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ORIGINAL ARTICLE

# An early oral health care program starting during pregnancy

## Results of a prospective clinical long-term study

**Karen Meyer · Werner Geurtsen · Hüsamettin Günay**

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**Abstract** This study covers phase IV of a prospective clinical long-term study. Objective of this clinical investigation was to analyze the effects of a long-term prevention program on dental and oral health of teenagers at the age of 13 to 14 years. The entire study was subdivided into four phases. Phase I comprised an individual preventive care during pregnancy ("primary-primary prevention"); phase II assessed mothers and their young children until the age of 3 years ("primary prevention"); and in phase III, mothers and children at the age of 6 years were investigated. In phase IV of the study, the oral health of 13- to 14-year-old teenagers was examined (13.4±0.5 years; $n$=29). All phases consisted of an examination, education about oral health care, and treatment based on the concept of an early oral health care promotion. The control group consisted of randomly selected adolescents at the same age ($n$=30). The following clinical parameters were assessed: decayed/missing/filled teeth (DMF-T)/decayed, missing, and filled surface teeth index, hygiene index, papilla bleeding index, Periodontal Screening Index, and Streptococcus mutans/Lactobacillus concentration in saliva. The teenagers of the "prevention" group of phase IV of our prospective study revealed a share of 89.7% caries-free dentitions (65.5% sound; 24.2% caries-free with fillings). Mean DMF-T was 0.55±1.0. The control group showed a significantly higher mean DMF-T of 1.5±1.5 ($p<$ 0.05) and revealed 56.7% of caries-free dentitions (30% sound, 26.7% caries-free with restorations). Our data clearly document that an early oral health care promotion starting during pregnancy may cause a sustained and long-term improvement of the oral health of children.

K. Meyer · W. Geurtsen · H. Günay (✉)
Department of Conservative Dentistry, Periodontology and Preventive Dentistry, Hannover Medical School,
Carl-Neuberg-Str. 1,
30625 Hannover, Germany
e-mail: Guenay.H@mh-hannover.de

**Keywords** Early oral health care · Clinical long-term study · Primary-primary-prevention · Pregnancy · Caries prevalence · Adolescents

## Introduction

Oral diseases (e.g., caries and periodontitis) are caused by a great variety of different factors and, therefore, require the application of different preventive strategies. Besides the four main factors, i.e., microorganisms, substrate, host, and time, additional secondary factors contribute to initiation and progression of caries. One of several important preventive approaches is the reduction of caries-relevant bacteria. An alternative to the reduction of the amount of caries pathogens in infected people is the prevention or at least retardation of an infection or transmission of toddlers or young children. There is indication that caries incidence is linked to the time of infection with caries pathogenic microorganisms. This means the later a child is getting infected, the lesser caries he will experience [2, 13, 27]. Usually, mothers are the main source of transmissible cariogenic bacteria [10, 11, 23, 24, 26, 28, 29]. It has been shown that *Streptococcus mutans* (SM) of mother and child are phenotypically and genotypically similar [24, 26, 28, 29]. Periodonto-pathogenic bacteria can be also transferred from parents to their children [3, 49]. In this case, the risk of a periodontal disease is also increased if the infection is taking place at an early stage.

The caries risk of a child is directly associated with the bacterial load of his mother. Previous studies revealed that pathogenic microorganisms require a hard or solid surface to colonize the oral cavity. Therefore, a permanent infection only takes place after the eruption of the first tooth [9, 13]. However, bacteria can be already

found in a child's oral cavity before the eruption of the first tooth [42, 46, 47].

Various studies documented that oral health care of pregnant women as an "early preventive strategy" for her child's oral health may improve the oral and systemic health of children [5, 12, 15–17, 19, 20, 22]. This "early oral health care-concept" includes dental prevention, prenatal and after delivery for mother and child, until the age of 3 (primary-primary prevention and primary prevention) [21]. Main goal of this approach is the improvement of "health awareness" of the mother or the parents, which may then reduce the risk of caries, periodontitis, and diet-associated systemic diseases of children and their parents as well [19–21]. Main factors of this strategy are oral examination (caries, periodontitis, mucosal diseases), education (e.g., about the etiology of caries and periodontitis, mechanisms of transmission/infection, dietary instructions), and treatment, for instance reduction of oral microorganisms by a comprehensive treatment of the entire oral cavity (concept of a "whole mouth therapy") of the pregnant women or both parents [21].

The efficiency of this "early oral health care" concept has been shown by Günay et al. in a long-term study that has been divided into four phases [19, 20, 22]. Phase I included the individual preventive care of pregnant women (primary-primary prevention); phase II comprised the preventive care of mothers and their children until the age of 3 (primary prevention), and in phase III, mothers and children until the age of 6 were preventively treated. In phase IV, adolescents at the age of 13 to 14, who participated in phases I–III, were examined. All participating mothers revealed a significant improvement of their oral health. All children in the "preventive" group were caries-free without any filling at the age of 3 years (sound; phase II), no oral colonization with SM could be detected. However, only 81.5% of the children of the control group were caries-free without fillings (mean decayed, missing and filled surface teeth index (dmf-s), 4.5). In phase III, 75% of the children of the preventive group were caries-free without any fillings (mean dmf-s, 3.7), whereas only 50% of the control group were caries-free and revealed no restoration (mean dmf-s, 5.5).

Objective of this study was to analyze phase IV of our long-term prevention study regarding the oral health of 13- to 14-year-old adolescents.

## Materials and methods

### Subjects

In May 1991, pregnant women attending 13 gynecologists in Hannover were offered an individual preventive program which was carried out at the Department of Conservative Dentistry and Periodontology. A total of 86 pregnant women from various social backgrounds in Hannover at the age between 20 and 37 years (mean age, 28.5± 3.5 years) were referred from the gynecologists and participated in phase I. In the second phase, 54 and, in the third phase, 40 of the mother–child couples remained. All participating mothers and their children were examined, instructed, and treated, if necessary, until the age of 3 years each 6 months, and, until the age of 6 years, each 12 months. The following clinical parameters were assessed at each examination for mother and child: DMF-S or dmf-s, proximal plaque index and the salivary level of *S. mutans* (tested by a dip-slide technique using the commercial test kit Dentocult® SM (Vivadent; Ellwangen, Germany)). The mothers were informed about their own dental and periodontal findings as well as about the goals of primary-primary prevention. Each mother received an individual oral hygiene instruction and a dietary counseling. Furthermore, the women were instructed on the etiology of caries, periodontitis, the importance of a less cariogenic diet, and the use of fluorides. Emphasis was on teaching mothers to avoid or minimize the possibility of infecting their children with their own *S. mutans*. They were also taught about how to establish the habit of daily tooth cleaning combined with dentifrice containing a low concentration of fluoride as soon as the primary tooth had erupted. The control group comprised children at the same age and number who were coincidentally selected from various kindergartens in Hannover.

Between phase III and IV, mothers and children were treated by their family dentists. 29 adolescents (15 female, 14 male) at the age between 13 and 14 years (mean age, 13.4±0.5 years) remained in phase IV. Phase IV comprised one examination, education, and professional oral hygiene treatment. The control group of phase IV consisted of adolescents, coincidentally chosen, at the same age and similar education of a high school (30 adolescents; 15 female, 15 male, mean age, 13.6±0.5 years).

The study was approved by the ethical committee of Hannover Medical School.

### Clinical examination

All adolescents were examined in the same way according to WHO criteria (Table 1) [48]. The examinations of the preventive group were conducted in the Department of Conservative Dentistry, Periodontology and Preventive Dentistry (Hannover Medical School), equipped with a dental chair and halogen lamp using a dental mirror, a periodontal probe, and a diagnostic explorer. The examination of the control group was performed in the high school with the aid of a headlamp, dental mirror and periodontal

**Table 1** Mean age and dental findings in both examined groups in phase IV

| | Prevention group | Control group |
|---|---|---|
| Number of teenagers | 29 | 30 |
| | (15 ♀, 14 ♂) | (15 ♀, 15 ♂) |
| Mean age | 13.41±0.5 | 13.57±0.5 |
| Caries-free dentition | 26 | 17 |
| | 89.7% | 56.7% |
| Nature-healthy dentition | 19 | 9 |
| | 65.5% | 30.0% |
| Rehabilitated dentition | 7 | 8 |
| | 24.2% | 26.7% |
| Caries | 3 | 13 |
| | 10.3% | 43.3 |

and diagnostic probe while the adolescents were lying on a cot.

The following parameters were examined:

- Oral assessment (teeth, periodontia, mucosa)
- *S. mutans* and *Lactobacillus* (LB) concentration in saliva (CRT®bacteria, Vivadent; Ellwangen, Germany)
- Hygiene index (HI)
- Papilla bleeding index (PBI)
- Decayed/missing/filled teeth (DMF-T)/DMF-S
- Periodontal Screening Index (PSI)
- Numbers of pit and fissure sealings

### Education

Because there is a direct correlation between oral health and oral hygiene behavior, the adolescents filled out a questionnaire to evaluate their knowledge about oral health. The questionnaire was self-invented and consisted of 19 multiple-choice questions about dental visits (e.g., frequency, implemented measures), oral hygiene habits (e.g., technique and systematic of teeth brushing, oral hygiene articles), etiology of caries and periodontitis and its prevention. Subsequently, based on the results of the questionnaire, the participants of the study were individually (re-)motivated and (re-)instructed. The education included oral hygiene instructions, dietary counseling, information about the etiology of caries, and periodontitis and the use of fluorides.

### Treatment

The adolescents of the prevention group received a professional oral hygiene treatment including chlorhexidine mouth rinsing and topical fluoride varnish application. No radiographs were taken. For organizational reasons, the control group received no treatment. In case of additional treatment needs, the participants of this study were referred to their family dentist.

### Statistical analysis

DMF-T/DMF-S, HI, PBI, and PSI were statistically analyzed using the *t* test. SM and LB concentration, number of pit and fissure sealings, and the questionnaire were statistically evaluated by means of the chi-square test, SPSS version 15 ($p<0.05$).

## Results

The data of phase IV of our clinical long-term study revealed that 89.7% of the examined teenagers of the prevention group were caries-free. Nineteen (65.5%) revealed a naturally caries-free dentition and seven (24.2%) a caries-free dentition with fillings. Three (10.3%) of these teenagers suffered from active carious lesions (Table 1). Mean DMF-T was 0.55±1.0 (DMF-S= 0.59±1.0). Mean HI was 71.3±15.9%, and mean PBI was 0.35±0.3. The adolescents of this group revealed a mean PSI of 0.47±0.7. Seventeen (58.6%) of them had a low SM, and 15 (51.7%) a low LB concentration (<$10^5$CFU/ml saliva). Twelve teenagers (41.4%), however, showed high SM, and 14 (48.3%) a high LB concentration (>$10^5$KFE/ml saliva; Figs. 1 and 2; Tables 1 and 2). Twenty-seven teenagers of the prevention group (93.10%) showed pit and fissure sealings. Only two of the 29 teenager had no fissure sealing, but these teenagers had a healthy dentition without any restorations.

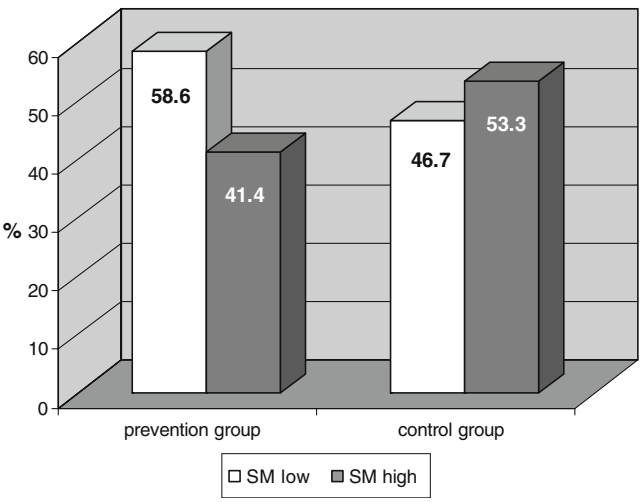


**Fig. 1** SM colonization in teenagers of the prevention and control groups in phase IV (SM low≤$10^5$KFE/ml saliva; SM high≥$10^5$KFE/ml saliva)

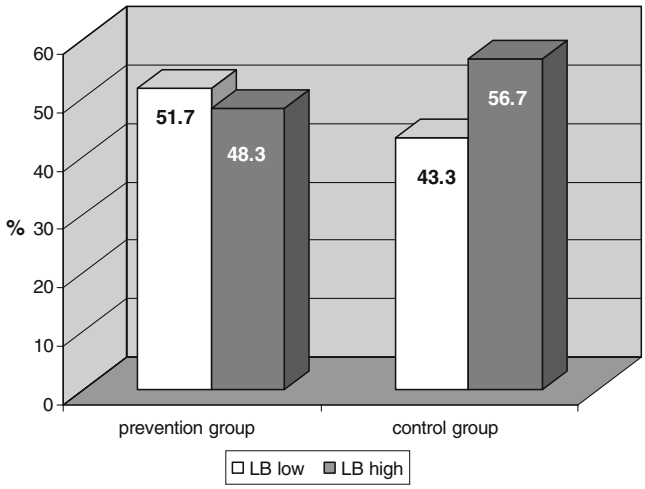


**Fig. 2** LB colonization in teenagers of the prevention and control groups in phase IV (LB low≤$10^5$KFE/ml saliva; LB high≥$10^5$KFE/ml saliva)

Of the teenagers of the control group, 56.7% revealed caries-free dentitions; nine (30.0%) of those were sound, and eight (26.7%) showed fillings. Thirteen (43.3%) suffered from active carious lesions (Table 1). Mean DMF-T was 1.53±1.50 (DMF-S=1.80±2.0). Mean HI was 60.1±19.5%, and mean PBI was 0.32±0.3. The teenagers of the control group showed a mean PSI of 0.77±0.7. Fourteen (46.7%) had a low oral concentration of SM, and 13 (43.3%) a low colonization with LB (<$10^5$ KFE/ml saliva). But 16 adolescents (53.3%) showed a high SM and 17 (56.7%) a high LB concentration (>$10^5$KFE/ml saliva; Fig. 1, Tables 1 and 2). In the control group, significantly fewer teenagers showed pit and fissure sealings ($p<0.05$). Pit and fissure sealings were observed on 21 "control" teenagers (70.00%). Nine of the 30 teenagers had no pit and fissure sealings.

Altogether, the teenagers of the "prevention group" had a significantly lower DMF-T/DMF-S compared to the "control individuals" ($p<0.05$). Regarding PBI, PSI, and SM/LB concentration, there was a tendency to lower values in the prevention group compared to the control group, whereas a tendency to a higher (better) HI was documented in the prevention group. But these tendencies were not significantly different ($p>0.05$).

The standard of knowledge about oral health was similar in the prevention and control group. The prevention group showed, compared with the control group, a tendency towards a "better" knowledge concerning oral health behavior, but this tendency was not significantly different ($p>0.05$). Twenty-seven teenagers of the prevention group (93.10%) and 26 (86.67%) of the control group answered the questionnaire. The evaluation of the questionnaires showed that the teenagers of the prevention and control group saw their family dentist on a regular basis. Of the prevention group, 59.26% visit their dentists twice and 37.04% more than twice a year. Only 3.7% visit the dentist only once a year. The teenager mainly received a dental routine check (81.48%). In the control group, 57.7% of the teenagers visit their dentists twice, 30.8% more than twice, and 11.58% once a year. Even in the control group, the teenagers received mainly a dental routine check (80.76%). The responses concerning the behavior of oral health (e.g., brushing teeth) were similar in the prevention and control groups. The majority of the prevention group brushes their teeth both in the morning (96.3%) and in the evening (92.59%). In the control group, 88.46% brush their teeth in the morning and 92.3% in the evening. In the prevention group, many teenagers had the impression to be well informed about the etiology of caries; 59.26% considered that bacteria are causative for caries, 37.07% referred to an increased sugar consumption and 77.78% lack of oral hygiene as a main factor for caries. Even in the control group, 65.38% referred to bacteria, 80.76% an increased sugar consumption and 76.92% a lack of oral hygiene as cause for caries.

**Table 2** Results of phase IV

| | Group | Number | Mean | Standard deviation | Significance ($p<0.05$) |
|---|---|---|---|---|---|
| DMF-T | Prevention group | 29 | 0.55 | 0.98 | 0.03 |
| | Control group | 30 | 1.53 | 1.50 | |
| DMF-S | Prevention group | 29 | 0.59 | 1.01 | 0.01 |
| | Control group | 30 | 1.80 | 2.02 | |
| HI (%) | Prevention group | 29 | 71.3 | 15.9 | 0.09 |
| | Control group | 30 | 60.1 | 19.5 | |
| PBI | Prevention group | 29 | 0.35 | 0.29 | 0.23 |
| | Control group | 30 | 0.32 | 0.26 | |
| PSI | Prevention group | 29 | 0.47 | 0.69 | 0.78 |
| | Control group | 30 | 0.77 | 0.73 | |

## Discussion

An intense early intervention using early preventive strategies or programs starting during pregnancy proved to be efficient with respect to the prevention of oral diseases, specifically caries. For instance, the "Nurse–Family Partnership Program" did not only influence the children's development in a positive way but also caused a long-term improvement of systemic health of mothers and their offspring [36]. This applies also to dentistry. An intense care with an early preventive treatment may result in a long-term improvement of oral and systemic health, particularly in children [5, 12, 15–17, 19, 20, 22].

A prenatal preventive program for pregnant women was introduced in Sweden in 1978, which is called "primary-primary-care." This program has been very successful. Between 1979 and 1991, caries incidence and prevalence dropped by 75% to 90% [4–7]. Brambilla et al. [12] delayed the colonization of toddlers and young children with caries pathogens by 4 months with a minimal preventive dental program limited to the period of pregnancy. In phase II of this study, we were able to delay the colonization of the children's oral cavities with caries pathogens for an even longer period of time (Table 3). No child of the "prevention-group" showed detectable SM levels at the age of 3 [19]. The differing results are obviously correlated to the length of preventive care.

Gomez et al. [15, 16] documented that a dental treatment starting during pregnancy until the age of 6 years of the children contributes significantly to a reduced caries experience of the infants. The structure of their program was similar to our approach. After 6 years, 87% of the 5-year-old children and 89% of the 6-year-old individuals of the preventive group were free of caries, compared to only 50% (5-year-old) or 62% (6-year-old) of the controls. Similar data were found in our previous studies. At the age of 6, 75% of the prevention group was caries-free vs. 50% of the control group [22]. Four years after the end of their study, Gomez et al. [17] re-examined the children. The children of the preventive group had a significantly lower caries incidence (mean dmf-s, 1.57±1.4) compared to the children of the control group (mean dmf-s, 0.51±0.9). Our results are comparable. Dental care for mother and child starting during pregnancy does not only influence health of deciduous teeth but has also a positive effect on permanent teeth, even in case of an extended period of time between re-examinations. This correlates with studies that documented a correlation between caries experience in deciduous and permanent teeth [30, 34, 40].

A German Study ("DAJ-study") from 2004 indicates a mean DMF-T of 0.98 in 12-year olds and of 2.05 in 15-year olds [37]. Another German study from 2005 ("DMS IV study") documented a mean DMF-T of 0.7±1.5 in 12-year-

**Table 3** Results of phases II–IV

| | Prevention group (at 3 years of age) [19] | Control group (at 3 years of age) [19] | Prevention group (at 4 years of age) [20] | Control group (at 4 years of age) [20] | Prevention group (at 6 years of age) [22] | Control group (at 6 years of age) [22] | Prevention group (at 13–14 years of age) | Control group (at 13–14 years of age) |
|---|---|---|---|---|---|---|---|---|
| Number and sex | 54 | 65 | 47 | 45 | 40 | 40 | 29 | 30 |
| | 27♀, 27♂ | 32♀, 33♂ | 27♀, 20♂ | 22♀, 23♂ | 24♀, 16♂ | 18♀, 22♂ | 15♀, 14♂ | 15♀, 15♂ |
| Children with nature-healthy dentition | 54 | 53 | 43 | 26 | 30 | 29 | 19 | 9 |
| | (100%) | (81.5%) | (91.5%) | (57.7%) | (75%) | (50%) | (65.5%) | (30%) |
| Children with caries | – | 12 | 4 | 19 | 4 | 15 | 3 | 13 |
| | | (18.5%) | (18.5%) | (42.3%) | (10%) | (37.5%) | (10.3%) | (43.3%) |
| | | (5♀, 7♂) | (1♀, 3♂) | (8♀, 11♂) | (2♀, 2♂) | (4♀, 11♂) | (3♀) | (6♀, 7♂) |
| dmf-s/DMF-S | – | 4.5 | 1.5 | 7.0 | 3.7 | 6.5 | 0.59 | 1.8 |

old children and 1.8±0.6 in 15-year-old teenagers [35]. We assessed 13- to 14-year old teenagers. Mean age of the prevention group in phase IV was 13.41±0.5, mean DMF-T was 0.55±1.0. Mean age of the control group was 13.57±0.5, mean DMF-T was 1.53±1.5. It is not possible to compare our data with the two aforementioned German studies because teenagers of different age were evaluated. We decided to select 13- to 14-year-old adolescents because, at this age, all permanent teeth (except for wisdom teeth) are already usually exposed to the potentially cariogenic oral environment for at least 1 year, in contrast to 12-year-old children. Specifically, this age group between 13 and 14 years belongs to Tanner-class >2 and has a tendency to develop a plaque-associated gingivitis [32]. Although there were no significant differences in phase IV of our study between "prevention" and "control" groups regarding HI, PBI, and PSI, the prevention group revealed a higher, i.e., better, HI and lower, i.e. better, PBI and PSI readings, which indicates a tendency towards a better oral hygiene of those teenagers, who had received preventive care. PBI values (mean, 0.35±0.3 vs. 0.32±0.2) were in correlation with HI readings (71.3±15.9% vs. 60.1±19.5%).

The participants of the prevention and control groups were coincidentally chosen. Both groups participated voluntarily. There was a relatively high dropout rate as a result of the very long period of the study. This was mainly due to a change of residence and private reasons. It may be speculated that, based on the dropout rate (75.06% at the end of phase IV compared to baseline), patients belonging to the high-risk group were not assessed in phase IV. This needs to be taken into consideration when interpreting the result of this study. Despite the high dropout rate within the 13-year period of this study, clear tendencies could be observed.

The questionnaire revealed that regular dental visits are considered as very important to maintain oral health and to prevent caries. The majority of the teenagers in both groups declared that they visit the dentist twice or more than twice a year. Only 3.7% of the participants of the prevention group and 11.5% of the control group visit the dentist just once a year. A German study (Kinder- und Jugendgesundheitssurvey-KiGGS) revealed similar results. This study indicates that only 6.4% of adolescents aged between 14 and 17 years visit the dentist less than once a year [43]. But the authors pointed out that there was a significant discrepancy between the supposed frequency of the dental preventive check-ups and the real frequency of the dental visits [43]. This aspect has to be considered in the present study as well.

The majority of the prevention and control group was at least partly aware about the etiology of caries. In the control group, 80.76% referred to an increased sugar consumption as a main factor for caries, whereas only 37.04% of the teenagers of the prevention took high sugar consumption into consideration as causative for caries. However, the consumption of sweets or sugar does not cause caries by itself. Various epidemiological studies indicate, particularly in the Western countries, a noncorrelated development of sugar sales and caries prevalence [33, 50]. Many researches showed only a weak or no relationship between the consumption of sugar or aliments containing sugar and the incidence of caries [31]. In many studies, diet never causes more than 6% of the caries variance. In fact, the parameters "oral health care," "plaque index," and "frequency of teeth brushing" (in combination with the use of fluorides) as well as educational background of the mother and economical status are of much higher importance [31].

Most teenagers of both groups brush their teeth twice a day. These results are much better than those reported by the KiGGS study. Of the examined 14- to 17-year-old teenagers of this investigation, 27.6% brushed their teeth less than twice a day [43]. This difference may be explained by the socioeconomic status. The KiGGs study showed significant correlation between oral hygiene and socioeconomic situation. A low socioeconomic status correlated with a low frequency of tooth brushing [43]. It may be concluded that both groups of our study consisted of participants that were not raised in poor families.

No significant difference of the knowledge about dental and oral health was observed between both groups. However, the teenagers of the prevention group seemed to perform oral hygiene more intensely or frequently than the control group. This is indicated by the higher number of pit and fissure sealings in the preventive group, which may be considered as one of the five pillars of caries prevention. Twenty-seven of the 29 teenagers of the prevention group had pit and fissure sealings, whereas only 21 out of 30 teenagers of the control group revealed pit and fissure sealings.

Early childhood caries (ECC) has become a severe public health problem in Western industrialized countries in socially disadvantaged groups of the society [1, 25]. Recent studies indicated a reduction of the number of carious deciduous teeth, which is associated with a pronounced concentration and high prevalence of early caries in a specific group at risk [8, 38, 44, 45]. These studies, therefore, support postulations for a targeted early education of pregnant women or parents and the implementation of specific prevention programs for mothers/parents and children with a high risk of ECC. However, the education of pregnant women about the necessity of dental care is not yet satisfactory, although numerous studies documented the interest of pregnant women for more detailed information about dental prevention and oral health [14, 18, 39, 41]. But dentists need the cooperation/support of other medical disciplines because many women do not see their family

dentist during pregnancy [14, 39, 41]. In order to improve this situation, a close interdisciplinary collaboration between gynecologists, pediatricians, midwives, and dentists is necessary.

## Conclusions

Based on our results, we conclude that the positive effect of an early oral health care program starting during pregnancy on the oral health of toddlers, children, and teenagers was clearly documented by our prospective clinical long-term study.

There is evidence that caries incidence generally declines in children and adolescents, but this does not apply to ECC, which is partially increasing. Specifically, the pronounced polarization or concentration of caries in low-income families points out the significant treatment need of this group at risk. In order to reach these groups at risk, dental examinations should be included into the battery of medical controls during pregnancy, and incentives should be implemented to motivate young mothers to see their family dentist with their infant after the eruption of the first tooth.

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**Conflict of interest** The authors declare that they have no conflict of interest.

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