European Journal of Public Health, Vol. 24, No. 6, 893–898

doi:10.1093/eurpub/ckt204 Advance Access published on 23 December 2013

Effect evaluation of an oral health promotion intervention in preschool children

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Objective. This study evaluates the effectiveness of a multi-component oral health intervention in preschool children in a non-randomized intervention study with a complementary baseline control. **Methods.** Participants in the main study were 2137 children born between October 2003 and July 2004 in Flanders, Belgium. In the intervention group (50.5% of participants), an oral health education program was added to a standard preventive care program during the first 3 years of life. Oral health examinations were performed by trained dentists when the children were 3 (2007) and 5 (2009) years old. Data on dietary habits, oral hygiene habits and dental attendance were obtained through structured questionnaires. Regression analyses were applied to compare the results of the intervention and control group with baseline measurements obtained before the intervention (2003) in other cohorts of 3- ($N = 1291$) and 5-year-olds ($N = 1325$) living in the same regions. **Results.** The prevalence of caries experience was generally lower in the main study compared with the baseline cohorts, with little differences between the intervention and control group. For the oral health-related behaviours, the control group scored mostly better. Nevertheless, compared with baseline, limited differences were observed in dental attendance, tooth brushing, helping with tooth brushing and consuming in-between drinks ($P < 0.05$). **Conclusion.** The study illustrates that a multi-component, theory-based intervention at community level had only a limited and temporary effect on oral health-related behaviours in the community under study. Further research is needed to determine how oral health in young children can be improved in the long term.

Introduction

Although largely preventable, dental caries remains one of the most common infectious diseases in childhood. According to the World Health Organization, 60–90% of school age children are affected by caries.[1] In Flanders (northern part of Belgium), visible caries experience was detected in almost one out of three 5-year-olds.[2] Oral health in preschool children is to a large extent determined by behavioural factors, in particular, inadequate oral hygiene habits, frequent consumption of sugared snacks and drinks and lack of preventive visits to the dentist.[2,3] These habits are established early in life,[4] and their development is mediated by parental behaviours, mostly of the mother.[5] In addition, dental caries is more prevalent among children who are raised in deprived communities or whose parents have a lower educational level or immigrant background.[6,7]

Several interventions have been developed to reduce dental decay by improving oral health-related behaviours through educational programs targeted towards parents.[8–10] To enhance their effectiveness, such interventions should preferably be based on theoretical models of preventive behaviour change and reach all subgroups in the population, including the less advantaged. An example of such an intervention is the multi-component community-based oral health promotion intervention program 'Smile for Life', which was developed in Flanders. This program, which targeted preschool children and their parents, aimed to improve oral health and oral health-related behaviours in this age group based on the 'Theory of Planned Behaviour' (TPB).[11] It was embedded in the framework of the 'well-baby clinics', a structured programme offering preventive health care and educational guidance by trained professionals free of charge to children from birth until the age of 3 years and to their parents. The aim of the present study was to evaluate the effectiveness of this intervention.

Method

Participants

All children born between October 2003 and July 2004 in two geographically circumscribed regions in Flanders were invited to participate in this study. One region, involving 1284 newborns, served as the intervention setting, and the other, involving 1171 newborns, as a control region. Criteria for the selection of the control region were (i) similar socio-economic characteristics and attendance rate at the well-baby clinics compared with the intervention region, and (ii) a sufficiently large distance away from the intervention region (at least 100 km) to minimize potential interventional 'contamination' of the control region.

Parents were informed about the project shortly after their child's birth by a nurse of the well-baby clinic and parental informed consent was obtained. As the preventive health services are free of charge and the coverage of the target group is high (up to 97% receives at least one home visit), parents from all social backgrounds were reached. Children were excluded if parents had insufficient language skills to complete a Dutch questionnaire, in case of

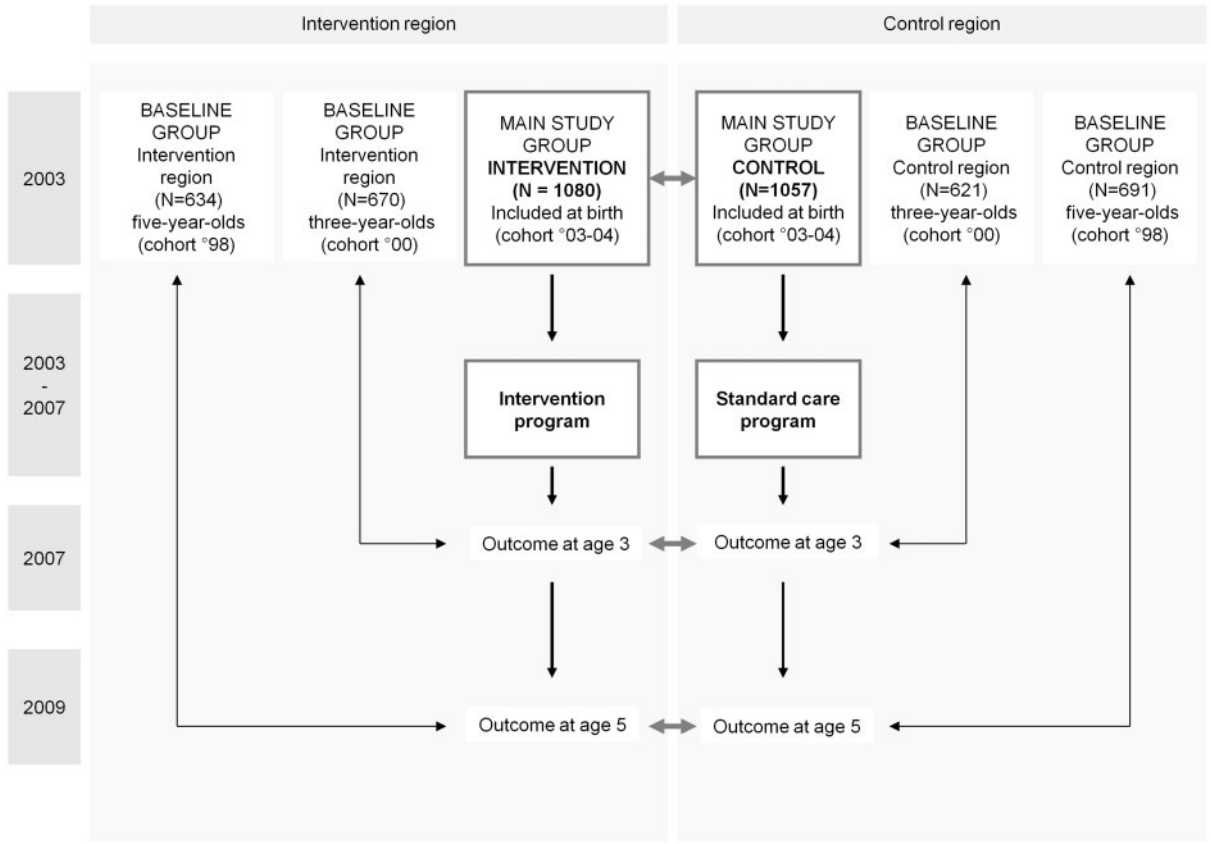

Figure 1 Schematic overview of the 'Smile for Life' study design

serious illness that could have an impact on the child's oral health, in case of premature birth (<37 weeks), if parents did not attend the well-baby care or if they moved out of the region shortly after birth. In case of twins, only the child whose name was alphabetically ranked first was included in the study. In total, 1080 (84.1%) and 1057 (90.3%) children in the intervention and control groups were included in the study and followed until the age of 5 years. They are further referred to as 'main study groups' (figure 1).

Before the intervention started (October 2003), complementary baseline data were collected in a randomly selected sample of 3- ($N=670$) and 5-year-olds ($N=634$) living in the intervention region and a sample of 3- ($N=621$) and 5-year-olds ($N=691$) living in the control region, all referred to as 'baseline cohorts' hereafter (figure 1). A detailed description of the baseline data was published elsewhere.[2]

Intervention program

A specific intervention program to promote oral health was developed and added to the standard programme of preventive health care at the well-baby clinics. The standard programme consisted of three home visits by a nurse and 11 consultations by a physician and nurse between the child's birth and age 3 years. It included regular assessments of the health, growth and development of the child and health education for the parents. Oral health-related education in the standard program is limited to information about oral hygiene and dental attendance at months 6 and 24. The control group received this standard program. For parents in the intervention group, additional oral health education was provided through a specifically trained nurse on 14 topics, including breast feeding, pacifier use, parental oral hygiene, water consumption, brushing behaviour, etc. As previous studies indicated that oral health education alone was only effective in increasing knowledge,[12,13] the parents also received supplementary educational materials (child health booklet, toothbrush, a fluoride-containing toothpaste sample, cup and placemat). Furthermore, all health care professionals practicing in the intervention region were informed about the project and posters were provided to inform their patients. The 'Smile for Life' study protocol received ethical approval from the Medical Ethics Committee at the KU Leuven, Belgium.

Measurements

Reported oral health-related behaviours and psychological determinants were assessed with pretested and validated questionnaires based on the TPB[14] shortly after birth (2003–04) and when the child had reached the age of 3 (2007) and 5 (2009) years. The questionnaires measured reported dietary habits (frequency of consumption of sugared in-between snacks and drinks by the child), oral hygiene habits (frequency of brushing by the child and helping with brushing) and dental attendance (timing of last dental visit). Oral health examinations were performed by trained dentist-examiners in the kindergartens at ages 3 and 5 years, to investigate the presence of dental plaque and clinical signs of visible caries experience. A record was made of untreated and treated (filled) teeth as well as teeth that were removed owing to caries experience and summarized using the dmft and dmfs index. A detailed description of the procedures is provided elsewhere.[15] For the data collection in the baseline cohorts in 2003, the same questionnaire and clinical examination protocol were used. An overview of the study design is presented in figure 1.

Data analyses

As the majority of children was caries-free, a zero-inflated Poisson model was applied on the clinical data of the 3- and 5-year-olds.[16] Differences in predicted counts of decayed teeth and odds ratios for

Table 1 Demographic characteristics and response in the baseline cohorts and main study groups in the intervention and control region

		Intervention region			Control region		
		Baseline 3 years (*N* = 670)	Baseline 5 years (*N* = 634)	Main study (*N* = 1080)	Baseline 3 years (*N* = 621)	Baseline 5 years (*N* = 691)	Main study (*N* = 1057)
Demographic characteristics							
Gender, % of boys		55.7	51.1	52.4	49.0	50.2	50.9
Age of child at examination in 2003, mean (years)		3.3	5.4	–	3.3	5.3	–
Age of child at examination in 2007, mean (years)		–	–	3.1	–	–	3.2
Age of child at examination in 2009, mean (years)		–	–	5.2	–	–	5.2
Age of mother at birth, mean (years)		28.7	28.9	28.7	29.6	29.7	29.9
Educational level of the mother, % highly educated[a]		50.7	48.8	53.8	53.4	61.7	56.1
Response							
Questionnaire completed, %	2003	89.6	91.2	98.8	87.9	86.7	91.5
	2007	–	–	70.6	–	–	55.8
	2009	–	–	83.9	–	–	66.1
Dental examination performed, %	2003	93.9	95.9	–	93.7	96.7	–
	2007	–	–	71.7	–	–	59.0
	2009	–	–	86.1	–	–	69.9

a: Highly educated = acquired a college (bachelor) or university (master) degree.

the excess amount of zeros (caries-free children) between intervention and control region were calculated for the baseline as well as main study with accompanying confidence intervals and *P*-values. In addition, the changes between the baseline and main study were analyzed and the interaction between groups and regions was tested. The analyses were performed both on the tooth- (dmft) and surface-level (dmfs) data. All analyses were adjusted for age and educational level of the mother.

For the oral health-related behaviours, the data were dichotomized; the recoded variables were the proportion of children (i) consuming a sugared snack or drink in-between meals at least once a day versus less; (ii) parents helping with tooth brushing at least once a day versus less; (iii) tooth brushing at least once a day versus less and (iv) having visited the dentist a year ago or less versus more than a year ago or never. Logistic regression analysis was performed to test the effect of the group (intervention vs. control) and study (baseline vs. main) and the interaction between both factors. The risk differences are presented after correction for age of the child and the educational level of the mother at children's age 3 (2007, i.e. shortly after the intervention, further called short-term outcome) and 5 (2009, i.e. 2 years after intervention, further called long-term outcome) years. The statistical analyses were performed with SAS version 9.2.

Results

Demographic characteristics and response rates of the main study groups and baseline cohorts are presented in table 1. More than half of the mothers was highly educated (i.e. at least a bachelor degree), and the mean age of giving birth was around 29 years. In most cases, the questionnaires were completed by the mothers (88% in the baseline groups, 93% in the study groups). The response rates in the baseline cohorts were high for both the completion of the questionnaire and the dental examination. For the study groups, a high response rate was observed for the first questionnaire, but lower rates were seen at follow-up. Lack of identification of the child's kindergarten was the main reason for the missing data: 18% of the original intervention group and 30% of the control group could not be retrieved at age 3 years, and 9% of the original intervention group and 25% of the control group could not be retrieved at age 5 years.

Because similar results were obtained for dmft and dmfs, only the dmfs scores are shown, as they give a better insight in the severity of the disease. In the main study (2007), there were no differences between the intervention and control group in the proportion of 3-year-olds without caries experience at the d_3-level. An increase in the proportion of caries-free children was observed between the baseline (2003) and main study (2007), but a different pattern was seen in the intervention and control regions, respectively. Compared with the baseline cohort, children in the main study living in the control region had a significantly higher chance to be caries-free (zero result), whereas children in the intervention region had significantly less decayed tooth surfaces. For caries experience at the d_1-level, the proportion of caries-free children was higher in the intervention group than in the control group (table 2), a difference that was observed both in the main (2007) and baseline (2003) study. Children who received the intervention (2007) had less decayed tooth surfaces compared with the baseline cohort (2003), a finding that was not observed in the control regions (table 2).

At age 5 (2009) years, there were no differences in the odds of children being caries-free (zero-result) at the d_3- and d_1-level in the main study groups, whereas at baseline, children in the intervention region had a significantly higher chance of being caries-free. There has been a significant decrease in the number of children with caries experience between both birth cohorts at age 5 (in 2003 and 2009, respectively) years in the control region only. Significant interactions were observed at the d_3- and d_1-level. However, when looking at the number of tooth surfaces affected, significant differences between intervention and control region were observed both at the d_3- and d_1-level. At baseline, children in the intervention region had a significantly lower number of affected surfaces (difference = 0.89 and 0.83), whereas in the main study the opposite was observed (difference = 1.46 and 2.00). At the d_1-level, a decrease in the number of affected surfaces was observed between 2003 and 2009 in the control region only (table 2).

Large differences between the intervention and control region were observed for the reported oral health-related behaviours of the children in the baseline cohort (2003) as well as in the main study groups (2007–09). Significantly more children in the control region had visited the dentist less than a year ago, brushed their teeth at least once a day and received help from a parent with tooth brushing. When compared with the baseline cohort, in the main study a significant higher rate of reported dental attendance was only present in the intervention region. A significant interaction was observed between the regions (intervention vs. control) and study (baseline vs. main) at age 3 years only. For tooth brushing frequency and help with brushing, in both regions, significantly higher rates were reported in 2007 and 2009 compared with 2003, but although the differences in proportions were bigger in the

Table 2 Zero-inflated Poisson Regression for dmfs and $d_1$mfs in 3- and 5-year-old children in the baseline cohort (2003) and main study groups (2007–09) adjusted for age and educational level of the mother

Age	Caries experience	Study	% caries-free		OR for prediction of Zero result		Ratio of predicted counts	
			Intervention region	Control region	OR (95% CI)	*P*	Difference (95% CI)	*P*
3-year-olds	$d_3$mfs	Baseline (2003)	93.8	91.0	1.60 (0.94–2.73)	0.09	1.05 (0.81–1.35)	0.72
		Main (2007)	97.5	95.7	1.25 (0.63–2.49)	0.52	0.66 (0.31–1.40)	0.28
		Interaction				0.58		**<0.001**
		Change within control region				**0.02**		0.37
		Change within intervention region				0.23		**<0.01**
	$d_1$mfs	Baseline (2003)	86.1	76.2	**2.05 (1.41–2.97)**	**<0.001**	0.99 (0.82–1.19)	0.92
		Main (2007)	91.9	77.9	**2.47 (1.70–3.59)**	**<0.001**	1.17 (0.74–1.84)	0.51
		Interaction				0.48		**<0.001**
		Change within control region				0.98		0.78
		Change within intervention region				0.39		**<0.001**
5-year-olds	$d_3$mfs	Baseline (2003)	73.3	64.9	**1.61 (1.21–2.15)**	**<0.01**	**0.89 (0.81–0.99)**	**<0.05**
		Main (2009)	76.5	76.1	0.99 (0.77–1.26)	0.92	**1.46 (1.08–1.97)**	**<0.05**
		Interaction				**<0.05**		0.83
		Change within control region				**<0.001**		0.80
		Change within intervention region				0.56		0.91
	$d_1$mfs	Baseline (2003)	63.8	46.0	**2.18 (1.67–2.85)**	**<0.001**	**0.83 (0.76–0.90)**	**<0.001**
		Main (2009)	61.3	60.6	0.99 (0.80–1.22)	0.91	**2.00 (1.51–2.64)**	**<0.001**
		Interaction				**<0.001**		0.09
		Change within control region				**<0.001**		**<0.01**
		Change within intervention region				0.13		0.50

OR = odds ratio; CI = confidence interval; $d_3$mfs = decayed tooth surfaces at d_3 level; $d_1$mfs = decayed tooth surfaces at d_1 level. Significant results are indicated in bold.

Table 3 Risk differences in oral health-related behaviours between control and intervention region in 3- and 5-year-old children in the baseline cohort (2003) and main study groups (2007–09) after correction for age and educational level of the mother

% of children who	Age 3 years					Age 5 years				
		Int	Cont	*P*	Interaction		Int	Cont	*P*	Interaction
Visited the dentist less than a year ago	Baseline (2003)	16.2	35.2	**<0.001**		Baseline (2003)	50.2	66.0	**<0.001**	
	Main (2007)	27.7	34.7	**0.05**		Main (2009)	59.3	70.3	**<0.001**	
	P	**<0.001**	0.8		**<0.001**	*P*	**<0.01**	0.1		0.37
Brushed the teeth once a day or more with a fluoride-containing toothpaste	Baseline (2003)	60.4	82.1	**<0.001**		Baseline (2003)	73.2	87.1	**<0.001**	
	Main (2007)	77.7	88.8	**<0.001**		Main (2009)	83.4	94.0	**<0.001**	
	P	**<0.001**	**<0.01**		0.22	*P*	**<0.001**	**<0.001**		0.38
Were assisted with tooth brushing once a day or more	Baseline (2003)	42.5	59.6	**<0.001**		Baseline (2003)	27.0	40.7	**<0.001**	
	Main (2007)	59.5	67.9	**<0.001**		Main (2009)	46.7	49.8	**0.05**	
	P	**<0.001**	**<0.01**		0.08	*P*	**<0.001**	**<0.001**		**<0.05**
Consumed sugared in-between drinks less than daily	Baseline (2003)	38.1	23.3	**<0.001**		Baseline (2003)	43.4	28.2	**<0.001**	
	Main (2007)	53.2	38.9	**<0.001**		Main (2009)	54.4	42.4	**<0.001**	
	P	**<0.001**	**<0.001**		0.53	*P*	**<0.001**	**<0.001**		0.31
Consumed sugared in-between snacks less than daily	Baseline (2003)	18.8	17.9	0.7		Baseline (2003)	19.3	14.7	0.1	
	Main (2007)	26.7	22.8	0.1		Main (2009)	17.6	14.8	0.3	
	P	**0.001**	**0.05**		0.47	*P*	0.4	0.9		0.53

Int = Intervention region; Cont = Control region. Significant results are indicated in bold.

intervention region, the interaction effects were not significant, except for help with brushing at age 5 years (table 3).

For dietary habits, the number of children not consuming sugared drinks daily was higher in the intervention region compared with the control region, for both the main study and baseline cohort at ages 3 and 5 years. This number also increased between 2003 and 2007–09 in both regions (table 3). There were no significant differences in the reported consumption of in-between snacks between the intervention and control group at both ages. At age 3 years, significantly higher rates were reported in 2007 compared with 2003 both in the intervention and control region (table 3).

Discussion

This study illustrates the complexity in evaluating longitudinal intervention programs. When only comparing the intervention and control group, no effects of the intervention were observed, as the control group generally performed better. However, when

comparing the data with a historical cohort, some small effects of the intervention program could be observed in the short term. Thus, the intervention seems to have had limited success in reducing the number of caries-affected tooth surfaces at the d_1-level and improving oral health-related behaviours such as visiting the dentist, which is in line with other studies.[17] However, on the long term, there was no effect on caries experience and only a limited impact on parental help with brushing. These results are in line with other reports indicating no or limited effects of oral health education on caries prevalence, as well as the fact that the positive effects of the intervention diminishes as soon as the contact with preventive health services decreases.[18,19]

What are possible explanations for these limited effects? First, during the time span of the intervention (2003–07), oral health and related behaviours have generally improved in Flanders in the entire population, probably due to increased attention for oral health by health care workers, schools, child-rearing brochures, the media or through increased advertising by the oral hygiene manufacturing industry. This makes it more difficult to observe an additional intervention effect. An overall improvement of attitudes, perceived control and intentions predicting the oral health-related behaviours was indeed observed among our participants.[20] Furthermore, it is also possible that participating in a study as a control group in itself had an impact on the oral health habits. This 'Hawthorne effect' makes it more difficult to detect any differences between the intervention and control group.[21]

Secondly, it is conceivable that the intervention was not fully implemented as planned or that the preventive health visits did not fully reach the participants. An evaluation of the program's implementation fidelity revealed that the program was largely carried out as planned.[22] However, an evaluation of the degree to which the participants were reached within the health visits indicated that although the majority of participants received the planned intervention components, attention for child-rearing or health problems during the consultations often resulted in a lack of time being dedicated to the oral health topics. It is realistic to assume that the families with many problems may have been the ones who needed the oral health education the most.

Thirdly, it may be that the program was only effective among those who are less literate in terms of oral health, i.e. the socially and educationally disadvantaged. Studies of the impact of social inequalities on oral health, including previous publications by this research group, revealed a higher prevalence of caries experience, worse oral health-related behaviours and worse behavioural determinant scores among parents with lower levels of education.[20,23,24] Further research should clarify if differential effects of the intervention were present in subgroups of higher- versus lower-educated parents.

Finally, it is possible that other methods are more suitable to improve oral health and related behaviours in the community. Community-based interventions based on individual behaviour change methods often show limited results because the community or system change is not part of it. Although the intervention was organized at several levels following an ecological approach, little theory was put forward on how these levels impact the unfolding of the intervention or how they affect intervention outcomes. Recent research suggests that the theory driving the intervention should be about the dynamics of the context or system, not about the psyche or attributes of the individuals within it.[25] It would be interesting to investigate whether different approaches can be used in combination for the development and implementation of health interventions.

It can be considered a limitation that the study was not randomized. Although the socio-demographic characteristics of the regions were comparable, differences in oral health and reported behaviours were present from the onset of the study, obscuring interpretations. Because of the methodological difficulties, a randomized controlled trial is, however, often not feasible or impractical in the context of health promotion interventions in complex settings, such as communities.[26] Secondly, as the behavioural data were collected with self-report questionnaires, a response bias towards socially acceptable answers may have occurred. The additional use of observational data would have added value, but was too labour-intensive and financially not feasible.

In conclusion, although overall oral health has improved in the Flemish population in the past decade, there remains a need for targeted oral health interventions. Our results indicate that a specific, multi-component, theory-based intervention at community level only had limited effect, and that this effect lasted only as long as the parents remained in contact with the preventive health services. More research is needed on the effectiveness of oral health promotion programmes in young children, containing process analyses to identify the effective components of a programme. To successfully replicate studies, a theoretical basis, adequate study design and appropriate methods for evaluation are essential. Longitudinal approaches are needed to investigate how oral health in young children can be improved on the long term. By providing publications based on the evaluation of both successful and unsuccessful studies, new insights can be gained and lessons can be learned for future research.

Acknowledgements

The following partners collaborated in the 'Smile for Life Project': Dominique Declerck (Project coordinator) and Roos Leroy (both from the Department of Oral Health Sciences, KU Leuven); Karel Hoppenbrouwers (Center of Youth Health Care, KU Leuven); Emmanuel Lesaffre (Erasmus University Rotterdam, the Netherlands, and I-Biostat, Leuven, Belgium); Stephan Vanden Broucke (Department of Psychology, Université Catholique de Louvain and Health Psychology, KU Leuven); Luc Martens (Dental School, Ghent University); and Erwin Van Kerschaver and Martine Debyser (Child and Family).

Funding

The study was supported financially by GABA Benelux and GABA International.

Conflicts of interest: None declared.

Key points

- In the past decade, oral health and related behaviours have generally improved in Flanders in the entire population, probably owing to increased attention for oral health by health care workers, schools, child-rearing brochures, the media or through increased advertising by the oral hygiene manufacturing industry.
- The study illustrates that a multi-component theory-based intervention at community level had only a limited and temporary effect on oral health and related behaviours in the community under study.
- Further research can provide insight on how oral health in young children can be improved in the long term, and whether different approaches can be used for the development and implementation of health interventions.

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