Can school-based oral health education and a sugar-free chewing gum program improve oral health? Results from a two-year study in PR China

Bin Peng, Poul Erik Petersen, Zhuan Bian, Baojun Tai and Han Jiang

Department of Preventive Dentistry, School of Stomatology, Wuhan University, China; School of Dentistry, Department for Community Dentistry and Graduate Studies, Faculty of Health Sciences, University of Copenhagen, Denmark

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The purpose of the study was to assess the outcome of school-based oral health education (OHE) and a sugar-free chewing gum program on the oral health status of children in terms of reduced caries increment and gingival bleeding over a period of 2 years. Nine primary schools randomly chosen from one district were divided into three groups: OHE group (Group E), sugar-free chewing gum in addition to OHE group (Group G), and the control group (Group C). All children of grade 1 (aged 6–7 years) were recruited ($n = 1342$). After 2 years, 1143 children remained in the study group at follow-up. The overall drop-out rate was about 15%. Data on dental caries and gingival bleeding were collected by clinical examination. The results showed that the mean increment of DMFS in Group G was 42% lower than in groups E and C ($P < 0.05$). The mean increments in F-S were higher in Groups G and E than in Group C ($P < 0.01$). The gingival bleeding scores were statistically significant among the three groups. Compared to Group C, the mean increment in bleeding scores of Group G was 71% lower ($P < 0.01$) and in Group E 42% lower ($P < 0.05$). The school-based OHE programs had some positive effect improving children's oral hygiene; in certain circumstances children may benefit from using polyol-containing chewing gum in terms of reduced dental caries. □ *Caries; gingival bleeding; oral education health; sugar-free chewing gum*

Bin Peng, Key Lab for Oral Biomedical Engineering of Ministry of Education, School and Hospital of Stomatology, Wuhan University, 65 Luoyu Road, Wuhan, P.R., China 430079. E-mail: phs301@vip.163.com

At the global level, prevalence rates and patterns of oral disease have changed considerably over the past two decades. In most industrialized countries, the prevalence rates of dental caries and the mean dental caries experience in children have declined (1–4). These changes have been ascribed primarily to changing living conditions and lifestyles, the effective use of oral health services, the implementation of school-based oral health care programmes, the adoption of regular self-care practices, and the use of fluoride toothpaste (5–7). In contrast, increasing levels of dental caries among children have been observed in some developing countries, especially those where community-based preventive oral care programs have not been established (1). A number of developing countries recently implemented school-based programs that aim at improving oral health behavior and status of the child population. Certain low-income countries introduced preventive programs based on the use of sugar-free chewing gums. The gums mostly offered to children included sorbitol and xylitol (8). Initial evaluations from these health projects have shown encouraging results in Belize (9), but less promising results in Madagascar (10).

In China, the prevalence of dental caries in children at age 5 was recently reported at 76.6%, while the mean DMFT of 12-year-olds was 1.0 (11). It is noteworthy that the d/D-component constitutes most of the caries index. Moreover, the gingival health status and oral health habits of children are poor (11–13). Epidemiological surveys have shown that oral health promotion programs for Chinese children are needed urgently. Thus, in China, demonstration projects have been established in order to gain experience from using low-cost intervention in primary schools. The purpose of the present study was to assess the outcome of school-based oral health education (OHE), supplemented by a sugar-free chewing gum program, on the oral health status of the children in terms of caries incidence and gingival bleeding over a period of 2 years.

Study population and methods

Setting

This evaluation study was based on a demonstration project carried out in the Hongshan District of Wuhan City, Hubei Province, which is located in central China. The fluoride concentration of drinking water in the district is 0.1–0.3 ppm. Dental care is mainly offered on demand from one dental hospital with about 100 dental units and no organized oral health care programs have been established in the district. Moreover, commercial sugar-free chewing gums were not available at the start of the study and the frequency on consumption of chewing gums among children in the area was low (13).

Study design

Nine primary schools were chosen at random from this district in 1998 and all children of grade 1 (aged 6–7 years)

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were recruited for the 2-year follow-up study. Children of three schools constituted the OHE group (Group E); three schools offered the children chewing gum in addition to OHE (Group G) and another three schools served as the control group (Group C). The parents of schoolchildren from Groups E and G were informed about the trial and were requested to tell the school if they did not wish their child to take part, but none did so.

The children in Group E participated in a school-based OHE program over 2 years. The program was based on the concept of the WHO Health Promoting Schools Project, which aims at involvement of schoolteachers in classroom activities. In summary, a 2-day training workshop for teachers was organized prior to the program (August 1998) and a 1-day follow-up workshop was arranged for reinforcement in August 1999. The teachers made use of a comprehensive package of health education materials. Oral health instructions were given monthly to the children and daily toothbrushing activities of the children were supervised by teachers. In addition, the parents were encouraged to be present during oral health instructions and were informed about family responsibility for their child's teeth. A senior public health dentist in charge of implementing the program visited the schools every 3 months to monitor the program and reinforce activities.

Group G children received sugar-free chewing gum in addition to the OHE program. The chewing gum contained 55.5% sorbitol, 4.3% xylitol and 2.3% carbamide, with each tablet weighing 0.8 g (V6, Fertin Laboratories) (10). The children were offered four chewing gum tablets each day during the study period, except on holidays. They chewed one tablet at 0800 h and one at 0930 h supervised by the classroom teachers, and one after lunch and one after supper at home supervised by the parents. The parents had agreed to supervise use of the tablets, and the chewing gums were supplied to the schools every month.

Group C children did not receive any kind of systematic instruction or intervention. However, the headteachers of the three control schools were aware of an ongoing program and at the end of the trial fluoride toothpastes were provided for all children in Group C.

A total of 1342 children were examined at the first visit and 1143 remained in the study group at follow-up. The overall drop-out rate was about 15%, i.e. 14%, 13%, and 17% for Group E, Group G, and Group C, respectively. At baseline, the mean age of the children was 6.5 ± 0.4 years, with no differences across study groups.

Clinical examination

The baseline oral examinations were carried out in September 1998 and the follow-up examinations in October 2000. Children from the nine primary schools were examined clinically for dental caries and gingival health conditions and the recordings were based on the criteria of the Recording System for the Danish Municipal Child Dental Health Services (14). In summary, broken enamel on smooth surfaces and cavitation with or without staining in fissures or pits are clinical criteria for recording caries. Gingival conditions were assessed by recording the presence/absence of bleeding on 12 indicator teeth, i.e. 16, 12, 11, 21, 22, 26 and 36, 32, 31, 41, 42, 46. The clinical examinations were performed in classrooms by the same four examiners under natural daylight and using standard explorers, mirrors, and the Community Periodontal Index probes (15). Prior to the baseline and follow-up registrations, the examiners were calibrated against a master examiner. The calibration trials were conducted on the same group of children not included in the final study but with similar disease level. The kappa statistic was used to assess the inter-examiner reliability of caries and the final kappa scores were higher than 0.85 (15).

Data analysis

All data sheets were transferred to the University of Copenhagen and analysed using the SPSS system. Means of dental caries experience (dmfs/dmft, DMFS/DMFT) were calculated and the main effect was estimated by the differences in caries increments (DMFS/DMFT) among groups. For analysis of gingival health, the mean percentage of teeth scored with gingival bleeding was calculated (14, 16). Between-group differences in mean scores were compared using one-way ANOVA, while the chi-square test was applied for binary variables.

Results

The study groups were well matched, since no significant differences in dental caries experience and gingival bleeding scores were found by gender and groups (Table 1). The over-time increments in prevalence proportion rates of dental caries (DMFT) were 9.6%, 12.4%, and 13.8% for Group G, Group E, and Group C, respectively ($P > 0.05$). Table 2 presents the changes in DMFS and DMFT scores over the 2 years. The mean increment of DMFS in Group G was 42% lower than in Groups E and

Table 1. Comparison of dental caries variables at baseline among children offered oral health education and chewing gum (G), oral health education (E), and controls (C) ($n = 1143$)

	G	E	C	*P* value
n	*363*	*410*	*370*	
Male (%)	54.8	52.0	53.0	0.73
Prevalence rate (%) (primary teeth)	74.7	69.0	71.4	0.22
Prevalence rate (%) (permanent teeth)	5.2	4.9	3.8	0.62
dmfs (mean)	8.3	7.5	7.7	0.59
d-s (mean)	7.7	7.1	7.2	0.64
m-s (mean)	0.2	0.1	0.2	0.63
f-s (mean)	0.3	0.3	0.3	0.97
dmft (mean)	4.1	3.4	3.7	0.06
DMFS (mean)	<0.1	<0.1	<0.1	0.30
DMFT (mean)	<0.1	<0.1	<0.1	0.57

Table 2. Mean (±*s*) caries increments (DMFS/DMFT) in children over the 2-year study period by groups ($n = 1143$)

	G	E	C	*P* value overall	*P* value between Groups G and E
DMFS					
Baseline	0.07 ± 0.32	0.06 ± 0.27	0.05 ± 0.30	0.30	0.45
Follow-up	0.22 ± 0.55	0.32 ± 0.80	0.31 ± 0.84	0.11	0.12
Increment	0.15 ± 0.42	0.26 ± 0.67	0.26 ± 0.75	0.02	0.03
DMFT					
Baseline	0.06 ± 0.29	0.05 ± 0.26	0.04 ± 0.23	0.57	0.58
Follow-up	0.20 ± 0.48	0.26 ± 0.59	0.26 ± 0.65	0.24	0.22
Increment	0.14 ± 0.39	0.21 ± 0.49	0.22 ± 0.60	0.06	0.08

C. The mean increments in F-S were higher in Groups G and E than in Group C ($P < 0.01$); in parallel, the mean increments of F-T were higher in Groups G and E than in Group C ($P < 0.01$).

The changes in mean gingival bleeding scores are given in Table 3, and significant differences were found among the three groups. Compared to Group C, the mean increment in bleeding scores in Group G was 71% lower ($P < 0.01$) and in Group E 42% lower ($P < 0.05$).

Discussion

In the People's Republic of China, the public oral health service is generally orientated towards curative care, and the population is served by public hospitals, health-care centers or clinics of schools or factories (17). Since the late 1980s, initiatives have been taken to implement preventive oral care programs and OHE. The nationwide mass campaign 'Love Teeth Day' has been conducted annually since 1989 in support of the implementation of community-based OHE (18). Oral health promotion in relation to schoolchildren is given high priority; however, systematic school-based oral health promotion programs have not yet been established at national level in China (19). In 1998, the Hubei Province Committee for Oral Health, with the assistance of the WHO Collaborating Centre for Community Oral Health Programmes and Research, University of Copenhagen, implemented demonstration projects in primary schools in Wuhan City, PR China. An OHE program was essential and the projects were based on the concept of the WHO Health Promoting Schools Project, which aims at involving schoolteachers in classroom health activities (20). The administration of sugar-free chewing gums to children was considered as a further attempt in oral health promotion in China to evaluate the effect of the low-cost intervention.

Table 3. Increment in mean (±*s*) bleeding scores over the 2-year study period by groups of children participating in programme ($n = 1143$)

	G	E	C	*P* value overall
Baseline	13.6 ± 21.1	11.7 ± 20.8	12.3 ± 24.3	0.48
Follow-up	18.8 ± 22.6	22.4 ± 24.0	30.8 ± 34.1	<0.01
Increment	5.3 ± 28.6	10.7 ± 31.6	18.5 ± 42.9	<0.01

The actual study was carried out as a community trial and was based on a 2-year follow-up design. The drop-out rate after 2 years was lower than in other 2-year chewing gum studies (19.9–52.3%) (21, 22) and at baseline no significant differences were found among the study groups as regards sex, dental caries experience, and gingival bleeding scores. Drop-out is therefore considered not to have any serious effect on outcome evaluation. The evaluation study was based on blinding of the examiners. Systematic calibration trials were conducted in order to ensure reliability in recording of dental caries, and the consistency level was high as measured by WHO standards (15).

Registration of dental caries was based on the criteria of the Recording System for the Danish Municipal Child Dental Health Services (14). This epidemiological system was established in order to plan and evaluate the services delivered. The clinical examination procedures and the diagnostic criteria are close to the WHO methodology (15) and therefore comparisons with other studies is possible. The present findings on dental caries at baseline are in agreement with previous Chinese surveys of 6-year-olds which have shown mean caries experience at the levels of 3.9–5.7 dmft and 0.1–0.4 DMFT (12, 23). The average bleeding scores of the child population examined are in accordance with similar studies of children in China (16) and in other countries such as Tanzania (24); the present data thereby confirm previous reports of poor oral hygiene status among Chinese children (13, 19).

After 2 years, no reduction in caries increment was found for the children who participated in the OHE program and this is in parallel to observations from other studies on the clinical effects of OHE (24, 25). However, it is worth noting that it may be difficult to demonstrate reductions of caries incidence rates in population groups with low caries levels, and the study period was relatively short. The bleeding scores were significantly lower for the children in the test group; this is in agreement with the results of a similar school-based OHE program in Tanzania, where a significant reduction in gingival bleeding was documented after 3 years (24). The higher

F-component of the caries indices observed for children in Group E reflects the changing dental visiting habits of children. Intervention studies of school-based OHE programs have shown equivocal results regarding the oral health effects (25). This may be ascribed to the different principles of education applied for promoting oral health among schoolchildren, which varied from simple once-only instruction to extensive and repeated OHE instructions. The present OHE program was characterized by active participation, empowerment and reinforcement, and such approaches are considered most important in behavior modification. Other OHE programs including these elements have been shown to be successful in improving oral health behavior and oral hygiene among children (26).

Over the past 20 years, several reports have indicated that the use of sugar-free chewing gum may inhibit dental caries (8, 9, 21, 22), and sorbitol and xylitol were the commonly used sweeteners in chewing gums. The potential effects of use of such sugar-free chewing gums relate to increased salivary flow, improved quality of saliva and the content of the gums (8). Xylitol gums significantly reduce caries rates. The xylitol–sorbitol mixtures appear less effective than xylitol, but they show reduced caries rates compared with the no-gum group (8, 9). More recently, sugar-free chewing gum containing carbamide has been investigated in field studies (10, 27). One study in vitro showed that the sugar-free chewing gum containing carbamide initiated a pronounced pH recovery in dental plaque when chewed after a sucrose rinse (28). The sugar-free chewing gum used in the present study contained sorbitol, xylitol, and carbamide, but it is emphasized that the research design does not allow assessment of the separate components of the chewing gum. Previous studies using the same sugar-free chewing gum showed minor clinical effects on reduction of dental caries in young children (10). The present 2-year trial indicated that the mean increment of DMFS in children who chewed the sugar-free gum was significantly lower than that in no-gum groups. However, the clinical effect was relatively low despite the statistical significance. This level of caries reduction is lower than that found in Belize (9) and Canada (22), and similar to the figure in Hungary (21), but higher than in Madagascar (10). The difference may be ascribed to different epidemiological profiles and socio-cultural conditions.

Dental plaque and gingival bleeding are commonly used to evaluate the status of the oral hygiene of children. For practical reasons, the dental plaque index of the children was not recorded in the present study; however, the children who chewed the sugar-free gum had lower gingival bleeding scores than the children of the no-gum groups. The results of the present trial are different from a previous study in which the chewing of sugar-free gum had no impact on plaque and gingival index (29).

In conclusion, the results of this community trial concur with most previous findings. The school-based OHE program effectively improved children's oral hygiene, and in terms of reduced dental caries children may benefit from using polyol-containing chewing gum. The implementation of such a school-based program may be a relevant approach to further improve the oral health behavior and status of young children, particularly in developing countries with limited resources for formal oral health care. Meanwhile, in the present study we were unable to assess the cost-effectiveness ratio of the chewing gum program.

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