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School-based oral health education increases caries inequalities

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Objective: To evaluate the effect of one and half years of an oral health promotion program in primary schools. ***Design:*** A cluster-randomized controlled trial. ***Participants:*** 740 students aged 9-12 years (48% female) recruited from the fifth grade of 18 different primary schools in West Pomerania, Germany. ***Methods:*** General and oral health education was provided to the teachers in the intervention schools, which they conveyed to their students. No additional measures were conducted in the control schools. Medical and dental school examinations, as well as questionnaires for the students and their parents were conducted at baseline and follow-up. Data were analysed using Poisson regression models. ***Results:*** A significant incident rate ratio between caries increment was found, with a 35% higher risk in the control group. However, parents' socioeconomic characteristics modified the effect of the program on their children, as high socio-economic status in the intervention group was associated with 94% reduction in the incidence risk ratio ($p < 0.001$). ***Conclusions:*** The program was effective in improving dental health among students with higher socio-economic status. No preventive effect could be found in low socio-economic status groups.

Key words: *Schools, health promotion, preventive program, school children, epidemiology.*

Introduction

In Germany, as in most western industrialized countries, the prevalence of dental caries in children and young adults has declined significantly over the past decades (Pieper *et al*., 2013; Qadri *et al*., 2014; Schulte *et al*., 2006). However, this general decline is polarized, in which approximately 25% - 30% of children experience most decay and treatment need (Marthaler, 2004; Pieper *et al*., 2013). These health inequalities reveal that not all population groups experience the same preventive effects.

Several studies that have targeted high-risk children living in low-caries communities have failed to report any benefit for their target groups (Hausen *et al*., 2000; Seppä *et al*., 1998). The lack of benefit might be attributed to the difficulty of engendering behavioural changes when health education is targeted only at high-risk individuals, while the rest of the population are not exposed to the same message (Brewster *et al*., 2013). Another reason for the lack of success might be the difficulty of reaching mutual understanding between dental personnel and school children.

In order to overcome these difficulties, a new method based on the modern concept of health literacy including oral health competence, could be employed (Nutbeam, 2008; Tang *et al*., 2009). Health literacy has been defined as 'personal, cognitive and social skills which determine the ability of individuals to gain access to, understand and use information to promote and maintain good health' (Schmidt *et al*., 2010). A major benefit could be gained by focusing on this concept for improving health for the whole population, focusing on empowering individuals to develop their own skills to avoid unhealthy behaviours, could enhance oral and general health promotion programs.

Schools represent a potential environmental setting for an entry to children with different socio-economic backgrounds. Oral health promotion can be integrated into general health promotion, and could contribute to changes in students' health, knowledge, beliefs, attitudes and behaviour (Maes and Lievens, 2003). It is necessary, though, to evaluate the effectiveness of school health promotion programs with different strategies.

The aim of this study was to investigate the effect of the oral health component of a multidisciplinary health-promoting program on children's dental health in primary schools in the administrative district of West Pomerania, Germany. This region has one of the highest unemployment rates in Germany 12.7% (Arbeit, 2009). We hypothesized that children exposed to the health promotion program would have a lower caries increment than children not exposed, and that oral health competence (knowledge, attitude and behaviour) would modify the relationship between exposure to the health promoting program and dental health status.

Methods

This was a cluster randomized trial. Approval for the study was granted by the research and ethics committees at Greifswald University and the Ministry of Education.

The participation requirements at the cluster level, were all primary schools willing to participate in the program and not considered as a special needs school. From 22 schools in the region, 18 were eligible to be included (Figure 1). The schools were randomly allocated into two groups, control and intervention using computer-generated random numbers.

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The minimum sample size was calculated based on comparing two proportions, a standard error of 5%, with 80% power, and estimated prevalence of dental caries among the sample population of 29%, which were determined in the baseline examination. The minimum sample size to satisfy the requirements for the main study was 285 for each group. To compensate for possible loss during follow-up, the sample size was increased by 20%, totalling 342 students in each group (285 + 20% = 342).

Data were collected in association with Mecklenburg-Vorpommern Regional Health Authority as part of their mandatory national dental school examinations in autumn 2007. In German schools, a dental examination is routinely offered to first, third, fifth, sixth and ninth grade children. This examination included a medical and dental examination and a self-completion questionnaire for the children. Parents additionally completed a previously validated questionnaire enquiring about socio-economic status (SES) and their child's health (Lange *et al*., 2007). After 18 months, the students were examined again in the sixth grade (final dental examination).

Participation was voluntary. Written informed consent forms were sent to the parents or guardians of the children. A supporting letter from the Minister of Education, in addition to detailed information on the purpose of the study and data safety was also sent to the families and participating schools.

The sampling frame consisted of all fifth-grade students, from all participating schools, whose parents/legal guardians gave written consent and who were present at both baseline and follow-up examinations. Students with significant systemic disorders were excluded from the study.

Dental and clinical examinations were conducted by three trained and calibrated examiners in participating schools. The data were collected as part of the extended school examinations. The baseline data were collected from fifth grade students from September to October 2007, and the follow-up was carried out after 19 months with the same children, where they were in the 6th grade, between February and March 2009. All examiners were blinded to schools' allocation status.

The dental examination was conducted under natural indirect light with additional electric light, using dental mirrors and explorers following WHO guidelines (World Health Organization, 1997). All examinations were conducted with the children in upright positions with the heads tilted back. Caries experience was expressed using the DMFT index (number of decayed, missing, and filled teeth).

The children´s questionnaire enquired about their general and oral health and had been validated in a national investigation (Lampert and Kurth, 2007). It comprised 15 variables measuring oral health competence (literacy) including oral health knowledge, attitudes, and behaviour. Each variable consisted of 3-8 items of 15 multiple-choice questions, some with more than one correct answer. A higher score indicated greater knowledge, a more positive attitude or better oral health behaviour.

A structured questionnaire adapted from Lange and colleagues (2007) was used to assess parental / care-giver SES, computed from four main factors: education, vocational training, net household income and employment status. The domains of the questionnaire were compatible with those of the national German Health Interview and Examination Survey for Children and Adolescents (Thyen, 2007). The parent questionnaire also enquired about child health and family background. Parents completed their questionnaires during parent-teacher meetings. The student questionnaire was completed at school under the supervision of the scientific coordinators.

The oral health promotion intervention was integrated into a general health promotion program and school curricula and activities, delivered by schoolteachers instead of dentists. The program centred on comprehensive educational training for all biology, sport and health teachers of the fifth-grade classes of all intervention schools. These sessions were run in association and with the support of each school health coordinator (Gesundheitslehrer). The program covered the following topics: oral health, healthy nutrition, health literacy, dealing with pain, healthy recreation (activities and leisure time), vaccination and smoking. Oral and general health education was provided to the teachers in the intervention schools, which they then conveyed to their students. This method aimed to give teachers the freedom to integrate this information into their own curricula.

The first step was to upgrade the teachers in topics such as caries preventive measures, caries pathology, their students' caries records, and non-operative caries management. The teachers were provided with the essential preventive information, materials and comprehensive information in the form of PowerPoint presentations, guidelines, open discussions and prevention regulations during three educational sessions. Besides the basic information about oral health, the teachers were asked to focus on key evidence-based messages (Kay and Locker, 1998; Madléna *et al*., 2002; Nourallah and Splieth, 2004; Marinho *et al*., 2003) such as:

- Frequent dental check-up and preventive visits provided by the national health system free of charge,
- Daily use of adult tooth paste (>1250 ppm fluoride)
- Tooth brushing should concentrate on the erupting teeth during mixed dentition (two times a day).
- Weekly use of fluoride gel.
- Reduction in the consumption of sugar-sweetened beverages

Direct contact between the teachers and the principal investigators was provided, through meetings and school visits, particularly during the first few months of the program.

In the control group, no additional educational program or training on general health promotion was implemented for teachers or students during the study period. Control schools that were interested in the program and one school for students with special needs received the intervention after data collection.

Soon after baseline data analysis, direct feedback was given to the teachers in the intervention schools. This information consisted of mean DMFT values, vaccination rates, weight distribution, smoking habits and school meals in comparison to the other schools in the district. Children and parents were also informed about the examination results regarding oral health status, especially of the presence of decayed teeth, and were advised to treat these teeth as soon as possible. In addition, prizes for the classes with the best caries status were announced in the intervention schools.

Statistical analysis

Caries increment in the permanent teeth was calculated by subtracting the DMFT values at baseline from those at follow-up. Descriptive analyses summarised distributions, means, and standard deviations (SDs). Then, after dichotomizing several variables (DMFT and caries increment), proportions for each of these variables were calculated.

Oral health-related knowledge, behaviour and attitudes were measured using several questions. The responses were summarised as "positive" and "negative" or "right" and "wrong", and then analysed as categorical data.

Appropriate bivariate and Poisson regression analysis were employed. Age, gender and socio-economic characteristics (SES) were included in the models as covariates. The incidence rate ratio (IRR) was calculated for the discrete dependent variables to study the effect of independent variables on oral health status. In all the analyses, the level of statistical significance was set at $p < 0.05$.

All data were first directly recorded in Microsoft Office Excel 2003® database and then into the SPSS® software. STATA® program (version 10 STATA Corp., 2007) was also used for processing and analysing.

Results

All fifth-grade children in the 18 participating schools were examined. A sample of 854 students aged 9-12 years (mean 10.34, SD ± 0.56, 48% females) was recruited.

From those recruited, only 740 (86%) students were included in the analysis. The 114 students (13%) were lost for the following reasons; failed to attend one or both examinations, illness (2.3%) on the examination day or moving away from the study region (6.7%) (neutral drop-out), special need students (2.9%) and those who changed their group (1.3%) (from intervention school to control, or vice versa). Students lost to follow-up had higher baseline caries experience (mean DMFT = 0.97), were more likely to be male (62%) and were older (mean age 10.5 years) than those who remained in the study (0.60, 52% male, 10.3 years respectively).

The intervention group consisted of 336 students (from 8 schools) and the control group of 404 students (10 schools). The interval between baseline and follow-up examinations was 19 months.

Interclass correlation coefficient (ICC) was used to assess the inter-examiner reproducibility between examiners at baseline and follow-up examinations for 20 randomly selected students (around 5% of the sample). The ICC values were 0.93 and 0.97 respectively.

Of the 740 students for whom data were analysed, the proportion who were female was similar in the study (48%) and control groups (47%). Students in the intervention group were of slightly lower SES (25% high SES, 47% middle and 29% low) than in the control group (32% high, 51% middle and 17% low SES).

The intervention group experienced a lower mean caries increment of 0.196 DMFT (±0.62) compared to the control group (0.242 ±0.82) (Table 1). In crude regression analysis, this difference failed to reach statistical significance ($p = 0.079$). The Poisson regressions were then adjusted for age, gender and SES further models (Table 2).

Table 1. Caries experience for intervention and control groups at baseline and follow-up

		Intervention *n = 336*	*Control* *n = 404*
Baseline	DMFT Mean (SD)	0.69 (1.27)	0.52 (1.10)
	DMFS Mean (SD)	1.03 (2.26)	0.78 (2.10)
	DMFT=0	68.1% (n=229)	73.8% (n=298)
	Age in years Mean (SD)	10.43 (0.62)	10.27 (0.49)
Follow-up	DMFT Mean (SD)	0.89 (1.49)	0.76 (1.43)
	DMFS Mean (SD)	1.26 (2.49)	1.10 (2.36)
	DMFT=0	62.4% (n=209)	65.4% (n=265)
Caries increment Mean (SD)		0.196 (0.62)	0.242 (0.82)

Data are reported as mean ± SD.

Table 2. Caries incidence rate ratio (IRR) and confidence intervals from Poisson regression analysis for intervention group in comparison to control group

Caries Increment	*IRRa*	*CI 95%*	*p-values*[a]
Crude	0.766	0.57, 1.03	0.079
Adjusted for gender	0.767	0.57, 1.03	0.081
Adjusted for age	0.695	0.51, 0.94	0.019*
Adjusted for SES	0.719	0.51, 1.01	0.060
Fully adjusted	0.646	0.45, 0.92	0.016*

[a] Poisson regression analysis.
* *p*-value < 0.05.

Whilst age exerted an effect in the model, SES also had an effect, moving the IRR from 0.77 to 0.72 and the p-value from 0.079 to 0.060 (Table 2). When gender, age and SES were included in the model, a significant difference was observed between control and intervention groups with an IRR of 0.65. From this analysis, SES was observed to be an effect modifier. Therefore, a comparison was performed for the socio-economic characteristics of the parents between the control and the intervention group.

There was a significant relationship between the parent's SES and child caries increment ($p = 0.002$).

In both groups, 24% of low SES children (n = 30) acquired caries (a total of 44 surfaces, mean = 1.47 per child). Fourteen percent (n= 39) of the middle-class SES developed new caries lesions (96 surfaces, mean 2.46 per child) and 9% children of high SES families (n = 15) exhibited 18 new carious, filled or extracted surfaces, (mean 1.2 per child). Due to this interaction, the analysis was stratified by the three levels of SES (Table 3). The program was highly protective from developing caries for high SES students ($p < 0.001$) but not for middle and low SES students.

Table 3. Caries incidence rate ratio (IRR) for intervention group in comparison to control group with different SES.

	DMFT Increment		
	High SES n=167	*Middle SES n=283*	*Low SES n=127*
Crude	0.09*	0.85	1.43
Adjusted for gender	0.09*	0.85	1.50
Adjusted for age	0.06*	0.81	1.51
Adjusted for gender & age	0.06*	0.82	1.58

Data are reported as IRR using Poisson regression analysis.
* *p*-value < 0.001.

Oral health competence items were compared with caries increment using Pearson chi-squared test.

Fewer students who knew that the fluoridated toothpaste was the most appropriate (14%) acquired carious lesions than those who did not (21%, $p = 0.046$, chi sq.). Likewise, fewer students who avoided chocolate to protect their teeth, acquired carious lesions (14%) than those who ate more chocolate freely (20%, $p = 0.048$ chi sq.).

Students who felt "nothing bad will happen to my teeth if sometimes I do not brush them" acquired carious lesions (26%) than those who lacked this attitude (8%, $p < 0.01$ chi sq.). Fewer students who felt oral hygiene and tooth brushing were of great importance in their homes acquired new carious lesions (20%) than those for whom oral hygiene was not a big issue (32%, $p < 0.02$, chi sq.). Fewer students who brushed their teeth early in the morning and at night before going to bed (14%) acquired lesions than those who did not (31%, $p < 0.01$. chi sq.).

The three main components of oral health competence: knowledge, attitude and behaviour did not change appreciably during the study period (Table 4).

Discussion

The main finding of this study was that the oral and general health-promotion program reduced caries incidence in the intervention group compared to control. However, the effect was only present among students from high SES families.

In general, a 35% higher risk of developing new carious lesions was found in the control group compared to intervention (Table 1). This is in contrast with other studies on oral health promotion (Kay and Locker, 1998; Vanobbergen *et al*., 2004) that found that implementing an oral health promotion program, on top of an existing good oral health climate, resulted in a non-measurable reduction of caries experience. These differences in findings could be attributed to the specific "tailor-made" program that targeted the young permanent dentition, concentrating on the importance of fluoride applications and erupting teeth. The Nexö-method has also employed this concept and achieved one of the lowest caries levels in the world (Ekstrand and Christiansen, 2005). However, the distribution of benefit in this study suggests that such behaviours were not taken up equally across socio-economic groups.

Table 4. Changes in frequency distribution of oral health competence variables for both intervention and control group.

Questionnaire items	*Baseline*		*Follow-up*	
	Inter.	*Control*	*Inter.*	*Control*
Oral health knowledge				
Using most effective tooth paste	76%	77%	78%	77%
Focusing on erupting teeth while brushing	33%	36%	49%	49%
Knowing that dental examination is for free	62%	65%	78%	85%
Oral health attitude				
Talk to their parents about oral health	89%	92%	68%	72%
Eat only a bit of sweet to protect their teeth	70%	72%	61%	66%
Healthy teeth are important for them	95%	95%	90%	86%
They take care of their teeth	90%	90%	85%	85%
Believe that nothing will happen to their teeth if they didn't brush it some time	43%	43%	41%	43%
Brushing teeth is a big issue in their houses	88%	91%	84%	87%
Will not eat sweet to keep their teeth healthy	71%	72%	66%	63%
Oral health behavior				
Eat fruits & sweets less than 3 times per day	83%	85%	80%	88%
They visit dentist more than twice per year	99%	99%	93%	94%
Brush their teeth every morning	93%	90%	94%	93%
Brush their teeth every night	93%	93%	93%	91%
Brush their teeth with Elmex gelee	65%	69%	75%	72%

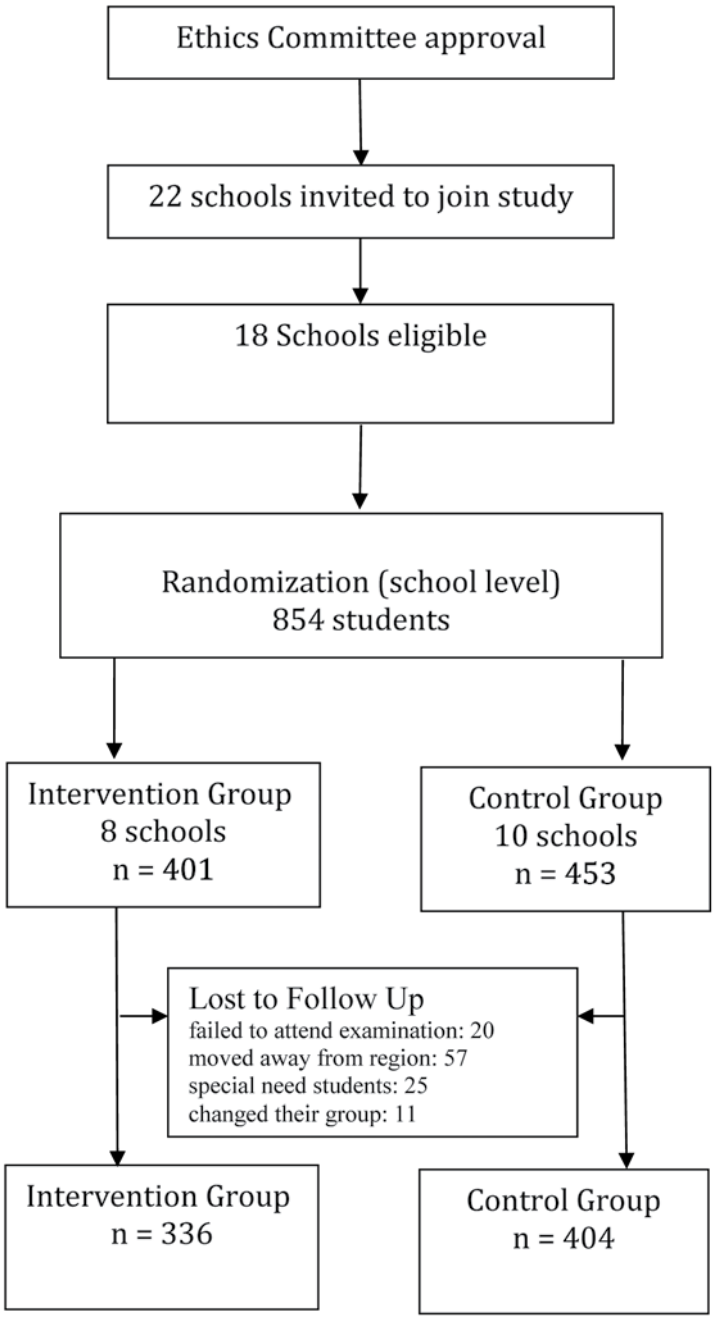

Figure 1. Flow chart of the study design and sample

The treatment effect showed a strong social gradient. The program was effective only among students from high SES families, as this group demonstrated a 91% lower risk of developing new caries compared to the control group. These results are in line with those from Schou and Wight (1994), where clinical prevention and education conducted in 92 primary schools, only showed a significant effect in non-deprived schools. Furthermore, a King's Fund study exploring the impact of health promotion campaigns in England showed little effect on health behaviours among people with few or no qualifications, who were less likely to use any disease prevention services (Buck and Frosini, 2012). It appears that whatever the type of health education provided, little effect has reached the lower SES groups. It may be that the difference in norms and attitudes between teachers and lower SES groups is one of the reasons for the missing effect (Schou *et al*., 1993) and that health behaviours are determined by broader social factors. Thus, the concept of health literacy could enhance capacity in medium or high SES families but may be difficult for those from low SES backgrounds. This has serious consequences for future preventive approaches for low SES groups.

A strong relationship between caries in school children and the socio-economic status of their parents has been demonstrated in Germany and most western countries (Schwendicke *et al*., 2015; Astrom *et al*., 2011; Locker, 2000). This was also confirmed in the present study, in which children among low socio-economic group had the highest risk of acquiring new lesions. A recent review of data from 43 countries with at least three data points for caries experience of 12-year-old children from 1980 to 2010 found that caries had changed from a disease of affluence to a disease of deprivation (Do, 2012).

An essential goal of the 'School Health Promotion' concept is equity in health promotion, but the results of this study show that this target is not easily achieved. The program increased the gap between high and low socio-economic groups, suggesting that the usefulness of programs using oral health competence strategies should be considered very carefully. This may require a change in approach from using such strategies to more upstream health promoting approaches (Watt, 2007).

The children's questionnaires revealed high tooth-cleaning frequencies among all students at baseline. As expected, regular tooth brushing was already a prominent element, which could explain the low caries levels found here. Students who received the intervention and were not brushing their teeth regularly at baseline had a significant decrease in risk of dental caries that reached up to 80% compared to the control group. This is in agreement with previous investigations showed the frequency of brushing to be an important risk indicator for caries in the primary and permanent dentition (Vanobbergen *et al*., 2004; Walsh *et al*., 2010).

As is the case for any research, this study has some limitations. Although the trial met most of the Consolidated Standard of Reporting Trials (CONSORT) guidelines and criteria, it was, not registered as a trial. Any study included in the clinical trials registry must be registered before the onset of participant enrolment. Still, the study is in line with the German Ministry of Education and Research (BMBF) guidelines and obtained a national registration to be conducted with a special research initiative to evaluate an existing preventive programme (registration no. 01EL0610).

The differences between those who remained in the study and those lost to follow-up suggests a risk of attrition bias. Drop-out groups have usually higher caries experience than the included samples (Skaret *et al*., 2000), but in the present study loss to follow-up was complex, being due to illness (2.3%), moving away from the study region (6.7%) or changing between intervention and control schools (1.3%). Thus, no relevant attrition bias can be detected and no additional drop-out analyses or corrections seem necessary.

Another potential limitation arises in the late publication that might be attributed to the potential for publication bias. Studies with positive results may be prioritized over negative results for publication, which leads to a preponderance of false-positive results in the literature (Schooler, 2011). Also, the wide aims and scope' of some journals and prolonged reviewing processes played contributed to the undue delay of the submission.

Conclusion

In this study, the concept of oral health literacy through school-based health education, failed to take account of different social and economic background of the students, and did not achieve widespread oral health improvement. Instead, oral health inequalities were widened, as observed in other research (Schou and Wight, 1994; Sprod *et al*., 1996). The health literacy concept employed here appeared to conflict with the remit of health promoting schools programs to reduce inequalities in oral health. Upstream health promoting interventions may be required, along with wider debate on how best to reach those most at need to improve oral health and reduce inequalities (Marmot and Bell, 2012).

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Conflicts of Interest

The authors declare no conflicts of interest.

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