

ORIGINAL ARTICLE

Effectiveness of multimodal dental health education with animated cartoons for improving knowledge, attitudes, oral hygiene practices and reducing dental plaque in 7-9 year-old children in Khon Kaen Province

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Abstract

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Good oral care in children, especially in those aged 7 to 9 years, is important if the risks of later serious dental carries and periodontal health problems are to be minimised. The purpose of this study was to evaluate the effectiveness of an innovative multimodal education programme, which included the use of animated cartoons, to improve knowledge, attitudes and oral hygiene practices of children among this critical age group. The present study was a cluster randomised controlled trial involving a total of 244 children selected from elementary classes in two districts in Khon Kaen Province, Thailand. The children in one district received the multimodal education programme, while the other district provided the no-treatment controls. The outcome variables comprised measures of dental health knowledge, attitudes to oral care, reported oral hygiene practices, and an objective assessment of plaque formation. Data were analysed using multiple logistic regression with a generalised estimating equation to estimate effect sizes in the intervention and control groups.

When compared with the controls, the new education programme resulted in statistically significant improvements in all the outcome variables including plaque formation which was the most objective measure of dental care. Recommendations were made for future research. Two important limitations of the study are noted: the exact contribution of each of the multimodal programme components remains unknown, in particular the use of animated cartoons, and the lack of a long-term follow-up.

Keywords: dental health education, animated cartoon, oral hygiene, dental plaque, children

ประสิทธิผลของโปรแกรมทันตสุขศึกษาหลายรูปแบบ ด้วยการ์ตูนแอนิเมชันในการพัฒนาความรู้ ทักษะ การปฏิบัติด้านอนามัยช่องปาก และการลดแผ่นคราบ จุลินทรีย์ในกลุ่มเด็กอายุ 7-9 ปี จังหวัดขอนแก่น

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บทคัดย่อ

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ประสิทธิผลของโปรแกรมทันตสุขศึกษาหลายรูปแบบด้วยการ์ตูนแอนิเมชันในการพัฒนาความรู้ ทักษะ
การปฏิบัติด้านอนามัยช่องปาก และการลดแผ่นคราบจุลินทรีย์ในกลุ่มเด็กอายุ 7-9 ปี จังหวัดขอนแก่น
วารสารสาธารณสุขและการพัฒนา. 2559;14(3):69-82

พฤติกรรมดูแลสุขภาพช่องปากที่ดีโดยเฉพาะในกลุ่มเด็กอายุ 7-9 ปี จะช่วยลดความเสี่ยงต่อการเกิดโรคฟันผุ และเหงือกอักเสบได้มาก วัตถุประสงค์ของการศึกษานี้เป็นการประเมินประสิทธิผลของนวัตกรรมโปรแกรมทันตสุขศึกษาหลายรูปแบบด้วยการ์ตูนแอนิเมชันในการพัฒนาความรู้ ทักษะ การปฏิบัติด้านอนามัยช่องปากของเด็กกลุ่มอายุที่สำคัญนี้ การศึกษานี้เป็นการทดลองแบบสุ่มและมีกลุ่มควบคุม (A cluster randomised controlled trial) ในเด็กวัยเรียน จำนวน 244 คน ซึ่งเลือกจากชั้นเรียนระดับประถมศึกษาในจังหวัดขอนแก่น กลุ่มทดลองได้รับโปรแกรมทันตสุขศึกษาหลายรูปแบบและกลุ่มควบคุมไม่ได้รับ ตัวแปรตามประกอบด้วยความรู้และทักษะในการดูแลสุขภาพช่องปาก การปฏิบัติด้านอนามัยช่องปาก และการสะสมของแผ่นคราบจุลินทรีย์ การวิเคราะห์ข้อมูลใช้การวิเคราะห์ถดถอยลอจิสติกพหุคูณ (Multiple logistic regression analysis) และสมการประมาณค่าโดยนัยทั่วไป (Generalised Estimating Equation) เพื่อเปรียบเทียบตัวแปรตามในกลุ่มทดลองและกลุ่มควบคุม

ผลการวิจัยพบว่า เด็กวัยเรียนในกลุ่มที่ได้รับโปรแกรมทันตสุขศึกษาหลายรูปแบบมีผลการพัฒนาในด้านความรู้ ทักษะ และการปฏิบัติในการดูแลสุขภาพช่องปากดีขึ้นอย่างมีนัยสำคัญทางสถิติ รวมทั้งการสะสมของแผ่นคราบจุลินทรีย์ด้วย การศึกษานี้มีข้อจำกัดที่สำคัญสองประการเกี่ยวกับการสนับสนุนที่แน่ชัดในแต่ละองค์ประกอบของโปรแกรมทันตสุขศึกษาหลายรูปแบบที่ยังไม่ปรากฏ โดยเฉพาะการใช้การ์ตูนแอนิเมชัน และความจำเป็นในการติดตามระยะยาวสำหรับการวิจัยครั้งต่อไป

คำสำคัญ: โปรแกรมทันตสุขศึกษา การ์ตูนแอนิเมชัน อนามัยช่องปาก แผ่นคราบจุลินทรีย์ เด็กวัยเรียน

Introduction

Worldwide, children have been found with oral cavity problems such as gingivitis due to the continuous accumulation of dental plaque. This common disease is a reversible condition, but the inflammation may precede more serious periodontal problems when children arrive at puberty and can finally result in the loss of their teeth.¹⁻⁴ Colonisation by dental plaque and its periodontal effects are a particularly important issue in children aged 7 to 9 years which is a period of mixed dentition following the time when permanent teeth begin to erupt. To avoid the development of serious problems plaque needs to be carefully removed every day.^{3,4} Previous studies have established that 32.8-59.6% of children have poor oral health, and a causal relationship between oral cavity care and various periodontal diseases has also been indicated.²⁻⁷

Researches into the effectiveness of oral health education programmes involving multimedia presentations have shown that they can improve knowledge, attitudes and oral care practices and reduce plaque, gingival bleeding and caries, but further efforts need to be made to improve these programmes.^{8,9} Although there is encouraging evidence to suggest that dental health education can promote good oral care in children,^{10,11} there is certainly room for further community-based studies into the effectiveness of this approach, especially in the context of non-Western cultures and in low or middle income countries.¹²

The present study focused on the need to promote children's oral health, especially a reduction in plaque, by attempting to improve their knowledge, attitudes and oral care practices by the use of a multimodal dental health education (MDHE) programme

which included the use of animated cartoons. These animated techniques have been found to be effective in other contexts,¹³⁻¹⁵ and learning can be enhanced by combining use of auditory verbal presentations with visual nonverbal materials.¹⁶ The findings are expected to be helpful if the study shows that MDHE is effective on improving knowledge, attitudes and oral care practices and plaque reduction. If this is the case, then this programme could be applied to dental practitioners and oral health care providers for this age group of children in everywhere in Thailand.

Methods

Study design, sampling and randomisation

This was a cluster randomised controlled trial conducted during the period of school year 2012 to 2013 among elementary school extension classes in Khon Kaen Province, Thailand. This province comprises 26 districts in which there were a total of 977 elementary schools. **Figure 1** summarises the multistage cluster sampling process used in the study and the process of random allocation to the intervention and control groups. **Figure 2** shows the progress of the participants in these two groups through the period of the study. Two of the 26 districts were selected by simple random sampling, and these were randomly assigned to the status of an intervention district (Phra Yuen, 22 schools) and a control district (Nam Pong, 36 schools). The directors of all schools in these two districts were contacted to determine their eligibility. Schools were eligible to participate if in the second semester of the school year of 2012 they (1) were non-profit and had extension school classes, (2) served at least 30 school children aged 7-9 years who were not intellectually disabled, (3) had at least

Figure 1 Chart of the sampling process

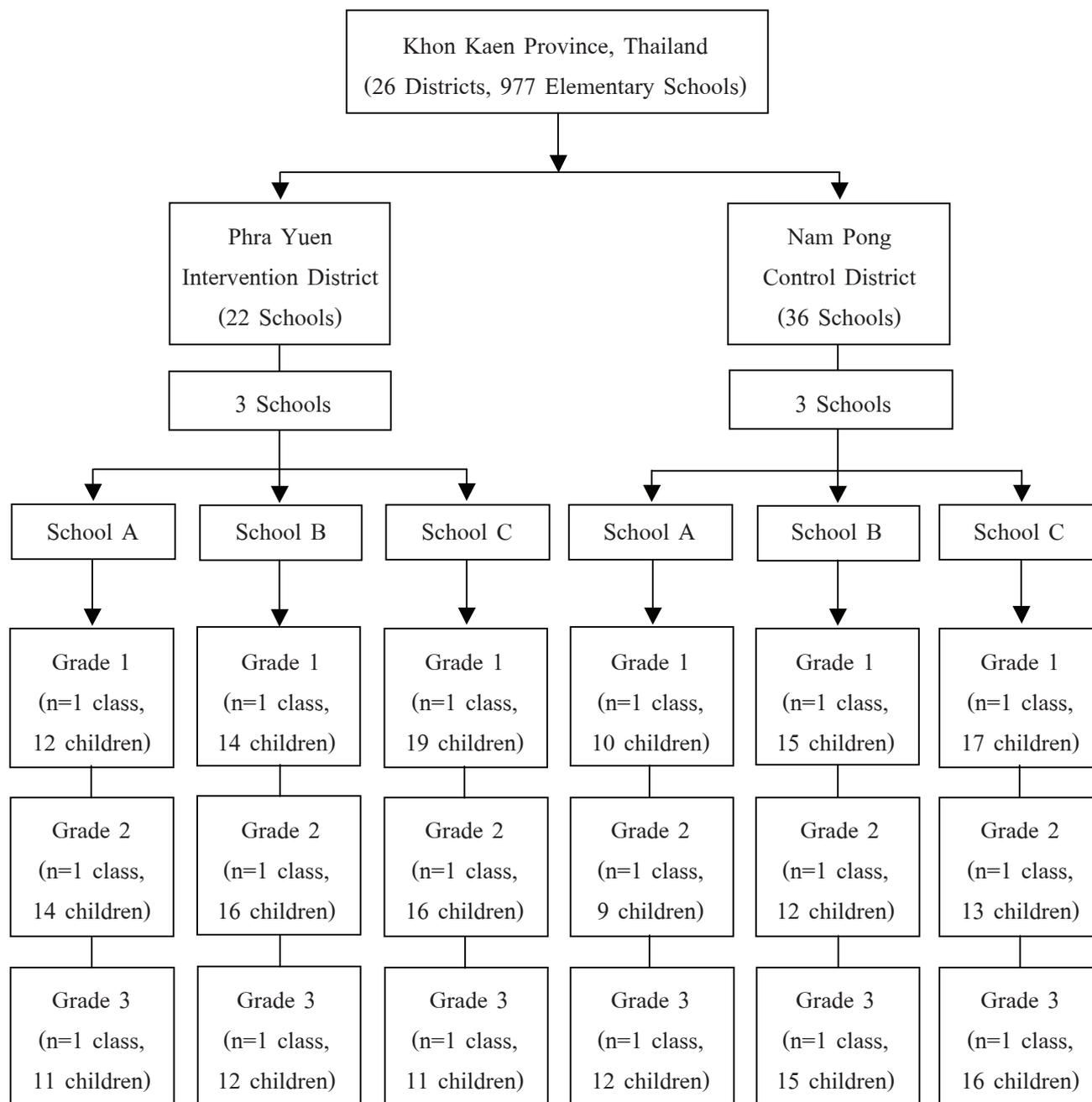
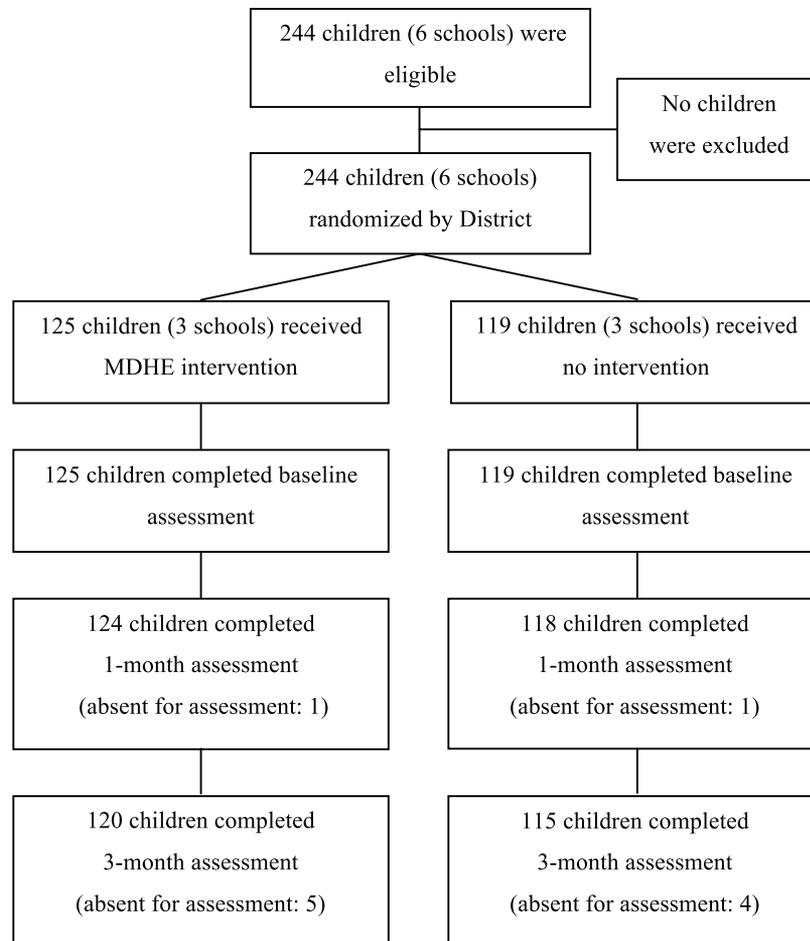


Figure 2 Progress of participants through the study



one full-time service teacher, (4) were willing to be randomised, and (5) agreed to implement the intervention procedures (if required) and cooperate with data collection over a three-month period. Schools participating in other similar projects in the same time (such as special oral health education campaigns) were excluded. Three eligible schools were then randomly selected from each district with schools stratified by the Ministry of Education classification of large,

medium and small schools. One of each school size was randomly selected in each district. In the final stage of sampling, three extension classes were randomly selected in each school, one at each grade 1-3. The result of the multistage cluster sampling process was nine classes of children aged 7-9 years in each of the intervention and control groups. The parents of all the children in these classes (n = 244) were contacted, and all provided their informed consent.

Sample size

A required sample size of 213 children was estimated using a method proposed for calculating required sample sizes in cluster randomized controlled trials with a fixed number of clusters.¹⁷ Power of the test was set at 80% with a confidence level of 95%. Further assumptions were a 15% reduction in gingivitis, an anticipated 30 participants in each cluster, and an intraclass correlation coefficient (ICC) in the range of 0.01-0.05. After consideration of the costs and feasibility of the number of schools, a final decision was made to adopt an ICC of 0.01

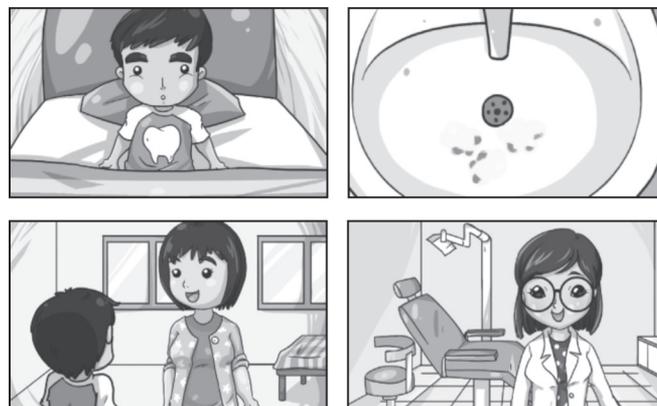
which has been the value recommended for evidence-based interventions in health care.¹⁸

Intervention

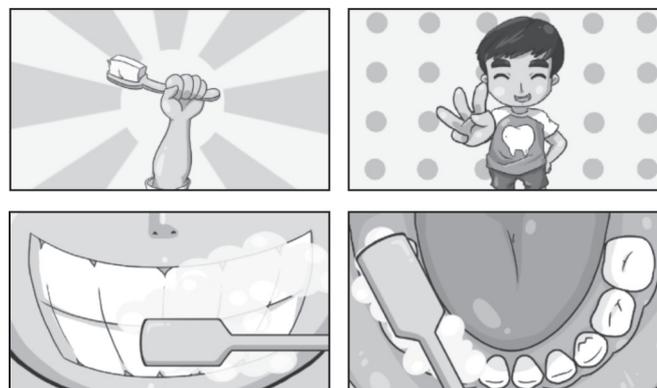
Children in the intervention classes received MDHE in two initial sessions requiring separate visits by three research assistants. The assistants attended a one-day training session conducted by the researcher. In the first session the children were presented with cartoons about dental health problems with a focus on the risks and harms associated with gingivitis and the benefits of prevention (see **Figure 3** for examples

Figure 3 Examples of cartoon screens used in the intervention (MDHE)

A: Cartoons about dental health problems



B: Music video depicting correct tooth-brushing



of cartoons). After the cartoon presentation which lasted 10 minutes, research assistants conducted a 15 minute question-and-answer interchange which ended with a brief discussion about how to prevent gingivitis in schools and in the community. The second session of MDHE began with a five-minute music video depicting correct tooth-brushing. This was followed by 15-minute period during which the research assistants explained the purpose of removing dental plaque thoroughly from all tooth surfaces to prevent gingivitis, demonstrated a systematic method of tooth cleaning using a tooth brush and a model of teeth, and allowed time for questions and answers. The video was subsequently presented three times every week after the initial session. In addition to the two MDHE sessions and follow-up video presentations, all a children in the intervention arm of the study were given fluoride toothpaste and a toothbrush, and teachers supervised the voluntary use of these by their students every lunch-time during school days. The children in the control arm classes received only the usual routine information about dental care as part of the health education curriculum.

Data collection and outcome variables

A self-administered questionnaire was completed by all the children at baseline to collect demographic information and to assess dental health knowledge, attitudes to dental care and oral hygiene practices. When necessary, the children were assisted in responding to the questionnaire items by the research assistants. Knowledge, attitudes and oral hygiene practices were also assessed using the same 20 items after one- and three- months. Higher and lower scores were

categorised in terms of whether individual scores were above or below the mean score.¹⁸ Knowledge was measured by seven items (for example, 'Gingivitis is caused by bacteria that accumulate in the oral cavity') to which the children were given two response options, 'true' or 'false'. Correct and incorrect responses were scored 1 and 0, respectively. For two of the items the correct response was 'false'. Total individual scores ≥ 5 were categorised as indicating higher knowledge and those <5 as indicating lower knowledge. The KR 20 internal reliability for this measure was computed to be 0.76. Attitudes were assessed by asking the children to rate their agreement with each of six statements (for example, 'Do you agree that frequent tooth brushing increases gum bleeding and gingivitis?') on a three-point rating scale ('disagree', 'not sure', 'agree', scored as 3, 2 and 1 respectively). Three of the items were worded so that agreement indicated a negative attitude, and responses to these items were reverse-scored. Scores ≥ 11 were categorised indicating a more positive attitude and those <11 as indicating a more negative attitude. Cronbach's alpha coefficient (α) was 0.75. Reported oral hygiene practices were assessed by the optional responses of never (score = 1), sometimes (score = 2) or always (score = 3) to seven items (for example, 'I brush my teeth at least twice a day'). Scores ≥ 13 were classified as indicating a higher level of good oral hygiene and scores < 13 were indicative of a lower level. Cronbach's alpha coefficient (α) for this measure was 0.71. The plaque index (PI) of Silness and Loe¹⁹ was used as the clinical and more objective measure of outcome and was assessed on oral examination by two dental nurses at baseline and at the three-month assessment.

The nurses had been previously trained to achieve a high degree of consistency and agreement in the use of the index. Six index teeth [#16, #12 (#52), #24 (#64), #36, #32 (#72), and #44 (#84)] were examined visually using a mouth mirror, an explorer and adequate natural light. No substitution was made for any missing tooth. Index scores ≥ 1 were deemed to indicate poor oral hygiene, and zero scores good oral hygiene. Agreement between the pair of dental nurses was high ($\kappa = 0.86$).

Blinding

The dental nurses who performed the oral examination and the research assistants who structured interview respectively were blinded to the intervention/control group status of the study participants from baseline until the end of the study. The children were also kept unaware of their intervention/control group status. Similarly, the data analysts were blinded to the intervention/control group source of the data with which they worked.

Statistical analysis

The data were analysed using Stata version 10.²⁰ Descriptive statistics were used to summarise the results in terms of frequencies and means (SD), and z tests were used to determine the statistical significance of proportion differences. Because the measures were all binary events (above versus below) and data from the same cluster were likely to be

correlated, multiple logistic regression with a generalised estimating equation (GEE)²¹ with log link function and exchangeable correlation with exponentiation were used to estimate the effect sizes in terms of risk ratios (RR) and their 95% confidence intervals (95%CI) for the comparisons between baseline and the various follow-ups. This approach took into account the confounding effects of gender and age. The statistical significance was set at $p < 0.05$.

Ethical consideration

The trial was approved by the Khon Kaen University Ethics Committee for Human Research (reference number: HE 542288).

Results

The study had recruited a total of 244 children, 125 of which were assigned to the intervention group (MDHE) and 119 to the control group. Almost all the participants in both the intervention and control groups attended the 1-month assessment (99.2% and 96.0%, respectively). Similarly, there were minimal losses of data at the 3-month stage (99.1% and 96.6% attendances, respectively). Since the loss of data was due to school absences, it was assumed that the data were missing completely at random, and no attempt was made to impute missing values. **Table 1** shows that the intervention and control groups did not significantly differ in gender, age or type of school.

Table 1 Distribution of children by gender, age and type of school at baseline

	MDHE (n=125) n (%)	Control (n=119) n (%)	P-value
Gender			
Male	61 (48.8)	69 (58.0)	0.254
Female	64 (51.2)	50 (42.0)	0.339
Age (years)			
7	45 (36.0)	42 (35.3)	0.922
8	46 (36.8)	34 (28.6)	0.450
9	34 (27.2)	43 (36.1)	0.401
Mean (SD)	7.91 (0.79)	8.01 (0.84)	0.338
Type of school (School size)			
A (Small)	37 (29.6)	31 (26.1)	0.748
B (Medium)	42 (33.6)	42 (35.3)	0.869
C (Large)	46 (36.8)	46 (38.6)	0.858

Table 2 presents the categorised rates of children's responses to the knowledge, attitude and oral hygiene practice outcome variables for the intervention (MDHE) and controls over the baseline and later assessments. For the 1- and 3-month assessments, the categorised rates were more favourable in the intervention group than in the controls. At the 1-month assessment all rates in the MDHE group showed major improvements over baseline, but in the controls all the rates were slightly worse. At the 3-month assessment these improvements were largely maintained in MDHE group. In the controls the rates were generally unchanged with only small differences in rates when compared with baseline. At both of the 1- and 3-month assessments the rates for knowledge, attitudes and oral hygiene practice were better in the MDHE group than in the controls.

Table 3 summarises the results of the multiple logistic regression with GEE analysis in terms of effect sizes (RR) for the knowledge, attitude and oral hygiene practice outcome variables. While the RR for knowledge declined between the 1- and 3 month follow-ups, at each stage the RRs showed statistically significant superiority for the intervention group over controls in terms of knowledge, attitudes and oral hygiene practices.

Table 4 shows the rates of children with poor plaque indices (plaque index ≥ 1) in the MDHE and control groups at the baseline and 3-month assessments. Also presented are the results of changes in the plaque index between baseline and 3-months. It is clear that, while the RR showed no significant difference between the two groups at baseline, the RR at 3-months indicates that, when compared with

Table 2 Number and percentage of children by oral health knowledge and attitudes, and practices over the study period in MDHE and control groups

	Distribution of responses (n, %)					
	MDHE			Control		
	Baseline (n=125)	1 month (n=124)	3 months (n=120)	Baseline (n=119)	1 month (n=118)	3 months (n=115)
Oral health knowledge level						
High	92 (73.6)	112 (90.3)	106 (88.3)	83 (69.8)	75 (63.6)	71 (61.7)
Low	33 (26.4)	12 (9.7)	14 (11.7)	36 (30.2)	43 (36.4)	44 (38.3)
Oral health attitude level						
Positive	86 (68.8)	108 (87.1)	114 (95.0)	76 (63.9)	69 (58.5)	71 (61.7)
Negative	39 (31.2)	16 (12.9)	6 (5.0)	43 (36.1)	49 (41.5)	44 (38.3)
Oral hygiene practice level						
High	90 (72.0)	121 (97.6)	115 (95.8)	76 (63.9)	71 (60.2)	75 (65.2)
Low	35 (28.0)	3 (2.4)	5 (4.2)	43 (36.1)	47 (39.8)	40 (34.8)
Oral hygiene status						
Good ^a	52 (41.6)	NA	117 (97.5)	63 (52.9)	NA	77 (66.9)
Poor ^b	73 (58.4)	NA	3 (2.5)	56 (47.1)	NA	38 (33.1)

Note: ^a The grouped variable included good oral hygiene (plaque score = 0); ^b The grouped variable included poor oral hygiene (plaque score ≥ 1); NA = Not applicable.

Table 3 Results of effect sizes (RR) for the knowledge, attitude and oral hygiene practice outcome variables over the study period

	RR (95 % CI)	P-value
1-month follow-up ^a		
Oral health knowledge level		
High	1.45 (1.25, 1.67)	<0.001
Low	1.0	
Oral health attitude level		
Positive	1.54 (1.31, 1.82)	<0.001
Negative	1.0	
Oral hygiene practice level		
High	1.65 (1.42, 1.91)	<0.001
Low	1.0	
3-month follow-up ^a		
Oral health knowledge level		
High	1.43 (1.22, 1.68)	<0.001
Low	1.0	
Oral health attitude level		
Positive	1.60 (1.38, 1.85)	<0.001
Negative	1.0	
Oral hygiene practice level ^b		
High	1.49 (1.30, 1.71)	<0.001
Low	1.0	

Note: ^a The outcomes are estimated by the risk ratio, confidence intervals and significance-values in multiple logistic regression model with GEE for adjusted analyses of gender and age; ^b The outcome is estimated by the risk ratio, confidence intervals and significance-value is adjusted for only age. The group (MDHE and Control) was treated as the independent variable.

Table 4 Number, percentage and estimated effect sizes for impacts of intervention on oral hygiene status at the baseline and 3-month assessment

Oral hygiene status	MDHE	Control	RR (95 % CI) ^c	P-value ^d
Baseline (n, %)				
Good ^a	52 (41.6)	63 (52.9)	0.79 (0.62, 1.02)	0.076
Poor ^b	73 (58.4)	56 (47.1)	1.0	
3-month follow-up (n, %)				
Good ^a	117 (97.5)	77 (66.9)	8.24 (2.75, 24.64)	<0.001
Poor ^b	3 (2.5)	38 (33.1)	1.0	

Note: ^a The outcome variable included good oral hygiene (plaque score = 0); ^b The outcome variable included poor oral hygiene (plaque score ≥ 1); ^c The estimates of the risk ratio and confidence intervals were calculated by event rates; ^d Significance-values adjusted for gender and age.

the controls, the plaque status of the intervention group was significantly and substantially improved and better at the 3-month assessment.

Discussion

The study achieved its objective in so far as the findings demonstrated that a multimodal educational programme involving the use of animated cartoons can be an effective method for improving dental health in children aged 7-9 years. The success of the programme was enhanced by the evidence that these improvements occurred in all the outcome measures, not only in dental knowledge, attitudes to dental care and reported dental hygiene practices, but also in the plaque index which is an objective measure of the outcome of good dental care. This finding, in particular, is an important strength of the study.

The use of animated cartoons in addition to verbal information is considered to be an important feature of the intervention programme. Both dual-coding theory²² and the multimedia principle²³ propose that learning and memory are increased when verbal and non-verbal methods of presentation information are combined. There is strong evidence to support this for learning both procedures and factual information.²⁴ In other words multimedia educational formats are likely to be more beneficial for both learning how best to brush teeth and also for conveying knowledge about oral health. A further and very similar educational model is the concept of an interactive multimodal learning environment.¹⁶ The additional notion supplied by this approach is that learning is further increased when the learner has an opportunity to interact with and change the information presented. Two-way communication occurs between the learner

and the instructors rather than just the usual one-way from instructor to learner. In the present study, this interactive feature of the learning environment was provided by the question-and-answer and discussion sessions. Other features of the education programme which are likely to have played a beneficial role were the incorporation of applications of social cognitive theory, guided practice and modeling.²⁵

There were several limitations to the present study. Firstly, it is not clear whether the results of the present study were due to the added ingredient of non-verbal material, let alone the animations of this. While it seems reasonably clear that a combination of verbal and non-verbal educational messages is likely to be more effective than verbal messages on their own, the best means for conveying the non-verbal material remains an open question, especially to the extent that animation of the non-verbal content adds further value. In a study of children aged 10-11 years, the use of animated cartoons was found to increase knowledge and understanding of difficulty science concepts such as density, but whether the cartoons needed to be animated was not explored.²⁶ Further empirical research is needed to resolve these uncertainties. Secondly, in the present study, the intervention continued until the final assessment at 3-months after baseline. There was therefore no true follow-up. Both the two systematic reviews cited earlier^{8,9} make the point that oral health education programmes often result in a reduction of plaque in the short-term, but not in the long-term; both these reviews cited an earlier systematic review by Kay and Locker²⁷ which came to the same conclusion. The long-term effectiveness of the present multimodal programme needs to be assessed in a future study

and components added which might be expected to make the short-term benefits more durable. On such additional component might be the involvement of parents and caregivers.²⁸

Conclusions and recommendations

The multimodal educational programme used in the present study proved to be a powerful tool for strengthening oral health knowledge, positive attitudes toward dental care and reported oral hygiene practices and for controlling dental plaque. However, further research is needed to explore the role played by the use of animated cartoons and the long-term effectiveness of the programme.

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References

1. Genco RJ, Evans RT, Ellison SA. Dental research in microbiology with emphasis on periodontal disease. *J Am Dent Assoc.* 1969; 78, 1016-36.
2. Pourhashemi SJ, Motlagh MG, Khaniki GRJ. Prevalence and intensity of gingivitis among 6-10 years old elementary school children in Tehran, Iran. *J Med Sci.* 2007; 7, 830-4.
3. Burt B. Research, science and therapy committee of the American academy of periodontology. Position paper: epidemiology of periodontal diseases. *J Periodontol.* 2005; 76, 1406-19.
4. Pauraite J, Milciuviene S, Sakalauskiene J. The prevalence of gingivitis among 4-16 year old schoolchildren in Kaunas. *Stomatol Balt Dent Maxillo Facial J.* 2003; 5, 97-100.
5. Division of Dental Public Health - Thai Ministry of Public Health. The 6th National Oral Health Survey in Thailand 2006-2007. Bangkok, The Veteran Organization Publishing, 2008.
6. Department of Dental Public Health. The report of oral health conditions in Khon Kaen. Khon Kaen, Khon Kaen provincial public health office, 2010.
7. Polson AM. Gingival and periodontal problems in children. *Pediatrics.* 1974; 54, 190-5.
8. Habbu SG, Krishnappa P. Effectiveness of oral health education in children - a systematic review of current evidence (2005-2011). *Int Dent J.* 2015; 65, 57-64, DOI: 10.1111/idj.12137.
9. Nakre PD, Harikiran AG. Effectiveness of oral health education programs: A systematic review. *J Int Soc Prev Community Dent.* 2013; 3, 103-15, DOI: 10.4103/2231-0762.127810.
10. Tai B, Du M, Peng B, Fan M, Bian Z. Experiences from a school-based oral health promotion programme in Wuhan city, PR China. *Int J Paediatr Dent.* 2001; 11, 286-91.
11. Ersin NK, Eden E, Eronat N, Totu FI, Ates M. Effectiveness of 2-year application of school-based chlorhexidine varnish, sodium fluoride gel, and dental health education programs in high-risk adolescents. *Quintessence Int.* 2008; 39, e45-51.
12. Jürgensen N, Petersen PE. Promoting oral health of children through schools - Results from a WHO global survey 2012. *Community Dental Health.* 2013; 30, 204-218.
13. Dale E. Audiovisual methods in teaching. 3rd ed. New York, The Dryden Press, 1969.

14. Perales-Palacios FJ, V'lichez-González JM. The teaching of physics and cartoons: Can they be interrelated in secondary education? *Int J Sci Educ.* 2005; 27, 1647-70.
15. Madden M, Chung PWH, Dawson CW. The effect of a computer-based cartooning tool on children's cartoons and written stories. *Comput Educ.* 2008; 51, 900-25.
16. Moreno R, Mayer R. Interactive multimodal learning environments. *Educ Psychol Rev.* 2007; 19, 309-326. DOI 10.1007/s10648-007-9047-2.
17. Hemming K, Girling AJ, Sitch AJ, Marsh J, Lilford RJ. Sample size calculations for cluster randomised controlled trials with a fixed number of clusters. *BMC Med Res Methodol.* 2011; 11, 1-11.
18. Ukoumunne OC, Gulliford MC, Chinn S, Sterne JA, Burney PG. Methods for evaluating area-wide and organisation-based interventions in health and health care: a systematic review. *Health Technol Assess Winch Engl.* 1999; 3, iii-92.
19. Silness J, Loe H. Periodontal disease in pregnancy II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand.* 1964; 22, 121-35.
20. Stata Corp LP. *Stata Release 10: User's Guide.* College Station TX, Stata Press, 2007.
21. Hilbe J. *Generalized estimating equations.* New York: Chapman & Hall, 2003.
22. Paivio A. *Mental representations.* New York, Oxford University Press, 1986.
23. Fletcher JD, Tobias S. The multimedia principle. In RE Mayer (ed). *The Cambridge handbook of multimedia learning.* New York, Cambridge University Press, 2005.
24. Brunye TT, Taylor HA, Rapp DN. Repetition and dual coding in procedural multimedia presentations. *Applied Cognitive Psychology.* 2007; 22, 877-895.
25. Bandura A. *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ, Prentice-Hall, 1986.
26. Dalacosta K, Kamariotaki-Paparrigopoulou M, Palyvos JA, Spyrellis N. Multimedia application with animated cartoons for teaching science in elementary education. *Computers & Education.* 2009; 52, 741-748.
27. Kay EJ, Locker D. Is dental health education effective? A systematic review of current evidence. *Community Dent Oral Epidemiol.* 1996; 24, 231-5.
28. Saied-Moallemi Z, Virtanen JI, Vehkalahti MM, Tehranchi A, Murtomaa H. School-based intervention to promote preadolescents' gingival health: a community trial. *Community Dent Oral Epidemiol.* 2009; 37, 518-26.