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## Early Childhood Caries and Caries Experience in Permanent Dentition

A 15-year Cohort Study

#### KEYWORDS

Early childhood caries,  
caries,  
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cohort study,  
oral hygiene

#### SUMMARY

In Germany, caries of young people has been declining since the late 1980s, while the prevalence of early childhood caries has remained steady. Data from a number of regional studies suggest a current prevalence between 10% and 15%. However, there is a dearth of longitudinal observational study data on the risk of caries in the permanent teeth of persons who as children had to undergo comprehensive treatment for caries under intubation general anesthesia. The aim of this study was to compare caries experience in the permanent teeth of patients who had to undergo surgical treatment under general anesthesia as a result of non-compliance with caries treatment in early childhood with the experience of patients who did not develop caries at a young age.

Analysis of the data revealed that severe caries experience during early childhood resulted in a more severe caries experience during adulthood (difference: 14.8 DMFS;  $p=0.001$ ). This increase in caries experience applied to both untreated and treated carious surfaces, and was also apparent in relation to tooth extractions. When compared with persons whose first teeth had been caries-free, patients with severe childhood caries experience tended to show poorer dental hygiene in relation to smooth ( $p < 0.06$ ) and interproximal ( $p < 0.04$ ) surfaces. Patients who had been non-compliant as young children were not found to suffer from dental anxiety as young adults. Patients in the treatment and control groups differed with regard to dental health. Aside from being statistically relevant, these differences also have implications for clinical dental practice.

## Introduction

Despite a persistent caries decline in the permanent dentition of younger population groups since the end of the 1980s (MICHEELIS & BAUCH 1996, SCHIFFNER ET AL. 2009), the prevalence of early childhood caries (ECC) has remained constant at 10% to 15%, according to various regional studies in Germany (SPLIETH ET AL. 2009). However, longitudinal observational studies on caries risk in the permanent dentition of individuals who underwent comprehensive treatment for caries under general anesthesia as children are largely lacking.

Today, ECC is still one of the most common diseases in very young children (NIES ET AL. 2008), and is found with the same clinical manifestation worldwide (DAVIES 1998). During post-eruptive maturation of dental enamel in the first year of life, the newly erupted primary teeth seem especially susceptible to caries (AAPD 2008). Regular, unsupervised use of nursing bottles filled with sugar-containing beverages promotes early childhood caries (thus also known as “nursing-bottle syndrome”), starting with the maxillary anterior teeth and progressing to other teeth (PIEPER & JABLONSKI-MOMENI 2008). ECC is classified into different degrees of severity according to this typical pathogenesis (WYNE 1999).

In a prospective study in China, the epidemiology of caries in children was observed over an 8-year period, demonstrating a significant correlation between caries prevalence in the primary and permanent dentitions: 94% of the children with carious primary teeth also exhibited carious lesions in their permanent teeth, while 83% of the children with a caries-free primary dentition remained caries-free in the permanent dentition (LI & WANG 2002). In a Swedish study, the prevalence of approximal caries over a 12-year period was examined in children starting at age 3: children with manifest caries in the primary dentition demonstrated a higher risk of developing approximal caries in the permanent dentition than did caries-free children (41% versus 17%) (STÜRZENBAUM ET AL. 2006).

It is apparent from the studies mentioned above that it is highly probable that ECC can serve as a predictor of increased caries experience in the permanent dentition. It is yet unknown how the caries experience of adults is affected who, as children, based on non-compliance with conventional treatment, underwent intubation general anesthesia (after pre-medication promoting retrograde amnesia) and consequently received minimally traumatic treatment of ECC. Thus, the purpose of this study was to compare the caries experience in the permanent teeth of patients who had undergone surgical treatment under general anesthesia as a result of non-compliance with caries treatment in early childhood with the caries experience of individuals who did not develop ECC.

## Materials and Methods

This was a prospective, inter-cohort study on the long-term caries experience of young adults who suffered from ECC, did not comply with conventional treatment and were therefore treated for caries under general anesthesia (intubation) in early childhood. This group was compared with individuals who were caries-free in early childhood. The present study is based on an examination begun by Jöhren et al. in 1995 (JÖHREN ET AL. 1997). After an average of 14.8 years, the participants were newly contacted and examined according to clinical and behavioral parameters. The Ethics Commission of the Witten/Herdecke University approved the study (reg-

istration number 39/2010), which is also listed in the German Register of Clinical Studies (DRKS-ID: DRKS00000516).

## Subjects

The subjects were divided into an intervention group and a control group. The inclusion criteria for both groups were birth year between 1989 and 1994, and dental treatment at the study center (University Dental Clinic, Witten/Herdecke) between 1992 and 1999. Participation in and conduction of the study were in accordance with the Declaration of Helsinki, and the subjects as well as both parents had to give written informed consent to participate in the study if the subjects were not yet of full age.

For the intervention group, patients were selected who, due to high caries experience and non-compliance, underwent comprehensive dental treatment under intubation general anesthesia (GA) at the age of 3 to 5 at the University Dental Clinic Witten/Herdecke. Inclusion criteria for intervention-group subjects were thus a dmfs score >10, non-compliance with conventional in-chair treatment, and comprehensive dental treatment under GA.

The inclusion criteria for the control group were: age between 3 and 5 years, caries-free dentition (dmfs = 0), treatment compliancy, and no prior invasive treatment.

Given the requirements for birth year and treatment period, 342 documented patients were identified using the medical documentation software Visident (BDV Branchen-Daten-Verarbeitung GmbH, Holzwickede, Germany). Of these, 86 patients had been treated at the age of 3 to 5 years under GA during the treatment period, and 15 patients were caries-free. The 241 patients who did not meet the inclusion criteria were excluded from the study. After identifying all potential study participants, a search for their current addresses and telephone numbers was conducted. The name of parents and/or the place of residence during the treatment period were additional search options. If the name sought was listed multiple times in the relevant address databanks, each individual was contacted. Of a total of 101 potential participants, 32 were found (19 GA patients, 13 caries-free persons) who declared willingness to participate in the study. The patients were sent a brief description of the study design, directions to the study center, and a suggested appointment for a clinical examination. Underage patients additionally received a consent form with a detailed description of the study design for their parents. The patients were also sent two hierarchical anxiety questionnaires (HAQ) (JÖHREN 1999) to determine the individual treatment anxiety of the patient and the parents; the questionnaires were to be filled out and brought to the clinical examination. The HAQ score consisted of a sum of points (minimum HAQ score: 11; maximum HAQ score: 55).

## Study setting

The study steps from the selection of subjects to the clinical examination took place between April 2010 and September 2011. During this period, the baseline findings (1995:  $t_0$ ) were also verified and documented for comparison with the follow-up (2011:  $t_1$ ) findings. The central examination site was the University Dental Clinic Witten/Herdecke. The clinical exam was conducted by a clinical investigator (N.B.) and the findings were documented by a study assistant. Twelve of 19 subjects in the intervention group came to the examination appointment, and 13 of 13 in the control group did so.

## Examination steps

After handing in the informed consent form and the HAQ, the subject was asked to fill out a sociological questionnaire containing sociodemographic items. These also included the father's occupation/profession in order to determine the social class based on the *International Socio-Economic Index of Occupational Status (ISEI)* (GANZEBOOM ET AL. 1992); the only exception to this was the one-parent/guardian family, in which case the single parent's/guardian's occupation was documented.

In the subsequent clinical exam, dental and oral hygiene findings were taken using a dental mirror (DA027R, B. Braun Aesculap, Tuttlingen, Germany), a dental probe (DA406R, B. Braun Aesculap), and loupes (magnification 2.5×). Initial caries lesions were not included in the findings. To take oral hygiene findings, a plaque disclosing agent was applied first (Mira-2-Ton, Hager & Werken, Duisburg, Germany).

## Study endpoints

### Primary study endpoint

The primary endpoint of the study was:

- (a) the difference in the mean caries experience value as given by the DMFS index (KLEIN ET AL. 1938) between subjects in the intervention and control groups at  $t_1$ .

### Secondary study endpoints

The secondary study endpoints were:

- (b-i) the difference in the mean number of functional teeth as given by the FST index (SHEIHAM ET AL. 1987) between subjects in the intervention and control groups at  $t_1$ .
- (b-ii) the difference in the plaque coverage of smooth surfaces given by the QH index (QUIGLEY & HEIN 1962) between subjects in the intervention and control groups at  $t_1$ .
- (b-iii) the difference in the plaque coverage of the approximal surfaces given by the mAP index (mAPI) (ZIMMER ET AL. 2005) between subjects in the intervention and control groups at  $t_1$ .
- (b-iv) dental treatment anxiety given by the HAQ score (JÖHREN 1999) between the subjects and parents in the intervention and control groups at  $t_1$ .

For comparative purposes, the clinical baseline ( $t_0$ ) values of the study endpoints were used.

## Statistical analysis

Statistical analysis was performed using SPSS 22 (IBM, Armonk, NY, USA). Categorical endpoints were described using frequency counts and/or scores. Constant endpoints were described as

the arithmetic mean and minimum/maximum. To compare the significance of independent series of measurements, Wilcoxon and Fisher's tests (constant and categorical endpoints, resp.) were used. Results were considered statistically significant at  $p$ -values  $< 0.05$ .

## Results

There were six female and six male participants in the intervention group, and seven female and six male participants in the control group. The mean age in the intervention group at baseline was 4.5 years and in the control group 5.3 years ( $p = 0.005$ ). At follow-up, the mean age of subjects in the intervention group was 19.4 years and in the control group 19.9 years ( $p = 0.2$ ).

### Primary endpoint

#### (a) Difference in mean caries experience at $t_1$

The mean caries experience of subjects in the intervention group was DMFS = 17.6, and in the control group DMFS = 2.8. The caries experience in the intervention group was significantly higher (14.8 more tooth surfaces) than in the control group ( $p = 0.001$ ). The mean scores of the individual components of the intervention group's higher DMFS were as follows: 4.5 more decayed surfaces, 4.2 more missing surfaces, and 6.1 more filled surfaces than in the control group ( $p = 0.01$ ) (Tab. I).

### Secondary endpoints

#### (b-i) Difference in mean number of functional teeth at $t_1$

The mean number of functional teeth per subject in the intervention group was FST = 22.8, and in the control group FST = 26.6. With 3.8 fewer teeth, this was significantly lower than in the control group ( $p = 0.006$ ). The mean scores of the individual components of the intervention group's lower FST were: 2.2 more filled teeth ( $p = 0.02$ ) and 6.1 fewer healthy teeth ( $p = 0.002$ ) (Tab. II).

#### (b-ii) Difference in plaque scores at $t_1$

Plaque coverage of the smooth surfaces was determined using the Quigley-Hein Plaque Index (QHI). The average QHI of subjects in the intervention group was 2.1 and that of the control group was 1.5, a difference of 0.6 points ( $p = 0.06$ ).

#### (b-iii) Difference in plaque scores on approximal surfaces

Plaque on approximal surfaces was evaluated using the mAPI. The mean mAPI of subjects in the intervention group was 1.4, and that of the control group 0.4. This difference of 1 point was significant ( $p = 0.04$ ) (Tab. III).

**Tab. I** Primary endpoint: difference in mean caries experience based on the DMFS index and its individual components between subjects of the intervention and control groups

	N	$t_0$				$t_1$				$t_1 - t_0$			
		ds	ms	fs	dmfs	DS	MS	FS	DMFS	$\Delta DS$	$\Delta MS$	$\Delta FS$	$\Delta DMFS$
<b>Intervention group</b>	12	13.7	8.5	0.75	23.0	<b>5.3</b>	<b>4.2</b>	<b>8.1</b>	<b>17.6</b>	<b>4.5</b>	<b>4.2</b>	<b>6.1</b>	<b>14.8</b>
<b>Control group</b>	13	0	0.4	0	0.4	<b>0.8</b>	<b>0</b>	<b>2.0</b>	<b>2.8</b>				
<i>p-value</i>										0.005	0.06	0.01	0.001

$t_0$ : baseline examination (1992 to 1999);  $t_1$ : follow-up (2011);  $\Delta$ : change in index score as intervention group minus control group at  $t_1$ ; ds/DS: decayed tooth surfaces; ms/MS: missing tooth surfaces due to caries; fs/FS: filled tooth surfaces; dmfs/DMFS: summed score of ds/DS, ms/MS and fs/FS. Lower-case letters indicate primary teeth and upper-case letters permanent teeth.

**Tab. II** Secondary endpoint: difference in mean number of functional teeth according to the FST index and its individual components between subjects of the intervention and control groups

	N	t <sub>0</sub>			t <sub>1</sub>			t <sub>1</sub> -t <sub>0</sub>		
		ft	st	fst	FT	ST	FST	ΔFT	ΔST	ΔFST
<b>Intervention group</b>	12	0.25	12.25	12.5	<b>3.4</b>	<b>19.4</b>	<b>22.8</b>	<b>2.2</b>	<b>-6.1</b>	<b>-3.8</b>
<b>Control group</b>	13	0	19.9	19.9	<b>1.2</b>	<b>25.5</b>	<b>26.6</b>			
<i>p-value</i>								0.02	0.002	0.006

t<sub>0</sub>: baseline examination (1992 to 1999); t<sub>1</sub>: follow-up (2011); Δ: change in index score as intervention group minus control group at t<sub>1</sub>; ft/FT: filled teeth; st/ST: caries-free (sound) teeth; fst/FST: summed score of ft/FT and st/ST. Lower-case letters indicate primary teeth and upper-case letters permanent teeth (fst: min. 0, max. 20; FST: min. 0, max. 28).

**Tab. III** Secondary endpoint: difference in oral hygiene according to the Quigley-Hein index (QHI) for smooth surfaces and the modified approximal plaque index (mAPI) between subjects of the intervention and control groups at t<sub>1</sub>.

	N	QHI	mAPI
		mean score (min./max.)	
<b>Intervention group</b>	12	2.1 (1.0/3.3)	1.4 (0.5/2.0)
<b>Control group</b>	13	1.5 (0.3/2.5)	0.4 (0/1.4)
<i>p-value</i>		0.06	0.04

t<sub>1</sub>: follow-up (2011), QHI (min. 0, max. 5), mAPI (min. 0, max. 5)

**Tab. IV** Secondary endpoint: dental treatment anxiety according to the HAQ score of subjects and parents of the intervention vs. control groups at t<sub>1</sub>.

	N	HAF subject	HAF parent
		mean score (min./max.)	
<b>Intervention group</b>	12	23.3 (12/30)	25.8 (11/47)
<b>Control group</b>	13	22.2 (11/40)	26.0 (11/50)
<i>p-value</i>		0.3	0.9

t<sub>1</sub>: follow-up (2011), HAQ: hierarchical anxiety questionnaire (min. 11, max. 55)

**(b-iv)** Dental treatment anxiety at t<sub>1</sub>

The mean HAQ of subjects in the intervention group was 23.3, and that of the control group 22.2; this difference of 1.1 points was not significant ( $p = 0.3$ ). The mean dental anxiety among parents of intervention group subjects was HAQ = 25.8, and that of parents of control group subjects was HAQ = 26.0, a difference which neither was significant ( $p = 0.9$ ) (Tab. IV).

## Discussion

This prospective inter-cohort comparison examined young adults in terms of caries experience, number of functional teeth, oral hygiene (plaque) and dental treatment anxiety; as children, these young adults had been comprehensively treated for ECC under intubation general anesthesia due to non-compliance with treatment. The aim was to discover how a high risk of caries in early childhood influenced caries in the permanent dentition. It was found that high caries experience in early childhood was related to a significantly higher caries burden

in adulthood. This increased caries burden was observed on both unrestored and treated carious tooth surfaces. The difference was also apparent in the number of missing teeth. In terms of oral hygiene (plaque), deficits existed compared to persons whose primary dentition had been caries-free, not only on smooth but also on approximal surfaces. In this study, early childhood non-compliance with treatment did not manifest as increased dental treatment anxiety or phobia in young adults.

In addition to their statistical significance, the differences in dental health found between the intervention and control groups in the present study are also clinically relevant. However, the current results must be interpreted with caution.

## Strengths and weaknesses

In terms of representativity, the loss of subjects over the lengthy observation period must be considered problematic for the study groups: where the control group only lost two people (13%), the intervention group lost 74 (86%). This unequal loss in the two branches of the study influences the interpretability of the results.

The scientific literature on caries experience in the primary and permanent dentition preferentially considers the dmfs/DMFS or dmft/DMFT index. While the DMFT index represents the disease and its consequences, the FST index reflects health and functionality (SHEIHAM ET AL. 1987). For a balanced view of disease experience and degree of restoration, not only the oral health status but also the disease status of the dentition should be described, since these two indices complement each other more than they compete (SCHULLER & HOLST 2001). In addition to the long observation period, this is one of the present study's strengths. To allow more exact conclusions about regular oral hygiene to be drawn, gingival indices to monitor oral health could also have been used. Plaque indices, e.g., mAPI and QHI, provide information on the oral hygiene at the moment. In contrast, gingival indices reflect positive changes in oral hygiene only after a few days, thus providing a more accurate picture of the actual oral hygiene behavior of a patient than do plaque indices, which are influenced by brushing well once (ROULET & ZIMMER 2003). Thus, the oral hygiene parameters applied must be interpreted with caution.

## Interpretation and implications

Because this study did not conduct recall exams between the baseline and follow-up appointments, no information is available on when and under what conditions the oral health improvement attained during treatment under GA worsened. However, it is clear that the subjects in the intervention group

could not maintain their oral health throughout the observation period. Knowing the critical time periods and fundamental oral-health attitudes are nevertheless important for developing suitable prophylactic programs for this risk group.

In a literature review by POWELL (1998) of 42 selected studies, the best predictors of caries in different age groups – and hence at different stages of dentition – were examined. For all age groups, it was found that previous caries experience was the most important predictor for developing caries in the future. The studies included spanned an observation period of 5 years and 8 months. It was concluded that shorter observation periods yield more precise results, since caries develops under certain oral health conditions which also change over a longer period of time. The literature contains many reports of an immigrant family background as being a predictor for developing ECC (WENDT ET AL. 1994; KALLESTAL & WALL 2002); however, other studies failed to find a relationship (ROBKE & BUITKAMP 2002). Although this particular parameter was not a criterion in the present study, only one of the 13 subjects in the control group had an immigrant family background, but 5 of 12 in the intervention group did.

No literature review was found that included studies which examined caries development for a period longer than 5 years and 8 months.

### Controversies

CARSON & FREEMAN (2001) showed that parents whose children underwent comprehensive treatment under GA had greater dental treatment anxiety than did parents whose children merely attended routine dental check-ups. A child's treatment anxiety can be influenced by the parents' fear of dental treatment (KLAASSEN ET AL. 2002) and lead to non-compliance with treatment (JANKE & VON WIETERSHEIM 2009) which the patients may exhibit even into adulthood (MARGRAF-STIKSRUD 2006). In contrast, TEN BERGE ET AL. (2002) reported a decrease in treatment anxiety with increasing age in children. The present study confirmed this decrease in children who were comprehensively treated under intubation GA due to non-compliance: as young adults, their treatment anxiety level did not differ statistically significantly from that of control-group subjects. This result contradicts that of KLAASSEN ET AL. (2008), who found that dental treatment anxiety did not lessen in patients comprehensively treated under intubation GA. However, it may be assumed that some of the patients who had been treated under GA refused to participate in the study due to fear of more dental treatment. Of the 15 caries-free patients, 13 returned for the follow-up. Of the 86 patients treated under GA, only 12 attended the follow-up. During the recruitment phase, the rate of refusal to participate in the study was much higher in the intervention than in the control group. Individuals suffering from dental treatment anxiety – who are characterized by avoiding dental treatment – would have markedly raised the mean anxiety score in the study group. Surprisingly, parents of both the intervention- and the control-group subjects exhibited a lower anxiety score of HAQ  $\leq$  30 at the follow-up.

In terms of the quantitative evaluation of oral hygiene, no clinically unambiguous difference between the two groups of subjects was detected. Because the plaque index values were found to correlate with the number of carious teeth in a different study (APOSTOLSKA ET AL. 2011), the QHI for smooth surfaces and the mAPI for approximal surfaces were included in the examinations performed in this study. Although the mAPI index

showed a statistically significant difference between intervention and control groups, the QHI revealed only tendencies. The reason of fact that the smooth tooth surfaces of intervention-group subjects had QHI values similar to those of the control group could be that differences in the quality of toothbrushing are less apparent on the easier-to-clean smooth surfaces than on approximal surfaces, where even correct brushing technique is not sufficient for optimal cleaning.

### Research impulses

Broadening the present study to include a dental examination of siblings in both study groups could potentially show whether their oral health is comparable to that of the study participants at the follow-up. These results might indicate whether an intra-familial caries risk can be confirmed clinically. Likewise, a dental examination of the parents is also conceivable. The unexpected result that previously uncooperative pediatric patients showed lower dental anxiety as young adults poses the question as to the reasons for this development. It could well be that treatment non-compliance was solely the result of oral hygiene so pronouncedly poor that it would have necessitated dental treatment of an extent that could have exceeded the child's ability to cooperate at that time. As such, this would emphasize the necessity of the much-discussed broadening of prevention strategies in early childhood. A survey of individual and group prophylactic measures performed during childhood could provide an indication of how effectively the existing prevention programs avoid early childhood caries.

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### Résumé

Malgré une diminution permanente du nombre de lésions carieuses dans la dentition permanente parmi une population en bas âge depuis la fin des années 1980, la prévalence des caries chez le jeune enfant reste à un niveau stable et, selon les résultats de différentes études régionales en Allemagne, elle se situe entre 10% et 15%. Cependant, des études observationnelles longitudinales portant sur le risque de caries d'enfants, ayant eu des soins de la dentition permanente sous narcose par intubation, font toutefois largement défaut.

L'objectif de cette étude était, par conséquent, de comparer l'expérience carieuse dans la dentition permanente de patients qui, du fait d'un manque de coopération lors du traitement dentaires dans la petite enfance, ont subi des soins bucco-dentaires sous narcose par intubation, à celle de personnes exemptes de caries pendant l'enfance dans le cadre d'une série de cas cliniquement contrôlés sur une période de 15 ans.

L'étude a montré qu'une expérience carieuse chez l'enfant en bas âge entraîne une augmentation significative de la présence de lésions carieuses à l'âge adulte (différence: 14,8 CAO;  $p = 0,001$ ). Cette différence accrue a été constatée autant pour les surfaces dentaires carieuses non traitées que traitées. Cette même différence fut également décelée d'après le nombre de dents manquantes. Une tendance déficitaire concernant l'hygiène buccale par rapport aux personnes exemptes de caries dans la dentition temporaire, tant au niveau des surfaces lisses qu'au niveau des espaces interdentaires, a pu être mise en évidence ( $p < 0,06$ ). Le manque de coopération lors du traitement

dentaire pendant la petite enfance n'a pas été retrouvé sous forme de peur des soins dentaires au début de l'âge adulte.

Dans le cadre de cette étude de la santé dentaire, les différences mises en évidence entre le groupe avec interventions

et le groupe témoin peuvent par conséquent, outre leurs résultats statistiquement significatifs, être aussi considérées comme cliniquement importantes sur le plan odonto-stomatologique.

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