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ORIGINAL ARTICLE

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Effect on caries experience of a long-term preventive program for mothers and children starting during pregnancy

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Abstract The aim of this three-phase prospective study was to determine the effects of a primary-primary prevention program on the oral health of children. Eighty-six pregnant women from various social backgrounds participated in the first phase of this study. In the second phase (at 3 years of age) 54 of the mother–child couples and in the third phase (at 4 years of age) 47 of the mother–child couples remained. Participants were recalled every 6 months and received individual prophylactic care. The following clinical parameters were assessed at each examination period for mother and child: DMF-S or dmf-s, proximal plaque index, and the salivary level of *Streptococcus mutans* (Dentocult *SM*). The control group consisted of 65 (at 3 years of age) and 45 (at 4 years of age) children from various kindergartens. All children in the second phase of the study group revealed a naturally healthy dentition with an API of 0–25% and a salivary *S. mutans* score of 0 (0–10^3 cfu/ml). In the third phase, only four of the 47 children of the study group showed caries, with a mean dmf-s of 1.5. No *S. mutans* could be detected in 20 (42.6%) children. Ten (21.3%) children of the study group showed a *S. mutans* score of ≥2 (>10^5 cfu/ml). In contrast, only 53 of the 65 children of the control group (second phase) and 26 of the 45 control children (third phase) revealed a naturally healthy dentition. The remaining 19 children of the control group revealed a mean dmf-s of 7.0 at 4 years of age. In the control group, no *S. mutans* could be detected in 25 (38.5%) children at 3 years of age whereas 21 (32.3%) children showed a *S. mutans* score of ≥2. In the third phase, a salivary *S. mutans* score of ≥2 was found in 27 (60%) children of the control group. The statistical comparison between the study and the control groups revealed significant differences for all results determined (P<0.001). Additionally, all mothers revealed a significant improvement in oral health and a reduction of salivary *S. mutans* colonization. From our data we conclude that a pre- and postnatal prevention program (primary-primary vs primary prevention) may significantly improve the oral health of mother and child.

Key words Primary-primary prevention · Pregnant women · Oral health of mother–child · Primary prevention · Salivary level of *Streptococcus mutans*

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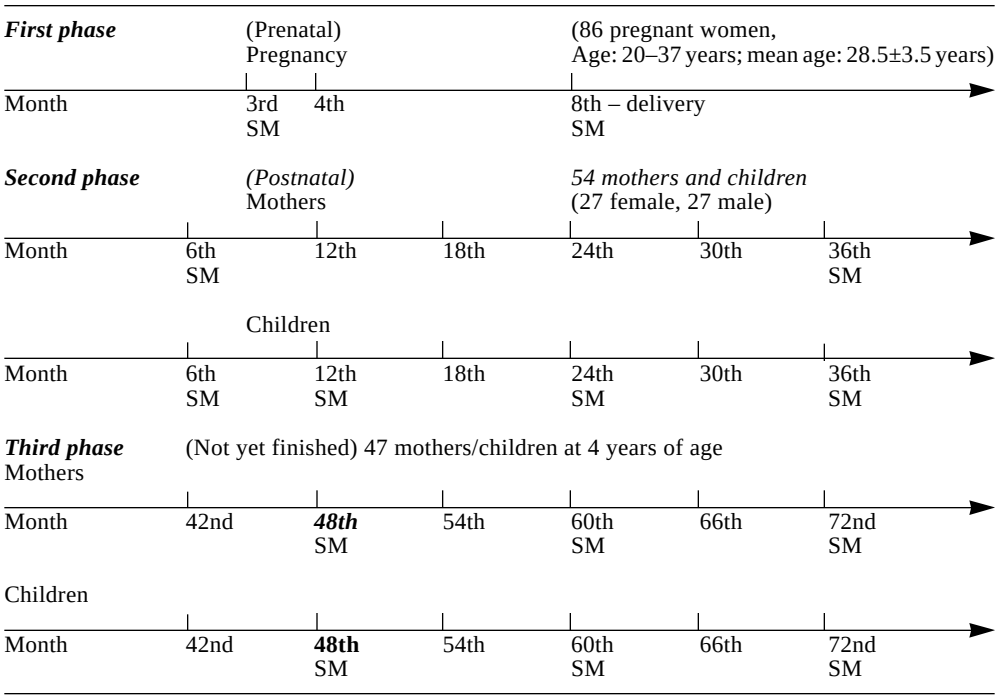
Introduction

An important strategy in modern caries prevention includes measures to avoid infection and colonization of the oral cavity with primary cariogenic mutans streptococci (MS), especially *Streptococcus mutans* and *S. sobrinus*. This approach is called primary-primary prevention [5], where all prophylactic measures are carried out in pregnant women in order to prevent the transmission of cariogenic bacteria, improvement of food habits, etc., to their children after birth. Primary prevention is the prevention of dental caries and gingivitis in a 100% healthy mouth. In addition, traditional prevention, including nutritional guidance, oral hygiene, fluoridation, and fissure sealing, is used complementarily. The primary-primary prevention of pregnant women is supposed to maintain the health of their own and a primary healthy oral cavity of their infants, so that in the caries-free primary dentition a smooth transmission to primary prevention programs for preschool children follows. According to Günay et al. [16], in Germany, 71% of pregnant women get no instruction during pregnancy regarding oral hygiene, even though this is a phase of increased acceptance of instruction which should be used by physicians and dentists as an opportunity to introduce preventive programs for individuals and groups [14]. The information and motivation of pregnant women is the

Table 1 Study design (*SM Streptococcus mutans* test)



basis required for passing on the health knowledge in a family.

MS are the principal bacterial species that initiate human dental caries [25]. Infants' mouths do not harbor this organism until some time after teeth erupt, since MS require the presence of a hard, non-desquamating surface for their colonization [8, 9]. Furthermore, there is a gradual increase in the isolation frequency of MS with age as the number of teeth and retentive sites increase [11, 26]. The main purpose of primary-primary prevention is to avoid early *S. mutans* transmission from the mother, father or other individuals with whom the child has contact. Axelsson [5] recommends not only the determination of the level of infections in pregnant women and, if necessary, the treatment of the oral cavity to reduce the number of cariogenic microbes and thus the risk of transmission, but also detailed information related to the means of transmission of cariogenic microorganisms. Bacterial transmission is possible, for example, directly through kissing or indirectly by objects such as spoons, pacifiers, and nipples of the nursing bottle, if they have previously been contaminated with saliva of the mother, the father or other persons [7, 9, 13, 23, 29].

It has been demonstrated that a reduction of the salivary level of *S. mutans* in highly infected mothers can inhibit or delay the establishment of these microorganisms in the mouths of their infants [21]. A reduction of the salivary level of *S. mutans* can be achieved, for example, with chlorhexidine. Various studies show a significant reduction of caries risk in new-born babies by mothers using a chlorhexidine–fluoride gel [30]. In this connection, Järvinen et al. [17] demonstrated that different short-term chlorhexidine regimes do not induce resistance in *S. mutans* or *S. sobrinus*, so that to reduce the build up of *S. mutans* by mothers, a combination of dental treatment, professional tooth cleaning, and chlorhexidine mouthrinsing is recommended [5].

The effect of primary-primary prevention begins with the eruption of the first tooth. Teeth are highly susceptible to dental caries in the first few years after eruption [32]. This period of increased caries susceptibility has often been attributed to poor maturation of the enamel surface. Additionally, at the critical age of 1–4 years, *S. mutans* becomes established in the oral cavity [12]. Now the primary prevention measure starts to help avoid or minimize the colonization with *S. mutans*.

It was the purpose of this prospective study to determine the effects of primary-primary preventive measures on the oral health of children. This report is part of an ongoing longitudinal study aimed at preventing transmission of cariogenic bacteria from mother to child.

Materials and methods

To achieve an effective primary-primary prevention, the Medical University Hannover offered a preventive program for the oral health of pregnant women and their children. This prospective study is divided into three phases (Table 1). The first phase started during pregnancy and was continued in the second phase for mothers/babies (0–3 years) and extended into a third phase for mothers/preschool children (4–6 years). Beginning in May 1991, pregnant women attending 13 gynecologists in Hannover were offered an individual prophylactic 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 (mean age: 28.5±3.5 years, ranging from 20 to 37 years) was referred from the gynecologists and participated in the first phase of this study. After a complete dental and periodontal examination, individual salivary *S. mutans* levels were tested by a dip-slide technique using the commer-

cial test kit Dentocult SM (Vivacare/Vivadent, Ellwangen, Germany). The *S. mutans* counts were scored as suggested by the manufacturer into four categories: 0=0–10^3 cfu/ml saliva; 1=10^3–10^5 cfu/ml; 2=10^5–10^6 cfu/ml; 3 ≥10^6 cfu/ml. Furthermore, the API (proximal plaque index: 0–25% optimal; 25–35% good; 35–70% insufficient; 70–100% poor) [24], the CPITN [1], and the DMF-S/DMF-T were taken and assessed. At the first appointment, the women were thoroughly informed about their own dental and periodontal findings as well as about the goals of primary-primary prevention. Each woman participating in the study received individual, preventive self-care instruction. The preventive treatment included oral hygiene instructions, professional tooth cleaning, topical fluoride varnish application, chlorhexidine mouthrinsing, and dietary counselling. In addition, selected high-risk and risk individuals received need-related preventive instructions in order to prevent transmission of cariogenic microbes and bad dietary habits to their babies. If treatment was required, participants were asked to contact their family dentist for appropriate preventive and, if necessary, restorative treatment. Furthermore, they were instructed on the etiology of caries and periodontitis as well as the importance of a less cariogenic diet (individual instructions of nutrition) and the use of fluorides. At their second visit, after the 8th month of pregnancy, the women were taught about infection, the oral disease caries, and the means of transmission to children as well as its avoidance.

In the second phase of this prospective study, 60 mothers and their babies participated. They were recalled every 6 months to receive individual preventive care. Table 1 shows the examination periods and the times when the Dentocult SM tests were taken. At the end of the second phase, 54 of the mothers and their children (27 female and 27 male) remained. These 54 participants received individual prophylactic care until the children's third birthday. The mothers were taught how to establish the habit of daily tooth cleaning combined with dentifrice containing a low concentration of fluoride as soon as the first primary tooth had erupted. They also learned how to establish healthy dietary habits for the baby. In the ongoing third phase, 47 mothers and their 4-year-old children (27 female, 20 male) are still participating. At present, the preventive treatment includes oral hygiene instructions, professional tooth cleaning, topical fluoride and chlorhexidine varnish application, as well as dietary counselling for the adults and their children. The following clinical parameters were assessed at each examination: DMF-S or dmf-s, API, and the salivary level of *S. mutans*. For *S. mutans* determination, a bacterial sample was taken from the dorsal surface of the tongue and rotated gently over the agar surface of the Dentocult SM dipslide [3].

The control group comprised 65 3-year-old children (32 female, 33 male; second phase) and 45 4-year-old children (22 female, 23 male; third phase), respectively, who were coincidentally selected from various kindergartens. In the control group, the same clinical parameters were determined as in the experimental group.

The results were statistically evaluated by analysis of variance and *t*-tests using the program SPSS. The level of significance was $P<0.05$.

Results

All 3-year-old children of the prevention (study) group revealed an intact dentition with an API of 0–25% and a salivary *S. mutans* score of 0. In contrast, in the 3-year-old control group, only 53 of the 65 children showed a naturally healthy dentition. The remaining 12 (18.5%) children revealed a mean dmf-s of 4.5. In this group, the API was 0–25% in 26 (40%) children, 25–35% in 16 (24.6%) children, 35–70% in 21 (32.3%) children, and 70–100% in 2 (3.1%) children (Fig. 1). A salivary *S. mutans* score of 0 was determined in 25 (38.5%) children of this group whereas 19 (29.2%) children revealed a *S. mutans* score of 1, 13 (20%) children a *S. mutans* score of 2, and 8 (12.3%) children a *S. mutans* score of 3 (Fig. 2).

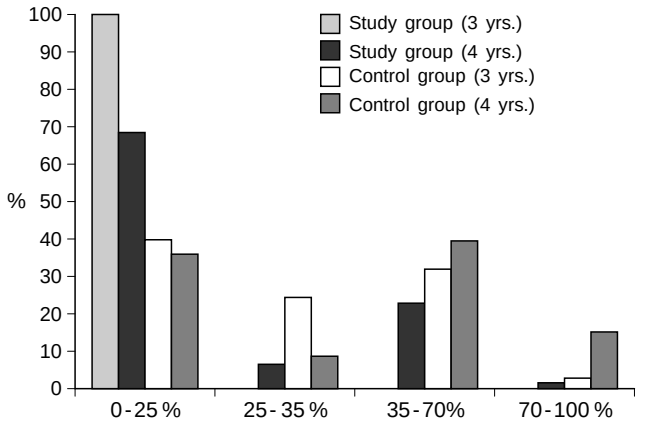


Fig. 1 Proximal plaque index (API) of the children examined at 3 and 4 years of age

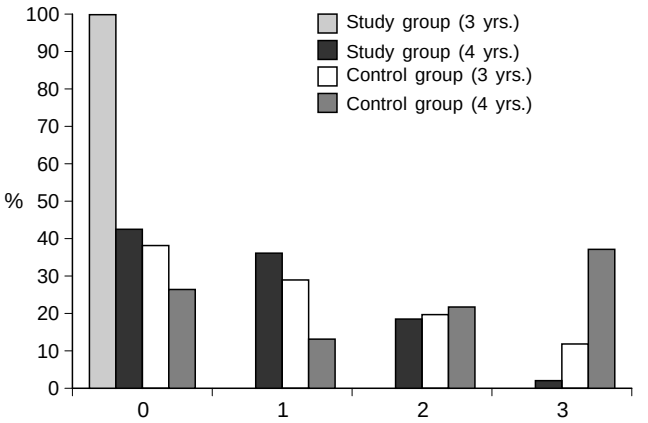


Fig. 2 Salivary level of *Streptococcus mutans* of the children examined at 3 and 4 years of age

In the present third phase (at 4 years of age), only 4 (8.5%) from 47 children of the study group showed caries with a mean dmf-s of 1.5 (Table 2). Of those children, 32 (68.1%) have an API of 0–25%, 3 (6.4%) children an API of 25–35%, 11 (23.4%) children an API of 35–70%, and 1 (2.1%) child an API of 70–100%. A salivary *S. mutans* score of 0 could be detected in 20 (42.6%) children; 17 (36.2%) children showed a *S. mutans* score of 1, 9 (19.1%) children a *S. mutans* score of 2, and 1 (2.1%) child a *S. mutans* score of 3.

In contrast, only 26 (57.7%) of the 45 children of the 4-year-old control group revealed a naturally healthy dentition. In the remaining 19 (42.3%) children, a mean dmf-s of 7.0 was found. A *S. mutans* score of 0 was determined in 12 (26.6%) control children. But 6 (13.3%) children showed a *S. mutans* score of 1, 10 (22.2%) children a *S. mutans* score of 2, and 17 (37.7%) children a *S. mutans* score of 3. The API was 0–25% in 16 (35.5%) children of the control group. Four (8.8%) of these children showed an API of 25–35%, 18 (39.9%) children an API of 35–70%, and 7 (15.5%) children an API of 70–100%. The statisti-

Table 2 Number, age, and sex of children in the study and control groups

	Number of children examined			
	Study group (at 3 years of age)	Control group (at 3 years of age)	Study group (at 4 years of age)	Control group (at 4 years of age)
	54 (27 female, 27 male)	65 (32 female, 33 male)	47 (27 female, 20 male)	45 (22 female, 23 male)
Caries-free	54 (100%)	53 (81.5%)	43 (91.5%)	26 (57.7%)
Children with caries	–	12 (18.5%) (5 female, 7 male)	4 (8.5%) (1 female, 3 male)	19 (42.3%) (8 female, 11 male)
dmf-s	–	4.5	1.5	7.0

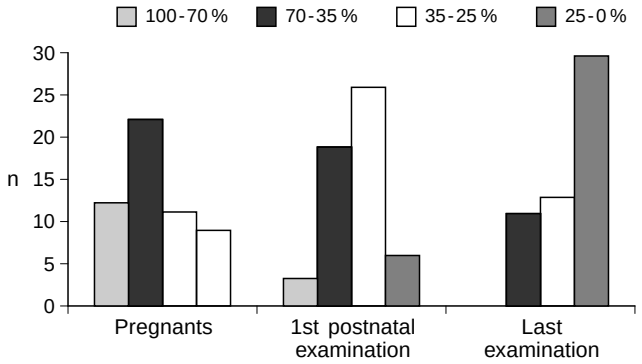


Fig. 3 Oral hygiene of the pregnant women and mothers (API)

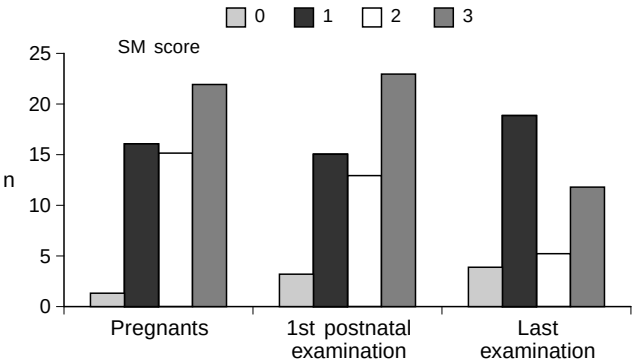


Fig. 4 Salivary level of *Streptococcus mutans* of the pregnant women and mothers

cal comparison between the experimental and the control groups revealed significant differences for all results determined ($P<0.001$).

Furthermore, all mothers showed a significant improvement in oral health and a reduction of *S. mutans* colonization during the study. The improvement of the API and the *S. mutans* scores from the first to the last examination after 4 years was also statistically significant ($P<0.001$). The mean API of the pregnant women in the first examination varied between 8.4% and 91.7% (mean 48.5±24.8%) whereas the first postnatal examination revealed a mean API of 37.5±16.8%. However, at the last examination, the values varied between 0% and 59.1% (mean 24.7±13.7%; Fig. 3). *S. mutans* scores were high among the mothers. At the first examination, 22 (40.7%) pregnant women showed a salivary *S. mutans* score of 3. Fifteen mothers revealed a *S. mutans* score of 2, six mothers a *S. mutans* score of 1, and only one mother showed a *S. mutans* score of 0. The first postnatal examination showed no significantly different results. A significant improvement, however, was found at the last examination. Only 12 (22.2%) mothers showed a *S. mutans* score of 3 and 19 mothers a *S. mutans* score of 2 or 1. Four mothers revealed a *S. mutans* score of 0 (Fig. 4). The CPITN values of the mothers at the beginning of the second phase revealed a treatment need (TN) grade III in 8 mothers, 37 mothers showed a TN of II, and one mother a TN of I. Eight mothers revealed no TN. At the last examination, CPITN values significantly improved. Now, only three mothers revealed a TN of III, 24 mothers a TN of II, and 11 mothers a TN of I; 16 mothers showed no need of treatment. At the first postnatal examination, the women had a mean DMF-T of 14.5±4.9 and a mean DMF-S of 46.4±25.2. Eight of the 54 mothers investigated showed active caries lesions. At the last examination, a mean DMF-T of 14.8±4.8 and a mean DMF-S of 49.4±25.6 were found. In addition, only two mothers suffered from active carious lesions.

Discussion

The objective of this prospective study was to determine the effect of primary-primary prophylactic measures on the oral health of children. Additionally, our goal was to achieve “no holes” through preventive programs for mothers and babies (0–3 years) in accordance with Axelsson’s [5] slogan. Our results show that most mothers with newborn babies have a high concentration of *S. mutans* (MS) in saliva. Thirty-seven pregnant women (68.5%) revealed a *S. mutans* concentration of more than 10^5 cfu/ml saliva. Comparable data were determined for 36 (66.6%) mothers of newborn babies. At the first reading, 40.7% of the mothers revealed the highest *S. mutans* score of 3. However, this proportion decreased during the second phase of our investigation from 45.6% to 22.2%. Köhler et al. [20] found that out of 249 Swedish mothers of newborn babies as many as 198 (80%) women showed a *S. mutans* concentration of

more than 10^5 cfu/ml saliva. In another study, about 50% of the pregnant women investigated and young mothers harbored more than 10^6 cfu of *S. mutans*/ml saliva [27, 28]. Although a high concentration of *S. mutans* is likely to facilitate the early transmission of bacteria by salivary contact to the primary dentition of the child, our present results indicate that all 3-year-old children of the study group showed a caries-free primary dentition, a salivary *S. mutans* score of 0, and an excellent dental hygiene.

This observation illustrates the success of our preventive program for mothers and babies (0–3 years), so that the objective of the present study was achieved in accordance with the slogan "our goals no holes". Additionally, the results of the 54 infants of the study group revealed that a *S. mutans* transmission due to primary-primary prophylaxis had been prevented. The initial acquisition of *S. mutans* occurred in children at the median age of 26 months (ranging from 19 to 31 months) during a discrete period which Caufield et al. [12] designated the "window of infectivity". In this phase the child is most likely to acquire *S. mutans* in its oral cavity. However, the applied *S. mutans* test indicated that all participants of our primary-primary prophylaxis program were not infected by MS during this critical phase. Mothers of infants who harbor high levels of MS in their saliva can easily be detected with microbiological tests [18, 22]. Simple instructions may help to avoid the transfer of cariogenic microorganisms with objects such as spoons into the mouths of infants during the critical age of between 1 and 4 years. High levels of MS in maternal saliva are a known risk factor at the time of tooth emergence for early infection of primary dentition by these bacteria and for concomitant development of dental caries [27]. Köhler et al. [23] reported that treatment of highly infective mothers with chlorhexidine may significantly reduce the number of cariogenic bacteria in their oral cavities amd may effectively prevent transmission of *S. mutans* from mother to child.

In contrast, only 53 (81.5%) of the 65 3-year-old children of the control group showed a naturally healthy dentition. The remaining 12 children (18.5%) revealed a mean dmf-s of 4.5. Gülzow et al. [15] reported that 60.2% of 423 investigated 3-year-old children were caries-free. The remaining 39.8% of the group, however, showed a mean dmf-s of 3.1. These results indicate higher caries prevalence than do the data of this study. The better results of our investigation may be due to the overall decline of caries prevalence during the last decade [15]. This is confirmed by Gülzow et al. [15] who found an increasing proportion of caries-free dentitions in 3-year-old children, starting from 12.4% in 1977/8, to 30.4% in 1987, and to 60.2% in 1993. In addition, the mean dmf-s values decreased from 7.3 in 1977/8, to 6.5 in 1987, and to 3.1 in 1993.

In our study, 25 3-year-old children of the control group revealed a salivary *S. mutans* score of 0, whereas the remaining 40 children (61.5%) showed a mean *S. mutans* score of 2. It may be concluded from these results that 28 out of 53 children with naturally healthy dentition had already been previously infected by *S. mutans*. Therefore, these children may develop carious lesions more frequently. This hypothesis is confirmed by various studies. In general, it was found that the time of infection with *S. mutans* is correlated with the risk of caries [19, 23]; an early infection of the oral cavity with *S. mutans* increases the risk of caries in the primary dentition [2, 4, 31]. Thus, it was expected that the children of our study group would reveal a lower caries incidence in the future in comparison to the control group. In fact, in the present third phase, only 4 (8.5%) of the 47 4-year-old children of the study group showed initial caries in fissures of deciduous molars with a mean dmf-s of 1.5. In contrast, 19 (42.3%) of the 45 4-year-old children of the control group revealed carious lesions with a mean dmf-s of 7.0. A salivary *S. mutans* score of 0 was determined in 20 (42.6%) 4-year-old children of the study group. Only 10 (21.3%) children of this group showed a high *S. mutans* score of ≥2. On the contrary, in the control group, only 12 (26.6%) of the 45 4-year-old children revealed a salivary *S. mutans* score of 0, whereas 27 (60%) children showed a high *S. mutans* score of ≥2. Our observations confirm data reported by Köhler et al. [23]. These authors report that 4-year-old children with previously detectable MS colonization at the age of 2 years suffered from a significantly higher caries prevalence than children with no or later *S. mutans* colonization. Furthermore, it was found that salivary *S. mutans* concentration generally increased in time. Additionally, Roeters et al. [28] evaluated in a 3-year cohort study that children older than 2.5 years revealed highly significant correlations between their caries prevalence and *S. mutans* concentrations in plaque or saliva. In conclusion, the results of various studies indicate the great importance of early preventive measures [6].

The children of the study group as well as those of the control group were selected coincidentally. Thus, both groups should contain individuals with a higher caries risk. In spite of this risk, the intense care in the sense of primary-primary prevention made it possible to keep these individuals caries-free in the study group. However, this area does need further investigation, because not all of the pregnant women (or mothers) participated in the study until the end. So far, our results are in accordance with those of Axelsson [5] and Axelsson et al. [6], who demonstrated the effectiveness of a primary-primary and primary prevention program for caries prophylaxis.

Conclusions

It appears to be convenient to combine a pediatric checkup with a dental one. This has already been recommended by Buhl et al. [10] and Günay et al. [16] and would assure early, regular inspection of the infant's oral cavity as well as a consequent and professional information for the mother (Table 3). The following schedule is important for the preventive dental care of pregnant women and children: P_1 = first third of pregnancy (12th–16th week), P_2 = last third of pregnancy (28th–32nd week). The objectives of the preventive dental care are maintenance/improvement of the oral health of pregnant women and the crea-

Table 3 Preventive dental care of mother and child

• *P1* – first third of pregnancy (12th–16th week)	• *PDC 1* – at 6th–9th months (first postnatal contact at eruption of deciduous teeth)
• *P2* – last third of pregnancy (28th–32th week)	• *PDC 2* – at 16th–20th months (second contact at eruption of deciduous molars)
	• *PDC 3* – 28th–32th months (third contact after complete eruption of deciduous teeth)

From 3 years of age: Primary – resp. traditional prevention

tion of the best conditions for lasting oral health in children. Professional help (thorough professional oral hygiene, caries-risk assessment, conservative dental care, dietary instruction of pregnant women, etc.) as well as the cooperation of pregnant women is important for this goal to be attained. In conclusion, our results showed that pre- and postnatal primary-primary and primary preventive measures may significantly improve the oral health of mothers and their children. Therefore, it is recommended that our prophylaxis concept is incorporated into the routine (dental) care of mothers and their young children.

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