SCIENTIFIC RESEARCH REPORT

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Effectiveness of fluoride varnish on caries in the first molars of primary schoolchildren: a 3-year longitudinal study in Guangxi Province, China

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Aims: To evaluate the effectiveness of 5% sodium fluoride varnish on caries in first permanent molars and to assess the suitability of using this method to control caries among children in rural areas of Guangxi province, China. **Methods:** A total of nine schools with 32 classes were selected by simple random sampling. There were 999 students in the experimental group and 1,004 in the control group. The experimental group received oral health education and topical application of 5% sodium fluoride varnish, while the control group received oral health education only. Dental examinations were performed in November 2014 and November 2017, and the modified International Caries Detection and Assessment System (ICDAS-II) was used to record the caries status of the first permanent molars. The data were entered into SPSS 22 for statistical analysis. **Results:** A total of 1,748 students (853 in the experimental group and 895 in the control group) completed the study. After 3 years of intervention, the experimental group had a lower prevalence of caries, a lower caries increment, a lower decayed, missing and filled teeth (DMFT) index and a lower decayed, missing and filled surfaces (DMFS) index compared with the control group (respectively: 58.9% *vs* 65.5%, 34.8% *vs* 42.1%, 1.38 *vs* 1.59 and 2.06 *vs* 2.38). All the differences were statistically significant ($P < 0.05$). **Conclusion:** In this study population, twice-yearly application of 5% sodium fluoride varnish and oral health education were more effective for preventing caries in first permanent molars than oral health education alone. The implementation of fluoride varnish application as a public health measure in schools in rural areas is recommended.

Key words: *Fluoride varnish, first molars, caries prevention, schoolchildren*

INTRODUCTION

Dental caries is a common oral disease among schoolchildren, and it affects children's oral health and quality of life[1,2]. The World Health Organization (WHO) reports that dental caries affects approximately 60%–90% of schoolchildren[3]. The results of the 4th National Oral Health Survey in 2015, in China[4], showed that the prevalence of caries in 12-year-old children was 38.5%, an increase of 11.8% since 2005. The first molar is the first permanent tooth to erupt in the mouth, and is more likely to develop dental caries than other tooth types as a result of the presence of deep pits and fissures on the tooth surface and poor oral hygiene[5]. Hence, it is necessary to undertake preventive strategies to reduce caries in the first permanent molars of children.

Pit and fissure sealants and fluoride varnish can effectively prevent dental caries[6,7]. Pit and fissure sealants have been shown to be more effective than fluoride varnish for preventing caries on occlusal surfaces[8]. Fissure sealants form a physical barrier that prevents bacterial growth and the accumulation of food particles, which can result in dental decay in the grooves of molars. Adequate moisture control is a prerequisite for successful sealants[9]. Therefore, newly erupted molar teeth are not suitable for pit and fissure sealants because of the difficulty in controlling moisture and gingival crevicular fluid in young children.

Fluoride varnish was developed in the 1960s and has been shown to be effective for preventing dental caries in both the primary and permanent teeth of children and adolescents[7]. The positive characteristics of fluoride varnish include adequate safety, good toleration by patients, long contact time on the tooth surface and the release of fluoride ions that inhibit demineralisation and enhance remineralisation[10,11].

Duraphat® (Colgate Palmolive, Ltd., Colgate Plamolive China, Guangzhou, China) varnish, containing 5% sodium fluoride, has been available for 50 years and has been widely used in comprehensive oral health programmes in many countries[12]. However, this product was not approved in China until 2012. To date, there have been few trials evaluating the effect of fluoride varnish on caries in the first permanent molars of children and adolescents in China. There is a higher prevalence of caries in 12-year-old schoolchildren (42.4%) in Guangxi province, than in other regions in China[13]. There are no university-educated dentists in many towns and villages in Guangxi, and children living in remote isolated areas with poor infrastructure have limited access to dental services. Therefore, public health approaches are required to reduce dental caries and improve the oral health of children living in rural areas of Guangxi province.

The aims of this study were therefore to evaluate the effect on caries of 3 years of application of fluoride varnish onto the newly erupted first permanent molars of children attending schools in rural areas of Guangxi and to assess the suitability of this method as part of a dental public health programme. The null hypothesis was that the anti-caries effect of fluoride varnish combined with oral health education did not differ from that of oral health education alone.

MATERIALS AND METHODS

Sampling

The present study was a randomised controlled trial conducted from 10 November 2014 to 06 November 2017. The sample size was calculated using PASS software 11.0 (NCSS, LLC, Kaysville, UT, USA). The incidence of caries was estimated to be 15% in the control group and 9% in the experimental group, with a significance level of 95% and 1−beta of 90%. A minimum sample size of 615 subjects was required for each group. To allow for the loss of subjects during the 3 years of the study, the final sample size of the study was 1,000 in each group. A total of nine schools with 32 classes were selected from 325 schools in the town by using simple random sampling. All students in the 32 classes were study participants. Those who agreed to take part in the study were recoded according to their student ID. A random number was generated for each student; those with a random number higher than the median were assigned to the experimental group and those with a random number lower than the median were assigned to the control group. Initially, 1,040 children were selected for each group. However, as 77 students refused to take part in this study, ultimately 999 students were included in the experimental group and 1,004 in the control group. Children with systemic diseases, a long history of medication use and a history of allergies were excluded. Ethical approval was granted by the Ethics Review Committee of the Chinese Stomatological Association. Informed consent was provided by the parents and the children, and the parents signed the consent. The consent procedure was approved by the Ethics Committee. The research was conducted in full accordance with the World Medical Association Declaration of Helsinki.

Intervention

The experimental group received oral health education and topical application of 5% sodium fluoride varnish to their first permanent molars twice a year, while the control group only received oral health education twice a year. All interventions were performed in the classrooms, and the examiners knew the group to which each child was assigned when they performed the examinations.

Topical application of fluoride varnish was performed by two trained dentists from the Hospital of Stomatology, Guangxi Medical University. Five percent sodium fluoride varnish (Duraphat®) was applied to all teeth, including the first permanent molars, in the experimental group. After brushing, the teeth were dried with cotton rolls, and 0.4 ml of fluoride varnish was applied to all the surfaces of the first molars using a disposable brush. The children who received fluoride varnish were instructed to avoid drinking for half an hour, not to chew hard foods for 4 hours and not to brush their teeth until the next day.

Oral health education for both groups included advice on healthy diet and oral hygiene and was provided by the same dentist. Fresh fruit and vegetables, instead of candy and soft drinks, were suggested to protect the teeth and keep the children healthy. In addition, the duration and method of toothbrushing were taught to the students using a tooth model. All students were provided with free fluoride toothpaste throughout the project and were asked to brush their teeth twice daily (morning and evening). The concentration of fluoride in the toothpaste was 600 ppm, and compliance with use of the toothpaste provided and the recommended toothbrushing frequency were checked regularly.

Dental examinations

Dental examinations were conducted at baseline (November 2014) and after 36 months (November 2017) to record the caries status of the first permanent molars. The examinations were performed using disposable mouth mirrors attached to an intra-oral light and CPI probes. Toothbrushing was required before the examinations. The caries status of each surface of

the first permanent molars was recorded according to the modified International Caries Detection and Assessment System II (ICDAS-II)[14]. In the modified ICDAS-II system, code 0 is defined as 0, codes 1–3 as 1, codes 4–5 as 2, and code 6 as 3. Codes 4–8 have been added to the modified ICDAS-II system (*Table 1*). All dental examinations and records were completed by two dental clinicians from the Hospital of Stomatology, Guangxi Medical University. Both inter- and intra-examiner reliability for assessing coronal caries were checked. To assess inter-examiner reliability, 30 subjects were each examined by three examiners, with the main examiner acting as the gold standard. To assess intra-examiner reliability, 101 subjects (approximately 5% of the total sample) were examined twice by the same examiner, during the two sessions, 1 week apart. The kappa values for inter-examiner agreement were 0.91 and 0.85, and those for intra-examiner agreement were 0.89 and 0.84. Prior to the 3-year follow-up, the calibration was repeated and also showed a very good level of consistency.

Statistical analysis

All data were double-entered into Microsoft Corporation (Redmond, WA, USA) and statistical analysis was carried out using IBM SPSS Statistics for Windows (Version 22.0; IBM Corp., Armonk, NY, USA). If one of the five surfaces of the first permanent molar was coded as 1–5, the tooth was classified as having dental caries. Sound surfaces at baseline that developed enamel decay, dentine decay or dentine decay close to the pulp after 3 years, were classified as ND01, ND02, or ND03, respectively. The variables that were recorded included prevalence (subjects with caries/all subjects × 100%), incidence (subjects with new caries/all subjects × 100%), decayed, missing and filled teeth (DMFT) index (number of all decayed teeth/all subjects), decayed, missing and filled surface (DMFS) index (number of all decayed surfaces/all subjects) and rate of ND01, ND02 and ND03 classifications (number of ND01, ND02 or ND03 surfaces/all surfaces × 100%). In addition, the incidence of caries in fissures and proximal surfaces (number of new occlusal, buccal and lingual surfaces with caries/all occlusal, buccal and lingual surfaces × 100%; number of new mesial and distal surfaces with caries/all mesial and distal surfaces × 100%) and in maxillary and mandibular first permanent molars (number of new maxillary molars with caries/all maxillary first molars × 100%; number of new mandibular molars with caries/all mandibular first molars × 100%) were also calculated. The chi-square test was used to compare the prevalence and incidence of caries, the rates of ND01, ND02 and ND03, and the incidence of caries in fissures and proximal surfaces and in maxillary and mandibular first permanent molars, between the two groups. The *t*-test was used to compare DMFT and DMFS between the two groups. For all statistical analyses, significance was considered at $P < 0.05$. The number needed to treat (NNT) with fluoride to gain one caries-free case compared with no fluoride was calculated as follows:

$$\mathrm{NNT} = \frac{1}{(\text{the prevalence of caries when not using fluoride} - \text{the prevalence of caries when using fluoride})}$$

Table 1 Description of the International Caries Detection and Assessment System (ICDAS-II) and modified ICDAS-II coding criteria

ICDAS-II		Modified ICDAS-II	
Code	Definition	Code	Definition
0	Sound	0	Sound
1	First visual change in enamel	1	Enamel decay
2	Distinct visual change in enamel		
3	Localised enamel breakdown (without clinical visual signs of dentinal involvement)		
4	Underlying dark shadow from dentin	2	Dentin decay
5	Distinct cavity with visible dentin		
6	Extensive distinct cavity with visible dentin	3	Dentin decay close to pulp
		4	Filled, sound
		5	Missing due to caries
		6	Sealed
		7	Unerupted
		8	Unrecorded

RESULTS

A total of 2003 children were included in the study at baseline. After 3 years, 255 children were lost to the study because they had transferred to other schools. The 255 children who dropped out lived in the same county, and their social class was similar to that of those who completed the study. The caries prevalence at baseline in the children who dropped out was 24.8%, and there was no significant difference between these children and those who completed the study.

A total of 1,748 children were assessed after 3 years, and their results were included in the statistical analysis. The final response rate was 87.3%. After 3 years, there were 853 children (467 male and 386 female) in the experimental group and 895 (482 males and 413 females) in the control group. There was no statistically significant difference in the gender distribution between the experimental and control groups

($P > 0.05$). A flow chart of the study is presented in *Figure 1*.

At baseline, the total number of unerupted first molars was 1,637 (1,147, 487 and 3 among 6-, 7- and 8-year-old children, respectively). After 3 years, all first permanent molars had erupted in all children. During the study, fluoride varnish was applied to all newly erupted first permanent molars. At baseline,

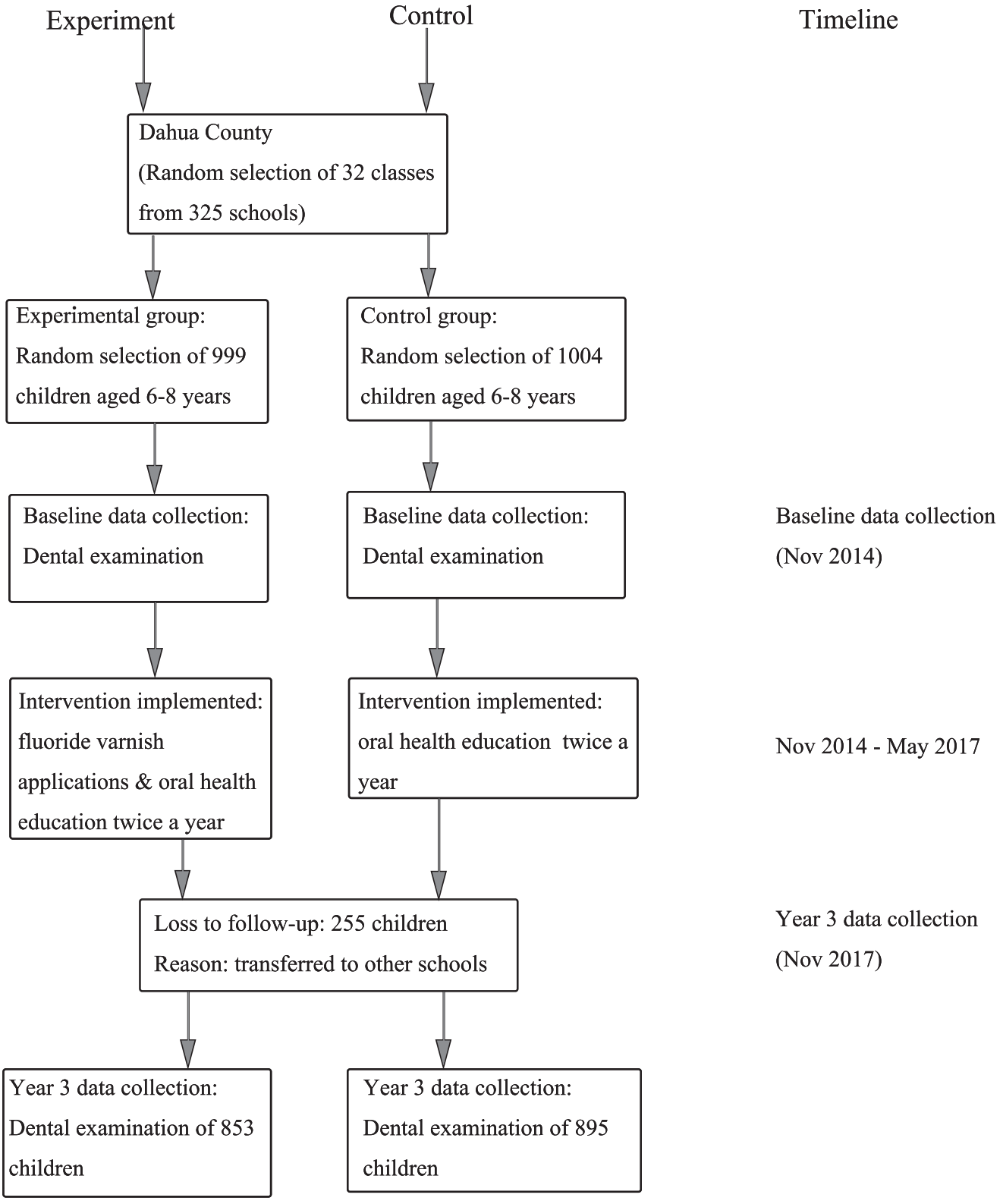

Figure 1 Flowchart of the study.

differences in the prevalence of caries and DMFT and DMFS scores in the first permanent molars of both groups were not statistically significant ($P > 0.05$). However, after 3 years of intervention, the prevalence of caries and DMFT and DMFS scores in the experimental group (58.9%, 1.38, 2.06, respectively) were significantly lower ($P < 0.05$) than those in the control group (65.5%, 1.59, 2.38, respectively). The incidence of caries in the two groups was 34.8% and 42.1%, respectively, and the difference was statistically significant ($P = 0.002$; *Table 2*).

After 3 years of intervention, the first permanent molars with sound surfaces that had deteriorated were categorised as ND01, ND02 or ND03, and the respective proportions were significantly lower in the experimental group (4.4%, 0.7% and 1.4) than in the control group (5.1%, 1.0% and 1.7%) ($P < 0.05$; *Table 3*).

At baseline, the differences between the experimental and control groups in the prevalence of fissures and proximal, maxillary and mandibular caries in the first permanent molar were not statistically significant ($P > 0.05$). After 3 years of intervention, the incidence of pit and fissure caries in the first permanent molars of the experimental group was statistically lower than that of the control group (10.9% vs. 14.1%) ($P < 0.05$). The incidence of proximal caries in the experimental group was lower than that in the control group (1.9% vs. 2.0%), but the difference was not statistically significant ($P > 0.05$; *Table 4*). In addition, the caries incidence in the maxillary and mandibular first permanent molars in the experimental group (18.9% and 27.4%, respectively) was significantly lower ($P < 0.05$) than that in the control group (22.5% and 35.5%, respectively) (*Table 4*).

Regarding the cost-effectiveness of application of fluoride varnish, $3978.73 was spent on the fluoride varnish and caries was prevented in a total of 179 first permanent molars in the experimental group, compared with the control group. Therefore, it was calculated that in this study it costs $22.23 to prevent one first permanent molar from developing caries. The NNT to gain one caries-free case was 15.2. Furthermore, no side effects or adverse events were reported by students during the 3 years of the study.

Table 3 Decay in tooth surfaces after intervention

Variable	Type of decay		
	ND01	ND02	ND03
Study group (*N*)			
Experimental (n = 17,060)	4.4 (746)	0.7 (116)	1.4 (231)
Control (n = 17,900)	5.1 (914)	1.0 (186)	1.7 (309)
Statistical data			
χ^2	10.386	13.157	7.958
P	**0.001**	**<0.001**	**0.005**

Data are presented as % (n).
The bold values indicated the differences between two groups were statistically significant.
Sound surfaces at baseline, which developed enamel decay, dentine decay or dentine decay close to the pulp after 3 years, were classified as ND01, ND02 or ND03, respectively.
A chi-square test was used to compare differences between the two groups ($P < 0.05$).

DISCUSSION

At present, topical application of fluoride, including the use of fluoride gel, fluoride foam and fluoride varnish, is one of the most widely used anti-caries measures. Studies have confirmed that fluoride varnish has a higher safety index[15], a shorter application time and greater acceptance by patients than fluoride gel and fluoride foam[16]. In this study, 5% sodium fluoride varnish (Duraphat®), with a concentration of 2.26% fluoride ions, was used to coat the surfaces of the first permanent molars in schoolchildren twice yearly, and after 3 years the anti-caries effect was evaluated.

Table 2 Prevalence of caries, mean decayed, missing and filled teeth (DMFT) score and mean decayed, missing and filled surfaces (DMFS) score in 2014 and 2017, and incidence of caries of the first permanent molars of the study children according to group

Year	Study groups (*N*)	Prevalence*	*P* 1	DMFT†	*P* 2	DMFS†	*P* 3	Incidence*	*P* 4
2014	Experimental (853)	24.0 (205)	0.738	0.46 ± 0.93	0.590	0.60 ± 1.38	0.285	–	–
	Control (895)	23.4 (209)		0.43 ± 0.90		0.53 ± 1.20		–	–
2017	Experimental (853)	58.9 (502)	**0.004**	1.38 ± 1.43	**0.002**	2.06 ± 2.58	**0.009**	34.8 (297)	**0.002**
	Control (895)	65.5 (586)		1.59 ± 1.47		2.38 ± 2.68		42.1 (377)	

N, number of children.
Data are presented as % (n) and mean ± SD.
The bold values indicated the differences between two groups were statistically significant.
P 1 = *P* value for Chi-square test difference in prevalence between two group.
P 2 = *P* value for *t*-test difference in DMFT between two group.
P 3 = *P* value for *t*-test difference in DMFS between two group.
P 4 = *P* value for Chi-square test difference in incidence between two group.
*Chi-square test.
†The *t*-test was used to compare differences between two groups ($P < 0.05$).

Table 4 Incidence of caries in fissures and proximal surfaces and in maxillary and mandibular first permanent molars (FPMs) in the two study groups after intervention

Variable	Site of caries			
	Fissure	Proximal surface	Maxillary FPM	Mandibular FPM
Study group				
Experimental	10.9 (1113)	1.9 (131)	18.9 (322)	27.4 (467)
Control	14.1 (1511)	2.0 (146)	22.5 (402)	35.5 (636)
Statistical analyses				
χ^2	48.898	0.257	6.831	26.91
P	**<0.001**	0.612	**0.009**	**<0.001**

Data are presented as % (*n*).
The bold values indicated the differences between two groups were statistically significant.
A chi-square test was used to compare differences between the two groups ($P < 0.05$).

The study found that, after 3 years, the prevalence and incidence of dental caries in the first permanent molars of the experimental group were significantly lower than in those of the control group, indicating that the topical application of fluoride varnish was effective for preventing caries of the first permanent molars. A previous study[17] reported that the DMFT score of 12-year-old children decreased continuously, from 2.77 to 1.64, after twice-yearly application of fluoride varnish for 1 year. An earlier Spanish study[18] evaluated the anti-caries effect of fluoride varnish on the first permanent molars, and the results showed that the incidence of caries in the first permanent molars decreased by 43.9% after fluoride application. In addition, a Cochrane review, in which a fluoride application group was compared with a control group, concluded that the topical application of fluoride varnish could reduce the DMFS score of the permanent dentition by 43% (95% CI: 0.3–0.57, $P > 0.0001$)[19]. In the current study, after 3 years of intervention, the rates of new caries at the ND01, ND02 and ND03 levels in the first permanent molars that had sound surfaces at baseline were lower in the experimental group than in the control group ($P < 0.05$). All these findings indicate that topical application of fluoride varnish was more effective for preventing dental caries than oral hygiene and dietary control alone. After 3 years of intervention, the incidence of dental caries was still relatively high, probably because as children grow older, and have more control over money, they have increased opportunities to use that money to buy snacks, which might increase the risk of dental caries developing.

Studies have confirmed that fluoride varnish can effectively prevent caries in pits and fissures and on proximal surfaces[20–23]. One of these studies[20] was a randomised controlled trial involving 501, 9-year-old children with deep-fissure or early pit and fissure caries of the first permanent molars. The results showed that only 2.4% of pit and fissure caries in the first permanent molars progressed to dentin caries in the fluoride group compared with 4.6% in the control group, indicating that topical application of fluoride varnish can also effectively prevent pit and fissure caries in first permanent molars[20]. Another study[21] found that following application of fluoride varnish, the DMFT score was 0.95 in the fluoride group and 3.05 in the control group, indicating that fluoride varnish can also effectively prevent the occurrence of proximal caries.

In the current study, the incidence of pit and fissure caries in the experimental group was significantly lower than that in the control group, while the incidence of proximal caries only decreased slightly ($P > 0.05$). Therefore, it can be speculated that, in the present study, the preventive effect of fluoride varnish on pit and fissure caries was better than that on proximal caries. The reason for the relatively poor prevention of proximal caries may be that it is difficult to apply fluoride varnish to the adjacent surfaces of teeth, especially the adjacent contact area, with a brush. A previous study[21] used a 1.2-ml syringe with a tiny needle tip, which is more conducive to applying fluoride varnish to the adjacent contact area. Considering the economic factors and the convenience of applying fluoride varnish in a school campus environment, it may be better to apply fluoride varnish to the adjacent surface with a brush combined with dental floss. After 3 years, the incidence of dental caries in both the maxillary and mandibular first permanent molars was significantly lower in the experimental group than in the control group. This may be a result of the release of fluoride ions from Duraphat® varnish, which forms a protective film after contact with saliva[24]. Thus, fluoride varnish had a good anti-caries effect on the maxillary and mandibular first permanent molars.

It was calculated that in the current study it costs $22.23 to prevent caries in a first permanent molar. According to standard local charges in Guangxi, a filling to restore a carious tooth costs $21.06 and a root canal treatment followed by a full-crown restoration

costs $184.20. Therefore, in the current study, fluoride varnish was easy to apply and economical regarding caries prevention in first permanent molars. The implementation of fluoride varnish application as a public health measure in schools in rural areas is therefore recommended.

There were several limitations to the study which must be addressed. First, it was not placebo-controlled, and the experimental group treated with fluoride varnish may have received more 'oral health reminders'. Accordingly, it might have been better to treat the control group with a placebo to reduce the errors. Second, the study was neither single- nor double-blinded, which might influence the evaluation of fluoride varnish application, leading to more favourable outcomes. Third, the molar teeth erupted at different time points during the intervention period and this may have introduced bias. These limitations should be avoided in any future study.

In conclusion, in the current study, the topical application of 5% fluoride varnish helped to prevent dental caries in the first permanent molars of schoolchildren. In addition, the fluoride varnish was easy to apply, and was safe, effective and suitable for use among large numbers of young children on a school campus. Therefore, the null hypothesis can be rejected. Fluoride varnish was very suitable for use in schools in rural areas and, if necessary, can be applied by health workers, other than dentists or dental hygienists, if there is a shortage or absence of dental professionals. The implementation of fluoride varnish application as a public health measure in schools in rural areas is therefore recommended.

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Conflicts of interest

The authors have no conflicts of interest.

Author contributions

Shanshan Wu collected and analysed the data and wrote part of paper. Tingting Zhang analysed the data and wrote part of the paper. These authors contributed equally to the paper and should be regarded as co-first authors. Qiulin Liu collected the data. Xueting Yu analysed the data. Xiaojuan Zeng designed the study, wrote the paper and revised the manuscript. All the authors discussed the results and revised the manuscript.

REFERENCES

1. Bagramian RA, Garcia-Godoy F, Volpe AR. The global increase in dental caries. A pending public health crisis. *Am J Dent* 2009 22: 3–8.
2. Mota-Veloso I, Soares ME, Alencar BM *et al*. Impact of untreated dental caries and its clinical consequences on the oral health-related quality of life of schoolchildren aged 8–10 years. *Qual Life Res* 2016 25: 193–199.
3. World Health Organization. *Global Oral Health Data Bank*. Geneva: WHO; 2016.
4. Quan JK, Wang XZ, Zheng SG *et al*. Permanent teeth caries status of 12- to 15-year-olds in China: findings from the 4th national oral health survey. *Chin J Dent Res* 2018 21: 181–193.
5. Wang JD, Chen X, Chen Z *et al*. Dental caries and first permanent molar pit and fissure morphology in 7- to 8-year-old children in Wuhan, China. *Int J Oral Sci* 2012 4: 157–160.
6. Ahovuo-Saloranta A, Forss H, Walsh T *et al*. Pit and fissure sealants for preventing dental decay in permanent teeth. *Cochrane Database Syst Rev* 2017 31: CD001830.
7. Marinho VCC, Worthington HV, Walsh T *et al*. Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2013 11: CD002279.
8. Ahovuo-Saloranta A, Forss H, Hiiri A *et al*. Pit and fissure sealants versus fluoride varnishes for preventing dental decay in the permanent teeth of children and adolescents. *Cochrane Database Syst Rev* 2016 18: CD003067.
9. Schlueter N, Klimek J, Ganss C. Efficacy of a moisture-tolerant material for fissure sealing: a prospective randomised clinical trial. *Clin Oral Investig* 2013 17: 711–716.
10. Gugwad SC, Shah P, Lodaya R *et al*. Caries prevention effect of intensive application of sodium fluoride varnish in molars in children between age 6 and 7 years. *J Contemp Dent Pract* 2011 12: 408–413.
11. Petersson LG. Fluoride mouth rinses and fluoride varnishes. *Caries Res* 1993 27: 35–42.
12. Azarpazhoon A, Main PA. Fluoride varnish in the prevention of dental caries in children and adolescents: a systematic review. *J Can Dent Assoc* 2008 74: 73–79.
13. Qi X. *Third National Oral Health Survey Report*. Beijing: People's Medical Publishing House; 2008. p. 11–17.
14. Ismail AI, Tellez M, Pitts NB *et al*. Caries management pathways preserve dental tissues and promote oral health[J]. *Community Dent Oral Epidemiol* 2013 41: e12–e40.
15. Hawkins R, Locker D, Noble J *et al*. Prevention. Part 7: professionally applied topical fluorides for caries prevention. *Br Dent J* 2003 195: 313–317.
16. Hawkins R, Noble J, Locker D *et al*. A comparison of the costs and patient acceptability of professionally applied topical fluoride foam and varnish. *J Public Health Dent* 2004 64: 106–110.

17. Dohnke-Hohrmann S, Zimmer S. Change in caries prevalence after implementation of a fluoride varnish program. *J Public Health Dent* 2004 64: 96–100.
18. Bravo M, Baca P, Llodra JC *et al*. A 24-month study comparing sealant and fluoride varnish in caries reduction on different permanent first molar surfaces. *J Public Health Dent* 1997 57: 184-186.
19. Marinho VCC, Higgins JPT, Sheiham A *et al*. Combinations of topical fluoride (toothpastes, mouth rinses, gels, varnishes) versus single topical fluoride for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2004 1: CD002781.
20. Liu BY, Lo EC, Chu CH *et al*. Randomized trial on fluorides and sealants for fissure caries prevention. *J Dent Res* 2012 91: 753–758.
21. Moberg Sköld U, Petersson LG, Lith A *et al*. Effect of school-based fluoride varnish programmes on approximal caries in adolescents from different caries risk areas. *Caries Res* 2005 39: 273–279.
22. Arruda AO, Senthamarai Kannan R, Inglehart MR *et al*. Effect of 5% fluoride varnish application on caries among school children in rural Brazil: a randomized controlled trial. *Community Dent Oral Epidemiol* 2012 40: 267–276.
23. Kalnina J, Care R. Prevention of occlusal caries using a ozone, sealant and fluoride varnish in children. *Stomatologija* 2016 18: 26–31.
24. Seppä L. Effect of dental plaque on fluoride uptake by enamel from a sodium fluoride varnish in vivo. *Caries Res* 1983 17: 71–75.

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