deficit Hyperactivity Disorder (ADHD), Conduct Disorder (CD), or Oppositional Defiant Disorder (ODD). This means a child will either fulfill the criteria for a diagnosis or not.

Another way is to evaluate the symptom variation, represented as dimensional variables, in which the severity of the disturbance ranges from none to severe, relating to externalizing behavior problems (EBP) and conduct problems. An advantage with the dimensional approach regarding EBP is that it allows for scores ranging from low to high, on any given dimension. The Disruptive Behavior Disorder (DBD) rating scale [10] can be used to acquire both dimensional and categorical information, here used in a dimensional way. The subscales on the Strengths and Difficulties Questionnaire (SDQ) [11] are also used in a dimensional way in this study.

1.3.1 Attention Deficit Hyperactivity Disorder (ADHD)

Attention Deficit Hyperactivity Disorder (ADHD) is a childhood-onset, neurodevelopmental disorder characterized by a pattern of impulsivity,

inattention and hyperactivity, associated with significant functional impairment [4, 6, 12].

According to DSM-IV [6], the diagnosis of ADHD includes three clinical subgroups; (i) Combined type, with both inattention and hyperactivity symptoms; (ii) predominantly inattentive type; and (iii) predominantly hyperactive-impulsive type. The symptoms interfere with functioning or development, and symptoms should be presented in two or more settings (e.g., at home, school, or work), and have a negative impact directly on social, academic or occupational functioning. The DSM-5 [4] includes the same symptom criteria as DSM-IV, but uses the term *presentations* instead of subtypes, since subtypes are unstable and may change over time, with age. In DSM-5, the age for the first appearance of symptoms has been amended to 12 years instead of 7 years, as in the DSM-IV criteria [4].

Inattention can be manifested as a lack of persistence, having difficulty sustaining focus, and being disorganized. Hyperactivity refers to excessive motor activity (in adults it may manifest as restlessness). Impulsivity refers to actions that occur at the moment, but also a desire of immediate rewards and decisions, without consideration of consequences [4].

1.3.2 Prevalence, gender, and comorbidity of ADHD

Reports from different parts of the world indicate a prevalence of ADHD of around 5% among children and adolescents [13, 14]. Previously, ADHD has been associated with a disorder of childhood, but the persistence of ADHD symptoms, across the lifespan from childhood to old age, has been shown in a Swedish population-based study in adults, aged 65 to 80 years [15]. The prevalence in adults is between 2.5-4.4% [16-18].

ADHD is more common in boys than in girls, with males being 2-4 times more likely to meet full DSM-IV criteria for ADHD than females [19, 20]. Girls with ADHD have a later referral age, compared to boys [21, 22], and even if they have the same severity of ADHD symptoms, boys have a five times higher chance to be referred, compared to girls [23]. It has been suggested that ADHD may have been misdiagnosed or underdiagnosed in girls due to different manifestations [24, 25]. The differences have been explained by ADHD girls having lower levels of hyperactivity and other externalizing behaviors, since girls have more inattention problems, which may be more difficult to detect [26]. In recent years, the increased research on ADHD girls has resulted in a shift, which clearly identifies ADHD as not being a predominantly male disorder [27].

Pure ADHD is rare and comorbidity seems to be the rule rather than the exception (87 % of children with ADHD have one or more diagnoses, and 67% have at least two comorbid diagnoses) [28]. Girls and boys with ADHD have similar comorbidity; whether defined in general, ADHD plus at least one other diagnosis [29].

1.3.3 Conduct Disorder (CD)

The diagnosis of CD is a repetitive and persistent pattern of behavior in which the basic rights of others, or major age-appropriate societal norms or rules, are violated. This includes bullying, threatening or intimidating others, and the destruction of property [4].

1.3.4 Oppositional Defiant Disorder (ODD)

ODD is a pattern of negativistic, hostile, and defiant behavior including arguing with adults, actively defying or refusing to comply with adult requests or rules, or being touchy or easily annoyed by others [4].

1.4 Intervention programs

In 2007, The National Board of Health and Welfare (*Socialstyrelsen*), which is a government agency in Sweden under the Ministry of Health and Social affairs, was commissioned by the Swedish government to establish a national development center for early interventions for children at risk of more difficult and unhealthy psychological behavior. The commission was to collect, coordinate, arrange and educate on effective methods to discover, prevent and implement evidence-based early interventions for children with unhealthy behavior. The first step was to investigate the methods used for children at risk, and by whom. The purpose was also to initiate evaluations supported with knowledge, in order to implement evidence-based methods, and create multi-professional educational opportunities [30, 31].

In Sweden, approximately 100 different programs, mainly to prevent mental illness of the aggressive type in children, were found. In Gothenburg, Sweden, the Family check-up (FCU) and Comet (COmmunication METHod) were chosen for a family-centered intervention, developed from the Parent Management Training program (PMT) for high-risk youth. The FCU is described in detail by Dishion and Stormshak [32], and is based on health maintenance, targeting parental involvement and motivation to improve parenting practices. A list of family-centered interventions is offered to support effective family management practices, and promote the well-being and

improved behavior of children and adolescents [33]. The FCU has been shown to reduce teacher-reported risk behavior, arrest rates, substance abuse, depression, and antisocial behavior [34-37]. Comet is a Swedish PMT program [38], from which the online version i-Comet was derived [39]. The families were randomized to one of these two programs. The Institute of Odontology, at the University of Gothenburg, was invited to participate in this comprehensive study regarding oral health.

1.5 The Gothenburg Child Neuropsychiatric Clinic

The Gothenburg Child Neuropsychiatric Clinic is a regional clinic for Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), and other neuropsychiatric disorders. Many children and adolescents are referred to the Specialist Clinic of Pediatric Dentistry, at the Public Dental Service, for dental behavior management problems. These children often have one of the above-mentioned diagnoses. A well-functioning cooperation between the Gothenburg Child Neuropsychiatric Clinic and the Specialist Clinic of Pediatric Dentistry has been established.

1.6 Dental care system in Sweden

Dental services in Sweden are regulated through laws and government regulations, including the National Dental Service Act. In addition, the National Board of Health and Welfare sets dental care standards through rules and general guidelines. Dental care is part of the health care system; therefore, most of the laws regulating health care also apply to dental care [40].

The County Councils in Sweden have the planning responsibility for all children's dental care. Everyone registered as a resident in Sweden is entitled to free dental care; up to and including the end of the year (December 31) they turn 21. [41]. Approximately 95-98% of all children receive dental health care from the Public Dental Service, but there are also private alternatives [42].

Despite the good intentions of dentistry for children and adolescents, caries, traumatic dental injuries, and the development of dental fear may occur, which can affect the oral health. Children and adolescents with externalizing behavior problems are a vulnerable group for these conditions.

1.7 Oral health

Oral health is an essential component of health throughout life, but the concept of oral health has changed over time, as well as the concept of general health. In 1946, the World Health Organization (WHO) established that health is “*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*” [43].

In 2003, a WHO Report concluded that oral health should be integrated with general health and is essential for well-being [44]. Parallel to this report, a Swedish consensus conference also formulated a definition for oral health: “*Oral health is a part of general health and contributes to physical, mental and social well-being with experienced and satisfactory oral functions in relation to the individual’s conditions and absence of diseases*” [45].

In 2012, oral health was defined in the WHO fact sheet No. 318: “*Oral health is essential to general health and quality of life. It is a state of being free from mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual’s capacity in biting, chewing, smiling, speaking, and psychosocial well-being*” [46].

In 2016, a new definition of oral health was approved by the FDI World Dental Federation General Assembly: “*Oral health is multifaceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and diseases of the craniofacial complex. Further, it is a fundamental component of health and physical and mental well-being. It exists along a continuum influenced by the values and attitudes of people and communities. It reflects the physiological, social, and psychological attributes that are essential to the quality of life. It is influenced by the person’s changing experiences, perceptions, expectations, and ability to adapt to circumstances*” [47].

According to WHO, Health topics webpage (2017); Oral health is “*a state of being free from chronic mouth and facial pain, oral and throat cancer, oral sores, birth defects such as cleft lip and palate, periodontal (gum) disease, tooth decay and tooth loss, and other diseases and disorders that affect the oral cavity. Risk factors for oral diseases include unhealthy diet, tobacco use, harmful alcohol use, and poor oral hygiene*” [48].

Today, the concept of oral health is less focused on the professionals' measure of illness and disease, and more attentive to the subject's own feelings of well-being and quality of life. Both psychological and social aspects with appearance, self-esteem, intimacy, communication, and social interactions are considered. However, parental perceptions of oral health and attitudes to dental care have been little studied. One Swedish study showed that oral health was not top of the agenda for parents of children with cognitive and/or physical disabilities [49].

1.7.1 Dental caries

Dental caries is one of the most prevalent chronic diseases among children and adolescents and may influence both oral and general health. Caries has a multifactorial etiology with an interaction, over-time, between acid-producing bacteria (plaque), fermentable carbohydrates (diet), and host factors (teeth and saliva). To predict the risk for dental caries, several risk factors can be detected, such as caries experience, high number of cariogenic bacteria, poor oral hygiene, inadequate saliva flow, and insufficient fluoride exposure, but also social and behavioral factors [50]. There is an increased risk of future caries development in children with an early onset caries experience [51].

According to epidemiological data from the National Board of Health and Welfare, 37 % of 19-year-olds were caries-free, and the percentage continues to rise. There was no difference between girls and boys. Furthermore, 70 % of the surveyed 19-year-olds had no approximal caries [52]. The World Health Organization (WHO) targets that 12-year-olds in Europe, on average, should have a maximum of 1.5 carious teeth (DFT, decayed-, filled- teeth) by 2020. Sweden crossed that border in 1995, and the results in 2015 were DFT 0.70. This indicates that Swedish 12-year-olds have good dental health. However, good dental health is not evenly distributed among the children in this age group since there still is a group of children with many decayed teeth. The WHO have introduced an index, the Significant Caries Index (SiC), that represents the calculated mean DFT for the third of the population with the most number of caries lesions. In 2015, the SiC-index in Sweden was 2.08, with the proportion of caries-free 6-year-olds being 75%. The WHO target for Europe is 80% caries-free 6-year-olds by 2020 [52].

An important distinction is that dental caries in children is mostly preventable. The challenge is to understand why dental caries is still highly prevalent and why some individuals and groups have higher levels of caries experience than others.

1.7.2 Dental caries in children and adolescents with externalizing behavior

The dental literature is inconclusive regarding dental caries and ADHD. Some studies have found higher DMFS scores among children with ADHD, while others did not find any differences. The question is if the ADHD diagnosis itself or other risk factors, such as less amount of saliva caused by medication or poor oral health behavior (less frequent tooth brushing/dietary habits), contributes to the caries development. In a case-control study among children 11-13 years of age, it was found that children with ADHD had 12 times the odds of belonging to the high disease group ($DMFT \geq 5$), compared to controls. However, the confidence interval was very wide, indicating some uncertainty [53].

Grooms *et al.* suggested children with ADHD (6-10 years of age) had more enamel caries in the primary and permanent dentition, and a higher prevalence of total caries experience, compared to controls. No difference in whole saliva production between ADHD children and controls was found [54].

In 11-year-old children with ADHD, higher caries prevalence and more BMP were reported in a retrospective study [55]. Higher caries prevalence in the primary dentition, but not in the permanent dentition, has also been reported in children with ADHD [56]. A Swedish study showed a higher prevalence of caries, as well as a higher caries incidence, in 17-year-old adolescents with ADHD [57]. In a large cohort of German children, a relationship between abnormal rates of hyperactivity/inattention symptoms and non-cavitated caries lesions was found in 10-year-old children characterized by the SDQ instrument [58]. In a review regarding ADHD and dental caries, Rosenberg *et al.* discussed the higher caries prevalence among these groups of children, but came to the conclusion that the side-effects of pharmacological treatment, with a decreased saliva flow, was not responsible for the caries development [59]. Children from Iran, with ODD/ADHD, showed higher DMFT/dmft scores compared to controls [60].

In a Swedish study of 13-year-old children with ADHD, no higher caries prevalence was found, despite poor oral health behavior, compared to controls [61]. In 2008, Bimstein *et al.* found a higher number of filled or decayed teeth in children with ADHD, compared to controls, but this was not statistically significant [62]. When the oral health status, saliva flow rate, and saliva quality were examined in children, adolescents, and young adults with ADHD (with no pharmacological intervention and with medication for ADHD), no difference in DMFT/dmft was found, compared to healthy controls [63]. In a

study by the same author, no statistical differences regarding DMFT/dmft were found in the three groups of children above (5-18 years of age with ADHD), despite a higher plaque index in the ADHD group [64]. In contrast to what was expected, Lorber *et al.* found child-externalizing problems less associated with dental decay [65]. Recently, children in Hong Kong, aged 12-17 years and with ADHD, were compared to medically healthy children, with no difference in caries prevalence found [66].

The connection between caries and externalizing behavior, and/or attention deficit, is still inconsistent depending on different study designs. A longitudinal study with the same children participating would have been desirable.

1.7.3 Traumatic Dental Injuries (TDI)

Worldwide, traumatic dental injuries (TDI) are common among children of all ages. The prevalence varies in studies from different countries, depending on age and how data has been gathered and compiled. In a study from the UK, the prevalence was 34.4% in children, 11-14 years of age [67]. Approximately the same prevalence of 35% was found in 16-year-old Swedish adolescents, with nearly twice as high frequency for boys (64%) as for girls (36%) [68]. In Brazilian children, 8-12 years of age, the reported prevalence was 12.6%, with trauma more prevalent in boys [69]. In the large Swedish BITA-study by Oldin *et al.* 2015, the prevalence for TDI was 37.6% in children 0-17 years of age, with no gender differences [70].

Many children encounter tooth injuries more than once during their lifetime [67, 71-73]. In a Swedish study, up to 25% of the children had more than one tooth injury with a higher prevalence for boys [68]. In the primary dentition, the majority of dental injuries affect the supporting tissue of the upper incisors. In the permanent dentition, the upper central incisors are the most commonly injured teeth (75%) [68].

Younger children suffered more occasions for TDI with a peak at 3 years of age in pre-school children, and 8 years of age in school children [70, 73-75]. The etiology for TDI varies with age, with the most common factor due to a fall, where children aged 2-3 years were most affected [76-78]. Injuries during play occurred in all ages, but were more common around 4-5 year of age. Sport injuries were more common in children aged 8-9 and 12-13 years. Finally, older teenagers injured their teeth when they were using them as a tool, biting on hard objects [70]. Additionally, a Swiss study reported a four-time higher risk of encountering trauma in children with an overjet ≥ 6 mm [79].

Even if a dental injury only affects a small part of the body, it can be both painful and frightening and may lead to a major impact for the child.

1.7.4 Traumatic dental injuries and externalizing behavior

The first study to find an association between ADHD and TDI was a Turkish study, in 2005. It was found that children with ADHD (7-17 years of age) had more TDI than children without ADHD [80]. This study was followed by other studies showing the same association [81-85]. Another study from Turkey suggested children with TDI had more hyperactive symptoms, compared to children without TDI [86]. Moreover, parental reported hyperactivity in a Brazilian study with schoolchildren (7-12 years of age), showed an increase in the chance of exhibiting TDI, compared to controls [87].

Temperament was measured by the Emotionality, Activity, and Sociability (EAS), and the Emotionality, Activity, Sociability and Impulsivity (EASI) instruments in children with multiple occasions of TDI. The report from the parents regarding their child's temperament showed that the 3-year-olds were less shy, the 7-year-olds were less impulsive, the 11-year-olds were more social, and the 15-year-olds were more active [88].

Other studies have not found any differences regarding TDI in children with attention and learning problems/ADHD, compared to controls [66, 89, 90]. When the SDQ instrument was used to measure problem behavior, neither emotional symptoms, conduct disorders, nor hyperactivity behavior showed a relation to dental injuries in children 7-15 years of age. [91].

In the BITA-study, children with TDI (11 years old) reported more pro-social behavior and fewer peer relationship problems, according to the SDQ questionnaire [92].

1.7.5 General Unintentional Injuries (GUI) and externalizing behavior

The risk of unintentional injuries is high in children with ADHD [93-101]. The prevalence for serious unintentional injuries in children with ADHD has been shown to be 12.8% [102]. It has also been shown that children with ADHD have a higher risk of severe injuries, multiple injuries, and longer durations of hospitalization [95, 98, 103, 104].

In children with psychiatric disorders, ODD was associated with burns and poisoning, while ADHD was related to fractures [98]. Likewise, high scores

for hyperactivity and conduct disorder were related to major and minor head injuries. The risk factors assessed were often stronger for major than for minor injuries, and stronger for head than other injuries. High scores for conduct disorder and emotional symptoms were reported as risk factors for other major injuries, when behavioral status was measured with SDQ [105].

In 7-year-old Swedish children with GUI, more hyperactivity/inattention was reported by the parents, when measuring behavior through the SDQ. Among 15-year-old adolescents, more pro-social behavior was found in the adolescents with GUI, according to the SDQ [92].

Children aged 3 and 7 years, assessed by their parents as being injured more often than other children, showed more conduct problems and more hyperactive/inattentiveness, than children who were assessed to be injured equally or less often than other children [92]. General unintentional injuries are common in children and adolescents with externalizing behavior.

1.8 Dental Fear and Anxiety (DFA) and Dental Behavior Management Problems (DBMP)

Fear and anxiety are often used synonymously in an interchangeable way in the dental literature, even though there are differences. Dental fear is a normal evolutionarily reaction to a specific external threatening object, with a wish to escape or avoid the stimuli. Anxiety is a more general state of distress, not attached to an object, but more related to thoughts and a non-specific feeling of apprehension of a future threat [106-108].

The prevalence of dental fear (DFA) in children and adolescents in Europe varies from 6% to 20% [109-113]. Dental fear is more common in younger children [114, 115] and in girls [112, 113, 116, 117], and has been shown to decrease with increasing age [114, 118].

Dental behavior management problems (DBMP) are the dentist's view of the child's behavior during treatment, and do not necessarily correspond with the child's evaluation. DBMP is defined as findings of notes in dental records, expressing disruptive behavior that delays treatment or renders treatment impossible [119]. Both dental fear and anxiety are associated with behavior management problems, a common issue when it comes to dental care for children [109].

The prevalence of both DFA and DBMP has been estimated to 9% in children and adolescents. But not all children with DBMP suffer from dental fear, and dental fear is not always revealed as BMP. DFA and DBMP partly overlap, with 27% of the children with DBMP also showing DFA, and 61% of the children with DFA also showing DBMP [120].

The origin of dental fear, dental anxiety, and behavior management problems is multifactorial and associated with age, social class, general fear, maternal dental fear, and experiences of pain, discomfort, lack of control, inadequate dental management, general emotional status, and temperament [111, 113, 119-122]. DFA and DBMP are also related to externalizing behavior problems [109].

Different techniques have been used to measure dental fear. A frequently used instrument among children and adolescents is the Children's Fear Survey Schedule-Dental subscale (CFSS-DS), initially presented in 1982 by Cutbeth and Melamed [123]. The CFSS-DS has been translated and used in large groups of patients in several countries [110, 112, 115, 124-128], and has been considered to be a reliable instrument. Another way to measure dental fear is the Corah Dental Anxiety Scale (CDAS) [129, 130], mainly employed in adults or older adolescents, but also used in children [131].

1.8.1 Dental fear and anxiety, and dental behavior management problems in children/adolescents with externalizing behavior

There are very few studies on DFA and DBMP in children with ADHD. In two case-control studies on children with attention/learning problems [55, 89], higher frequencies of DBMP were found in dental records in the children screened positive for attention problems, compared to controls [89]. In a second study, including the first study children having ADHD and dental records showing DBMP, no differences regarding DFA as measured through the CFSS-DS were found, compared to controls [55].

When measuring dental anxiety, the ADHD children with the hyperactivity/impulsivity subgroup reported higher levels of dental anxiety, than the controls [131]. Regarding DFA and externalizing problems, a Dutch study found that children, referred to special dental care due to a high degree dental fear, also had several problems in other behavioral and emotional areas [132]. Locker *et al.* found the odds ratio (OR) was 5.0 of having the diagnose conduct disorder, among highly anxious individuals [133]. In a study from

Iran, higher levels of dental anxiety and DBMP were found among children with ODD/ADHD, compared to controls [60].

Dentists, with varying experiences of behavioral management problems, have interpreted the terms dental fear and dental anxiety in an interchangeable way. The DFA has been measured with different instruments in children with various diagnoses.

1.9 Inductive methods

Data files contain information that can be analyzed by employing different statistical methods, depending on the basic question. Data may be in the form of discrete and/or numeric variables, representing relationships and patterns and thus, inborn knowledge. Inductive machine learning methods are a powerful complement to statistical methods in making knowledge explicit, in order to learn from the information gained. The inductive approach has been used for the analyses of, e.g., questionnaires, data from dental records, and the chemical composition in dental hard tissues [134-139]. Analysis of qualitative data, utilizing inductive methods, can show structures and establish links derived from the raw data [140]. By combining traditional statistical analyses and inductive analyses, more explicit information can be acquired.

Inductive analysis is based on algorithms applied on a set of data, aiming to find rules that reveal relationships between the variables, by producing a generalized knowledge tree, which is graphically displayed. The knowledge tree is generated by repeatedly splitting the given data set according to different attributes (variables), until terminal points (leaves) are reached. The order by which the attributes are used in the knowledge tree depends on a measure of the classification power of each attribute. The generated rules and the knowledge tree present the information in a transparent way, which can be validated.

Data for inductive analysis may be discrete and/or numeric, and can be compiled in an Excel spreadsheet. Each column in the spreadsheet represents an attribute with different values, and each row represents one example in the data set. One column is used to denote an Outcome with different outcome values, which has to be discrete. Each row in the spreadsheet thus constitutes an example, consisting of different attribute values and an outcome value.

The results are presented in a hierarchic diagram (knowledge tree), in which the importance of every variable (attribute) in the inductive analysis is

specified, by its position in the knowledge tree. The higher in the tree, the more important for the outcome, and thus the tree shows how different attributes affect the outcome and each other.

The accuracy of the knowledge tree is validated against a test data set, which is a portion of the development data, automatically set aside by the software program. The program randomly selects 50% of the data for the induction of rules (training), while the remaining 50% is used in the verifying process (test). A table displays the accuracy (predictability) of each leaf by comparing the probabilities of the leaf outcome in the training and testing data sets, expressed as a percentage correctly classified. A useful feature in the rule induction is “normalization”, used for the correction of the imbalance in the frequency of occurrence of outcome groups in the data set.

2 AIMS

The overall aim of this thesis was to study children and adolescents with externalizing behavior and a subgroup diagnosed ADHD from an odontological perspective.

The specific aims were:

- to study oral health and oral health behavior
- to study parental evaluations of their child's oral health and experience of dental care
- to study the frequency of high caries risk among children with externalizing behavior, and to compare children with externalizing behavior problems having low and elevated caries risks, with regard to behavioral characteristics and family structure
- to study dental fear and dental behavior management problems

3 SUBJECTS AND METHODS

In Sweden, dental care is free of charge for all children aged 0-21 years, and virtually all children attend regular check-ups from the age of one year. Government laws direct guidelines and regulations for dental records, found at The National Board of Health and Welfare (*Socialstyrelsen*), which is a government agency in Sweden under the Ministry of Health and Social Affairs. All children in the present study went to regular examinations and check-ups at their ordinary dentist.

3.1 Subjects

3.1.1 Study Groups 1 & 2

(Papers I, II)

Study Groups 1 & 2 were based on data from a randomized comprehensive Family Check-up (FCU) study of parent management training (PMT) programs (2011-2015), examining early intervention for children with externalizing behavior problems. Education and training for coaches regarding the FCU intervention were performed before the study start. All data were collected before parents were enrolled in the intervention.

A total of 13,000 families were informed and invited to the study through direct mailings; by letters sent to families with children at the targeted ages (10-13 years of age), at all participating municipalities in Gothenburg, by advertisements on bulletin boards, as well as parental meetings at schools.

A total of 796 families, who experienced some degree of externalizing behavior in their child, reported an interest to participate in the study. A research assistant contacted the interested parents and conducted a screening interview by telephone (Appendix I), ensuring the families belonged to the targeted group; (e.g., parents with children in conflict with peers, parents or other adults, protesting against demands, often restless, having friends with bad influence or having been involved in vandalism, shoplifting or truancy). After obtaining written informed consent, the parents were asked to fill out the Strengths and Difficulties Questionnaire (SDQ) (Fig. 1).

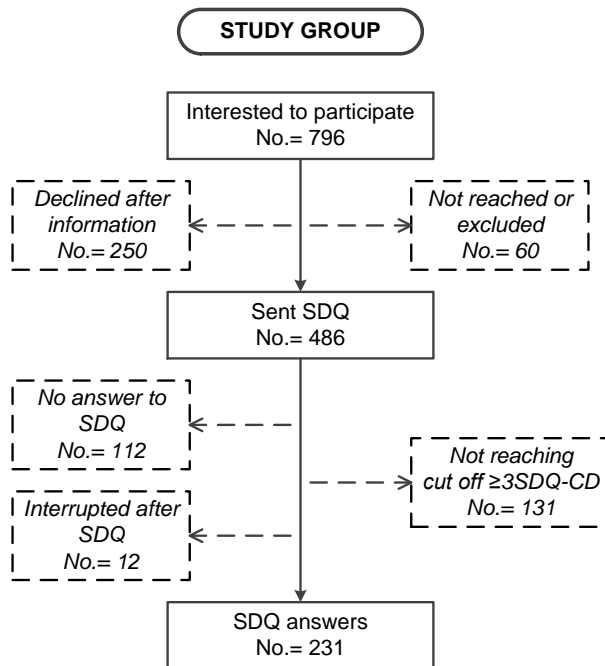


Figure 1. Flow chart describing the recruitment of patients to the study group and to the control group, respectively. (SDQ=Strengths and Difficulties Questionnaire; SDQ-CD=Strengths and Difficulties Questionnaire conduct problem subscale; No.=number).

The exclusion criterion to participate in the studies above was a value of <3 on the conduct problem subscale of the Strength and Difficulties Questionnaire, or having autism, obsessive-compulsive disorder, or ongoing psychiatric treatment.

The final study population consisted of 231 families with children, 10-13 years of age, where the parents experienced the child had externalizing behavior problems, which was confirmed by the SDQ (Fig. 2).

The distribution of children by age was as follows: 59 children (10 yrs.) (25.9%), 46 children (11 yrs.) (20.2%), 45 children (12 yrs.) (19.7%), and 78 children (13 yrs.) (34.2%). All socioeconomic areas in Gothenburg were represented in the study. The distribution of gender and age in the study group and the control group were approximately the same. The mean age in the study group was 11.7 years and in the control group 11.6 years.

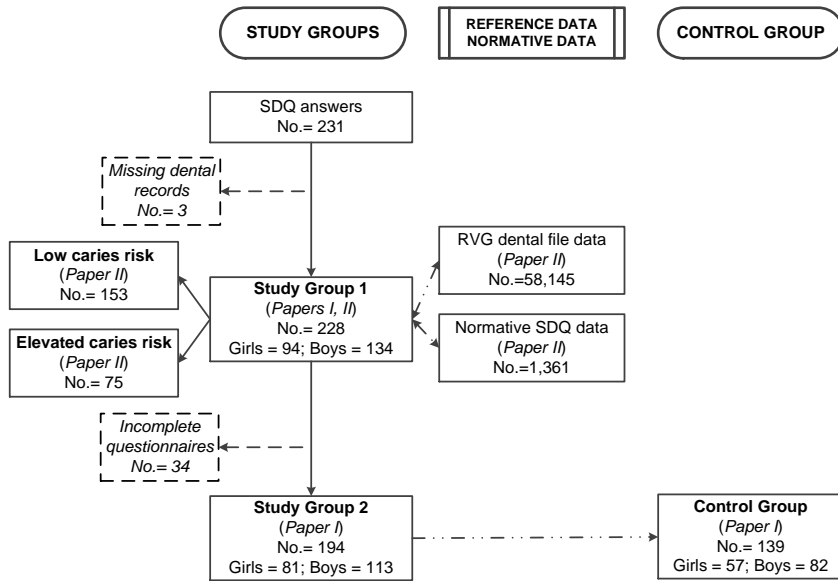


Figure 2. Flow chart illustrating the relation between study group, reference group and normative data. (SDQ=Strengths and Difficulties Questionnaire; No.=number; RVG=Region of Västra Götaland)

3.1.2 Control group for Study Group 2

(Paper I)

For each child in the study group, three possible matched controls with the same age, gender, dental clinic and socioeconomic area (residential address), were identified. The first of the three matched controls accepting the invitation was selected. All parents in the control group were asked to fill out the same background information questionnaire and SDQ as the parents in the study group. Children with a value ≥ 3 , on the conduct problem subscale of the Strengths and Difficulties Questionnaire, were excluded to ensure a control group without externalizing behavior problems (Fig. 3).

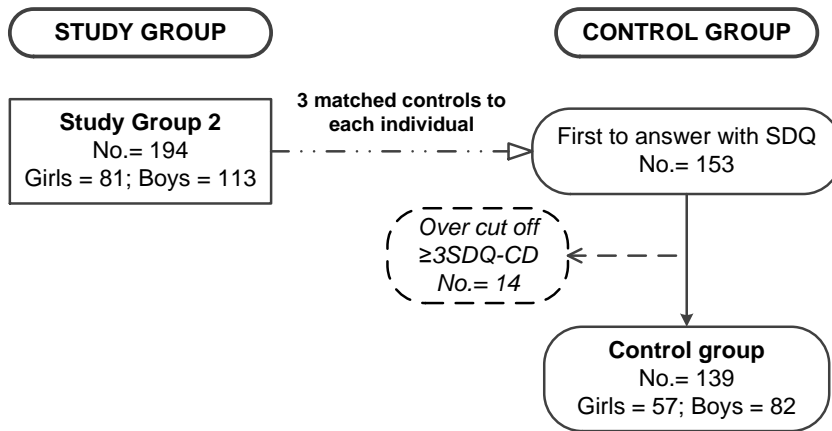


Figure 3. Flow chart illustrating the relation between Study Group 2 and the Control Group. (SDQ=Strengths and Difficulties Questionnaire; No.=number.)

3.1.3 Reference data

(Paper II)

Reference data regarding caries risk assessment was obtained from 58,145 children aged 10-13 years who were treated in 2013 by the Public Dental Service in the Region of Västra Götaland, Sweden (Fig. 2).

3.1.4 Normative data

(Paper II)

Normative data for the Strengths and Difficulties Questionnaire (10-13 years), from 1,361 children [141], was obtained from a random selection of 2,800 families with children at each age (10, 11, 12 and 13 years old), with adequate distribution of both sexes across Sweden, using the Swedish Population Address Register (Fig. 2).

3.1.5 Study Group 3

(Papers III, IV)

Ninety-three patients (93) with ADHD (Attention Deficit Hyperactivity Disorder), visiting their physician at the Gothenburg Child Neuropsychiatric Clinic, a regional clinic for ADHD, Autism Spectrum Disorder (ASD) and other neuropsychiatric disorders, were invited to the study. Parents of 31

patients contacted the clinic and agreed to participate. Three of the children in the study group had one sibling participating and one teenager had two siblings. The final study group consisted of 11 girls and 20 boys, aged 5-19 years, diagnosed with ADHD.

Information about the child (e.g., parental attitudes and experiences of dental care) was given by the child's mother (26 mothers to 31 children and adolescents). The inclusion criterion to participate in the studies above was full DSM-IV [142].

3.2 Methods

3.2.1 Background information questionnaires

(Papers I, II)

Social background questionnaire

The parents were asked to provide background information through a questionnaire containing 18 questions, from the original Family Check-up questionnaire about the informant and the family structure (parents' marital status, native country and number of children in the household) (Appendix II).

Parental questionnaire and medical history

(Papers III, IV)

The parents provided information concerning the informant, social relations (if the child was living with biological parents or own apartment), siblings, and their regular dental clinic.

The parents completed a medical history regarding medical and psychiatric diagnosis, diseases and medication. The child's physicians at the Child Neuropsychiatric Clinic confirmed the psychiatric diagnosis and medication at the time for the clinical examination (Appendix III).

3.2.2 Psychological questionnaires

The Strengths and Difficulties Questionnaire (SDQ)

(Papers I, II)

The SDQ [11] is a brief behavioral screening instrument used for children and adolescents with good psychometric properties [143] (Appendix IV). The SDQ symptom scales contain 25 items divided into five subscales, namely,

emotional symptoms, conduct problems, hyperactivity-inattention, peer problems, and prosocial behavior. A 3-point Likert scale is employed to indicate how each attribute applies to the target child (0=*Not true*; 1=*Somewhat true*; 2=*Certainly true*). All subscales, with the exception of Prosocial Behavior, are summed together to a Total Difficulties score. A high score on the Prosocial Behavior subscale indicates a strength, while high scores on the other four subscales indicate difficulties.

The parental version of the SDQ for children 4-16 years, used in this study, is validated for Swedish conditions [144]. Due to high skewness and kurtosis on item level, polychoric ordinal alpha was used as a measure of internal consistency, instead of Cronbach's alpha. The internal consistency of the SDQ (polychoric ordinal alpha) ranged between 0.84 and 0.91 (Emotional Problems: 0.89, Hyperactivity-Inattention: 0.88, Peer Problems: 0.84, Prosocial Behavior: 0.91, and Conduct Problems: 0.88).

Disruptive Behavior Disorder rating scale (DBD)

(Paper II)

The DBD [10] is originally an instrument designed with 45 items, whereas, the version responded to by the parents, in the present study, included 41 items [145] (Appendix V). The subscales are Attention Deficit/Hyperactivity Disorder (ADHD: 18 items), Oppositional Defiant Disorder (ODD: 8 items), and Conduct Disorder (CD: 15 items). The items are worded as closely as possible to the DSM criteria, taking into account the scale format [6]. Each item is rated on a 4-point Likert-type scale (0=*Not at all*, 1=*Just a little*, 2=*Pretty much*, and 3=*Very much*). The DBD has shown good psychometric properties [10]. The internal consistency (polychoric ordinal alpha) of the subscales of the DBD ranged between 0.94 and 0.99.

Family Warmth and Family Conflict (FW/FC)

(Paper II)

The questionnaire Family Warmth and Family Conflict consists of five questions regarding warmth and four questions regarding conflict (Appendix VI). The items concerning warmth are from the Adult-Child Relationship Scale [146], which is an adaptation of the School-based Student-Teacher Relationship Scale [147]. Internal consistency has previously been shown [141]. The questions on conflict are adapted from the PAL 2 project by the Child and Family Center, University of Oregon, USA. The Family Warmth subscale is responded to on a 5-point Likert scale from "*Definitely not*" to "*Definitely*". The Family Conflict subscale is responded to on a 7-point Likert scale from "*Never*" to "*More than 7 times during the last month*". The internal

consistency (Cronbach's alpha) for Family Warmth in the present study was 0.82, and the corresponding value for Family Conflict was 0.72.

Parental Knowledge and Monitoring Scale (PKMS)

(Paper II)

The PKMS questionnaire (Appendix VII) [148] consists of two parts: 1) Parental Knowledge (8 items), providing an overall measurement of parental knowledge (what parents know about their child, the child's activities and whereabouts), and 2) Three subscales measuring different ways of gathering information, including monitoring strategies; *Parental Solicitation* (i.e., a way of actively obtaining information/asking questions about the child's whereabouts) (5 items), *Parental Control* (rules and restrictions on the child's activities) (4 items), and *Child Disclosure* (the child's spontaneously shared information) (5 items). Items are answered on a 5-point Likert scale that ranges from "Almost always" to "Never" or from "Several times a week" to "Never" or from "Very often" to "Almost never" or from "Very good knowledge" to "None or almost no knowledge".

As a result of subsequent research and investigations of the psychometrics of the PKMS, the first two items on Disclosure have been classified into the new Secrecy subscale, and the remaining three questions represent the Child Disclosure subscale. Splitting the Child Disclosure subscale into Secrecy and Child Disclosure led to a higher internal consistency for each subscale (Secrecy and Child Disclosure) [149].

The internal consistency (Cronbach's alpha) of the PKMS subscales in the present study ranged between 0.70 and 0.85 (Parental Knowledge 0.85, Parental Solicitation 0.70, Parental Control 0.81, Child Secrecy 0.80 and Child Disclosure 0.78).

3.2.3 Child's Fear Survey Schedule-Dental Subscale (CFSS-DS)

(Paper I)

The child's dental fear was measured by the questionnaire CFSS-DS, in a Swedish translation, answered by the child (Appendix VIII).

The Dental Subscale of the Children's Fear Survey Schedule is a well-known instrument for assessing dental fear in children, initially presented by Cuthbert and Melamed [123]. The CFSS-DS consists of 15 items, related to various

aspects of dental treatment. Each item can be scored on a 5-point scale from 1 (*not afraid*) to 5 (*very afraid*). Total scores range from 15 to 75.

The cut-off score of 38 or higher on the CFSS-DS has commonly been used to define dental fear, irrespective of age, gender, and informant. In the present study, the cut-off score was set to ≥ 32 points, indicating “borderline” or “risk for dental fear”, which has been used in previous studies [112, 118]. Some children have no, or very limited experience of invasive dental treatment and are therefore unable to answer all 15 questions in the survey on the CFSS-DS. Where one or a maximum of three survey question responses were missing, an average score was calculated and used, thereby, a total of CFSS-DS could still be established. Questionnaires with more than three missing answers were excluded from the analyses.

3.2.4 Dental questionnaires

(Paper I)

The parents answered a number of dental questions included in the Family Check-up (FCU) questionnaire, regarding dental care and evaluation of their child’s oral health (Appendix II). The children responded to a questionnaire regarding dental fear (CFSS-DS) (Appendix VIII), tooth brushing frequency and dietary habits (Appendix IX).

(Papers III, IV)

The parents completed a questionnaire containing 76 multiple-choice questions and two open questions about pain experience, dental experience, and feelings regarding it. The parents were also asked to evaluate their child’s oral health, including dietary habits, oral hygiene routines, fluoride exposure, dental trauma, and earlier dental treatment and dental care. Furthermore, the parents were asked questions about the child’s dental fear, medical fear, general fear, and fear in the family (Appendix X).

The questions were designed in collaboration with one of the specialists in child and adolescent psychiatry at the Gothenburg Child Neuropsychiatric Clinic, at Queen Silvia Children's Hospital. The questions were tested in advance on some of the dental clinic's regular families with children/adolescents with ADHD.

To the open questions, “*Is there anything else you would like to tell us about dentistry for children/adolescents with ADHD*” and “*Is there anything you think dentists could do better/different concerning dentistry for*

children/adolescents with ADHD”, the parents were able to give their reflections.

3.2.5 Retrospective data from dental records

Caries

(Paper I)

Data from dental records regarding caries in the primary teeth (deft, 12 teeth canine, first and second primary molars) and caries experience (manifest caries in primary and/or permanent teeth, decayed, missing or filled first permanent molars, and initial caries in first permanent molars) were compiled. The children had different dental stages, DS₂M₁-DS₄M₂ [150], therefore caries in the first permanent molar was chosen as an expression for the caries status.

(Paper III)

Dental records for all visits to dental clinics for the children with ADHD were obtained from their respective dental clinics. Data from caries registrations at the age of 3, 6, 12 and 19 years, and the number of extracted permanent molars, were compiled. The caries data for the ages 3, 6, 12, and 19 years was chosen to be comparable with epidemiological data collected by The National Board of Health and Welfare.

The indices calculated for caries in the dental records were deft (d=decayed; e=extracted; f=filled; t=teeth) for the primary dentition and DFT (D=decayed; F=filled; T=teeth) for the permanent dentition.

Longitudinal caries data

(Paper III)

In order to evaluate the caries status over time, data in the dental records of the patients were compiled both before and for five years after the clinical examination, or until the adolescents had reached the age of 19 years. An overview of the number of subjects in the different age groups is shown in Figure 4.

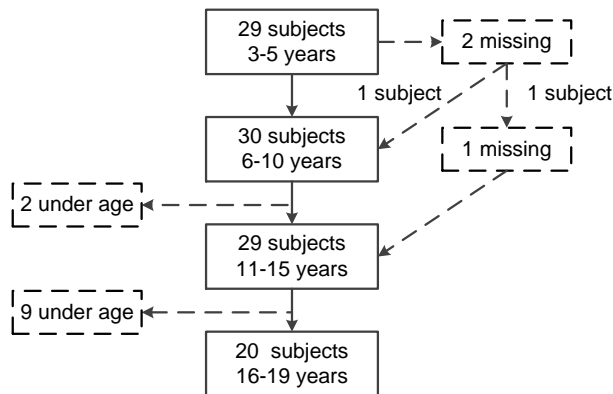


Figure 4. Flow chart showing number of subjects and corresponding age groups.

Traumatic dental injuries (TDI)

(Papers I, III)

The total number of dental trauma and number of TDI in the primary and permanent dentitions were registered. In children with ADHD, the number of TDI and the child's age and gender were collected.

Other findings in the dental records regarding dental visits

(Paper III)

Data, regarding the number of total and attended appointments and the number of cancelled and missed appointments for the children with ADHD at different ages, were collected.

Operative dental treatment, with and without notations on the use of local anesthetics, preventive appointments, and appointments with dental behavior management problems (DBMP), were compiled. DBMP was defined as findings of notations in the dental records expressing disruptive behavior that delayed treatment or rendered treatment impossible [110, 119].

3.2.6 Caries risk assessment

(Papers I, II)

All Swedish children are assessed for caries risk at their regular dental recall examinations. Information about caries risk, estimated by the computerized algorithm-based system R2 [151], used by the Public Dental Service in the Region of Västra Götaland, was obtained from the dental file system. The child's regular dentist makes the clinical caries risk assessment according to the regional standardized guidelines by the Region of Västra Götaland,.

Briefly, the caries risk assessment in R2 is conducted in three steps: First, the patient's current dental caries activity is estimated based on new caries lesions and caries progression in all proximal, buccal and lingual tooth surfaces, including both enamel and dentine caries. Second, modifying factors are recorded such as diet, fluoride usage, oral hygiene, previous caries experience, age and medical risk. Finally, positive and negative factors are weighed by the R2 system to characterize the caries risk as low, intermediate or high.

In *Paper II*, data for caries risk were dichotomized into two groups: *Low* and *Elevated* (intermediate + high) caries risk (Fig. 2).

3.2.7 Clinical examination

(Paper III)

Clinical and radiographic caries registration

All patients underwent an ordinary clinical examination under working light, using a mouth mirror. In order to do a complete survey, radiographs were taken when indicated, since this may be a medical risk group difficult to investigate. Caries was registered using a mouth mirror and on bitewing radiographs (Appendix XI).

Manifest occlusal caries was registered in a fissure when seen as a cavity or clearly noted as a radiolucency in the dentine on the bitewing radiographs. Approximal caries on the radiographs was recorded as manifest when the lesion clearly extended into the dentine. Caries on smooth surfaces, buccally and/or lingually, was defined as initial when the surfaces were demineralized with the loss of translucency along the gingival margin, and as manifest when seen as a cavity.

The examiner's reliability to perform caries diagnostics on bite-wing radiographs was tested using bite-wing radiographs from 30 randomly selected patients not involved in the study. The radiographs were diagnosed for caries

according to the above-mentioned criteria, twice, with a four-week interval. The intra-examiner agreement resulted in a Cohen's kappa value of 0.8.

Plaque and periodontal examination

Plaque was noted using a probe passing on the buccal and lingual surfaces of the upper and lower incisors and first molars along the gingival margin. Plaque was noted if registered both at the incisors and the molars. In all other cases, it was noted as plaque-free. The periodontal examination was performed using a Hu-Friedy 4 color-coded probe (Hu-Friedy Europe, Rotterdam). Periodontal registrations were made according to the WHO guidelines for clinical examinations [152]. Bleeding on probing and pocket depths ≥ 4 mm for each site (mesial, buccal, distal and lingual), on the upper and lower incisors and first molars, were registered.

Saliva tests

Saliva tests were carried out with the patient sitting in an upright position. The flow rate was sampled from un-stimulated and stimulated whole saliva, consecutively. First, un-stimulated saliva was collected in a measuring cylinder. Then stimulated saliva was collected in a measuring cylinder after the patient chewed on a paraffin block for five minutes.

The obtained volume of saliva was normalized to the collection time of five minutes and the secretion rate was expressed as ml/min. The parents were instructed not to let their child eat, drink, smoke, use snuff or brush their teeth one hour prior to the saliva sampling. All children were asked about problems with dry mouth at the clinical examination.

3.2.8 Statistical analyses

(Papers I-III)

Statistical analyses were performed using the statistical software R (GNU General Public License, Free Software Foundation, Inc., Boston, USA) [153], the Statistical Package for Social Sciences (SPSS version 21, Armonk, New York, USA) and SAS Version 9.3 (SAS Institute. Inc, Cary, North Carolina, USA) [154].

(Paper I)

A logistic regression was used in order to assess the association between children with externalizing behavior problems and dental caries, traumatic dental injuries, oral health risk factors, dental fear and parental evaluation of dental care, and the child's oral health, compared to controls. Data were adjusted for age and gender. The results were expressed as odds ratio (OR), with a 95% confidence interval. For multiple interferences, the significance level was adjusted according to the Bonferroni-Holm method and in the results; both un-adjusted and adjusted values are presented.

(Paper II)

Pearson's Chi-square test for categorical variables, and t-test for continuous variables, were used to analyze family structure and to compare means for the low caries risk group to the elevated caries risk group regarding child behavioral characteristics. Chi-square test was employed for comparing the caries risk assessment between the study group and the reference group. The significant level was set to be $p < 0.05$. The internal consistencies of the various subscales, where a measure of how closely related a set of items is as a group, were calculated using Cronbach's alpha, for all instruments. Due to some skewness and/or kurtosis on some items on the SDQ and the DBD, polychoric ordinal alpha [155] was calculated instead of Cronbach's alpha, when more appropriate. The effect sizes are presented as Cohen's d. A Cohen's d of 0.8 or above was considered a large effect, 0.5 a medium effect, and 0.2 a small effect [156]. The Phi coefficient (ϕ) was calculated to estimate the magnitude of the associations of the Chi-square test. A magnitude of 0.5 was considered strong, 0.3 intermediate, and 0.1 weak.

(Paper III)

A scatterplot of the number of individuals with and without plaque, and number of preventive treatment times related to age, was constructed in OriginPro 2014 (OriginLab Corp., Northampton, SAS Version 9.3, USA). In Origin, an F-test was applied on the graph in order to evaluate possible correlations between the number of preventive treatments and plaque found at the clinical examination.

3.2.9 Inductive analyses

(Paper II)

Data from the dental records of the patients in the present study were compiled in an Excel spreadsheet. As “*attributes*”, the factors “*Caries Activity*”, “*Dietary Habits*”, “*Oral Hygiene*” and “*Medical Risk Factors*” were set in columns, each having a discrete value “*Low caries risk*”, “*Intermediate caries risk*” or “*High caries risk*”, as given in the dental records.

A fifth column was inserted as outcome, representing the caries risk values. As in the main study, intermediate and high caries risk was merged into one group consisting of values for intermediate and high caries risk; thus, the two outcome values were “*Low Risk*” or “*Elevated Risk*”. The data were imported to the inductive analysis program XpertRule Analyser (Attar Software, Lancashire, UK). The results are presented in a hierarchic diagram (knowledge tree), in which the importance of every attribute in the inductive analysis is specified by its position/level in the knowledge tree. The higher up the tree, the more important for the outcome; thus, the tree shows how different attributes affect the outcome. In the analysis, 50% of the examples were randomly selected by the program for use in the induction of a knowledge tree (*training set*), and the remaining examples were used for verification of the generated rules (*test set*).

3.3 Ethical approvals

For *Paper I* and *Paper II*, ethical approval was given by the Ethical Committee in Uppsala (dnr 2010/119), and for *Paper II* and *Paper IV*, ethical approval was given by the Regional Ethical Review Board at the University of Gothenburg, Sweden, (2003-03-28) number SO16-03.

In all four studies, the children, adolescents, their parents and all families participating were given written and verbal information regarding the study and asked to give written consent to participate. Written consent from the participating families was received in order to acquire access to their children's dental records.

4 RESULTS

4.1 Background information

4.1.1 Study I & II

(Papers I, II)

Of the 228 parents answering the questionnaires, 200 were mothers (87.7%) and 28 were fathers (12.3%). There were 66 single parents (53 mothers and 13 fathers). In cases where both parents answered the questionnaires, answers from the parent participating in the parent-training program were used.

The distribution by the parents' native country showed that there were 164 mothers (71.9%) and 135 fathers (59.2%) with a Swedish origin. There were two mothers (0.9%) and nine fathers (3.9%) with an origin from the other Nordic countries. Sixty-two mothers (27.2%) and 84 fathers (36.8%) had origins from other countries. For the statistical analyses, the parents' country of birth was divided into two groups: Nordic countries (Sweden, Norway, Denmark, Finland, and Island) and Non-Nordic countries, representing all other countries in the world. The number of children living in the household was divided into 1-2 and 3-6 children (Table 1).

Table 1. Number of children in the household and the father's ethnicity in the low and elevated caries risk groups, respectively.

	Low risk n=153	Elevated risk n=75	Total n=228	<i>p</i> value	ϕ
Number of children					
1 to 2 children	109	40	149		
3 to 6 children	44	35	79	0.008	0.177
Fathers's ethnicity					
Nordic	107	37	144		
Other countries	46	38	84	0.002	0.201

Effect size is denoted by ϕ (0.5=strong; 0.3=intermediate; 0.1=weak.)

4.1.2 Study III & IV

(Papers III, IV)

All the children with ADHD, 11 girls and 20 boys, were born in Sweden to a Swedish mother, except one mother who was from Finland. All fathers were from Sweden except two; one came from former Yugoslavia and one from Italy. The children lived with their biological parents, except two having their own apartment.

According to the medical history, 26 of the 31 subjects had psychiatric diagnoses other than ADHD. Medication such as Ritalin®, Concerta®, or Strattera® was prescribed for 28 of the 31 individuals (Table 2).

Other medical diagnoses were also common; six children/adolescents had asthma and 12 had some kind of allergy. Seventeen individuals had at least one of the following medical conditions and/or treatments; according to their medical history: Heart disease, urinary bladder operation, anorexia/bulimia, intoxication, broken arm, cyst, scarlet fever, eye operation, meningitis, adenoid surgery, neonatal care, tonsillitis, bronchitis, and ear-nose-throat problems.

Table 2. Frequencies of co-morbid conditions and medication among the 31 patients. (ADHD=Attention deficit hyperactivity disorder; DCD=Developmental coordination disorder; ASD=Autistic spectrum disorder; ODD=Oppositional Defiant Disorder; OCD=Obsessive-Compulsive Disorder.)

Disorder	Number
ADHD	31
<i>Multiple diagnoses</i>	26
DCD	13
Dyslexia + learning disabilities	13
ASD	5
ODD	4
Depression	3
Tics	3
OCD	1
Tourette's syndrome	1
Panic disorder	1
<i>Medication</i>	28
Ritalin®	14
Concerta®	10
Strattera®	4
<i>Other medications</i>	
Zoloft®	1
Cipramil®	2
Risperdal®	1
Fontex®	1

4.2 Oral Health

4.2.1 Caries

Caries data from dental records

(Paper I)

Upon entering the study, 28.9% of the children in Study Group 2 had filled or decayed first permanent molars, compared to 18.7% of the controls. The OR for having decayed/filled first permanent molars was 1.78. No statistical difference was found after Bonferroni-H correction (Table 3).

(Paper III)

The caries data for children with ADHD concerning deft and DFT for the ages 3, 6, 12 and 19 years of age, respectively, were compiled, and the mean values are presented in Table 4. At the time for the clinical examination, 20 subjects had permanent teeth, 10 had a mixed dentition and one subject had primary teeth.

Since the number of individuals in the different age groups varied, caries life tables for the primary and permanent dentitions were constructed in order to present the caries development over time in the study group. Based on the caries life tables, a graph was made representing each dentition (Fig. 5). The curves indicate a theoretical prognosis for risk of caries. The slope of the curve was markedly steeper between 3 and 6 years of age for the primary dentition, and had almost the same slope for the permanent dentition in early adolescence. At the age of 6 years, no permanent teeth were decayed.

At the age of 6-10 years, 12 teeth were extracted, range 1-6. At least five permanent molars were extracted in the whole study group of children with ADHD.

Table 3. The **upper part** of the table shows the number of children with primary dental caries and permanent dental caries, caries in the primary and/or permanent dentitions, number of decayed/missing/filled first permanent molars in Study Group 2 and the Control Group, the distribution in low and elevated caries risk groups, respectively, when entering the study. Percentage within brackets. (**deft**=decayed/extracted/filled primary teeth; **DMFT**=decayed/missing/filled first permanent molars; **DMFTi**=decayed/missing/filled first permanent molars and initial caries).

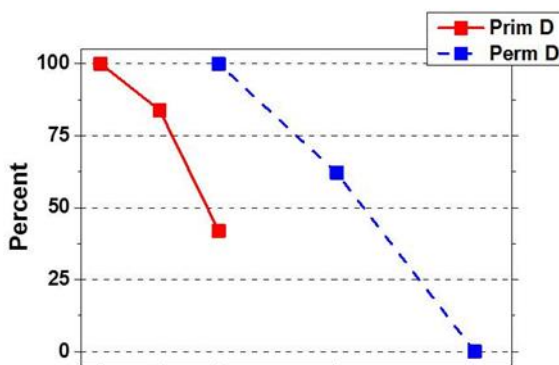
	Study group 2		Control group		Total	
	n	%	n	%	n	%
Caries						
Caries in primary teeth						
deft=0	137	(70.6)	108	(77.7)	245	(73.6)
deft >0	57	(29.4)	31	(22.3)	88	(26.4)
Caries in permanent teeth						
DMFT=0	130	(76.0)	102	(73.4)	232	(69.7)
DMFT>0	64	(33.0)	37	(26.6)	101	(30.3)
Caries in primary and/or permanent dentition						
deft & DMFT =0	96	(49.5)	82	(59.0)	178	(53.5)
deft & DMFT >0	98	(50.5)	57	(41.0)	155	(46.5)
Number of decayed/missing/filled first permanent molars						
DMFT=0	138	(71.1)	113	(81.3)	251	(75.4)
DMFT>0	56	(28.9)	26	(18.7)	82	(24.6)
Number of decayed/missing/filled first permanent molars including initial caries						
DMFTi=0	111	(57.2)	93	(66.9)	204	(61.3)
DMFTi>0	83	(42.8)	46	(33.1)	129	(38.7)
Caries risk assessment						
Low risk	138	(71.1)	114	(82.0)	252	(75.7)
Elevated risk	56	(28.9)	25	(18.0)	81	(24.3)
<hr/>						
	n	OR	CI	p log reg	p log reg B-H	
Caries in primary teeth	333	1.45	0.88-2.42	n.s.	n.s.	
Caries in permanent teeth	333	1.35	0.82-2.22	n.s.	n.s.	
Caries prim and/or perm dent	333	1.46	0.94-2.28	n.s.	n.s.	
DMFT	333	1.78	1.04-3.09	0.038	n.s.	
DMFTi	333	1.51	0.95-2.43	n.s.	n.s.	
Caries risk assessment	333	2.42	0.98-6.86	n.s.	n.s.	

The **lower part** of the table shows the results from the logistic regression. (**n**=number; **n.s.**=non-significant; **OR**=odds ratio; **CI**=confidence interval (95%); **p log reg**=p-value logistic regression; **p log reg B-H**=p-value logistic regression with Bonferroni-Holm correction.)

Table 4. Mean values and within brackets the range for the deft and DFT at the ages of 3, 6, 12 and 19 years, respectively, from the dental records in the study group and the corresponding mean values in the Public Dental Service in the Region of Västra Götaland (RVG) (No.=number).

	3 years	6 years	12 years	19 years
Study group	1.40 (5-15)	2.80 (1-14)	1.50 (1-10)	6.40 (1-15)
RVG	0.27 1.14	0.68 2.42		
No. in RVG	18,281	17,116	16,254	22,675

The curves indicate a theoretical prognosis for risk of caries. At the age of 6 years, no permanent teeth were decayed. Distribution of the number of individuals at risk, those withdrawn from the study, with caries and without caries. **Year 0** denotes the base line year for the life table, **Year 3, Year 6, Year 12** and **Year 19** denotes the ages 3, 6, 12 and 19 when caries data were compiled for the subjects in the study. At Year 0, it is assumed that the patients are caries free and therefore the first caries registration is performed at the age of 3 years.



Years	0	3	6	12	19
Individuals at risk (Prim D)	31	31	26		
<i>Withdrawn</i>	0	0	0		
<i>Individuals with caries</i>	0	5	11		
<i>Individuals without caries</i>	31	26	15		
Individuals at risk (Perm D)			31	31	15
<i>Withdrawn</i>			0	5	11
<i>Individuals with caries</i>			0	11	4
<i>Individuals without caries</i>			31	15	0

Figure 5. Life table analysis of caries-free teeth (**Prim D**=primary dentition; **Perm D**=permanent dentition) for 31 subjects diagnosed with ADHD.

Longitudinal caries data

(Paper III)

The five-year longitudinal follow up in dental records, regarding caries after the clinical examination, found that all 11 teenagers with dental records up to the age of 19 years had caries, and 15 of the remaining 20 subjects in the study group had caries at the end of the study.

Caries, salivary data and dental plaque (clinical examination)

(Paper III)

Initial and manifest caries, either in the primary or in the permanent teeth, were found in 27/31 of the children/adolescents with ADHD, and initial caries was found in 46 permanent teeth in 15 children.

It was possible to collect unstimulated whole saliva for five minutes from all of the children with ADHD. The mean values for unstimulated saliva for the 31 children were 0.27 ml/min (STD 0.16 ml/min; range 0.06-0.7 ml/min); 11 had a value <0.1 ml/min and all 11 of these children received medication. The mean value for stimulated whole saliva from the 31 subjects was 1.2 ml/min (STD 0.47 ml/min; range 0.1-2.2 ml/min); 6 individuals had a value lower than 1.0 ml/min and 5 of these children received medication. None of the children/adolescents with ADHD reported having a dry mouth.

Visual plaque was found in 17 subjects with ADHD; however, none had pockets deeper than 4 mm. In order to estimate a possible correlation between the presence of plaque found in the clinical examination and notations regarding the number of preventive treatments in the dental records, a scatter plot was made with linear fittings (Fig. 6). The F-test showed that at the 0.05 significance level, the two data sets (plaque/no plaque) were not statistically significant.

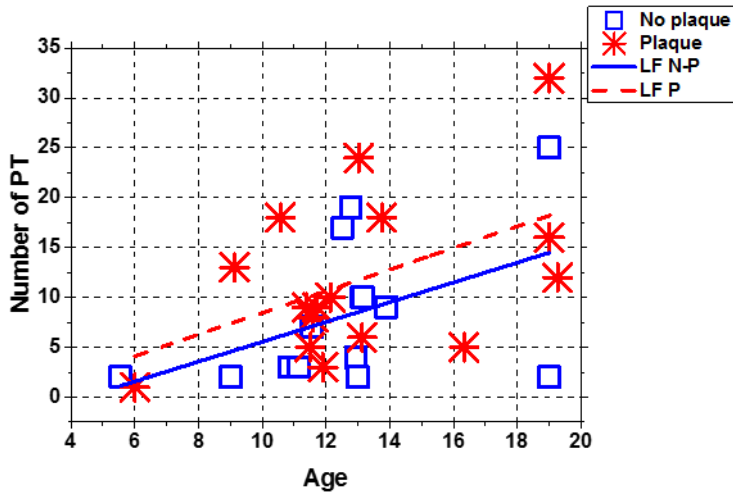


Figure 6. Number of total preventive treatments for the studied individuals diagnosed with ADHD without plaque (**No plaque**) and with plaque (**Plaque**), related to the age at the time for the clinical examination and the linear fitting for the variables (**LF NoP**=linear fitting for No plaque; **LF P**=linear fitting for Plaque). An F-test of the two linear fittings showed no statistically significant difference.

4.2.2 Traumatic dental injuries

(Paper I)

A total of 100 children with traumatic dental injuries were identified through dental records, resulting in a prevalence of 51.5% for TDI in children with early detected externalizing behavior. The prevalence in the control group was 30.2%, ($p < 0.0001$), OR: 2.47. After Bonferroni-Holm (BF-H) correction, the p -value remained significant ($p = 0.002$) (Table 5).

In the primary dentition, the prevalence for TDI in externalizing children was 32%, compared to 16.5% for the controls, ($p = 0.001$), OR: 2.42. The p value remained significant after BF-H correction ($p = 0.020$). The prevalence for TDI in the permanent dentition was 30.9% vs. 18%, ($p = 0.008$), OR: 2.04, in children with externalizing behavior, but did not reach the significant level after the BF-H correction.

The children with risk for dental fear $CFSS-DS \geq 32$ had not been exposed to more traumatic dental injuries, compared to those without dental trauma.

(Paper III)

The parents of children with ADHD reported 13 traumatic dental injuries through the parental dental questionnaire, and another four were identified through supplementary questions at the dental examination. In the dental records, traumatic dental injuries were noted in 20 children and adolescents with ADHD (7/11 girls and 13/20 boys), with a total number of 37 trauma occasions evenly spread over the different ages (Fig. 7). The prevalence of traumatic dental injuries did not differ between genders and multiple dental trauma episodes, up to seven times for some subjects, were found. Six subjects had experienced more than one dental trauma.

Table 5. The upper part of the table shows the frequencies of traumatic dental injuries (TDI) in the primary and permanent dentitions in children with externalizing behavior problems, compared to controls. Percentage within brackets.

	Study group		Control group		Total	
	n	%	n	%	n	%
TDI both dentitions						
No TDI	94	(48.5)	97	(69.8)	191	(57.4)
TDI	100	(51.5)	42	(30.2)	142	(42.6)
TDI primary dentition						
No TDI	132	(68.0)	116	(83.5)	248	(74.5)
TDI	62	(32.0)	23	(16.5)	85	(25.5)
TDI permanent dentition						
No TDI	134	(69.1)	114	(82.0)	248	(74.5)
TDI	60	(30.9)	25	(18.0)	85	(25.5)
	n	OR	CI	p log reg	p log reg B-H	
TDI both dentitions	333	2.47	1.57-3.93	0.0001	0.002	
TDI primary dentition	333	2.42	1.42-4.22	0.0014	0.020	
TDI permanent dentition	333	2.04	1.21-3.52	0.0082	n.s.	

The lower part of the table shows the results from the logistic regression. (n=number; n.s.=non-significant; OR=odds ratio; CI=confidence interval (95%); p log reg=p-value logistic regression; p log reg B-H=p-value logistic regression with Bonferroni-Holm correction.)

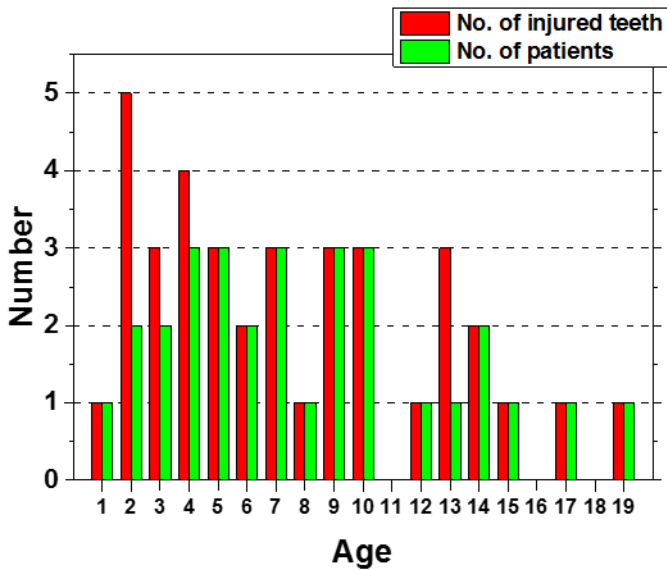


Figure 7. Number of patients diagnosed with ADHD with dental trauma and number of injured teeth in relation to age of the subject (No.=number).

4.2.3 Parental evaluation

(Paper I)

Regarding the parent’s evaluation of their child’s dental health, there were no differences between children with externalizing behavior problems, compared to controls (Table 6).

(Paper IV)

Oral health being *very important* or *important* was claimed by 25 of the parents of children with ADHD answering the questionnaire. Nineteen parents stated their child’s dental health was *very good* or *good*, while seven parents thought it was *bad* and five *did not know*. Three children with dental fear were also evaluated by their mothers to have poor oral health and they were not siblings.

Table 6. The upper part of the table shows the frequencies of behavior management problems (BMP), risk for dental fear according to Children's Fear Survey Schedule (CFSS-DS) and parental evaluation of dental care and the child's dental health in children with externalizing behavior problems, compared to controls. Percentage within brackets.

	Study group		Control group		Total	
	n	%	n	%	n	%
Behavior management problems						
No BMP	174	(89.7)	136	(97.8)	310	(93.1)
BMP	20	(10.3)	3	(2.2)	23	(6.9)
Risk for dental fear						
CFSS-DS <32p	164	(84.5)	135	(97.1)	299	(90.0)
CFSS-DS ≥32p	30	(15.5)	3	(2.2)	33	(9.9)
Dental health (parental evaluation)						
Very good	95	(52.5)	97	(69.8)	192	(60.0)
Good/poor	86	(47.5)	42	(30.2)	128	(40.0)
Dental care (parental evaluation)						
Well-functioning	178	(91.8)	136	(97.8)	314	(94.3)
Poor	16	(8.2)	3	(2.2)	19	(5.7)

	n	OR	CI	p log reg	p log reg B-H
BMP	333	5.25	1.75-22.63	0.0086	n.s.
Risk for dental fear	332	8.61	2.96-36.60	0.0005	0.0089
Evaluation by parents					
Dental health	320	2.34	0.68-10.71	n.s.	n.s.
Dental care	333	4.05	1.31-17.66	0.0289	n.s.

The lower part of the table shows the results from the logistic regression. (n=number; n.s.=non-significant; OR=odds ratio; CI=confidence interval (95%); p log reg=p-value logistic regression; p log reg B-H=p-value logistic regression with Bonferroni-Holm correction.)

4.3 Oral health behavior

4.3.1 Caries risk and behavior

Study Group 2 (n=194) and Control Group

(Paper I)

In the study group, 28.9% of the children had an elevated caries risk, compared to 18% in the control group. This difference was not statistically significant. The OR of belonging to the elevated caries risk group was 2.42 for the children in the study group (Table 3).

Low and elevated caries risk groups in Study Group 1 (n=228)

(Paper II)

There were 153 children in the low caries risk group; 47 children in the intermediate group and 28 children in the high risk group. The intermediate and high risk groups were merged and formed the elevated caries risk group, consisting of 75 subjects. There were statistically significant more children with elevated caries risk in the study group, compared to what was found in the 58,145 children forming the reference data in the Region of Västra Götaland, both for the genders ($p<0.001$) and for the total groups ($p<0.001$) (Table 7).

Table 7. The percentage and number (in brackets) of boys and girls in the low, intermediate and high caries risk groups, and in the elevated caries risk group (combining the intermediate and the high caries risk groups), respectively.

Study group	Low caries risk	Intermediate caries risk	High caries risk	Elevated caries risk	Total
Girls	68.1% (64)	22.3% (21)	9.6% (9)	31.9% (30)	94
Boys	66.4% (89)	19.4% (26)	14.2% (19)	33.6% (45)	134
Total	67.1% (153)	20.6% (47)	12.3% (28)	32.9% (75)	228
Reference data					
Girls	81.2%	14.1%	4.8%	18.9%	2,8022
Boys	78.5%	15.4%	6.1%	21.5%	3,0123
Total	79.8%	14.7%	5.5%	20.2%	5,8145

The corresponding values are given for the girls, boys and the total number of children in the reference group in the Region of Västra Götaland, Sweden. The reference group having a total number of 58,145 children aged 10–13 years in 2013. The brackets show the statistically significant differences ($p<0.001$) regarding elevated caries risk between girls, boys and total numbers, respectively, of children with externalising behavior in the Study Group and children in the Reference Group.

The children with an elevated caries risk lived statistically significant more often in households with more than two children. They also had statistically significant more often a father from a non-Nordic country. No relationship was found between the mother's native country and an elevated caries risk (Table 1).

Strengths and difficulties and caries risk

The children in the elevated caries risk group had a significantly higher mean value of conduct problems based on the SDQ, compared to those with low caries risk (4.69 vs. 4.15; $p=0.041$) (Table 8), although the effect size (Cohen's d) was small. No statistically significant difference was found between the low caries risk group and the elevated caries risk group for the other subscales (*i.e.*, Hyperactivity-Inattention problems, Emotional problems, Peer problems and Prosocial Behavior) (Table 8). For wider comparisons, mean values for parental SDQ from the normative study are also presented [141].

Table 8. Mean values (Mean) and standard deviation (SD) of the low and elevated caries risk groups in relation to the results of the SDQ subscale.

SDQ parent	Low risk		Elevated risk		t	p value	Cohen's d	Norms*	
	Mean	(SD)	Mean	(SD)				Mean	(SD)
	n=153		n=75					n=1361	
Emotion	3.73	(2.44)	4.11	(2.80)	-1.037	n.s.	0.14	1.5	(1.7)
Hyperactiv/Inatt	5.53	(2.57)	6.20	(2.56)	-1.853	n.s.	0.26	2.4	(2.1)
Peer	2.80	(2.16)	2.81	(1.90)	-0.032	n.s.	0.00	1.2	(1.5)
CD	4.15	(1.60)	4.69	(1.97)	-2.070	0.041	0.30	1.1	(1.3)
Pro social	6.69	(2.14)	6.45	(2.34)	0.748	n.s.	0.12	8.4	(1.7)
Tot. Difficulties	16.22	(5.66)	17.81	(6.31)	-1.928	n.s.	0.27	6.2	(4.8)

Norms from the parents of the children aged 10-13 years are presented for comparisons (Bjornsdotter *et al.* 2013) [141].

SDQ parent The Strengths and Difficulties Questionnaire for parents, *Hyper/inatt* hyperactivity-inattention, *CD* conduct disorder; *Peer* peer problems, *Prosocial* prosocial behavior {generosity and thoughtfulness}, *Total difficulties* all subscales but Pro social behavior are summed together to a Total Difficulties score, n number of children, p value level of significance, *Cohen's d* effect size (small=0.2; medium=0.5; large=0.8).

Disruptive behavior and caries risk

The mean values from the DBD showed higher mean values for conduct problems and impulsivity in the elevated caries risk group, compared with the lower caries risk group (0.29 vs. 0.20; $p=0.009$) and (1.34 vs.1.10; $p=0.021$), respectively (Table 9).

The effect size (Cohen's d) was between medium and small. For the subscales DBD-Inattention and ODD, no statistically significant difference was found between the caries risk groups (Table 9).

Table 9. Mean values (Mean), and standard deviation (SD) from the Disruptive Behavior Disorder rating scale for parents, Family Warmth and Conflict and Parental Knowledge and Monitoring Scale, for the low versus elevated caries risk groups.

	Low risk Mean (SD) n=153	Elevated risk Mean (SD) n=75	t	p value	Cohen's d
DBD parent					
CD	0.20 (0.17)	0.29 (0.25)	-2.65	0.009	0.42
Inattention Impulsivity/ Hyperactivity	1.38 (0.72)	1.48 (0.82)	-0.94	n.s.	0.13
ODD	1.10 (0.65)	1.34 (0.78)	-2.34	0.021	0.33
	1.53 (0.61)	1.51 (0.73)	0.22	n.s.	0.03
Family Warmth and Conflict					
Warmth	19.39 (3.71)	18.56 (4.02)	-1.55	n.s.	0.21
Conflict	9.03 (4.88)	7.11 (5.11)	-2.76	0.006	0.38
Monitoring					
Parental	1.76 (0.58)	1.91 (0.61)	-1.71	n.s.	0.25
Disclosure	7.78 (2.76)	7.88 (3.04)	-0.25	n.s.	0.03
Control	1.36 (0.51)	1.49 (0.85)	-1.46	n.s.	0.19
Solicitation	2.26 (0.70)	2.47 (0.77)	-2.01	0.046	0.29
Secrecy	7.88 (1.76)	7.79 (1.88)	0.35	n.s.	0.05

DBD parent Disruptive Behavior Disorder rating scale for parents, *CD* Conduct Disorder, *ADHD* Attention Deficit/Hyperactivity Disorder, here divided into Inattention and Impulsivity/Hyperactivity, *ODD* Oppositional Defiant Disorder, *Knowledge* parental knowledge, *n* number of children, *p value* level of significance, Cohen's d effect size: small=0.2; medium=0.5; large=0.8.

Family Warmth and Family Conflict and caries risk

For the Conflict scale, a statistically significant difference was found with a higher mean value in the low caries risk group, compared with the elevated caries risk group for *less conflict* (9.03 vs. 7.11; $p=0.006$) (Table 9). This indicates there were less conflicts in the families with children belonging to the elevated caries risk group. The effect size was small. No differences were found for warmth in the family.

Parental Knowledge and Monitoring and caries risk

Regarding the PKMS, a higher mean value was found in the elevated caries risk group for *more parental solicitation* (2.47 vs. 2.26; $p=0.046$), although the effect size was small. For the other subscales, no statistically significant difference was found (Table 9).

4.3.2 Oral hygiene behavior

(Paper I)

The dental questions concerning tooth brushing habits, answered by the externalizing children, showed that more children with externalizing behavior brushed their teeth less than twice a day, compared to controls ($p=0.0007$). After Bonferroni correction, the p -value=0.01 (Table 10).

Table 10. The **upper part** of the table shows the frequencies of the risk factors connected to oral health behavior in children with externalizing behavior problems, compared to controls. Percentage within brackets.

	Study group		Control group		Total	
	n	%	n	%	n	%
Tooth brushing (TB)						
TB <2 times/day	56	(28.9)	18	(12.9)	74	(22.2)
TB ≥2 times/day	138	(71.1)	121	(87.1)	259	(77.8)
Drink when thirsty						
Water/milk	144	(74.2)	125	(89.9)	269	(80.8)
Other than water/milk	50	(25.8)	14	(10.1)	64	(19.2)
Sweet /soft drinks at meals						
Never, seldom, 1/week	116	(59.8)	98	(70.5)	214	(64.3)
Several times /week/daily	78	(40.2)	41	(29.5)	119	(35.7)
Sweets						
Never, seldom, 1/week	127	(65.5)	103	(74.1)	230	(69.1)
Several times /week/daily	67	(34.5)	36	(25.9)	103	(30.9)
Cakes, buns biscuits						
Never, seldom, 1/week	163	(84.0)	109	(78.4)	272	(81.7)
Several times /week/daily	31	(16.0)	30	(21.6)	61	(18.3)

	n	OR	CI	p log reg	p log reg B-H
Tooth brushing	333	2.80	1.58-5.19	0.0007	0.010
Drink when thirsty	333	3.13	1.68-6.19	0.0005	0.009
Sweet/soft drinks at meals	333	1.61	1.02-2.58	0.0447	n.s.
Sweets	333	1.50	0.93-2.45	n.s.	n.s.
Cakes, buns, biscuits	333	0.69	0.39-1.21	n.s.	n.s.

The **lower part** of the table shows the results from the logistic regression. (n=number; n.s.=non-significant; OR=odds ratio; CI=confidence interval (95%); p log reg=p-value logistic regression; p log reg B=p-value logistic regression with Bonferroni-Holm correction.)

(Paper IV)

In the parent's report regarding oral hygiene routines, 17 parents of children and adolescents with ADHD reported their child had poor oral hygiene or did not manage to brush their teeth at all. Sixteen of the parents reported it had

been difficult or not possible to help their child brush their teeth during childhood (<8 year). According to the questionnaire, all children in the age-group 8-19 years (number=29) brushed their own teeth, while children aged 5-8 years received help from an adult (number=2). Fourteen of the children brushed once a day or less and all children used fluoride toothpaste. Extra fluoride supplementation was used by 15 individuals, according to the questionnaires. An ordinary toothbrush was used by 17 children, 3 used an electric toothbrush, and 11 children used both an electric and an ordinary brush.

4.3.3 Dietary habits

(Paper I)

Compared to controls, children with externalizing behavior preferred drinks other than water and milk when thirsty $p=0.0005$, and after Bonferroni correction $p=0.009$ (Table 10). 40.2% of the children in the study group frequently drank sweetened drinks at meals, compared to 29.5% in the control group. No statistical difference was found. OR: 1.62 (Table 10). No differences were found between children with or without externalizing behavior regarding the consumption of cakes, buns, and biscuits between the two groups (Table 10).

(Paper IV)

Regarding children with ADHD, the beverage for dinner was mainly milk or water, while syrups, soft drinks, and juices were more frequent when thirsty (Table 11, Table 12).

Table 11. Results of the questionnaire from the 26 parents of children diagnosed with ADHD (representing 31 subjects), regarding beverage intake for dinner and when thirsty. (Several alternatives were possible).

	Milk	Water	Syrup	Soft drinks	Juice	Other
Drink at dinner	23	21	9	5	5	0
Drink when thirsty	8	22	12	9	6	8

Table 12. Results of the questionnaire from the 26 parents of children diagnosed with ADHD (representing 31 subjects), regarding frequency of sweet beverages and the consumption of sweets, biscuits, sweet cereals and spreads.

	Never	Seldom	Once a week	Several times/week	Daily	No answer
Sweets	0	2	13	13	2	1
Syrup/soft drinks	0	4	11	11	4	1
Juice	1	12	8	7	2	1
Cookies, biscuits	0	8	15	6	1	1
Sweet cereals	14	8	4	1	3	1
Bread with marmalade jam/Nutella	12	10	7	1	0	1

4.4 Dental fear and behavior management problems

4.4.1 Dental fear

(Paper I)

Among children with externalizing behavior problems, 10 children with dental fear were found (CFSS-DS \geq 38); no one in the control group reached a value of \geq 38.

Considering the CFSS-DS, 30 children (15.5%) in the study group and three subjects (2.2%) in the control group were classified as having a higher risk range for dental fear (CFSS-DS \geq 32) $p=0.0005$, and after Bonferroni correction $p=0.009$, OR: 8.61 (Table 6). The mean value for the CFSS-DS score was 24.07, (SD: 7.403) in the study group and 20.16, (SD: 4.677) in the control group.

(Paper IV)

According to the parents, 5 children with ADHD suffered from dental fear, but 17 parents thought their child did not manage dental care in a suitable way. Four children had problems going to the physician because they were afraid of injections, 3 children with dental fear were also afraid of going to the physician. Only one individual with dental fear also had fear of medical care and had a sibling with dental fear. According to the answered questionnaires, 13 mothers, 5 fathers, and 11 siblings had dental fear. However, only one mother with dental fear reported having a child with dental fear.

4.4.2 Behavior management problems

(Paper I)

The prevalence of BMP in children with early-detected externalizing behavior problems was 10.3%, compared to 2.2% in the control group. This difference was not statistically significant. The OR for BMP was 5.25 for children in the study group (Table 6).

(Paper III)

In children and adolescents with ADHD, 17 out of 31 children (11 boys, 6 girls) were noted in their dental records as having dental behavior management problems, on at least one occasion. Dental behavior management problems were more common among the younger individuals than the older. Fourteen of the children with ADHD (5 girls and 9 boys) and dental behavior management problems (DBMP), had received operative treatment without the use of local anesthetics (Table 13; Fig. 8).

Table13. Number of subjects diagnosed with ADHD with dental records (**DR**), mean number of treatments without notations of local anesthesia (**TW-la**), mean number of missed and cancelled appointments (**MC-app**) and mean number and range of behavioral management problems (**BMP**) in the age groups.

	DR	TW-la	MC-app	DBMP	
0-5 years	29	6 (1-6)	16 (1-7)	11	(1-3)
6-10 years	30	14 (1-5)	21 (1-13)	6	(1-5)
11-15 years	29	7 (1-3)	19 (1-16)	7	(1-2)
16-19 years	20	6 (1-4)	13 (1-10)	2	(1-3)

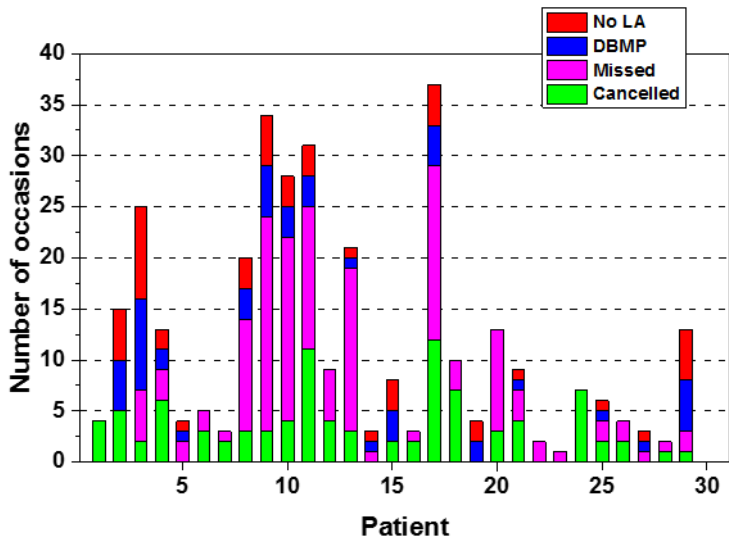


Figure 8. Number of dental visits with dental behavior management problems (DBMP), missed (Missed) and cancelled (Cancelled) appointments and treatments without evidence of use of local anesthetics (No LA) for each patient diagnosed with ADHD.

4.5 Dental care data from dental records

4.5.1 Preventive dental treatment

(Paper III)

All subjects had received preventive treatment at their regular dental clinics. The health promotion comprised changing oral hygiene habits and disease prevention, oral hygiene instructions and education, including the removal of plaque, fluoride varnishing, and when indicated, fissure sealing. The number of preventive treatments differed considerably within the study group.

4.5.2 Other findings in dental records

(Paper III)

At least one appointment was cancelled by 24 out of 31 children with ADHD. Cancelled appointments were found in all ages, with no age group having more cancelled appointments than the other. At least one appointment was missed by 26 out of 31 children. Missed appointments were more common in the 6 to 10-year-old group, compared to the 0 to 5-year-olds and the 16 to 19-year-olds (Table 13).

Operative treatment without recorded notations of the use of local anesthetics was carried out on 75 occasions on 19 patients, with a range from 1-10 treatments (Fig. 9). In total, 19 out of 31 had received operative treatment without any notations of local anesthetics.

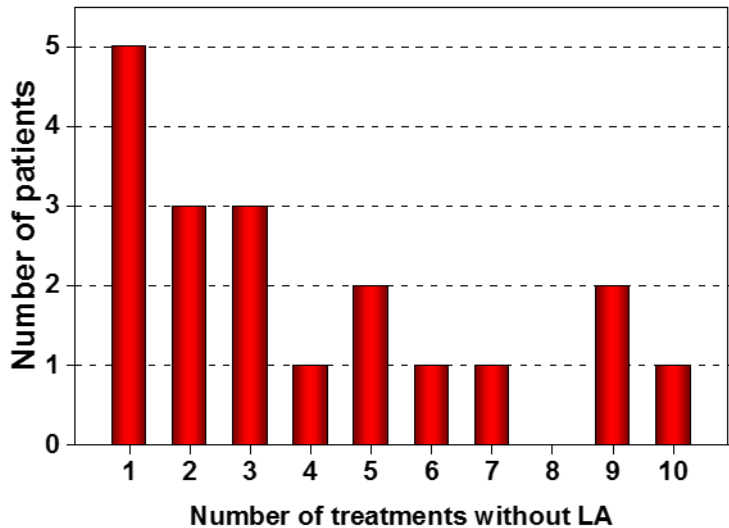


Figure 9. Number of operative treatments, occasions without notification of use of local anesthetics (LA) for the patients diagnosed with ADHD in the study.

4.6 Parental evaluation of dental care

(Paper I)

Regarding the parent's evaluation of the child's dental care, there were no differences between children with externalizing behavior problems, compared to controls (Table 6).

(Paper IV)

All of the 31 children/adolescents with ADHD in Study Group 3 had received dental care at their regular dental clinics; two had received specialist dental care and two had received dental care under general anesthesia. The children had experienced taking X-ray images, local anesthesia, filling therapy and tooth extractions (Table 14).

Table 14. Results of the questionnaire from the 26 parents of children diagnosed with ADHD (representing 31 subjects) during previous dental experiences,

Report of previous dental experiences					
	Yes	No	No answer	Pain	Discomfort
X-ray	29	2	0	11	14
Local anesthesia	19	12	0	15	15
Filling therapy	18	12	1	11	13
Polishing of teeth	18	12	1	4	6
Tooth extraction	16	14	1	8	11
Dental trauma	13	18	0	12	11

A majority of the parents also expressed their children had experienced pain and discomfort during different treatments. Fifteen parents reported their children had experienced both discomfort and pain from local anesthesia, 12 reported pain from treatment of a dental trauma, and 11 parents reported pain in connection with filling therapy (Table 14). The answers indicated no influence of siblings.

Most of the parents thought their child had received necessary dental treatment, good dental information, and considered the dental staff was kind to their child, while 17 believed the staff's knowledge regarding neuropsychiatry was not sufficient (Table 15).

Table 15. Evaluation of treatment at the Public Dental Service according to the questionnaire filled out by the 26 parents of the 31 children with ADHD.

Evaluation	Good	Less good/doubtful	No answer
Received with kindness	23	7	1
Dental information	23	7	1
Necessary dental treatment	21	10	0
Patience	18	12	1
Care	18	13	0
Knowledge	12	17	2

The answers to the 76 questionnaires are first presented as annotations from the parents grouped under *sweets*, then grouped into four sections: *Preparation* before the dental visit and knowledge in advance regarding the dental treatment, enough *time* and *care* regarding the child and *patience* from the dental staff. There were also annotations regarding *knowledge of neuropsychiatry* and *the parents' reflections* of their child during dental visits.

Twenty parents made comments in the questionnaire to the two open questions; “*Is there anything else you would like to tell us about dentistry for children/adolescents with ADHD*”, and “*Is there anything you think dentists could do better/different concerning dentistry for children/adolescents with ADHD?*” The comments are listed in Appendix X. The most frequent comments concerned time, care and patience regarding personnel in the dental clinic (30 comments), followed by the parents' general reflections (16 comments).

4.7 Evaluation of caries risk with inductive analyses

(Paper II)

In the analysis with the two outcome values “**Low Risk**” and “**Elevated Risk**”, the factor “**Caries Activity**” appeared at the top level, thus being the most important factor (Fig. 10). The attribute “**Medical Risk Factors**” did not appear in the knowledge tree, thus being redundant for the outcome.

The verifying option in XpertRule Analyser showed, in the *training set*, that the outcome value “**Low Risk**” was correctly classified in 99% and “**Elevated Risk**” in 93.2%. The correctly classified pattern rules in the *test set* were 99.0% and 93.2%, respectively.

From the results of the inductive analysis, it can be concluded that the pattern rules for the caries risk grouping into “**Low Risk**” and “**Elevated Risk**” are realistic.

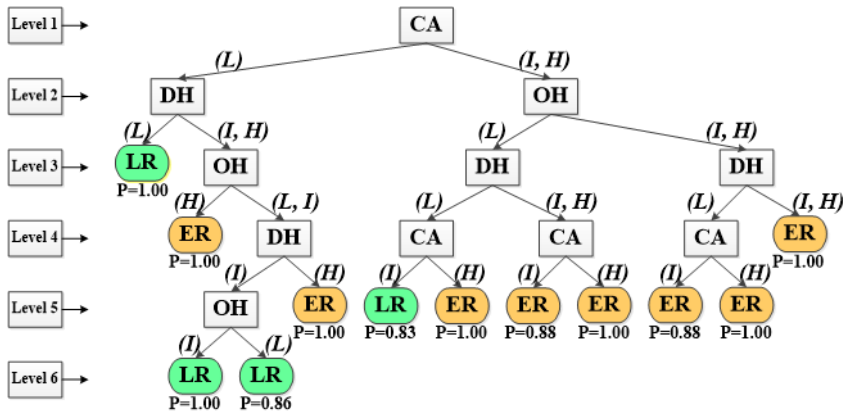


Figure 10. Knowledge tree based on the risk factors “Caries Activity” (CA), “Dietary Habits” (DH), “Oral Hygiene” (OH) and “Medical Risk Factors” from the electronic file system. The values for the attributes are “Low risk” (L), “Intermediate risk” (I) and “High risk” (H). As outcomes in the inductive analysis, the caries risk values “Low Risk” (LR) and “Elevated Risk” (ER) were used. The square boxes represent an attribute and the rounded boxes represent the outcome. In connection with the arrow, the value for each attribute is given. Below the outcomes, the probability value (P) is shown. **Level 1 – Level 6** marks the positions in the induced knowledge tree. Values for CA: Low (L) = no or low caries activity; Intermediate (I) = moderate caries activity; High (H) = high caries activity; values for DH: Low (L) = healthy foods; Intermediate (I) = cariogenic diet with moderate intake frequency; High (H) = cariogenic diet with high intake frequency; Values for OH: Low (L) = plaque on few approximal surfaces (PI=20%); Intermediate (I) = general approximal plaque (PI 20–50%); High (H) = more than general approximal plaque (PI=50%).

5 DISCUSSION

The focus of this thesis has been on Swedish children and adolescents with early-detected externalizing behavior and a subgroup of children and adolescents diagnosed ADHD, in regard to oral health, oral health behavior, and parental evaluation of their child's oral health and experiences of dental care. Two groups of children with externalizing behavior problems, having low and elevated caries risk, were compared regarding gender, behavioral characteristics, and family structure.

This thesis has shown that there are differences regarding oral health between the children and adolescents with externalizing behavior, compared to controls, although no difference in caries prevalence between the groups was found. However, there were more children with an elevated caries risk among externalizing children, compared to children in general, in the Region of Västra Götaland, both in total and within the genders. Differences with regard to behavioral characteristics were observed in externalizing children with an elevated risk for caries, having higher mean values for conduct problems and impulsivity/hyperactivity. An interesting observation was fewer conflicts in the families and more parental solicitation for the externalizing children with an elevated caries risk. There were no differences regarding the parental evaluation of the child's oral health for the children with externalizing behavior, compared to controls.

Children diagnosed ADHD had a high caries prevalence compared to children in the Region of Västra Götaland. Additionally, children with externalizing behavior, and those with ADHD, had a high prevalence of traumatic dental injuries.

Children with externalizing behavior brushed their teeth less frequently, compared to controls. Tooth brushing less than twice a day was also common among children with ADHD.

The strength of this thesis is the collaboration in prevention and health promotion between the Public Dental Service, schools, and social services (*Papers I, II*), which is necessary for identifying these children at an early stage.

Another strength of this thesis is the collaboration between the Public Dental Service and the child and adolescent psychiatry specialists at the Child Neuropsychiatry Clinic at Queen Silvia Children's Hospital, Sahlgrenska University Hospital, Gothenburg, regarding children diagnosed with ADHD

(*Papers III, IV*). This has enabled a multidisciplinary research project involving disciplines in odontology (Institute of Odontology, Sahlgrenska Academy, University of Gothenburg), psychiatry (Institute of Neuroscience and Physiology, Gillberg Neuropsychiatry Center) and psychology (Division of Psychology, Department of Clinical Neuroscience, Karolinska Institutet, Stockholm), which potentially add new knowledge regarding children with externalizing behavior and ADHD.

The families, invited to the different study groups and the control group, were derived from diverse socioeconomic areas, thus representing the general population in Gothenburg, which is a strength of this study. However, since participation was voluntary, it cannot be excluded that some families of children with externalizing behavior did not respond to the invitation to participate.

A limitation is the number of parents of children with ADHD willing to participate in the ADHD studies, and the children's wide age range. On the other hand, it had been unethical not to compile data from the participating families. Access to data from medical or dental records is regulated by Swedish Laws and Acts. Approval by an ethical committee, written information, and signed consent of voluntary participation is mandatory. Therefore, no data was available regarding the families who chose not to participate.

Strengths in the studies were the use of the well-known and validated instruments, SDQ [144] and CFSS-DS [116, 124, 157-159]. For the psychological instruments DBD [10], PKMS and the FW/FC, good psychometric properties were shown [145].

Mainly parents answered the questionnaires, but the child itself answered the dental fear survey (CFSS-DS) and the questionnaire regarding dietary habits and tooth brushing frequencies. Even though the parents' answers have their limitations, and do not fully reflect reality, the information they provide is valuable and useful.

The computerized algorithm-based system R2, for caries risk assessment, is used by the Public Dental Service in the Region of Västra Götaland. The verification of the pattern rules evolved in the inductive analysis, using the original data forming the R2 risk groups and pooling the values for intermediate and high caries risk, indicated that the risk assessment was relevant.

Retrospective studies have limitations, since several dentists are involved and data may be missing. A strength is the possibility to follow single subjects over time.

In children with externalizing behavior, no statistical significant difference in caries prevalence was found, when comparing the children with externalizing behavior problems to the controls, but the caries risk was higher. This observation may be related to the child's dental stage and thus caries may not yet have developed. Another factor to be considered is preventive measures performed by the dental staff or by the family in-home care. This is in line with Williamson *et al.*, who found that children with externalizing behavior were more caries-active [160], which could be explained by these children not having received sufficient preventive measures. However, the present results are in contrast to Lorber *et al.*, who found that children with externalizing behavior had less caries [65].

In this thesis, the fact that the children with ADHD had high caries prevalence indicates that preventive measures for this group were not sufficient. Although in the literature, there are conflicting results regarding caries prevalence in children with ADHD. This thesis is in line with other studies [53-57, 60], suggesting a positive correlation between caries prevalence and ADHD. However, other studies have failed to show an association between ADHD and caries prevalence [61-66].

In Sweden, all children are assessed for caries risk by their dentist at their regular dental examinations. Caries risk assessment is defined as the probability of an individual patient to develop caries lesions over a certain period of time. A risk assessment is important for decisions regarding adequate prevention, management of dental caries, and for the individual recall interval. An individual caries risk assessment is also of importance in order to target prevention resources for children who need it the most [161].

There were more children with an elevated caries risk among the externalizing children, compared to children in general in the Region of Västra Götaland, indicating a need for special attention regarding caries in children with externalizing behavior. To the knowledge of this thesis, this has never been demonstrated before.

Children with externalizing behavior and an elevated caries risk had higher mean values of conduct problems and impulsivity/hyperactivity. Therefore, including these factors in the caries risk assessment is valuable.

An interesting observation was fewer conflicts in the families in externalizing children with an elevated caries risk, which could mean that these parents may be less strict when maintaining positive oral health habits.

Significantly more children with externalizing behavior problems brushed their teeth less than twice a day. Brushing twice a day with fluoridated toothpaste is an evidence-based preventive measure for dental caries [162]. Good oral hygiene requires persistence, patience, and routine, which can be difficult for children with impulsivity/hyperactivity. The child might not listen to the parent's urging, is too tired and may not remember to brush, is unmotivated or finds it hard to understand the consequences of their actions.

More than half of the parents of the ADHD children reported poor oral hygiene and difficulties maintaining proper tooth brushing during childhood. This may be due to the child's symptoms of hyperactivity and conduct behavior and is in agreement with Blomqvist *et al.*, who showed that tooth brushing fewer than twice a day is common among Swedish children, 13 years of age with ADHD [61].

The high amount of plaque present in the children with ADHD is in line with what has been reported in other studies [56-57, 63-64, 66]. Several of the ADHD children with plaque had received numerous preventive measures; this could be interpreted as information and motivation not reaching the recipients. This shows that it may not be the amount of preventive measures that is crucial if the child brushes their teeth or not. Instead, other underlying factors may relate to the child's behavior and how the preventive measures are given by the dental staff.

A common risk factor, found in both children with externalizing behavior and children with ADHD, is the preference for sweetened drinks, soft drinks and juices when thirsty. The above findings are interesting considering the results by Blomqvist *et al.*, who showed that children with ADHD are 1.74 times more likely (OR 1.74) to eat or drink more than five times a day [61]. The open questions answered by the parents indicate that they are well aware of their child's passion for sweets. This risk factor should be attended to in the anamnesis and a reduction of the consumption of sweets, soft drinks, snacks, and pastry should be emphasized to the parents by promoting non-cariogenic alternatives. Therefore, notations in dental records regarding sweets are an important reminder that a caries-risk assessment should be performed at each visit to assess changes in an individual's risk status.

The high prevalence of traumatic dental injuries (TDI) (51.5%) in externalizing children was considerably higher compared to what was found in the large Swedish BITA study in children 0-17 years of age (37.6%) [70]. However, the connection between hyperactivity symptoms and TDI has been shown by other studies [86-87]. On the other hand, findings of more TDI are in accordance with several other studies, showing that children with ADHD had more TDI than children without this diagnosis [80-85]. General unintentional injuries have also been linked to children with hyperactivity/inattention [92]. Both children with externalizing behavior and those with ADHD seem to exhibit a risk behavior linked to hyperactivity that makes them more prone to TDI.

With regard to children with externalizing behavior, the parents' evaluation of their child's oral health did not differ, compared to controls. A high number of parents of children with ADHD considered their child's oral health to be good or very good. This is an interesting finding in relation to the observations of this study and shows a higher prevalence of caries and traumatic dental injuries, which could reflect that parents do not perceive caries and dental injuries as an oral health problem.

According to the Child's Fear Survey Schedule-Dental Subscale (CFSS-DS), children with externalizing behavior had a higher risk range for dental fear. This higher risk for dental fear should be considered during treatment of children with externalizing behavior, as suggested by ten Berge *et al.* [112].

The majority of parents of children with ADHD reported that their child did not suffer from dental fear. This is in line with Blomqvist *et al.*, who did not find any differences between ADHD children, compared to controls, when using the parental version of the CFSS-DS [55].

Children with externalizing behavior did not show any differences regarding BMP, compared to controls. This was somewhat surprising, but may be a reflection of the fact that these children had a limited experience of dental treatments. Furthermore, the parents' evaluation of dental care did not differ in externalizing children, compared to controls.

In children with ADHD, a majority (55%) had notations in dental records of BMP. This result is in agreement with the results reported by Blomqvist *et al.* [89]. To some extent, this could be explained by the fact that more than half of the children with ADHD had received operative treatment without notations of the use of local anesthesia in the dental records. Some children had even received repeated treatments without notations of anesthetics. Several studies have shown a connection with BMP and experiences of pain [111, 119,163].

Moreover, the parents of the children with ADHD believed that knowledge regarding neuropsychiatry was insufficient among dental staff, and there were many comments regarding time, care and patience.

In Sweden, the County Councils are responsible for all children's dental care. All children are called to the Public Dental Service (PDS) or their private clinic with individual recall intervals. Participating in a research study is voluntary. The assessment is that the findings in this thesis are representative for the children and adolescents in the present context, but should not be generalized to the entire population. However, the information in this thesis gives a deeper understanding of oral health among externalizing children and adolescents, but also in regard to the subgroup of children and adolescents diagnosed ADHD. The valuable multidisciplinary collaboration regarding the studies of these groups of children is, to the knowledge of this thesis, unique.

5.1 Ethical considerations

Approval from appropriate ethical committees is the legal and moral prerequisite when conducting research, especially research involving human beings. A number of issues should be addressed prior to the start of a study.

- ✓ How does the study contribute to knowledge in the research area?
- ✓ How can the patients involved or society benefit from the results?
- ✓ Are there any risks for the patients involved that should be considered?
- ✓ How can possible risks, integrity problems, and discomfort for the patients involved be handled?
- ✓ Is the written information to the patients satisfactory and understandable?
- ✓ Are the patients involved adequately informed that participation is by free will and can be terminated by the participant at any point, and all information is confidential?
- ✓ How can the patients involved receive feedback of results from the studies?

Studies involving children compose special problems regarding the child's autonomy and its right to make decisions. A human being below the age of 18 is regarded as a child, according to The Convention on the Rights of the Child by UNICEF and the United Nations [164]. In The Swedish Ethical Review Act

2003:460, the child's right to decide in respect to informed consent is regulated [165]. However, a child's autonomy and understanding of participating in a research project depends highly on the child's maturity and development, as well as the family situation.

The studies in the present thesis were conducted according to legal and ethical rules. All participants in the studies were given written information and a signed consent was returned. All returned questionnaires were coded and kept under locked conditions.

Irrespective if an ethical approval is given by appropriate ethical committees, the academic has the ultimate responsibility for conducting the research with full respect for the integrity of the subjects involved in the studies.

5.2 Clinical implications

Children with externalizing behavior need special attention in dental care. Many of these children have an elevated risk for caries, adverse oral health behavior, and a considerable risk for traumatic dental injuries. The clinicians should pay attention to conduct behavior, impulsivity, and hyperactivity in the caries risk assessment. In addition to general preventive programs, individually designed measures should be offered.

It is important that all children have access to dental care on equal terms, based on their own conditions. In order to prevent dental fear and future behavior management problems, it is desirable to provide knowledge to the dental staff regarding children with externalizing behavior.

6 CONCLUSIONS

- There were differences in oral health in children and adolescents with externalizing behavior, compared to controls, though no differences in caries prevalence between the groups were found. In the subgroup of children diagnosed Attention Deficit Hyperactivity Disorder (ADHD), high caries prevalence was found, compared to children in the Region of Västra Götaland.
- Children with externalizing behavior and those with ADHD had a high prevalence of TDI.
- Children with externalizing behavior brushed their teeth less frequently than twice a day, compared to controls. Poor oral hygiene was also reported by the parents of children and adolescents with ADHD, where half of the children brushed once a day or less. Both children with externalizing behavior and those with ADHD preferred sweetened drinks when thirsty.
- There were no differences regarding the parental evaluation of the child's oral health in the children with externalizing behavior, compared to controls. A majority of the parents of children/adolescents with ADHD claimed oral health was very important or important.
- There were no differences regarding the parental evaluation of the dental care in children with externalizing behavior, compared to controls, but more than half of the parents of children/adolescents with ADHD thought their child did not manage dental care in a suitable way. Moreover, the parents of children/adolescents with ADHD experienced a lack of child neuropsychiatric knowledge, care, and patience from dental staff.
- There were more children with an elevated caries risk among the externalizing children, compared to children in general in the Region of Västra Götaland. Behavioral characteristics, such as hyperactivity/impulsivity and conduct problems, were found in externalizing children with an elevated caries risk, compared to those with a low caries risk. Additionally, there were less conflicts in the families. Children with an elevated caries risk lived more often in households with more than two children and had a father from a non-Nordic country.

- The children with an elevated caries risk had a higher risk range for dental fear. In the subgroup of children/adolescents with ADHD, few children suffered from dental fear.
- There were no differences regarding dental behavior management problems (DBMP) in children with externalizing behavior, compared to controls. Notations in dental records on DBMP, on at least one occasion, were found in more than half of the children and adolescents with ADHD.

7 FUTURE PERSPECTIVES

A multidisciplinary approach has demonstrated a way of finding these children at an early stage and has given access to methods and analyses not commonly used in dentistry.

This approach has the potential to increase knowledge for other groups of children in need of special care.

An example of a future interesting study would be to follow oral health, longitudinally, in the children whose families have participated in successful parental training programs.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the help and support of so many people around me. First of all, my deepest gratitude to all the children, adolescents and their parents, who generously participated in the studies and helped me to understand more about externalizing behavior.

I would like to give my special thanks to:

Docent Agneta Robertson, my main supervisor, for your genuine interest in my research project, your enthusiasm and endless support, and for generously sharing and guiding me through your vast knowledge of the world of scientific research. Thank you for your encouragement and the many stimulating discussions, and for being my great inspiration, always believing in me and for being my friend.

Professor Emeritus Jörgen G. Norén, my co-supervisor, for teaching me the scientific way of thinking, and for great and inspiring guidance. Thank you for always being there for me throughout my whole PhD process.

Professor Lars Gahnberg, my co-supervisor, for your enthusiastic support and guidance in the scientific field. Thank you for allowing me to be a part of your positive way of thinking. Being my friend and always having a smile on your face has helped me to reach this goal.

Professor Ata Ghaderi, my co-author, for your generous help and guidance in statistics and the interpretation of psychological instruments, and for sharing your excellent knowledge in the field of psychology and research.

Svenny Kopp and Mats Johnson, my co-authors, for being excellent physicians and professionals in the research field of children and adolescents with ADHD, and for sharing your great knowledge.

Christina Kadesjö, my co-author, for initiating the collaboration between the odontological and psychological institutions, the schools, social services, public health care, and public dental care.

Annika Björnsdotter, for all your valuable contributions in helping me to understand psychological instruments and language.

Sandra Ståhlberg, for your great help with the proofreadings and translations, and for making my English possible to read and understand.

Jenny Thunberg, for your helpful administrative support as a project leader/team leader at the Center for Progress in Children's Mental Health.

Anna Oldin, for your great friendship and help, and for sharing the life as a PhD student with me.

Bodil Eklund, my wonderful dental assistant for many years. Thank you for all the happy moments we shared, laughing together with our lovely patients and their parents, always having fun.

Caroline Hafström, Hilde Garvald, Judith Hansson, my dearest colleagues and friends, for encouragement and support during my thesis and for all the laughter and fun during the creation of songs and other improvisations.

Lillian Annelund, for your kindness and helpful administrative support.

All my colleagues and friends in Gothenburg, at the Specialist Clinic for Pediatric Dentistry and the Department of Pediatric Dentistry.

Per Arne, my beloved husband, for supporting me while I have been finishing this thesis.

Hugo, Johan and Klara, my wonderful children, who complement my life and for just being who you are.

Berit and Rolf, my parents, who have always supported me in whatever I have been doing throughout life, and for still being there in my thoughts.

GRANTS

Paper I

This study was supported by the Region of Västra Götaland and the Swedish National Board of Health and Welfare.

Paper II

This study was supported by the Region of Västra Götaland.

Paper III

This study was supported by grants from The Research & Development Council in the Region of Västra Götaland, Sweden (Grant numbers: VGFOUGSB-3334, VGFOUGSB8871); The Dental Society of Gothenburg; The Foundation of Sigge Person and Alice Nyberg for Research in Odontology, and from the Swedish Society of Paediatric Dentistry.

Paper IV

This study was supported by grants from The Research & Development Council in the Region of Västra Götaland, Sweden; The Dental Society of Gothenburg; The foundation of Sigge Person and Alice Nyberg for Research in Odontology, and from the Swedish Society of Paediatric Dentistry.

My sincere gratitude to the **University of Gothenburg**, for giving me incites to research and opportunities to present my thesis.

Special thanks to the **Public Dental Service** in the Region of Västra Götaland, for financial support to complete my PhD project.

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APPENDIX

Appendix I.	Screening interview by telephone
Appendix II.	Social background questionnaire
Appendix III.	Parental questionnaire and medical history
Appendix IV.	The Strengths and Difficulties Questionnaire
Appendix V.	Disruptive Behavior Disorder rating scale
Appendix VI.	Family Warmth and Family Conflict
Appendix VII.	Parental Knowledge and Monitoring Scale
Appendix VIII.	Child's Fear Survey Schedule-Dental Subscale
Appendix IX.	Dental questions to the child
Appendix X.	Annotations from parents
Appendix XI.	Clinical examination form