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# ORAL HEALTH AND BEHAVIOR IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

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*To Kenneth and Max*



## ABSTRACT

Attention deficit hyperactivity disorder (ADHD) is a common developmental disorder and has a substantial impact on many situations in the child's daily life. The present thesis investigates the behavior of children with ADHD in a dental setting—that is, behavior management problems (BMP), interaction between child and dentist, dental anxiety, and stress—and the oral health of these children compared to a control group.

The specific aims of this thesis were to test the hypotheses that children with ADHD display more BMP during dental treatment, display more problems in the interaction process with the dentist, exhibit a higher degree of dental anxiety, have a different stress reaction (measured as salivary cortisol) during a dental recall visit and a different diurnal cortisol variation, have a higher prevalence of caries and gingivitis, and have poorer oral health behavior than children in a control group.

All children born in 1991 ( $n=555$ ) in one Swedish municipality were screened for behavior, attention, and learning problems with Conner's 10-item questionnaire and a questionnaire focused on executive and learning problems. Thirty-five children fulfilled the criteria for ADHD and were classified according to whether they had ADHD of the combined, inattentive, or hyperactive-impulsive type. Children with no behavior, attention, and learning problems from the same population constituted a control group.

In the first study, dental records of the subjects were obtained and data regarding notes on BMP between 3 and 10 yr of age were compiled. The children underwent a clinical dental examination at age 11 yr, and bite-wing radiographs were taken. The parents completed the Dental Subscale of Children's Fear Survey Schedule (CFSS-DS). In the ADHD group, the prevalence of BMP increased between age 7 and 9 yr. A significant difference between the groups was found at age 8. Compared to controls, children with ADHD had a significantly higher number of decayed, missing, or filled surfaces (DMFS,  $1.0 \pm 1.5$  vs  $2.0 \pm 3.0$ ,  $P = 0.032$ ) and decayed surfaces (DS,  $0.5 \pm 0.9$  vs  $1.7 \pm 3.6$ ,  $P = 0.016$ ). Differences between the groups in CFSS-DS scores were nonsignificant.

In the second study, the dental recall visit at age 11 was recorded on video and analyzed in detail. Interaction between the dentist and the child was scored as verbal and nonverbal initiatives and responses. Compared to the children in the control

group, the children with ADHD made significantly more initiatives, especially initiatives that did not focus on the examination or the dentist. The children with ADHD made fewer verbal responses and had more missing responses. These problems in communication resulted in less two-way communication between the dentist and the children with ADHD than between the dentist and the children in the control group.

In the third study, the children, all age 13, underwent a clinical dental examination and completed two questionnaires on dietary habits and dental hygiene habits. Differences between the groups regarding DMFS, DS, initial caries lesions, and gingival inflammation were nonsignificant. Forty-eight percent in the ADHD group brushed their teeth every evening compared to 82% in the control group. Corresponding frequencies for brushing the teeth every morning were 48% and 75%. Children with ADHD were 1.74 times more likely to eat or drink more than five times a day than children in the control group.

In the fourth study, the children, all age 13, underwent a clinical dental examination and completed the Corah Dental Anxiety Scale (CDAS). Four saliva samples were gathered for analysis of cortisol: one before the dental examination, one after, and two the following morning. The subgroup ADHD with hyperactivity-impulsivity had significantly lower cortisol levels than controls 30 min after awakening. When cortisol values were plotted on a timeline, this subgroup always had lower cortisol concentrations than children in the control group. The correlation between CDAS scores and cortisol concentrations before the dental examination was significant in both the ADHD and the control groups.

In conclusion, this thesis found that children with ADHD compared to a control group have more dental behavior management problems; exhibit more problems interacting with the dentist, with particular difficulties staying focused on the examination; do not exhibit a higher degree of dental anxiety, except if the child has several symptoms of hyperactivity or impulsivity; have a blunted cortisol reaction, if the child has several symptoms of hyperactivity or impulsivity; have a higher caries prevalence and incidence at age 11, but not statistically significantly higher at age 13; do not have a higher prevalence of gingivitis; and have poorer oral health behavior.

**Key words:** ADHD, adolescent, behavioral science, child, cortisol, dental anxiety, dental caries, dentistry, health behavior, HPA axis

## SAMMANFATTNING

Neuropsykiatriska funktionshinder är vanligt förekommande hos barn i skolåldern. Attention deficit hyperactivity disorder (ADHD) är en klinisk diagnos som baseras på kriterier av ouppmärksamhet, överaktivitet och/eller impulsivitet, och kan ses hos 3-6 % av alla barn.

Denna avhandling studerar beteende i tandvården samt oral hälsa hos en grupp barn med ADHD. Barnen jämförs med en kontrollgrupp bestående av barn utan uppmärksamhets- eller inlärningsproblem. Avhandlingen innefattar en journalstudie och kliniska studier av barn 11 och 13 år gamla.

Alla 555 barn födda år 1991 boende i Sigtuna kommun norr om Stockholm år 2001 medverkade i studien. Barnen genomgick en undersökning för att utreda om de hade uppmärksamhets- eller inlärningsproblem. Trettiofem barn uppfyllde diagnoskriterierna för ADHD.

I den första delstudien genomlästes alla journalanteckningar mellan tre och 10 års ålder för barnen med ADHD och barnen ur kontrollgruppen för att registrera kooperationsproblem i tandvården. Vid 11 års ålder genomgick barnen en klinisk tandläkarundersökning, då även röntgenbilder togs. Barnens föräldrar fyllde i en enkät om barnens tandvårdsrädsla. Jämfört med barnen i kontrollgruppen hade barnen med ADHD mer kooperationsproblem, vilket märktes tydligast vid sju till nio års ålder, då personalen förväntar sig att barnet skall klara av behandlingssituationen. Barnen med ADHD hade en högre kariesförekomst, men uppvisade inte mer tandvårdsrädsla än barnen i kontrollgruppen.

I den andra delstudien videofilmades tandläkarundersökningen vid 11 års ålder. Ur videoinspelningarna analyserades barnens och tandläkarens kommunikation och samspel. Jämfört med barnen i kontrollgruppen hade barnen med ADHD svårare att koncentrera sig på behandlingssituationen. Barnen med ADHD ställde fler frågor till tandläkaren och gav mer kommentarer, speciellt kommentarer som inte rörde själva undersökningen. Svaren barnen gav var mer otydliga och barnen lät oftare bli att svara tandläkaren.

I den tredje delstudien genomgick barnen en klinisk tandläkarundersökning vid 13 års ålder, då även röntgenbilder togs. Barnen fyllde i ett formulär om munhygien- och kostvanor. Barnen med ADHD borstade mer sällan tänderna på morgonen och på kvällen, och åt oftare fem eller flera gånger per dag jämfört med kontrollgruppen.

Barnen med ADHD hade vid 13 års ålder inte en högre kariesförekomst än barnen i kontrollgruppen, men på grund av det sämre orala hälsobeteendet kan ADHD utgöra en risk för sämre oral hälsa i framtiden.

I den fjärde delstudien undersöktes stresshormonet cortisol i samband med tandbehandling. Barnen lämnade salivprov för analys av koncentration av cortisol före och efter tandläkarundersökningen vid 13 års ålder. Barnet fyllde vid tandläkarbesöket i ett formulär som mäter tandvårdsrädsla. De barnen med ADHD som uppfyllde flest kriterier på överaktivitet eller impulsivitet hade en högre grad av tandvårdsrädsla och lägre koncentrationer av cortisol än barnen i kontrollgruppen. Då man analyserade dygnskurvan av cortisol i saliv hade dessa barn ett avtrubbat cortisolsvar. Bland både barnen med ADHD och barnen i kontrollgruppen fanns ett samband mellan tandvårdsrädsla och cortisol inför tandläkarbesöket. Däremot steg inte koncentrationen av cortisol under själva tandläkarbesöket, vilket tyder på att stressreaktionen i samband med tandbehandling infaller före behandlingen och inte i samband med att barnet genomgår tandläkarundersökningen.

Vid tandbehandling av barn med ADHD bör tandläkaren inte misstolka barnets beteende och tro att barnet inte vill samarbeta, när det istället handlar om att barnet inte kan. Barn med ADHD fungerar oftast bäst i en lugn miljö. Tandläkaren måste hjälpa barnet att hålla fokus på behandlingen. Berätta på ett tydligt och enkelt sätt vad som skall ske och ge barnet uppmaningar istället för att ställa för många frågor. Barnet behöver korta instruktioner och vägledning igenom behandlingen ett steg i taget. Beröm för lämpligt beteende hjälper och vägleder barnet i behandlingssituationen. Barn med ADHD kan ses som en riskgrupp för oral ohälsa som behöver tidig och kontinuerlig kariesprevention.



## LIST OF PUBLICATIONS

This thesis is based on the following articles, which are referred to in the text by their Roman numerals (I–IV):

- I. BLOMQVIST M, HOLMBERG K, FERNELL E, EK U, DAHLLÖF G. Oral health, dental anxiety, and behavior management problems in children with attention deficit hyperactivity disorder. *Eur J Oral Sci* 2006; 114: 385-390.
- II. BLOMQVIST M, AUGUSTSSON M, BERTLIN C, HOLMBERG K, FERNELL E, DAHLLÖF G, EK U. How do children with attention deficit hyperactivity disorder interact in a clinical dental examination? A video analysis. *Eur J Oral Sci* 2005; 113: 203-209.
- III. BLOMQVIST M, HOLMBERG K, FERNELL E, EK U, DAHLLÖF G. Dental caries and oral health behavior in children with attention deficit hyperactivity disorder. *Eur J Oral Sci* 2007; *submitted*.
- IV. BLOMQVIST M, LINDBLAD F, HOLMBERG K, FERNELL E, EK U, DAHLLÖF G. Salivary cortisol levels and dental anxiety in children with attention deficit hyperactivity disorder. *Eur J Oral Sci* 2007; 115: 1-6.

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## LIST OF ABBREVIATIONS

ADHD	Attention deficit hyperactivity disorder
ANOVA	Analysis of variance
BMP	Behavior management problems
CDAS	Corah Dental Anxiety Scale
CFSS-DS	Dental Subscale of the Children's Fear Survey Schedule
CI	Confidence interval
DAMP	Deficits in attention, motor control, and perception
DMFS	Decayed, missing or filled surfaces
DMFT	Decayed, missing or filled teeth
DS	Decayed surfaces
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, fourth edition
EFSQ	Executive function screening questionnaire
GBI	Gingival bleeding index
HPA	Hypothalamus-pituitary-adrenal
IS	Surfaces with initial caries lesions
IQ	Intelligence quotient
OR	Odds ratio
PDS	Public Dental Service
SPSS	Statistical package for the social sciences
WISC-III	Wechsler Intelligence Scale for Children, third edition



## INTRODUCTION

Swedish children between ages 3 and 19 yr are offered free dental care, including dental examinations on a regular, often annual basis. In contrast to medical health care providers, a dentist usually meets the same child regularly throughout its childhood and adolescence. The dentist is in a special position to follow development over time and should be familiar with developmental variations that are common among children, such as different developmental disorders.<sup>1-3</sup>

About 10% of all children exhibit behavior management problems (BMP) during dental visits, and for many children, the causes are unknown.<sup>4</sup> A study on BMP in relation to child personality characteristics concluded that uncooperative child dental patients constitute a heterogeneous group regarding fear, temperament, behavior, and intelligence.<sup>5</sup> Externalizing and impulsive children constitute a special challenge in dentistry.<sup>6</sup> Attention deficit hyperactivity disorder (ADHD)<sup>7</sup> is the most common behavioral disorder in school-age children. Despite the high prevalence of ADHD in the child population, few studies on oral health and behavior during dental treatment of children with ADHD have been published. The cognitive and behavioral characteristics of children with ADHD make it likely that they will encounter problems coping with a dental examination or treatment, since children with ADHD often have problems adjusting their behavior to ongoing demands.

### DENTAL BEHAVIOR MANAGEMENT PROBLEMS IN CHILDREN

In dentistry, BMP is commonly defined as uncooperative and disruptive behaviors that cause a delay in treatment or render treatment impossible.<sup>4</sup> BMP is based on the dentist's evaluation of the child's behavior. According to a Swedish study by Klingberg *et al.*,<sup>4</sup> 10.5% of all children have dental BMP at least once in the age ranges 4–6 or 9–11 yr. In a study on 6–8-yr-old Danish children, a history of BMP, measured as a cumulative frequency, was observed in 37.2% of the sample.<sup>8</sup> In a Swedish study on BMP, rated as acceptance during annual regular dental care, most 3–16-yr-old children needed no more than one dental visit.<sup>9</sup> Eight percent of the children reacted in such a way that treatment could not be carried out without undue delay. Arnrup *et al.*<sup>5</sup> identified four different subgroups among child patients with BMP based on fear, temperament, behavior, and verbal intelligence using cluster

analysis: “non-fearful, extrovert”; “fearful, extrovert”; “fearful, inhibited”; and “externalizing, impulsive”. Besides dental fear, a higher level of impulsivity—that is, impatience and lack of perseverance—most clearly discriminated uncooperative child dental patients from a reference group of children.

## **DENTAL FEAR AND ANXIETY IN CHILDREN**

Among Swedish children exhibiting BMP between ages 4–6 and 9–11 yrs, 27.3% report a high level of dental fear, as defined by the Dental Subscale of the Children’s Fear Survey Schedule (CFSS-DS).<sup>10</sup> Sixty-one percent of the children with dental fear reacted with BMP.<sup>11</sup> Dental fear is the experience of fear in relation to a threatening stimulus.<sup>12</sup> Dental anxiety relates to anticipatory fear which is not necessarily connected to a specific external stimulus.<sup>12</sup> A distinction between fear and anxiety is not easy to make, and in this thesis, *dental fear* and *dental anxiety* are used synonymously. Unlike BMP, dental fear and anxiety are based on the subjective experience of the patient.

The prevalence of dental fear and anxiety in children has been reported to be between 5.7% and 6.7%,<sup>8,13,14</sup> with anxiety decreasing with increasing age.<sup>13,15</sup> Dental fear is associated with dental caries and missed appointments.<sup>11</sup> Etiological factors in the development of dental fear in children are direct conditioning, including procedural pain (i.e., pain caused by dental or medical treatment) and negative experiences; general fears; maternal dental fear; and age of the child.<sup>11,16,17</sup> There is an increasing awareness of how procedural pain and frequent invasive medical care contribute to the development of fear and anxiety in a dental or medical setting.<sup>18-22</sup> Regarding how temperament and personality characteristics relate to dental fear, it has been concluded that children who express shyness, negative emotionality, or internalizing behavior have an increased risk of dental fear.<sup>6,23</sup> A Belgian study reported that 15% of the children referred to a center for special dental care because of a high level of dental fear had attention problems.<sup>14</sup>

## **DEVELOPMENTAL DISORDERS**

Developmental disorders are characterized by delays in the development of multiple basic functions, including motor and different cognitive abilities, such as learning, speech and communication, attention, planning, memory, and social interaction. According to several epidemiological studies from various countries, the prevalence of neurodevelopmental disorders with cognitive and/or motor involvement is about 10%

in school-age children.<sup>1-3</sup> In these children, various cognitive functions may be impaired, leading to significant behavioral problems that affect school achievement and social interaction with peers and in the family.<sup>24</sup> The most common developmental disorders are ADHD (3–6%); mental retardation, defined as an intelligence quotient (IQ)  $\leq$  approximately 70 in combination with low adaptive functioning (0.5–1.5%); and autism spectrum disorders (0.6–1%).<sup>1,25-29</sup> In addition, children with borderline functioning within different developmental domains, such as children with milder degrees of attention-related problems or with intellectual functions or cognitive capacities in the low normal area (IQ approximately 71–85), may also exhibit behavioral problems in situations that place high demands on an individual's behavior.<sup>30</sup>

## **COGNITIVE FUNCTIONING AND INTELLIGENCE**

Cognitive functions comprise mental processes such as intelligence, memory, attention, and mental imagery. Intelligence is a property of mind that encompasses many related mental abilities such as the capacities to reason, solve problems, think abstractly, comprehend ideas and language, and memorize. Intelligence can be measured by IQ, which has an arbitrarily chosen mean value of 100 and a standard deviation of 15. Intelligence also encompasses the ability to understand complex ideas, to adapt effectively to the environment, to engage in various forms of reasoning, and to overcome obstacles. A person's intellectual performance will vary on different occasions in different domains, as judged by different criteria.<sup>31</sup> Wechsler described intelligence as the overall capacity of an individual to understand and cope with the world around him, and assumed one general component of intelligence and several additional mental abilities.<sup>32</sup> In most intelligence tests, which reflect a person's standing in relation to his or her age cohort, the intelligence quotient or level is the result of a total score, including both verbal and non-verbal subtests.

## **DENTAL CARE IN CHILDREN WITH DEVELOPMENTAL DISORDERS**

Few studies on the relationship between general intelligence and oral health or behavior during dental appointments have been published. In a review article, Winer<sup>33</sup> reported that the few studies on intelligence and dental fear that are available in the literature found relations between dental anxiety and both high and low IQ. Rud and Kisling<sup>34</sup> studied the behavior of children with mental retardation during dental appointments and concluded that children with an IQ  $<$  68 needed a significantly longer time to adjust to

and accept dental treatment. In a study from Spain on 8–16-yr-old children with no medical or psychological problems, less dental anxiety on the first dental visit was found in children with a high general intelligence.<sup>35</sup>

Learning difficulties and behavioral problems have been found to be associated with the child's behavior during dental appointments.<sup>36</sup> In a study on children with attention and learning problems, Blomqvist *et al.*<sup>37</sup> found the cumulative percentage of appointments in the dental records with notes on BMP between ages 2 and 10 yr was 13% compared to 7% in a control group.

Children with autism do not have the capacity to cooperate adequately in a dental setting.<sup>38</sup> But the prevalence of caries in children with autism does not differ from that of children of the same age without developmental disorders.<sup>38</sup> In children with a higher cognitive ability, better verbal skills can mask significant learning and behavioral problems and mislead clinicians, teachers, and parents.<sup>30</sup> Children with Asperger syndrome, an autism spectrum disorder, often have good verbal skills, which may lead teachers and other professionals to focus on the child's behavioral problems rather than on the nonverbal learning difficulties that these children frequently exhibit.

## **ATTENTION DEFICIT HYPERACTIVITY DISORDER**

ADHD is defined according to a specific set of symptoms – inattention, hyperactivity, and impulsivity – as described in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)<sup>7</sup> (Table 1). Children who fulfill at least six criteria of inattention and/or at least six criteria of hyperactivity-impulsivity and for whom there are reports of impairment in at least two settings, for example, at home and at school, are classified as having ADHD of the combined, inattentive, or hyperactive-impulsive type. Behavior for the child's mental age must be excessive to be recorded as symptoms indicative of ADHD.<sup>7</sup> Deficits in attention, motor control and perception (DAMP) is a concept used mainly in Scandinavia and Finland to describe ADHD in a child who also has a motor-perceptive dysfunction. DAMP can be described as a combination of ADHD and developmental coordination disorder.<sup>39</sup>

The prevalence of ADHD is reported to be between 3% and 6%.<sup>27,40,41</sup> This variation is due to several factors such as the definition applied, the characteristics of the study population, and the methods of ascertainment.<sup>42</sup> Boys are diagnosed with the disorder



Table 1. DSM-IV Criteria for ADHD according to American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition. Washington, DC, American Psychiatric Association, 1994.

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I. Either A or B:

- A. Six or more of the following symptoms of inattention have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level:

*Inattention*

1. Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities.
2. Often has trouble keeping attention on tasks or play activities.
3. Often does not seem to listen when spoken to directly.
4. Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions).
5. Often has trouble organizing activities.
6. Often avoids, dislikes, or doesn't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework).
7. Often loses things needed for tasks and activities (e.g. toys, school assignments, pencils, books, or tools).
8. Is often easily distracted.
9. Is often forgetful in daily activities.

- B. Six or more of the following symptoms of hyperactivity-impulsivity have been present for at least 6 months to an extent that is disruptive and inappropriate for developmental level:

*Hyperactivity*

1. Often fidgets with hands or feet or squirms in seat.
2. Often gets up from seat when remaining in seat is expected.
3. Often runs about or climbs when and where it is not appropriate (adolescents or adults may feel very restless).
4. Often has trouble playing or enjoying leisure activities quietly.
5. Is often "on the go" or often acts as if "driven by a motor".
6. Often talks excessively.

*Impulsivity*

1. Often blurts out answers before questions have been finished.
2. Often has trouble waiting one's turn.
3. Often interrupts or intrudes on others (e.g., butts into conversations or games).

- II. Some symptoms that cause impairment were present before age 7 years.
- III. Some impairment from the symptoms is present in two or more settings (e.g. at school/work and at home).
- IV. There must be clear evidence of significant impairment in social, school, or work functioning.
- V. The symptoms do not happen only during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder. The symptoms are not better accounted for by another mental disorder (e.g. Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).

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Based on these criteria, three types of ADHD are identified:

1. ADHD, *Combined Type*: if both criteria 1A and 1B are met for the past 6 months
  2. ADHD, *Predominantly Inattentive Type*: if criterion 1A is met but criterion 1B is not met for the past six months
  3. ADHD, *Predominantly Hyperactive-Impulsive Type*: if Criterion 1B is met but Criterion 1A is not met for the past six months.
-

three to six times more often than girls,<sup>43</sup> although girls with ADHD are probably under-diagnosed due to less prominent hyperactivity and fewer observable difficulties.<sup>26,44</sup>

Strong evidence supports a genetic component in the majority of children with ADHD. Concerning neurobiology, frontal lobe and dopamine and norepinephrine neurotransmitter systems appear to be involved.<sup>45</sup> Management of ADHD involves the use of psycho-educative strategies such as educational programs for parents and teachers and specific interventions for the child, including medication.

Psychostimulants are first-line agents and have been shown to be highly effective in treating ADHD.<sup>46</sup> Methylphenidate and amphetamine are medications that inhibit the dopamine transporter and therefore increase dopamine concentration in the synapse. Atomoxetine is a new drug that acts mainly on the noradrenergic system; it is a noradrenergic re-uptake inhibitor.<sup>47,48</sup>

As a result of following children with attentional difficulties over time, it has become evident that their problems can be quite persistent and associated with a range of difficulties in adulthood.<sup>49</sup> In a Swedish longitudinal study on 7–22-yr-olds, it was found that 58% in the ADHD/developmental coordination disorder group had a poor outcome compared with 13% in the comparison group, which means that they were either living on a pension; had a drug or an alcohol abuse; had a major personality disorder, a severe chronic psychiatric disorder, or an autism spectrum disorder; or had been convicted of crime.<sup>50</sup> Antisocial personality disorder, reading disorders, low educational level, and remaining symptoms of ADHD were overrepresented in the ADHD/developmental coordination disorder group. Hopefully, with increasing knowledge and awareness of ADHD and the treatment possibilities that are now being evolved, negative consequences of the disability will decline in the future.

## **ADHD AND ASSOCIATED DISORDERS**

More than two-thirds of children with ADHD have at least one additional diagnosis.<sup>26,51</sup> ADHD is frequently associated with other conditions such as dyslexia, developmental coordination disorder, Tourette syndrome, oppositional defiant disorder, conduct disorder, anxiety disorders, mental retardation, dyslexia, and learning disorders.<sup>1,24,26,27,41,52</sup> Delayed or deteriorated speech and language development is also common.<sup>53</sup>

## **INTELLECTUAL FUNCTIONING IN ADHD**

In children with ADHD, specific cognitive abilities are impaired, which cause significant behavioral problems that affect everyday life.<sup>24</sup> Lower cognitive levels have been reported in children with ADHD compared to controls—especially concerning verbal abilities—although individual variability is large.<sup>54,55</sup> A study on non-mentally retarded children with autism spectrum and attention deficit disorders found that girls were more severely affected with respect to intellectual abilities and overall functioning.<sup>56</sup> Because pronounced deficits in attention will add to learning difficulties, it is also meaningful to diagnose ADHD in children with mental retardation.<sup>57</sup> Among children with mild mental retardation (IQ approximately 50–70), children with attention and conduct problems have poorer academic outcomes after 3 years compared with other children with mild mental retardation.<sup>58</sup> Children with ADHD have a considerable risk of academic underachievement at school; support, specific educational measures, and treatments are therefore needed.<sup>59-62</sup>

## **EXECUTIVE FUNCTIONS**

The cognitive mechanism that is principally affected in ADHD has been termed *executive functions*.<sup>63</sup> Executive functions can be described as mental control processes that enable self-control and are necessary for maintaining an appropriate problem-solving set to attain a future goal.<sup>64</sup> The functions encompass four different cognitive domains: (1) nonverbal working memory—sensing the hypothetical future from the experienced past, (2) verbal working memory—self-reflection, self-instruction, and problem solving, (3) self-regulation of affect/motivation/arousal, and (4) reconstruction—fluency, flexibility, and analysis.<sup>65</sup> Executive functions make it possible for an individual to apprehend and adjust to a social situation; they therefore become more important with increasing age.<sup>66</sup>

According to Barkley,<sup>65</sup> poor behavioral inhibition is the central deficiency in ADHD. The inhibition deficit causes a secondary deficiency in executive functions. The functions permit the construction, execution, and control of behavior by internally represented information, which removes behavior from control in the present and brings it under the control of time. In children with ADHD, these processes are disrupted. A blindness to the past, the future, and time in general and an inability to direct behavior toward the future and to sustain it are among many of the deficits for persons with ADHD.<sup>67</sup>

Children with ADHD often have difficulties shifting focus.<sup>68</sup> One explanation according to Brown<sup>69</sup> is that inattention is a result of a deficiency to organize oneself at the prospect of a task, which leads to difficulties in concentrating and staying focused during the task. Individuals with ADHD easily lose their focus on what they are doing when other things surrounding them become equally important, because the energy needed to repress the distracting stimuli cannot be properly mobilized. Thus, these highly important executive functions will be of considerable importance in several everyday activities, and it can be assumed that deficits in these cognitive domains will also influence a child's behavior and coping in a clinical setting, such as a dental examination.

## **DENTAL BEHAVIOR MANAGEMENT PROBLEMS IN CHILDREN WITH ADHD**

Felicetti *et al.*<sup>70</sup> studied the behavior of children with ADHD in a clinical trial and measured cooperation using the four-point Frankl scale. The researchers found no differences in behavior compared to a control group. Atmetlla *et al.*<sup>71</sup> used a psychometric scale developed to evaluate the presence of ADHD. They did find differences between children with ADHD and a control group during a dental visit concerning behavioral features in these three areas: inattention, impulsivity, and hyperactivity.

In a study by Arnrup *et al.*<sup>72</sup> on four different subgroups among child patients with BMP, the children in the subgroup characterized as externalizing and impulsive had the lowest acceptance of treatment compared to the other subgroups. Although undiagnosed at the start of the study, these children had temperament and behavior profiles similar to those of children diagnosed with oppositional defiant disorder and conduct disorder and sometimes further complicated by attention deficit problems, hyperactivity problems, or both. During the study period, some of the children in the subgroup were diagnosed with ADHD. At the 1-year follow-up, the dentist rated the risk of non-acceptance in the group of externalizing and impulsive children to be higher (risk ratio 3.7) than in the other groups.<sup>6</sup>

## **INTERACTION AS A MEASURE OF BEHAVIOR**

Interaction is a complex process that requires certain cognitive abilities such as adaptation, attention, and self-regulation, functions that are impaired in children with ADHD.<sup>65</sup> A detailed way to study behavior is to study interaction between two

persons. Video analysis has previously been used to study interaction between the dentist and the patient,<sup>73,74</sup> but the evaluation method has been limited due to its lack of detail. The Marte Meo therapy model can be used to study interaction between two persons in more detail,<sup>75</sup> and it is commonly used to study parent-child interaction. The interaction between a parent and a child is video recorded and then divided into short sections to help the parent observe the fine components of interaction and thereby identify interaction problems. The same method could be used to study interaction between the dentist and the patient during a dental examination. The interaction problems the child might experience with the dentist can make the dental appointment a stressful event.

### **STRESS REACTION IN CHILDREN WITH ADHD**

Stress is commonly defined as the physiological and psychological reactions that mobilize an organism's defense against external or internal threats (stressors). Reaction to the stressor includes activation of the hypothalamus-pituitary-adrenal (HPA) axis followed by the release of cortisol. Cortisol has a diurnal variation and cortisol secretory activity is characterized by peak levels 20–30 min after awakening followed by a decline in concentration.<sup>76</sup> The diurnal rhythm of cortisol is a robust rhythm and is largely unaffected by age, gender, or pubertal status.<sup>77</sup> Salivary cortisol is an indicator of unbound concentrations of cortisol in serum.<sup>78</sup> There are indications that children with ADHD have an altered cortisol response,<sup>79-81</sup> where hyperactivity and impulsivity in children with ADHD might be associated with dysfunction of the HPA axis.<sup>79</sup>

A correlation between dental anxiety and cortisol would be expected, but studies on the subject are conflicting.<sup>82,83</sup> Adult patients with dental anxiety, as determined by the Corah Dental Anxiety Scale (CDAS),<sup>84,85</sup> have been found to have significantly elevated concentrations of *salivary* cortisol,<sup>82</sup> but other results have suggested that it is the *urinary* cortisol levels—which are said to reflect a long-term response to stress—that are related to CDAS scores.<sup>86</sup> Cortisol concentrations and dental anxiety during restorative treatment have been studied in children with previous experience of dental treatment, and the results suggest that it is the cavity preparation step that creates stress and anxiety in children.<sup>87</sup>

## ORAL HEALTH IN CHILDREN

Dental caries is one of the most common preventable chronic diseases.<sup>88,89</sup> It is a multifactorial disease that starts with microbiological shifts within the complex biofilm (dental plaque) and is affected by salivary flow and composition, exposure to fluoride, consumption of dietary sugars, and preventive behaviours.<sup>90</sup> Caries lesions are the outcome of events that progress over time,<sup>91</sup> and the rate of disease progression slows down with age.<sup>92</sup>

Despite the widespread decline in caries prevalence in high-income countries in recent decades, disparities remain, and many children and adults still develop caries.<sup>90</sup> A person's risk of caries can vary with time since many risk factors are changeable. Physical and biological risk factors for caries include inadequate salivary flow and composition, high numbers of cariogenic bacteria, insufficient fluoride exposure, gingival recession, immunological components, need for special health care, and genetic factors.<sup>90,93</sup> Caries is related to lifestyle, and behavioral factors under a person's control are clearly implicated. These factors include poor oral hygiene, poor dietary habits, and frequent use of oral medications that contain sugar.<sup>90,94,98</sup> Other factors related to caries risk include poverty, deprivation, or social status; number of years of education; and foreign-born parents.<sup>90,98-100</sup>

A Swedish study on 4-yr-olds that comprised eight cross-sectional studies between 1967 and 2002 found that the number of children with caries declined from 1967 to 1987 and then leveled out.<sup>101</sup> Another Swedish study, this time a population-based study of 11 age groups, compared data on caries prevalence in four cross-sectional epidemiological studies carried out every tenth year between 1973 and 2003.<sup>102,103</sup> During the 30-year period, the number of caries lesions and restorations decreased in general.<sup>103</sup>

Mejàre et al.<sup>92</sup> studied caries incidence and lesion progression in Swedish adolescents and young adults. The increase in both new approximal enamel lesions and lesion progression was greatest during early adolescence, that is, in the first 2–3 yr after eruption. If a child had more than four approximal caries lesions or restorations at the ages of 11–13, the risk of developing new caries lesions was 3–4 times higher compared to those who were caries free.<sup>104</sup> The rate of approximal lesion progression was lower during young adulthood than during adolescence.<sup>92</sup> In other words, adolescence can be seen as a risk age for the development of caries.

## ORAL HEALTH IN CHILDREN WITH ADHD

Results from New Zealand on 11–13-yr-olds suggest that children with ADHD run a higher risk of having a high caries score, that is, a decayed, missing, or filled teeth (DMFT) score  $\geq 5$ .<sup>105</sup> In a study from the United States, more enamel caries lesions were found in 6–10-yr-old children with ADHD compared to a control group.<sup>106</sup> A higher risk for caries in children with ADHD medicated with methamphetamine has also been suggested.<sup>107</sup>

Occasional studies report other oral health problems in children with ADHD, such as a higher prevalence of mineralization disturbances in children with ADHD compared to a control group<sup>71,108</sup> and a higher prevalence of bruxism,<sup>71</sup> especially among children medicated with amphetamine or methylphenidate.<sup>109</sup> An increased risk of traumatic dental injury in children diagnosed with ADHD compared to other psychiatric diagnoses has been reported,<sup>110</sup> but the result was not controlled for gender (distribution of boys was 5:1 in the ADHD group and 3:2 in the reference group). Amphetamine medication in children with ADHD has also been associated with an increased risk of gingival enlargement.<sup>111</sup>

Non-effective toothbrushing and a high frequency of food intake are well-known risk factors for the development of dental caries.<sup>94-97</sup> Studies indicate that children with ADHD have inappropriate health behavior, such as a higher risk for overeating and for alcohol, substance, and tobacco use,<sup>112-115</sup> but few studies on risk behavior regarding oral health and hygiene habits have been published. No differences between ADHD and non-ADHD subjects in toothbrushing or diet were found among 6–10-yr-olds in the United States.<sup>106</sup>

In conclusion, little is known about the oral health aspects of ADHD. Several studies indicate that among uncooperative dental patients, children with hyperactivity and impulsivity are frequent. A dental appointment can be experienced as stressful, and there are reports of abnormal stress reaction in children with ADHD. Indications of an increased risk of caries and poor health behavior have also been found in this group of children.

Since ADHD is a common disability, most dentists are likely to see these children in their dental practice. Accordingly, the clinician needs to be familiar with the disorder

and with strategies for managing it. Children with ADHD often receive negative feedback, because others perceive that the children “do not want to behave and cooperate”, although this is not actually the case. Children with ADHD do want to cooperate, just as other children, but often they are unable to do so.<sup>116</sup> If we can understand more about how children with ADHD function in a dental setting, the behavioral challenge for the child could be decreased or even prevented.



# **AIMS OF THE THESIS**

## **GENERAL AIM**

The general aim of this thesis was to characterize behavior in a dental setting—that is, BMP, interaction between child and dentist, dental anxiety, and stress—and the oral health of children with ADHD.

## **SPECIFIC AIMS**

The specific aims of this thesis were to test the hypotheses that children with ADHD, when compared with children in a control group:

- Display more behavior management problems during dental treatment.
- Display more problems in the interaction process with the dentist.
- Exhibit a higher degree of dental anxiety.
- Have a different stress reaction (measured as salivary cortisol) during a dental recall visit and a different diurnal cortisol variation.
- Have a higher prevalence of caries and gingivitis.
- Have poorer oral health behavior.

# **MATERIAL AND METHODS**

## **STUDY DESIGN**

A retrospective and prospective double-cohort design was chosen (Fig. 1). One cohort (ADHD group) comprised children who fulfilled criteria for ADHD. The other cohort (control group), drawn from the same population, consisted of children randomly chosen from the group that had been screen negative concerning attention and learning problems.

## **STUDY POPULATION**

The study population comprised all 555 children (285 boys, 270 girls) born in 1991 and living in Sigtuna in 2001. The municipality has about 36,000 inhabitants and a socioeconomic status similar to Sweden as a whole and to Stockholm County. Twelve percent of the adult population had a higher education (of at least 3 years after senior high school) while the corresponding rate for Sweden as a whole was 15%. The proportion of individuals with a background from a foreign country was 21% and comparable to that of Stockholm County.

## **Screening procedure and ADHD diagnosis**

This thesis is part of a population-based study on behavior, attention, and learning problems in children, with a special focus on ADHD. Children born in 1991 and attending mainstream and special schools in the municipality of Sigtuna in Stockholm County were screened for attention and learning problems at their regular health examination during the 2001–2002 school year. The screening procedure included two questionnaires to be filled out by the parents and the teachers: Conners' 10-item questionnaire pertaining to the child's attentional functions, hyperactivity, and behavior,<sup>117</sup> and the executive function screening questionnaire (EFSQ), which was specially constructed for the study to add a symptom scale that covered mainly inattentive and passive behavior and specific learning problems.<sup>118</sup> To minimize the false negative outcome of the screening, the teachers underwent an additional, semi-structured interview by a pediatrician experienced in neuropsychiatry. This interview included questions about the children's behavior and school achievements, and ADHD criteria according to the DSM-IV<sup>7</sup> were added.



The criteria for screen positivity were chosen to identify children with different degrees of attention and learning problems. The cut-off scores, which indicate definite problems, were 10 on Conners' scale (range 0–30) and 17 on the EFSQ (range 0–51). According to parents and teachers, 12% and 15% fulfilled Conners' criteria and 12% and 20% fulfilled the EFSQ criteria, respectively. A child was considered screen positive if the cut-off score was reached on at least two of the four questionnaires. Children with one positive questionnaire and who met the criteria for ADHD in the semi-structured interview with the teachers were also considered screen positive. In all, 155 (104 boys, 51 girls) of the children were found to be screen positive.

All screen-positive children underwent a pediatric, clinical evaluation and cognitive assessment according to the Wechsler Intelligence Scale for Children (WISC-III).<sup>119</sup> Clinical data and DSM-IV<sup>7</sup> ratings concerning the ADHD criteria were then compiled, and the children fulfilling criteria for ADHD were classified according to whether they had ADHD of the combined, inattentive, or hyperactive-impulsive type. Children who had previously been assessed on clinical grounds and who had received a diagnosis of ADHD or DAMP were classified as ADHD. One of these did not fulfill the DSM-IV criteria at the time of clinical assessment. Thirty-five (30 boys and 5 girls) of the 155 screen-positive children (6.3% of the total population of 555 children) were classified as having ADHD. Regarding general cognitive level among the children with ADHD, an IQ between 70 and 85 was found in 18 children and an IQ > 85 in 16 children. One child was not cognitively assessed because the parent refused to allow testing.

A control group of the same size as the screen-positive group was chosen from the children with no attention and learning problems according to the screening, that is, the 369 children who did not reach the cut-off point in Conners' scale or the EFSQ. The children in the control group in studies I and II were randomly chosen from the children with no attention and learning problems in the same school classes as the screen-positive children. But this procedure resulted in an uneven gender distribution with fewer boys in the control group because more boys than girls had a positive outcome in the screening (Table 2). To attain a more even sex distribution between the groups in studies III and IV (Table 3), a new control group was selected. Girls in the control group in studies I and II who dropped out were excluded from the control group in studies III and IV. More boys with no attention and learning problems according to

Table 2. The experimental groups in studies I and II and dropouts explained in detail. The control group was randomly chosen from the children with no behavior, attention, or learning problems who were in the same school classes as the children with a positive outcome in the screening for these problems. (PDS = Public Dental Service, ADHD = attention deficit hyperactivity disorder)

Cohort, i.e., all children born in 1991 and living in Sigtuna community in 2001 N= 555 Girls=270 Boys=285	Included in study I	Included in study II	Children excluded from study I and II					
			Child went to private dentist/dentist in other community	Child missed or cancelled appointment	Child had already visited the dentist in 2002	Dental record was not found at PDS (study I only)	Child did not want to be recorded on video (study II only)	Video recording was of poor quality (study II only)
ADHD group N=35 Boys=30 Girls=5	N=25 Boys=21 Girls=4	N=22 Boys=18 Girls=4	N=4 Boys=4 Girls=0	N=2 Boys=2 Girls=0	N=2 Boys=2 Girls=0	N=2 Boys=1 Girls=1	N=1 Boys=0 Girls=1	N=4 Boys=4 Girls=0
Control group N=149 Boys=65 Girls=84	N=58 Boys=23 Girls=35	N=47 Boys=18 Girls=29	N=36 Boys=18 Girls=18	N=11 Boys=4 Girls=7	N=41 Boys=20 Girls=21	N=3 Boys=1 Girls=2	N=4 Boys=2 Girls=2	N=10 Boys=3 Girls=7

the screening were randomly chosen from the same Public Dental Service (PDS) clinics as the screen-positive children.

### **Children included in studies I and II**

Studies I and II comprised 35 children with ADHD (30 boys, 5 girls) and 149 controls (65 boys, 84 girls). The children were called for their annual recall visit between April and June 2002 at the PDS at age 11. Table 2 describes the dropouts in detail.

The final group for analysis in study I consisted of 25 children (21 boys, 4 girls) in the ADHD group and 58 children (23 boys, 35 girls) in the control group. Sixteen children (14 boys, 2 girls) had ADHD of the combined type, 7 children (5 boys, 2 girls) of the inattentive type, and 2 boys of the hyperactive-impulsive type. Regarding general cognitive level measured as full scale IQ, 12 of the children with ADHD had an IQ between 70 and 85 and 12 an IQ above 85. One child was not tested. Two of the 25 children were treated with methylphenidate and one with amphetamine.

In study II, the final group for the video analysis comprised 22 children (18 boys, 4 girls) in the ADHD group and 47 children (18 boys, 29 girls) in the control group. Fourteen children (12 boys, 2 girls) had ADHD of the combined type, 6 children (4 boys, 2 girls) of the inattentive type, and 2 boys of the hyperactive-impulsive type. Eleven children had an IQ between 70 and 85 and 10 had an IQ above 85. One child was not tested. One of the 22 children was treated with methylphenidate and one with amphetamine.

### **Children included in studies III and IV**

Studies III and IV comprised only those children whose dental care was provided by the PDS: 30 children with ADHD (25 boys, 5 girls) and 101 controls (65 boys, 36 girls). The children were called for their annual recall visit between January and February 2004 at the PDS at age 13. Table 3 describes the dropouts in detail.

The final analysis group in study III comprised 21 children (18 boys, 3 girls) in the ADHD group and 79 children (54 boys, 25 girls) in the control group. Fifteen children (14 boys, 1 girl) had ADHD of the combined type and 6 children (4 boys, 2 girls) had ADHD of the inattentive type. Of the 21 children with ADHD,

Table 3. The groups in studies III and IV and dropouts explained in detail. The control group was randomly chosen from children with no behavior, attention, or learning problems at the same Public Dental Service clinics as the children who had a positive outcome in the screening for these problems. (ADHD = attention deficit hyperactivity disorder)

Cohort, i.e., all children born in 1991 and living in Sigtuna community 2001 N= 555 Girls=270 Boys=285	Included in study III	Included in study IV	Children excluded from studies III and IV					
			Child went to private dentist /dentist in other community	Child missed or cancelled appointment	Child had already visited the dentist in 2004	Child did not want to participate in the study	Child did not return morning cortisol sample (study IV only)	Suspected error at cortisol sampling or analysis (study IV only)
ADHD group N=35 Boys=30 Girls=5	N=21 Boys=18 Girls=3	N=18 Boys=15 Girls=3	N=5 Boys=5 Girls=0	N=5 Boys=4 Girls=1	N=4 Boys=3 Girls=1		N=3 Boys=3 Girls=0	
Control group N=149 Boys=65 Girls=84	N=79 Boys=54 Girls=25	N=71 Boys=47 Girls=24		N=15 Boys=8 Girls=7	N=3 Boys=2 Girls=1	N=4 Boys=2 Girls=2	N=7 Boys=6 Girls=1	N=1 Boys=0 Girls=1

the IQ of 9 children was between 70 and 85 and of 11 children above 85. Two of the 21 children were treated with methylphenidate and one with amphetamine.

The final analysis group in study IV comprised 18 children (15 boys, 3 girls) in the ADHD group and 71 children (47 boys, 24 girls) in the control group. Thirteen children (12 boys, 1 girl) had ADHD of the combined type and 5 children (3 boys, 2 girls) had ADHD of the inattentive type. The 13 children with ADHD of the combined type all fulfilled  $\geq 6$  criteria for hyperactivity-impulsivity according to DSM-IV<sup>7</sup> (based on parental reports, teacher reports, or both) and constituted a subgroup in the ADHD group: ADHD with hyperactivity-impulsivity. Of the 18 children with ADHD, 9 children had an IQ between 70 and 85 and 9 children an IQ above 85. Two of the 18 children were treated with methylphenidate and one with amphetamine. One child in the ADHD group and one child in the control group had been prescribed glucocorticoid inhalators due to asthma.

### **Educational level and country of birth (I, III)**

During the screening for attention, behavioral, and learning problems, information on background variables describing the mother's educational level and country of birth were collected from the parents. Educational level of the mother was stratified according to years of schooling as 0–9 yr/11 yr/12 yr/ $\geq 13$  yr. In the multivariate analyses, the categories 0–9 yr and 11 yr were combined into one group, *0–11 yr*, and 12 yr and  $\geq 13$  yr into one group,  *$\geq 12$  yr*. The mother's country of birth was coded on a geographic basis: Sweden/other Nordic country/other European country/rest of the world. In the multivariate analyses, the categories other Nordic country, other European country, and rest of the world were combined into one group, *mother born abroad*.

## **METHODS**

### **Dental behavior management problems (I)**

Data on BMP was collected retrospectively from dental records obtained from the PDS. One examiner (MB), blinded to any possible diagnosis of ADHD, studied the dental records, and information on the dental appointments attended by the child between age 3 and 10 yr was collected. The children had been recalled yearly up to the age of 7 and thereafter biannually by their dentist. Eighty-one percent of the dental records described 8 years or more of the attended visits. Data regarding



number of appointments and appointments with BMP were compiled. BMP were defined as notes in the records expressing disruptive behavior that delayed treatment or rendered treatment impossible.<sup>4</sup> The percentage of appointments with notes on BMP per yr and the percentage of children with appointments with BMP per yr were registered. The dental records were analyzed for the cumulative prevalence of BMP between age 3 and 10 yr, that is, if the child had a note regarding BMP in the record any yr, between age 3 and 10 yr.

### **Interaction between child and dentist (II)**

To analyze the interaction between the dentist and the child, a new method for video analysis was developed in study II. The dental recall visit was recorded on video. The dentist, the patient in the dental chair, and the parent positioned behind and to the right of the child were seen on film. A dental assistant was also in the room but did not interact with the child. The same dentist (MB), who was blinded to the results of the screening or any ADHD diagnosis, examined all children. The first phase of the examination was chosen for an analysis of behavior since it contained many possibilities for interaction between the dentist and the child and because it was short, about 1–2 min. During this phase, the dentist welcomes the child and parent, the child is seated in the dental chair, the dentist explains the purpose of the examination, and the dentist lowers the back of the dental chair into a horizontal position. The time for this phase was recorded.

The video recording was divided into detailed sequences. Two psychologists, both blinded to the results of the screening, scored the interaction on the video recordings. The interaction between the dentist and the patient was divided into three main levels according to detail. The first level was called the *interaction phase*. An interaction phase consisted of one or more initiative-responses (question-answer) on the same theme or subject. The next level was called the *interaction sequence* and consisted of one initiative-response. This made it possible to study how long a specific theme was touched upon and how many turns of initiative-responses were taken. The most detailed level was called the *interaction element* and comprised one initiative (e.g., question) or one response (e.g., answer).

The interaction element had different properties: (1) it was a statement/information, question, or request, (2) the source was the dentist or the patient, (3) the focus of the interaction was to carry out the examination or to create a good relation, and (4) the

interaction element was verbal or nonverbal. If the child actively avoided responding or simply did not respond, this was also described. An interaction element where the verbal and nonverbal responses that the child gave were different (e.g., the child says “no” and nods “yes” at the same time) was called an unclear response or incongruity between verbal and nonverbal response. To quantify the interaction, all these properties were considered variables. Table 4 describes the variables. Three summary variables were also calculated: the degree of missing response (i.e., no response or avoidance of response), the degree of coordination (i.e., verbal or nonverbal response), and the degree of non-coordination (i.e., no response, avoidance of response, or incongruity between verbal and nonverbal response). Inter- and intrarater agreement were calculated.

Table 4. Interaction variables

Interaction element (variables)	Explanation
Syntax	Statement/information Question Request Implicit, indirect, unclear, or other
Source	Dentist Child
Focus	Dentist’s focus to carry out the examination Dentist’s focus to create a good relation Child’s focus other or unclear
Type of initiative	Verbal Nonverbal Incongruity between verbal and nonverbal
Type of response	Verbal Nonverbal Incongruity between verbal and nonverbal No response Avoidance of response

### Dental fear and anxiety (I, IV)

In study I, the CFSS-DS<sup>10</sup> (appendix A) was used to measure the dental anxiety of the child. The CFSS-DS questionnaire was filled out by the parents of the child and covers different aspects of dental and medical treatment situations. It consists of 15 items with a total score varying between 15 and 75, and children with a CFSS-DS score  $\geq 38$  are defined as dentally anxious.<sup>120</sup>

At the dental examination at age 11 yr, the CDAS<sup>84</sup> (appendix B) was used to measure the dental anxiety of the parent of the child. In study IV, the CDAS was used to measure the dental anxiety of the child, and the child filled out the CDAS by herself/himself and was helped, if needed, by the same dental assistant for each child. Since the patients also filled out their questionnaires on oral health behavior at the same appointment (study III), the CDAS was chosen for study IV because it was short and easy to complete. The CDAS is filled out by the patient, and the primary focus of the scale is on the anticipation of dental treatment. The CDAS comprises four multiple-choice questions dealing with the individual's reactions and expectations of going to and being treated by a dentist; the total score varies between 4 and 20. A CDAS score  $\geq 15$  indicates high dental anxiety.<sup>85</sup>

#### **Stress reaction measured by cortisol in saliva (IV)**

In study IV, the child was asked to give a saliva sample for the analysis of cortisol on four occasions: (1) before and (2) immediately after the dental examination, which took place between 08.45 and 15.00, and (3) in the morning upon awakening and (4) 30 min later at home on the first school day after the dental examination with the help of their parents. The children were instructed not to eat or drink between morning samples but to otherwise go about their usual routine.

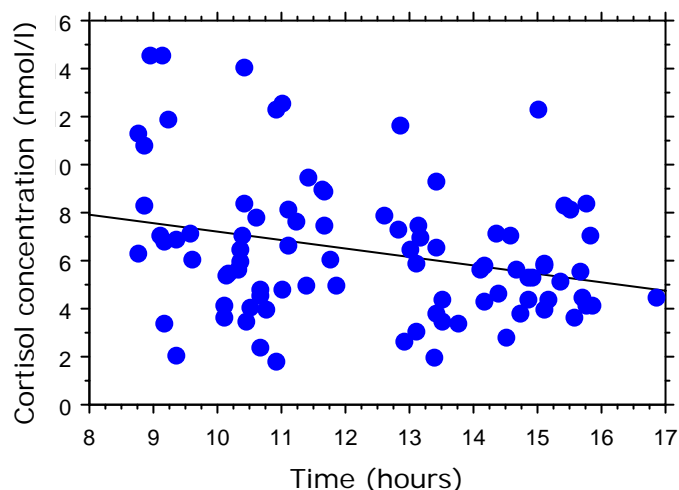


Fig. 2. Correlation between the time of the day for sample collection, and cortisol concentration in the sample before the dental examination in the whole group studied ( $n = 89$ ) ( $r = 0.28$ ,  $P = 0.008$ ); Pearson's correlation.

The mean time difference between the time of the earliest cortisol sample collected before the dental examination and the time the samples were collected from other children was 3h 27min  $\pm$  1h 33min in the ADHD group and 3h 36min  $\pm$  2h 27min in the control group (n.s.). Figure 2 illustrates the correlation between the time of day the sample was collected and the cortisol concentration in the sample before the dental examination. The mean total time between collection of cortisol samples before and after dental examination was 33  $\pm$  9 min in the ADHD group and 30  $\pm$  9 min in the control group (n.s., Student's *t*-test).

Saliva samples at the dental clinic and at home were collected with swabs, which the participants were instructed to keep in their mouth until they were soaked with saliva. The samples were stored at +5°C for 1–4 d and then frozen at -80°C. All samples were analyzed on one occasion. Cortisol in saliva was measured using the Spectria Cortisol (<sup>125</sup>I) kit (Orion Diagnostica, Espoo, Finland).

### **Caries and gingivitis (I, III)**

Children were called for their annual recall visit at the PDS in 2002 at age 11 in study I and in 2004 at age 13 in study III. All children underwent a clinical examination in the dental chair, and two bite-wing radiographs were taken. The same dentist (MB) examined all the children and was blinded to any possible ADHD diagnosis. Manifest dental caries was scored according to Hollender and Koch,<sup>121</sup> and non-cavitated lesions on smooth surfaces, defined as white chalky areas, were rated separately as initial caries lesions. Manifest and initial interdental lesions on the radiographs were assessed according to Schwartz *et al.*<sup>122</sup> The gingival bleeding index (GBI) was calculated according to Axelsson and Linde.<sup>123</sup>

### **Oral health behavior (III)**

In study III, the child completed two questionnaires, one on oral health and dental hygiene habits and one on dietary habits. The child filled out the two questionnaires by herself/himself and was helped, if needed, by the same dental assistant for all children.

The oral health and dental hygiene habits questionnaire comprises seven questions on oral hygiene habits, use of fluoride, and self-perceived gingival bleeding. The frequency of each habit was expressed on a five-point scale: never/once a week/2–3 times a week/4–6 times a week/every day. In the statistical analyses, the categories

once a week/2–3 times a week/4–6 times a week were combined into one group *not every day*. The questions were previously used in a Swedish study,<sup>98</sup> but the response alternatives were modified for study III. The dietary habits questionnaire comprises three questions on frequency of food and beverage intake and frequency of fermentable carbohydrate snacking. Each question consists of the response alternatives *yes* or *no*. The questions were validated in a clinical setting in the United States and include the dietary behaviors that were most predictive of caries risk.<sup>124</sup>

### **Statistical methods**

Comparisons between the two groups of variables on a continuous scale were made using Student's *t*-test. Confidence intervals (CIs) were calculated. Associations between variables were evaluated with the Pearson correlation for data on a continuous scale. Repeated measurement ANOVA was used to analyze cortisol measured in the same patients over time and between groups. Linear regression was used to adjust for gender, mother born abroad, and mother's education.

Categorical data were compared with the chi-square test or Fisher's exact test. The odds ratio (OR) was calculated with logistic regression. A multivariate logistic regression analysis was carried out to adjust for gender, mother born abroad, and mother's education. A stepwise logistic regression was used to analyze variables related to BMP.

The statistical software package SPSS 14.0 were used for statistical analyses.

### **ETHICAL CONSIDERATIONS**

The examinations at age 11 and 13 yr substituted the regular annual checkup at the PDS. The parents of the children selected for the studies were given written information about the aims and procedures of the study before the examinations and were informed that participation was voluntary. The children and their parents could choose not to participate in the study when scheduling their dental appointments or when entering the dental clinic for their examination. The names of the children were substituted with registration numbers to ensure anonymity. Approval from the Research Ethics Committee of Karolinska University Hospital, Huddinge, was obtained before the studies were begun.

# RESULTS

## DENTAL BEHAVIOR MANAGEMENT PROBLEMS (I)

In the group of children with ADHD, the prevalence of children with BMP increased between age 7 and 9. This increase was not observed in the control group. A significant difference between the groups was found at age 8. Fig. 1 illustrates the distribution of children with BMP at different ages. At 8 yr, the children in the ADHD group had notes in their dental records of BMP at 19% of their appointments compared to 2% in the control group ( $P = 0.015$ ). Notes concerning BMP on at least one occasion between ages 3 and 10 yr were found in 14/24 (58%) in the ADHD group compared to 22/58 (38%) in the control group ( $P = 0.090$ ).

When diagnosis of ADHD, mother's educational level 0–11 yr, and mean CFSS-DS score were analyzed as factors with a possible influence on the outcome “BMP” or “no BMP” between ages 3 and 10 yr, ADHD ( $P = 0.090$ ), mother's education 0–11 yr ( $P = 0.082$ ), approached but did not reach significance, while mean CFSS-DS score was significant ( $P = 0.013$ ).

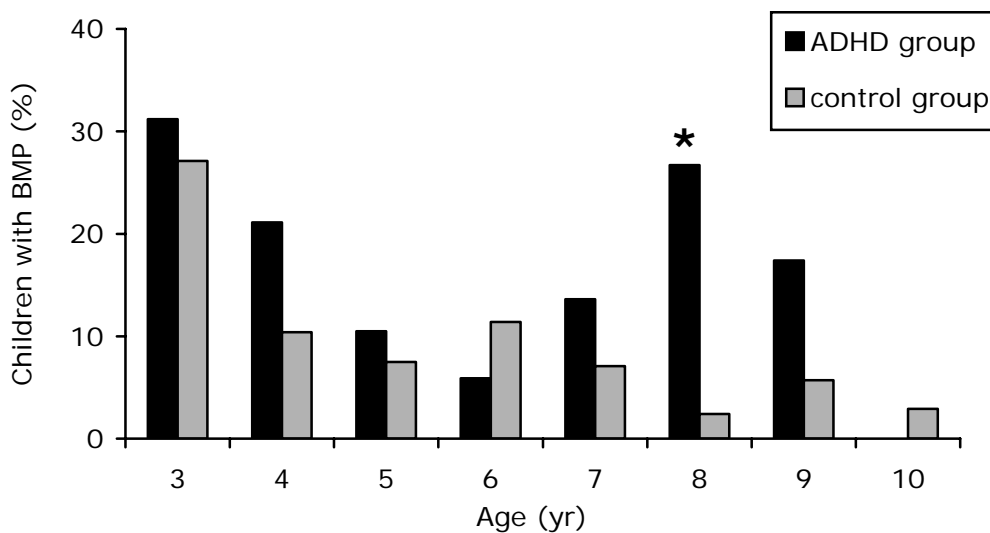


Fig. 3. Frequency (%) of children with notes in the dental records on behavior management problems (BMP) between ages 3 and 10 yr. \*  $P < 0.05$ ; chi-square test.

## **INTERACTION BETWEEN CHILD AND DENTIST (II)**

In study II, two main topics emerged: the children with ADHD took more initiatives and their responses were fewer, less verbal, more avoiding, and more conflicting or contradictory compared to the control group (Table 5).

Children with ADHD made significantly more initiatives than the children in the control group during interaction with the dentist ( $P = 0.002$ ; Table 5). Among all children, the focus of the initiative of five individuals (all boys) was unclear or directed toward goals other than the examination or the relation to the dentist. Four were in the ADHD group, 4/22 (18%), and one was in the control group 1/47 (2%) ( $P = 0.018$ ).

In comparisons of child responses, the trend was for children in the ADHD group to make fewer verbal responses ( $P = 0.090$ ) and more responses of the type no response to initiatives made by the dentist ( $P = 0.080$ ) than in the control group. There was also a trend for the variable degree of missing response to be more frequent in the ADHD group ( $P = 0.061$ ) and the variable degree of non-coordination to be higher in the ADHD group ( $P = 0.072$ ) compared to the control group.

The mean time from when the child entered the surgery until the dental chair was lowered to the horizontal position was  $106 \pm 30$  seconds in the ADHD group and  $96 \pm 18$  in the control group ( $P = 0.089$ ). There were no differences between the groups in the number of interaction sequences per interaction phase; that is, the group of children with ADHD did not take more turns of initiative-responses per theme than the control group (Table 5).

### *Inter- and intrarater agreement*

Interrater agreement was assessed using paired coding of 21 different parameters of the interaction elements. Exact agreement was found for 90% of the comparisons. Weighted kappa, calculated to take into account the degree of disagreement, was 0.98.<sup>125</sup> Assessment of intrarater agreement was tested and retested in five randomly selected cases with a 6-week interval. Concerning interaction elements, agreement was 89% and weighted kappa 0.95.

Table 5. Interaction variables for children with ADHD and children in the control group; Student's *t*-test. *P* values were adjusted for gender using linear regression.

Variables	ADHD group		Control group		<i>t</i> -test	Linear regression
	(n=22)		(n=47)		<i>P</i> value	<i>P</i> value adjusted for gender
	X	s.d.	X	s.d.		
Interaction sequences per interaction phase	2.0	0.5	2.0	0.4	0.724	0.724
Initiatives from child (proportion of all initiatives, %)	7	8	1	2	<0.001	0.002
No response from child	8	6	4	6	0.030	0.080
Avoidance of response from child	1	2	0	1	0.209	0.225
Degree of missing response from child (no response or avoidance of response)	8	7	4	6	0.023	0.061
Proportion of verbal responses from child (%)	22	17	28	13	0.144	0.090
Proportion of nonverbal responses from child (%)	46	15	50	12	0.256	0.954
Degree of coordination (verbal or nonverbal response)	68	16	78	16	0.028	0.136
Unclear response (degree of incongruity between verbal and nonverbal response)	31	17	22	16	0.026	0.125
Degree of non-coordination (avoidance of response, no response or incongruity between verbal and nonverbal response)	40	22	26	20	0.014	0.072



Table 6. Dental anxiety measured with the Dental Subscale of Children’s Fear Survey (CFSS-DS) in children with attention deficit hyperactivity disorder (ADHD) and a control group at age 11 yr. All differences between groups were nonsignificant; Student’s *t*-test.

	ADHD group (n=24)	Control group (n=57)
Mean ± s.d.	21.4 ± 6.5	22.0 ± 6.3
Median	20.5	20.0
Range	15–40	15–41
Dental anxiety (CFSSDS ≥ 38)	1/24	2/57

### DENTAL FEAR AND ANXIETY (I, IV)

Although all CFSS-DS and CDAS scores were higher in the ADHD group, the children did not report significantly more dental fear and anxiety than the children in the control group at ages 11 (study I) and 13 yr (study IV) (Tables 6 and 7). In study IV, however, the subgroup ADHD with hyperactivity-impulsivity reported a significantly higher mean CDAS score,  $8.0 \pm 3.8$ , than did the controls,  $6.5 \pm 1.7$  ( $P = 0.030$ ). The median CDAS score in the ADHD with hyperactivity-impulsivity subgroup was 7, and the range was 4–15. At age 11 yr, the correlation between the dental fear of the parent and the dental fear of the child in the whole group studied was significant ( $r = 0.28$ ,  $P = 0.017$ ) (Fig. 4).

Table 7. Dental anxiety measured by the Corah Dental Anxiety Scale (CDAS) in children with attention deficit hyperactivity disorder (ADHD) and a control group at age 13 yr. All differences between groups were nonsignificant; Student’s *t*-test.

	ADHD group (n=21)	Control group (n=79)
Mean ± s.d.	7.4 ± 3.5	6.5 ± 1.7
Median	7	6
Range	4–15	4–11
Dental anxiety (CDAS ≥ 15)	1/21	0/79

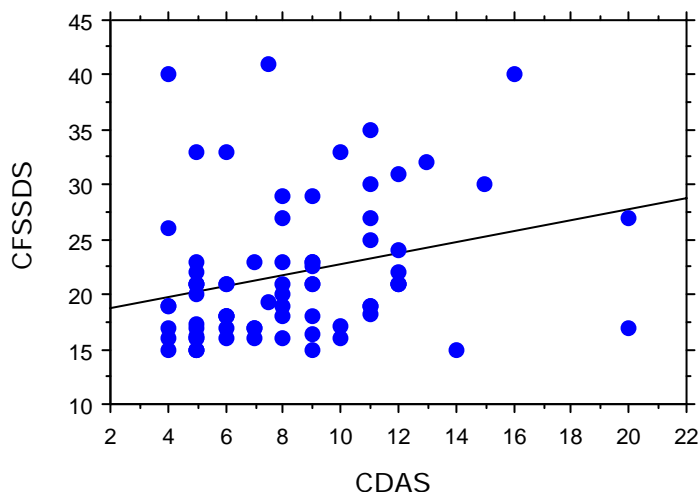


Fig. 4. Correlation between dental anxiety in parents according to the Corah Dental Anxiety Scale (CDAS) and dental anxiety in children at age 11 yr according to the Dental Subscale of Children’s Fear Survey Schedule (CFSS-DS) in the whole group studied ( $n = 75$ ) ( $r = 0.28$ ,  $P = 0.017$ ); Pearson’s correlation.

#### **STRESS REACTION MEASURED BY CORTISOL IN SALIVA (IV)**

When the cortisol samples were plotted on a timeline, cortisol concentrations were significantly lower in the subgroup of ADHD with hyperactivity-impulsivity than in the control group ( $P = 0.034$ ) (Fig. 5). Thirty min after awakening, the children in the hyperactivity-impulsivity subgroup had significantly lower cortisol levels than did the controls ( $10.4 \pm 3.3$  nmol/l vs  $14.9 \pm 6.1$  nmol/l,  $P = 0.030$ ). But differences between the ADHD group and the controls in cortisol concentrations were nonsignificant. Neither were any within-group differences in cortisol levels before and after the dental examinations noted.

The correlation between CDAS and cortisol concentration before the dental examination was significant in both the ADHD ( $P = 0.021$ ) and the control ( $P = 0.019$ ) groups (Fig. 6): the more dental anxiety the child reported, the higher was the cortisol concentration in saliva before the dental examination.

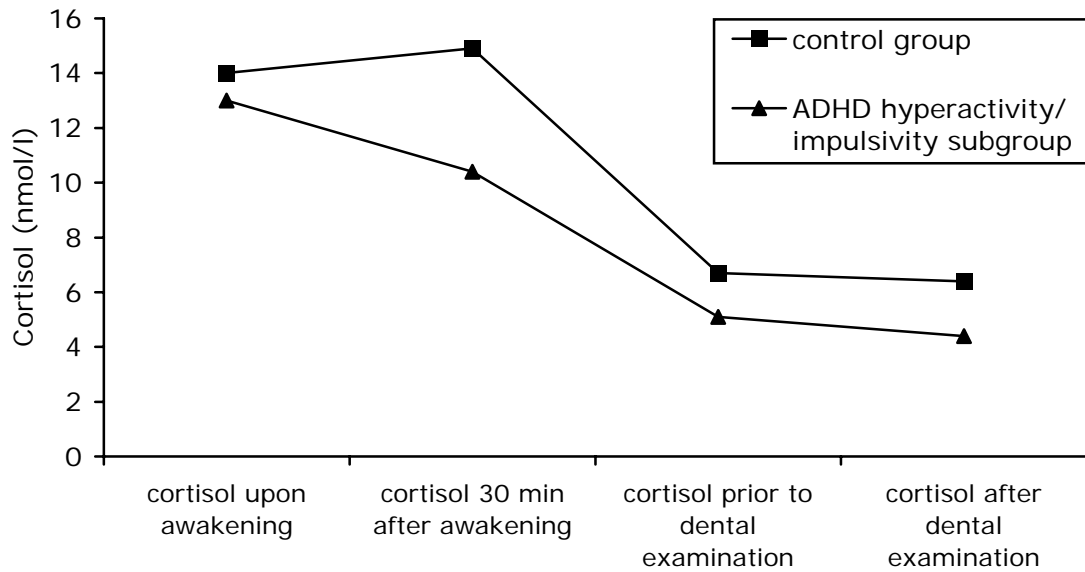


Fig. 5. Salivary cortisol levels (nmol/l) in children with attention deficit hyperactivity disorder (ADHD) with hyperactivity-impulsivity and in a control group. The ADHD timeline lies significantly lower than the timeline for the control group ( $P = 0.034$ ); repeated measurement ANOVA.  $P$  values were adjusted for gender using linear regression.

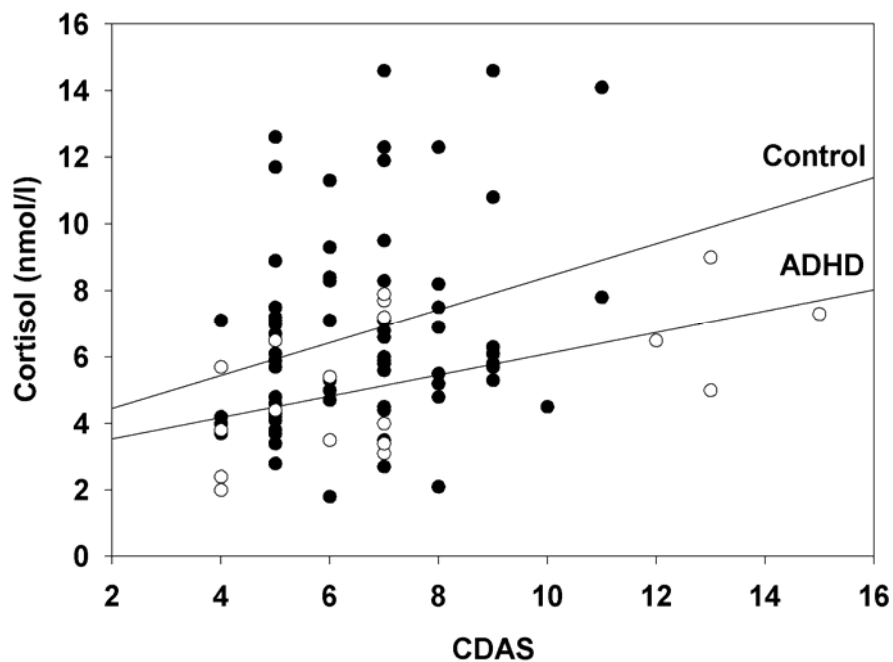


Fig. 6. Correlation between dental anxiety according to the Corah Dental Anxiety Scale (CDAS) and cortisol concentration in the salivary cortisol sample before the dental examination in the attention deficit hyperactivity disorder (ADHD) group ( $r = 0.54$ ,  $P = 0.021$ ) and in the control group ( $r = 0.28$ ,  $P = 0.019$ ). White circles, ADHD group; black circles, control group; Pearson's correlation.

## CARIES AND GINGIVITIS (I, III)

At age 11 yr (study I), the children in the ADHD group had a significantly higher caries prevalence and incidence than the children in the control group, but at age 13 yr (study III) this difference could not be demonstrated.

In study I at age 11 yr, the children in the ADHD group had a significantly higher number of decayed, missing, or filled surfaces (DMFS),  $2.0 \pm 3.0$ , compared to the control group,  $1.0 \pm 1.5$  ( $P = 0.032$ ). The children in the ADHD group also had a significantly higher number of decayed surfaces (DS),  $1.7 \pm 3.6$ , compared to the control group,  $0.5 \pm 0.9$  ( $P = 0.016$ ). None of the factors gender, mother's educational level, or mother born outside Sweden had a significant impact on DMFS or DS when ADHD was considered. Between-group differences in number of surfaces with initial caries lesions (IS) were nonsignificant ( $2.2 \pm 1.9$  in ADHD,  $1.9 \pm 2.0$  in controls). The GBI was  $4.3 \pm 4.5\%$  in the ADHD group and  $4.1 \pm 4.5\%$  in the control group—a nonsignificant difference.

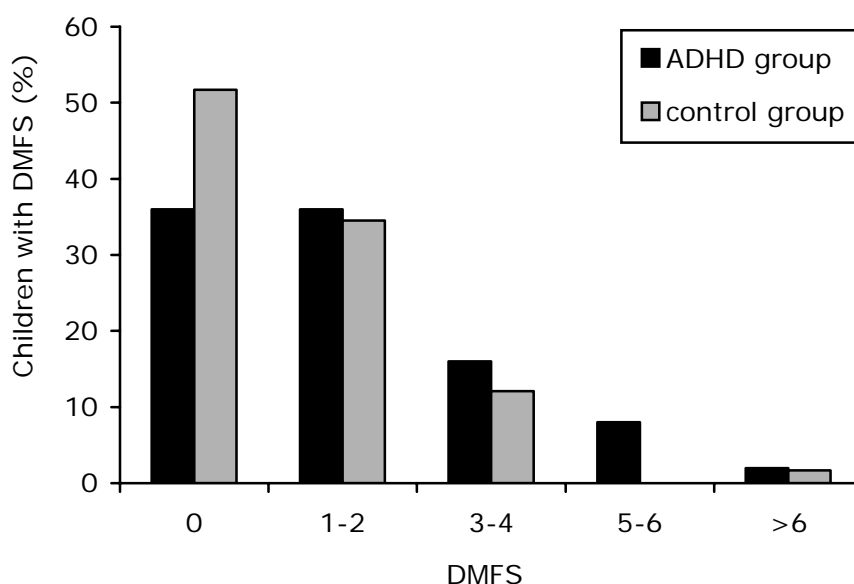


Fig. 7. Distribution of children with decayed, missing, or filled surfaces (DMFS) in the attention deficit hyperactivity disorder (ADHD) group and the control group at age 11 yr.

Figure 7 presents the distribution of DMFS in the two groups at age 11 yr. Thirty-six percent (9/25) of the children in the ADHD group had a DMFS = 0, compared to 52% (30/58) in the control group; this difference was nonsignificant. Odds ratios (ORs)

regarding caries variables for the ADHD group compared to the control group were 2.05 (95% confidence interval [CI]: 0.78–5.37) for DS, 1.91 (95% CI: 0.73–5.00) for DMFS, and 1.27 (95% CI: 0.40–4.02) for IS.

In study III, at 13 yr the DMFS in children with ADHD was  $2.8 \pm 4.0$  compared to  $2.2 \pm 3.2$  in the control group, a statistically nonsignificant difference. Between-group differences in DS ( $1.0 \pm 4.8$  in ADHD,  $0.7 \pm 2.4$  in controls) and IS ( $3.4 \pm 2.9$  in ADHD,  $3.6 \pm 4.0$  in controls) were nonsignificant. Between-group differences in GBI were also nonsignificant ( $7.0 \pm 5.4\%$  in the ADHD group,  $8.1 \pm 6.3\%$  in controls).

Figure 8 presents the distribution of DMFS in the two groups at age 13 yr (study III). Thirty-eight percent (8/21) of the children in the ADHD group had a DMFS = 0, compared to 48% (38/79) in the control group; this difference was nonsignificant (Fig.1). ORs regarding caries variables for the ADHD group compared to the control group were 1.26 (95% CI: 0.76–2.09) for DS, 1.23 (95% CI: 0.75–2.01) for DMFS, and 1.04 (95% CI: 0.59–1.82) for IS.

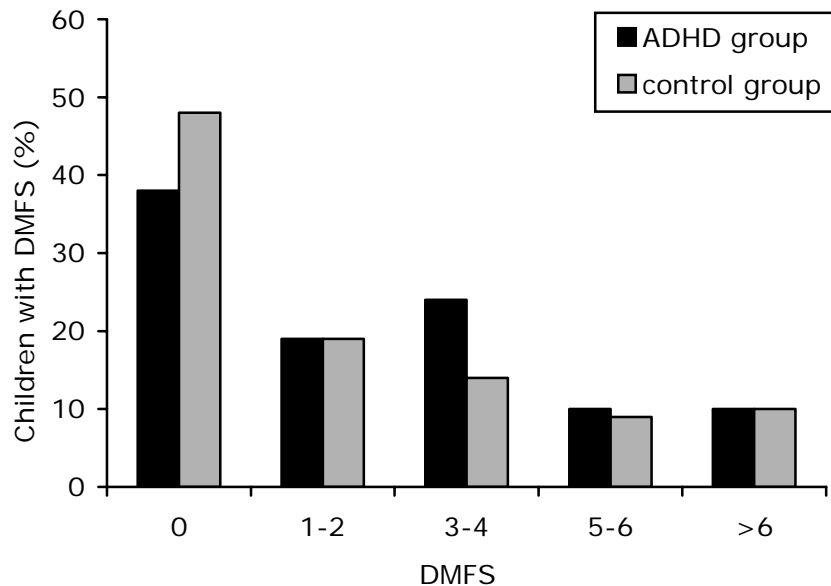


Fig. 8. Distribution of children with decayed, missing, or filled surfaces (DMFS) in the attention deficit hyperactivity disorder (ADHD) group and the control group at age 13 yr.

### *Inter- and intraexaminer agreement*

Regarding manifest and enamel caries lesions registered on bite-wing radiographs in study III, interexaminer agreement between three examiners was assessed using paired coding of five different randomly selected patients. Exact agreement was found for 100 % of the comparisons regarding manifest lesions and 95 % of the comparisons regarding initial caries lesions. Weighted kappa was calculated to take into account the degree of disagreement<sup>125</sup> and was found to be 0.76 and 1.0 regarding manifest lesions and 0.86 and 0.90 regarding initial caries lesions. Assessment of intraexaminer agreement was tested and retested in 30 randomly selected cases with a 2-month interval. Exact agreement was found for 99 % of the comparisons regarding manifest lesions and 99 % regarding initial caries lesions. Weighted kappa was 0.99 regarding manifest lesions and 0.99 regarding initial caries lesions.

### **ORAL HEALTH BEHAVIOR (III)**

In study III, fewer children in the ADHD group brushed their teeth every evening (10/21 vs. 65/79,  $P = 0.007$ ) and fewer children brushed their teeth every morning (10/21 vs. 59/79,  $P = 0.034$ ) than in the control group, after controlling for gender, mother's educational level, and mother born abroad. A trend for more children to eat or drink any food or beverage  $\geq 5$  times/d was found in the group of children with ADHD compared to the control group ( $P = 0.068$ ), after controlling for gender, mother's educational level, and mother born abroad. OR for eating and drinking  $\geq 5$  times/d for the group of children with ADHD compared to the control group was 1.74 (95% CI: 1.01–3.02). OR for only the boys in the group of children with ADHD compared to the boys in the control group was 1.77 (95% CI: 0.95–3.28).

## GENERAL DISCUSSION

The present thesis investigates the behavior in a dental setting and the oral health of a group of children with ADHD compared to a control group. Our main findings were that there were differences between the two groups regarding BMP, interaction between child and dentist, caries prevalence at age 11 yr and oral health behavior at age 13 yr. Comparisons of a subgroup of children who showed the highest number of symptoms of hyperactivity or impulsivity with the control group revealed additional differences in dental fear and stress reaction at age 13 yr.

### DENTAL BEHAVIOR MANAGEMENT PROBLEMS

An increase in BMP was observed in the ADHD group between ages 7 and 9 yr, with a significant difference compared to the control group at age 8, indicating that children with ADHD find it increasingly difficult to cope with the dental treatment situation at an age when they are expected to cope. This is not unexpected since the difficulties children with ADHD exhibit usually become evident in early school age when demands on behavior and cooperation increase.<sup>126</sup> The frequency of children with BMP tended to decrease with increasing age in the control group; this trend was not as strong in the ADHD group. Klingberg *et al.*<sup>4</sup> reported similar findings as in the control group, that is, that BMP decreased with age.

A history of BMP was observed in 58% of the children with ADHD compared to 38% in the control group. This difference was borderline significant. This cumulative frequency of BMP in the control group is in agreement with the findings in 6–8-yr-old Danish children where the corresponding frequency was 37%.<sup>8</sup> The frequency of 9-year-old children with notes on BMP in their dental records in study I was 17% in the index group and 6% in the control group compared to 5.5% reported by Klingberg *et al.*<sup>4</sup> for children aged 9–11 yr.

In the entire group studied (i.e., the children with ADHD and the children in the control group), the child's dental fear at age 11 yr, as measured with the CFSS-DS, was the only factor with a significant relation to BMP. On the other hand, a higher level of dental anxiety in the ADHD group compared to the control group was not found. Our results of these studies of children with ADHD support previous

assumptions that dental anxiety and BMP are two different entities in children that in some children overlap.<sup>11</sup>

Felicetti *et al.*<sup>70</sup> studied the behavior of 6–10-yr-old children with ADHD during a dental visit. They found no significant differences in observed behavior between children with ADHD and children without ADHD. The study was cross-sectional during a single, standardized dental visit, and the technique of registering BMP was therefore not comparable with the method used in study I. In the study, conducted in the United States, 21% of the children with ADHD were taking medication for their condition, which probably influenced the results of the most hyperactive children. Because the data for study I were collected from dental records covering up to 8 yr of the child's life, the proportion of children taking medication is not known, but the tradition of medicating children with ADHD at that time was more restrictive in Sweden than in the United States.

One problem with a retrospective dental record study is that the observations were made by several dentists at different clinics, and each dentist will have a different attitude and experience regarding child dental care. Generally, notations of behavior problems in the dental records have been preceded by severe behavior problems.<sup>4</sup> But a retrospective dental record study is the only convenient way to investigate BMP. If the measure of BMP is to be reliable, BMP must be recorded over a time period in a real life situation (dental examination), because no test is available for BMP. An advantage of a retrospective study design is that information recall bias is decreased because the dentists who make the notes on BMP in the dental records write what they observe and not what they think is expected of them. The information bias of nonrandom or differential misclassification in this study was low because the person collecting the data from the dental records was blinded to any ADHD diagnosis and to the results of the screening for attention and learning problems.

## **INTERACTION BETWEEN CHILD AND DENTIST**

In study II it was revealed that there were specific problems in the interaction process between the child and the dentist. These problems became evident when behavior was studied by a technique that allowed analysis at a very detailed level. The problems resulted in less two-way communication between the child and the dentist, that is, the



child displayed poor adaptation and timing compared with the situation observed in the control group.

The children with ADHD took more initiatives and made more irrelevant comments. This could be explained by poor behavioral inhibition in children with ADHD. Behavioral inhibition is regarded as the central deficiency in ADHD, with secondary implications for the development of executive functions.<sup>64,65</sup> Another reason could be that the child was searching for confirmation in an unpredictable situation. A child with attention deficits due to executive problems might have difficulties comparing the present situation with earlier experiences and have a less clear model for how to act, factors that easily create insecurity.

The children in the ADHD group made fewer verbal responses and had more missing responses and a higher degree of non-coordination of their responses (i.e., avoidance of response, no response or incongruity between verbal and nonverbal responses) than the children in the control group. This might be a result of their limited attention and executive functions. In a demanding situation, this might lead to a lower degree of simultaneous capacity, and the child must focus on either doing or talking. Moreover, the child might not know what is expected of her/him. The child might nod “yes” and answer “no” at the same time, and the answer becomes unclear, or the child gives no answer at all. Unclear responses can also be a result of bad timing due to a slower cognitive processing. It has previously been shown that the time interval between an action and a response cannot be too long in interactions with children with ADHD,<sup>127</sup> but the results from our study also indicate that the interval should not be too short.

The number of interaction sequences per interaction phase did not differ between the two groups. That means that the number of initiative-response turns taken was the same. A child with ADHD needs to take more turns while interacting in order to make the situation comprehensible. Interaction problems might decrease if the dentist would encourage children with ADHD to take more turns during the conversation.

A new method was developed to record and quantify the different parts of interaction between the dentist and the child at a very detailed level. Both inter- and intrarater tests yielded a high level of agreement and high weighted kappa values. Weinstein *et al.*<sup>73</sup> used video recordings to develop a coding system for the observed behavior of

the dentist and the child. For example, when the dentist “reassured the child, both verbally and non-verbally”, this was classified as one parameter. The study evaluated the influence of the dentist’s behavior on the child’s fear-related behavior. Prins *et al.*<sup>74</sup> further developed the coding system and found that children treated by experienced dentists showed more fear-related behaviors and that dentists communicated more with high- than with low-anxious children. Prins *et al.* concluded that some of the behaviors recorded in their study needed to be differentiated more clearly to make the analysis more detailed. In our study, each behavior was broken down to the lowest level, the individual interaction elements, for a more detailed analysis of mainly verbal, but also non-verbal behavior, which gave a clearer picture of the specific support needed by children with ADHD. Kulich *et al.*<sup>128</sup> constructed a theoretical model for the interaction between dentist and patient during history-taking and therapy discussions. The model was developed after a qualitative study of the video recordings of five dentists and 15 adult patients with dental phobia. One of the conclusions from the study was that a relationship between dentist and patient is established if the dentist’s behavior is appropriate and adjusted to the patient’s needs and the requirements of the situation.

That the dentist was unknown to all the children is an advantage in study II. The dentist had no prejudices—positive or negative—regarding the child or her/his family and the behavior of the dentist could be analyzed equally in all patients.

## **DENTAL FEAR AND ANXIETY**

The main finding regarding dental anxiety was that no significant differences in dental fear between the ADHD and the control groups were found at age 11 when measured by the CFSS-DS (completed by the parent study I) or at age 13 when measured by the CDAS (completed by the child in study IV). At age 13, however, the subgroup of children with ADHD with several symptoms of hyperactivity-impulsivity had significantly higher mean CDAS scores than controls. Thus dental anxiety might be related to hyperactivity-impulsivity in children with ADHD. According to Klingberg *et al.*,<sup>11</sup> 61% of children with dental anxiety react with BMP. Arnrup *et al.*<sup>5</sup> found that in uncooperative child dental patients, impulsivity in combination with dental fear was more common than in a control group.

In study I, 4.2% of the children with ADHD and 3.5% in the control group had a high level of dental anxiety (CFSS-DS  $\geq 38$ ), a nonsignificant difference. These figures can be compared to 6% of children in the general population aged 4–11 yr in a Dutch study and 5.7% in a sample of Danish schoolchildren aged 6–8 yr.<sup>8,14</sup> Mean CFSS-DS values were reported to be 23.8 in the Danish study and 22.1 in a Finnish study of school-aged children;<sup>129</sup> this is comparable to the results in study I. The relation between dental anxiety in the parent and dental anxiety in the child, which we found in both groups of children aged 11 yr, supports previous findings.<sup>11,22</sup>

The mean values of CDAS in study IV were lower than those reported in a study from New Zealand on 15-yr-old children.<sup>130</sup> No child had a CDAS over 15, compared to 7.1% of 13- and 14-yr-old children in a study from Scotland.<sup>131</sup> This difference between study results is probably due to a higher level of oral disease in Scotland compared to Sweden, which leads to more negative experiences of dental treatment.

A well-known factor in the development of dental fear in children is previous negative experience of dental treatment. In child dental patients, results have indicated that within the direct conditioning pathway, objective dental experiences seem to play a minor role in children's fear acquisition, and it was suggested that subjective dental experiences may play a more decisive role.<sup>132</sup> A child's expression of dental fear might be influenced by the child's difficulties to take in and understand the treatment situation. A child with ADHD has difficulties anticipating what is going to happen,<sup>67</sup> so the child might have a problem using the information in the questionnaire to generalize an answer since the situation being described is one that was previously experienced.

### **STRESS REACTION MEASURED BY CORTISOL IN SALIVA**

An indication of a blunted HPA-axis response in children with ADHD with high hyperactivity-impulsivity scores compared to controls was found. But differences in salivary cortisol levels between the entire group of children with ADHD and the controls were nonsignificant. A correlation between dental anxiety (measured as CDAS) and cortisol concentration before dental treatment was found in both the ADHD and the control groups.

Previous studies have shown that cortisol response upon awakening is a useful index of HPA-axis activity,<sup>133,134</sup> that is, a lower cortisol value 30 min after awakening

indicates a blunted diurnal variation. In study IV, this cortisol value was significantly lower in the subgroup of children with ADHD with hyperactivity-impulsivity than in the controls. The generally lower levels over time in the children with ADHD with hyperactivity-impulsivity compared to controls also point in the same direction.

Abnormal variations in diurnal salivary cortisol in children with ADHD have previously been reported, especially in severely and moderately hyperactive children, with neither maximum levels occurring in the morning nor minimum levels in the evening.<sup>79</sup> A dampened HPA-axis response in children with ADHD has been suggested, both regarding diurnal variation<sup>80</sup> and as a response to a stressor,<sup>81,135</sup> but there have also been findings of higher cortisol values compared to a control group.<sup>136</sup> The findings illustrate that cortisol is an outcome measure which is complicated to evaluate and that different types of stressors may lead to different types of reactions.

Some of our findings illustrate the capacity of the stressor—the dental examination—to elicit HPA-related stress reactions. Firstly, there were no differences in cortisol levels before and after dental treatment. This indicates that the major stressor is anticipation of what will happen rather than entering the treatment room and being seated in the dental chair. This finding is supported by previous studies.<sup>137</sup> Secondly, the correlation between CDAS and cortisol before dental treatment was significant in both the ADHD and the control group. This is in agreement with a study by Benjamins *et al.*,<sup>82</sup> who found that in adult patients with severe dental anxiety, anticipation of a dental visit without any treatment resulted in increased cortisol levels. Kreuger *et al.*<sup>83</sup> found no correlation between cortisol and dental anxiety, although patients with high dental anxiety scores had higher concentrations of salivary cortisol during an information session about dental treatment than those with low dental anxiety scores.

Seemingly paradoxical, although the children in the subgroup ADHD with high hyperactivity-impulsivity scores had lower cortisol values than the controls after the dental examination (borderline significance), the subgroup had more dental anxiety (i.e., higher CDAS scores). This illustrates that the cortisol levels of these children are expressions of both a generally dampened response and the subjective perception of an emotionally more stressful event. If the subjective impact of the event had been equal in this group and in controls, the blunted response would probably have emerged more distinctly. So the behavioral expressions of the anxiety of children

with ADHD may be different than in other children, not only due to the characteristics of their disorder but also due to lower stress reactivity.

Study IV represents several new approaches to investigating HPA-axis function in children with ADHD: reactions to a real life stressor (a dental examination) were investigated; the investigation of both the diurnal rhythm and reactions to a stressor were combined; and the group of children with ADHD displaying prominent symptoms of hyperactivity-impulsivity were compared to healthy controls of the same age. Our findings demonstrate that HPA-axis dysfunction may be a noteworthy characteristic of this important subgroup. It has been suggested that the dysfunction in stress reactivity may be due to an elevated threshold for detection of stressors, but the higher levels of reported anxiety in our study do not support this.<sup>80</sup> It is more probable that the changes express a lowered sensitivity of the axis. Physiological characteristics of subgroups of ADHD may be important for prognostic considerations, as Kariyawasam *et al.* suggested.<sup>80</sup> They may also be useful in genetic research, which is generally complicated by the heterogeneity of the ADHD spectrum.<sup>135</sup>

A general validity problem concerns salivary cortisol sampling compliance, which is the accuracy of the time of sampling reported by the participants. In a study on salivary cortisol sampling compliance, compliant samples expressed the expected morning rise whereas non-compliant samples did not.<sup>138</sup> Moreover, “waking up” may be understood differently by different individuals, implying further uncertainty about the interpretation of the morning rise in cortisol concentrations. Consequently, self-collected samples must be evaluated with caution; more specifically, the rapid dynamic changes in morning cortisol concentrations appear to be sensitive to compliance bias.

Three of the children in study IV were on stimulant medication due to an earlier diagnosis of ADHD. When methylphenidate has been used for a longer period, the medication should not influence cortisol levels,<sup>139</sup> but the influence of the medication on hyperactivity-impulsivity might have resulted in a selection bias when the children were classified according to these symptoms. Two children, one in the ADHD group and one in the control group, were using inhaled glucocorticoids due to asthma on the day of the dental examination. A previous study found median salivary cortisol levels to be lowered 30 min after awakening, but unaffected 12 h after awakening, in patients who inhaled glucocorticoids.<sup>140</sup> Children with allergic asthma may also have a blunted

cortisol response to stress, but cortisol levels 30 min after awakening did not differ from those of a control group.<sup>141</sup> In study IV, the child with a glucocorticoid inhalator was not in the ADHD subgroup of children with hyperactivity-impulsivity, so the possible lower cortisol levels of the child cannot have influenced the results in this subgroup.

## **CARIES, GINGIVITIS AND ORAL HEALTH BEHAVIOR**

At age 11 yr (study I), the prevalence of caries in the permanent dentition of children with ADHD was higher than in the control group. Previous findings have indicated a higher caries prevalence in children with ADHD.<sup>105,106</sup> Broadbent *et al.*<sup>105</sup> conducted a case-control study on children with a DMFT score  $< 5$  or  $\geq 5$ ; 128 case-control pairs aged 11–13 yr were included in the study, and 14 of the children (11 of the cases and 3 of the controls) had an ADHD diagnosis according to parental reports and dental records. Nine of the children with ADHD were medicated for their condition. It was concluded that children with ADHD had an OR of 10.2 (95% CI: 1.13–91.81) of having a high DMFT score compared to children who did not have ADHD. But a DMFT  $< 5$  may not be considered a clinically significant low caries score. Moreover, the results were derived from 14 children with ADHD, and the confidence interval reported for the OR was large with the lower bound close to 1, so the results should probably be interpreted with caution. In a cross-sectional study by Grooms *et al.*<sup>106</sup> on 38 children with ADHD aged 6–10 yr and a matched control group, no differences in DMFS in the primary or permanent dentition were found. The study group reported more enamel caries in the permanent dentition in children with ADHD. Contrary to study I, no radiographs were used in the study and all children with ADHD were medicated for their condition. In a study from Colombia on 36 children with ADHD between ages 5 and 13 yr and a control group of 47 children, the DMFT score was significantly higher in the control group than in the ADHD group.<sup>71</sup>

At age 13 yr (study III), the children in the ADHD group had neither a higher DMFS nor a higher DS than the children in the control group. Caries prevalence was comparable to what a Swedish study found for 12-yr-old girls, where DMFS was 1.7 and the proportion of caries-free individuals 44%.<sup>142</sup> Lack of significant differences between the groups regarding caries in study III could be due to several factors. First, at age 13, several permanent teeth have recently erupted, and although adolescence is a period of higher caries progression, the lesions develop slowly.<sup>92</sup> Second, the study

group may be too small. The mean value of DMFS was higher and the frequency of caries-free (DMFS = 0) individuals was lower in the group of children with ADHD compared with the control group, but the differences were nonsignificant. Third, the oral health of children with ADHD might not be poorer than the oral health of other children, and ADHD might not be a risk indicator for the development of dental caries. The primary deficiencies in ADHD might not affect the children's ability to carry out the proper self-care needed to maintain their oral health.

The study groups at ages 11 and 13 yr did not comprise exactly the same individuals, but since the groups of children with ADHD and the controls were drawn from the same population, the results in this thesis can be discussed from a longitudinal viewpoint. The frequencies of caries-free (DMFS = 0) individuals were about the same at 11 and 13 yr: 36–38% in the ADHD group and 48–52% in the control group. Mean DMFT increased more rapidly in the control group than the ADHD group—it seems that the controls played “catch up” regarding caries prevalence between ages 11 and 13.

The prevalence of gingivitis was not higher in the ADHD group compared to the controls at age 11 or at age 13. However, GBI in both study groups increased between 11 and 13 yrs, a result that is supported by Matson and Goldberg.<sup>143</sup>

At 13 yr (study III) regular toothbrushing morning and evening was less common in the ADHD group. There is some disagreement about the correlation between irregular toothbrushing and caries. In a Dutch study, toothbrushing frequency at age 11 and 14 was clearly related to DMFS, independent of ethnicity and level of maternal education.<sup>144</sup> Irregular toothbrushing at night was also strongly associated with high caries experience in a recent study on 19-yr-old Swedish adolescents.<sup>98</sup> But another Swedish 3-yr longitudinal study of 12-yr-old girls found toothbrushing to have no significant influence on caries development.<sup>142</sup> Grooms *et al.*<sup>106</sup> detected no differences between ADHD and non-ADHD subjects in toothbrushing or diet.

The odds for eating or drinking any food or beverage  $\geq 5$  times/d at age 13 yr (study III) was higher in the group of children with ADHD compared to the control group. Previous studies have shown that caries lesions increase significantly with increasing number of intakes.<sup>96</sup> In a group of Swedish 12-yr-olds followed for 5 years, a higher

caries risk was observed in 17-yr-olds who reported eating sweets and not brushing their teeth twice a day at all examinations during the study period.<sup>145</sup> On the other hand, in a systematic review of scientific articles examining sugar and caries risk, sugar consumption was classed as a moderate risk factor for caries in most people who had consistent exposure to fluoride.<sup>146</sup> Because the use of fluorides by the children in the ADHD group was more infrequent than by the control group due to irregular toothbrushing, the more frequent “snacking” by the children in the ADHD group must be considered a risk behavior for poor oral health. It has been reported that children with ADHD anticipate less severe consequences following risky behavior.<sup>147</sup> Children with ADHD also have more difficulty generating solutions to complex problems<sup>148</sup> and may have more difficulties foreseeing cause-effect relationships in general. In families with children with ADHD, greater conflicts in parent-child interactions have been reported,<sup>149,150</sup> which might influence oral health behavior.

A caries diagnosis can differ according to examiner. In a systematic review of caries diagnoses, Bader *et al.*<sup>151</sup> estimated the sensitivity of lesion detection to be 39–59% in both the enamel and dentin of occlusal surfaces, depending on study methodology. The same review showed that, for approximal surfaces, radiographs had an overall sensitivity of 50% and a specificity of 87%. In this thesis, all children were examined by the same dentist, who was blinded to possible ADHD diagnoses; this is a strength that makes the diagnosis of caries consistent. The intra- and interexaminer tests yielded a high level of agreement and high weighted kappa values.

## **METHODOLOGICAL CONSIDERATIONS**

The present thesis has a clinical, prospective and retrospective, double-cohort design, in which one cohort comprised children with ADHD and the other cohort (the control group) children who had no behavior, attention, and learning problems according to a screening. The study was population based, and the screening procedure included all children born in 1991 and living in the same municipality in 2001.

All children with ADHD were identified in an extensive clinical investigation following a screening procedure. The method of screening for attention problems, ADHD, and other developmental disorders using Conner’s 10-item questionnaire has been used in previous Swedish studies and found to have good inter-rater and test-retest reliability.<sup>41,152,153</sup> To also identify children who may have behavioral problems,



but who were not hyperactive-impulsive, a questionnaire pertaining to passive and slow behavior and learning problems (the EFSQ) was constructed.<sup>118</sup> The EFSQ covers problems with (1) executive functions, such as the child's ability to organize and plan things, the child's working memory, and the way the child relates to time, (2) inattention and passive behavior, and (3) problems with learning, such as reading, spelling, and mathematics. When Conner's 10-item questionnaire, the EFSQ, and an additional interview with the teachers, including the DSM-IV criteria for ADHD, were used to screen the group of children entering the study, our screen-positive group was 27% of the population examined.

Since all children underwent the same screening procedure for ADHD, misclassification is limited. Thirty-five children were diagnosed with ADHD, which corresponds well with previously reported prevalence rates between 3% and 6%.<sup>27,40,41</sup> The number of children diagnosed in a population of 555 children will be quite small, which affects the size of our study group. The ADHD group comprised more boys than girls, which was expected since it has been reported that ADHD is more prevalent among boys.<sup>43</sup> The results of our studies were adjusted for gender in the statistical analyses.

The studies in this thesis are part of a population-based investigation of attention, behavior, and learning problems in children. Previous studies in the project were done on the screen-positive children compared to a control group that was the same size as the screen-positive group.<sup>37</sup> This control group was the same group that participated in studies I and II. In studies III and IV, the control group consisted of the same individuals as in studies I and II, but adjustments were made regarding the uneven gender distribution. Controls visiting a private dentist were also excluded in studies III and IV. Because the controls were randomly chosen from the same school classes (studies I and II) or the same PDS clinics (studies III and IV) as the children with ADHD, the socioeconomic distribution in the ADHD and the control groups should be similar.

The prospective part in this thesis consisted of four cross-sectional studies on two occasions, that is, year 2002 in studies I and II and year 2004 in studies III and IV. A cross-sectional study will only reveal a relation between two variables and will say nothing about cause and effect or the development of an outcome, as would a longitudinal study design. As discussed above regarding dental caries, the thesis on the

whole can be considered to have a longitudinal design, since the ADHD group and the control group were drawn from the same populations.

A retrospective study has potential problems. First of all, it was difficult to collect the dental records of all the children. In study I, 139 of 184 dental records were identified. Second, not all dental records covered the entire life of the child. This can be explained by immigration to Sigtuna community. Eighty-one percent of the children in study I had dental records from 3 to 10 yr at the PDS and 94% from 7 to 10 yr.

The most serious limitation of this study is the small size of the study group. ADHD is a heterogeneous condition concerning etiology, subgroups, and associated disorders. To show significant differences in the variables studied between children with ADHD and controls, a larger study group is probably needed. The most common reason for dropping out of the studies was that the child had already visited the PDS for its annual recall visit the year of the study examination. In the control group, this was a particular problem in studies I and II, where examinations were done in April to June and 41/149 of the children in the control group were not included in the studies for this reason. In the ADHD group, the corresponding number was 2/35. In 2004 data was collected in January and February, and the number of dropouts for this reason was 4/35 of the children in the ADHD group and 15/101 of the children in the control group. This selection bias is random and should therefore not influence the results.

In studies I and II, another common reason for dropping out was that the child received its dental care from private dentists or a dentist in another community, which was the case in 4/35 of the children in the ADHD group and 36/149 of the children in the control group. The frequency of children visiting private dentists in Stockholm County is 17%. That the frequency in the control group is twice as high as the frequency in the ADHD group cannot be explained. In Sweden the dental care provided both by the PDS and by a private dentist is free until the child reaches 19. No data compare the oral health or BMP of children who receive their dental care in the PDS with children treated by private dentists.

The number of dropouts due to missed and cancelled appointments, or because the child did not want to participate in the studies, was 3/35 in the ADHD group and

15/149 in the control group in studies I and II. The corresponding numbers in studies III and IV were 5/35 and 19/101. Besides this, 3/35 children in the ADHD group in study IV did not return their morning cortisol sample, which also could be a way of saying that the child did not want to participate. The appointments could have been missed or cancelled due to dental fear<sup>154</sup> and could therefore influence the result regarding CFSS-DS in study I and CDAS or cortisol concentration in study IV. Dental fear can be related to experiences from earlier, potentially painful dental treatments,<sup>16-18,22</sup> so the dropouts due to cancelled or missed appointments might include children with high DMFS scores, which may have caused a differential information bias that might have affected the results in studies I and III. On the other hand, the frequency of missed and cancelled appointments was similar in the two groups, about 10% in studies I and II and about 20% in studies III and IV. An increase in missed appointments by age has previously been reported by Skaret *et al.*<sup>155</sup>

Regarding general cognitive level, the ADHD groups in the studies were considered to be representative of the group of 35 children with ADHD in the background population, as the proportions of full scale IQ between 70 and 85 or above 85 were about the same in the study groups as in the group of 35 children.

## CLINICAL IMPLICATIONS

ADHD is a frequently occurring neurodevelopmental disorder and about one child per class of 20–25 pupils can be regarded as having this cognitive disability. It is at all times important to consider that children with ADHD are first and foremost *children*, with their different individual personality and strengths. Terms such as “ADHD children” should be avoided. ADHD is related to specific cognitive dysfunctions, and the clinical manifestations—such as a short attention span, restlessness, and difficulties to wait for one’s turn—are insufficiently recognized as a disability. Although the bulk of knowledge about ADHD is enormous, concepts prevail that the behavioral symptoms are due to the individual’s own will. This means that there is a constant risk that the underlying impairment will be overlooked and that the child will be at risk of being interpreted as disobedient, unwilling, lazy, and naughty. Although many children today get a proper clinical assessment, many children with the disorder have never had a clinical examination and therefore have not had their specific difficulties explained. Accordingly, many children with ADHD, and their parents, have received no specific educational measures or treatment.

The main clinical implication from this thesis is that knowledge about ADHD is of vital importance when meeting and treating these children. If the dental personnel treating a child with ADHD know more about the underlying mechanisms behind the child’s behavior, the dentist will be able to adjust the situation and help the child to cope and adapt to the examination. As adults we must keep in mind that “children do well if they can, and if they can’t we need to figure out why, so we can help”.<sup>116</sup> Since ADHD is a common disorder and all dentists encounter these children, knowledge on such developmental disorders should be included in undergraduate dental education. Knowledge is the most important tool for understanding and for coping with the child in the most effective and positive way.

A child with ADHD appears in many ways to be a considerably younger child and function at about a 30% lower age level, regarding executive functions such as planning, staying focused, time perception, and flexibility.<sup>156</sup> This means that a 12-yr-old child with ADHD will function at a developmental age comparable to that of an 8-yr-old child. There is a risk that dental personnel will demand too much of the child if they do not understand the characteristics of the child’s deficits. What is important

to achieve during the dental appointment should be prioritized. The surgery should be calm and stressful situations should be avoided. No interruptions that can distract the child's attention, such as personnel entering the room and asking questions, should be allowed.

Entering the surgery and meeting the dentist normally reminds the child how the procedure, for example, the dental examination, was performed the last time the child visited and thereby helps the child compare the present situation with an earlier experience. A child with cognitive limitations may find it difficult to generalize from previous experience and need our help to cope with the examination situation.

A child with ADHD functions best if the dental visit is predictable and well structured. The child needs to know: (1) what to do, (2) with whom, and (3) for how long, and (4) what to do when the procedure is finished. Many problems can be prevented by paying attention and foreseeing situations that may be too demanding for the child. To change from one activity to another is often complicated for the child, and the child will need to be prepared in advance. Personnel should plan what they are going to do and give the child a "travel plan" with exact instructions of what the child is supposed to do in a given situation. Time can be illustrated with the help of a sandglass or a timer to make time more concrete.

Internalized speech is needed to aid self-regulation and to solve problems. During development the social, outer, language is internalized and becomes the inner language, necessary for thinking and planning. Studies have found that children with ADHD are less mature in self speech, so-called inner speech. The child with ADHD therefore needs cognitive support, such as cues, reminders, or visual support. For patients with autism, it is often easier to communicate via pictures than via words, and visual pedagogy is something that could be helpful when treating dental child patients with ADHD.

Children with executive dysfunctions, that is, the core problem in ADHD, display problems with several abilities and their cognitive tempo is often slower (i.e., things take time). Thus, in interactions with the child, it is crucial to adjust to the child's ability to sustain attention, to keep their focus, and to shift focus. Taking turns is important for the child, which means that the child must be able to answer and communicate according to the dentist's request, before the dentist gives more

information: for example, *dentist*: “*Sit down*”; *child*: “*Here in the dental chair?*”; *dentist*: “*Yes*”.

The child with ADHD has less recall of previous experience and takes more initiatives to get control of an incomprehensible situation. In such a situation, the dentist should not be distracted by the numerous initiatives from the child, particularly if the questions are not related to the treatment situation. The child needs help to keep the main thread. Dentists should guide the child through the examination process with the aim of keeping focus, telling her/him what they are doing as they do it and why they are doing it.

It is difficult for the child to grasp messages that are ambiguous, vague, or long-winded. The information given to the child should not be too extensive, as the child with ADHD often has difficulties remembering more than one instruction at a time. The dentist should be clear, simple, and straightforward while talking to the child, especially when making a request. The number of words and sentences should be kept to a minimum. Instructions should be given to the child after first making sure that the child is listening. Dentists should tell the child exactly what they want it to do and use statements and positive requests instead of questions: for example, “*I want you to...*” instead of “*Do you think you could possibly...*”

The dentist easily demands simultaneous capacity and should preferably not ask questions, which forces the child to make a decision, but be direct and more concrete instead, guiding the child verbally. “*You’re doing fine!*” instead of “*How are you doing?*”. Positive reinforcement, in terms of praise and small rewards, will help the child to keep up with the situation, and negative behavior should be ignored. The child should be reinforced often, also in behaviors that most adults would expect from a child that age and take for granted, such as following directions, listening, and sitting patiently.

The dentist should try to learn about the child’s abilities. Parents are experts on their children and should be consulted. It should also be remembered that ADHD often has a genetic component, and the parent might also have an executive dysfunction. If the parent gives negative comments to the child during the dental treatment, the dentist should explain that the child is doing fine, to the best of her/his ability, and that it is

important that communication during the dental appointment is primarily between the dentist and the child.

Children with ADHD find it difficult to start activities that are not stimulating or motivating. They need more support from parents in many daily activities, including coping with their oral health. If the child also has a low IQ, the need for extra support is even more necessary. The child can have difficulties storing information and need to be reminded often. Tasks can be divided into smaller parts and be visualized. It is good to write down instructions. Placing pictures in the bathroom that depict an appropriate brushing technique appears to reinforce the learning process and help children with autism who have intact motor skills improve their oral hygiene. Children with ADHD could also benefit from such guidance.

Children with ADHD may constitute a risk group for dental caries, and early caries preventive measures are recommended (dental checkups and reminders of oral self care). The children should be followed up at shorter intervals between dental examinations to prevent caries progression during adolescence due to their oral health behavior.

## CONCLUSIONS

In conclusion, children with ADHD, when compared to a control group:

- Have more dental behavior management problems.
- Exhibit more problems interacting with the dentist, in particular, they have difficulties staying focused on the examination.
- Do not exhibit a higher degree of dental anxiety, except when the child has several symptoms of hyperactivity or impulsivity.
- Have a blunted cortisol reaction, if the child has several symptoms of hyperactivity or impulsivity.
- Have a higher caries prevalence and incidence at 11 yr, but not a statistically significantly higher prevalence and incidence at 13 yr.
- Do not have a higher prevalence of gingivitis.
- Have poorer oral health behavior.



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## THE CHILDREN'S FEAR SURVEY SCHEDULE – DENTAL SUBSCALE (CFSS-DS)

Estimate the level of fear your son/daughter would perceive in the situations described below. Mark your answer with X.

### How afraid is your son/daughter of.....

	Not afraid at all	A little afraid	A fair amount	Pretty much afraid	Very afraid
1. dentists.....	_____	_____	_____	_____	_____
2. doctors.....	_____	_____	_____	_____	_____
3. injections (shots).....	_____	_____	_____	_____	_____
4. having somebody examine your mouth.....	_____	_____	_____	_____	_____
5. having to open your mouth.....	_____	_____	_____	_____	_____
6. having a stranger touch you.....	_____	_____	_____	_____	_____
7. having somebody look at you.....	_____	_____	_____	_____	_____
8. the dentist drilling.....	_____	_____	_____	_____	_____
9. the sight of the dentist drilling.....	_____	_____	_____	_____	_____
10. the noise of the dentist drilling.....	_____	_____	_____	_____	_____
11. having somebody put instruments in your mouth.	_____	_____	_____	_____	_____
12. choking.....	_____	_____	_____	_____	_____
13. having to go to the hospital.....	_____	_____	_____	_____	_____
14. people in white uniforms.....	_____	_____	_____	_____	_____
15. having the nurse clean your mouth.....	_____	_____	_____	_____	_____

## CORAH DENTAL ANXIETY SCALE

Estimate the level of fear you would perceive in the situations described below. Mark your answer with X.

1. If you had to go to the dentist tomorrow, how would you feel about it? Mark the alternative that best describes your feelings.

- I would look forward to it as a reasonably enjoyable experience.
- I wouldn't care one way or the other
- I would be a little uneasy about it.
- I would be afraid that it would be unpleasant and painful.
- I would be very frightened of what the dentist might do.

2. When you are waiting in the dentist's office for your turn in the chair, how would you feel?

- Relaxed.
- A little uneasy.
- Tense.
- Anxious.
- So anxious that I sometimes break out in sweat or almost feel physically sick.

3. When you are in the dentist's chair waiting while he gets his drill ready to begin working on your teeth, how do you feel?

- Relaxed.
- A little uneasy.
- Tense.
- Anxious.
- So anxious that I sometimes break out in sweat or almost feel physically sick.

4. You are in the dentist's chair to have your teeth cleaned. While you are waiting and the dentist is getting out the instruments which he will use to scrape your teeth around the gums, how do you feel?

- Relaxed.
- A little uneasy.
- Tense.
- Anxious.
- So anxious that I sometimes break out in sweat or almost feel physically sick.