Effectiveness Of Varnish Fluoride Among Preschool-Aged Children In Preventing Early Childhood Caries

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ABSTRACT

Objectives: This study aimed to evaluate the effectiveness of varnish fluoride among preschool-aged children in preventing early childhood caries.

Methods: A quasi-experiment study, comprising pre- and post-test controlled groups, was conducted at four public preschools in Phu Ly city, Ha Nam province. Children with an age range of 36 to 47 months at the time of the study were invited to participate. A total of 430 children (208 intervention groups and 222 control groups) participated in the study. The intervention group received varnish fluoride (5% NaF) and basic oral health care instruction, while the control group received basic oral health care instruction. The Generalized Estimating Equations (GEE) regression model was utilized in measuring the interventions' effectiveness on dental caries.

Results: The overall rate of primary ECC was 71.2% in the intervention group and 80.2% in the control group at baseline. The rate of ECC in the intervention group decreased to 66.8% after 6 months and 62.0% after 12 months, while the rate in the control group increased to 86.6% atfer 6 months and 89.2% after 12 months. The rate of ECC level D1-D2 and D3 in the intervention arm was significantly lower than the control arm after 6 and 12 months ($p<0.05$). The DMFT index reduced from 3.69 (SD=3.83) at baseline to 3.45 (SD=3.72) after 6 months and 3.07 (SD=3.40) after 12 months ($p<0.04$). Meanwhile, in the control arm, the DMFT index increased from 5.73 (SD=4.88) at baseline to 7.81 (SD=4.92) after 12 months ($p<0.05$). Overall, children receiving the intervention had a risk of ECC 0.33 times (OR=0.33; 95%CI=0.21-0.51) compared to children who did not receive intervention.

Conclusion: This study indicated that the use of of 5% NaF varnish fluoride demonstrates efficacy in mitigating dental caries progression among preschool-aged children.

Keywords: varnish fluoride, preschool, children, dental caries

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INTRODUCTION

Early childhood caries (ECC) is a complex oral disease that commonly affects the maxillary primary incisors soon after eruption and can rapidly spread to other primary teeth. ECC is a global public health problem with important behavioral, social, and dental implications, affecting infants and young children worldwide. In 2003, the American Academy of Pediatric Dentistry defined ECC as the presence of one or more decayed, missing due to caries, or filled tooth surfaces in any primary tooth in children aged 71 months or younger. The presence of smooth surface caries in children under three years of age is considered a sign of severe ECC [1].

ECC is one of the most common diseases in children globally [2]. A large-scale synthesis of data from 86 countries reported that the prevalence of ECC among children aged 3–5 years was 57.3% [3]. In contrast, in many developed countries, ECC prevalence ranges from 1% to 12% [4]. Another global analysis covering 193 countries during the period 2007–2017 showed that ECC prevalence among children aged 36–71 months was highest in East Asia and the Pacific (68.7%) and the Middle East and North Africa (66.2%), and lowest in Europe and Central Asia (43.9%). It was estimated that approximately 173.5 million children in this age group were affected by ECC, with more than 50% prevalence reported in 55

countries [5]. These findings indicate marked differences in ECC prevalence between developed and developing countries, as well as across socioeconomic regions within the same country.

Untreated dental caries leads to progressive destruction of tooth structure and is often associated with pain, discomfort, and reduced quality of life in children. In developed countries, the treatment and restoration of decayed primary teeth require considerable time, financial resources, and professional effort. Given the high prevalence of ECC and its negative impact on child health, prevention is a major priority in pediatric dentistry. Fluoride therapy has been a key component of caries prevention for nearly seven decades, particularly following the introduction of water fluoridation programs [6]. Fluoride varnish is a topical fluoride supplement with several advantages, including reduced risk of fluorosis and prolonged contact time between fluoride and tooth enamel [7]. Fluoride varnish forms a protective film on the tooth surface, helping to prevent enamel demineralization caused by bacterial acids and to slow the progression of caries. Evidence suggests that fluoride varnish is an effective, safe, and convenient method for the prevention and early management of dental caries in children, with high levels of acceptance [7].

In recent decades, Vietnam has made notable progress in improving public health. However, effective oral health strategies remain limited, and existing preventive measures have not fully met population needs [8]. Previous studies have reported a high prevalence of dental caries among Vietnamese children aged 2–5 years, reaching 89.1% [9]. Despite this high burden, evidence on the use of fluoride varnish among preschool children in Vietnam remains limited. Therefore, this study aimed to evaluate the effectiveness of fluoride varnish in preventing early childhood caries among preschool-aged children.

MATERIALS AND METHODS

Study setting and participants

A quasi-experimental study with pre-test and post-test control groups was conducted at four public preschools in Phu Ly city, Ha Nam province. Children aged 36–47 months who were attending these preschools at the time of the study were invited to participate. Exclusion criteria were as follows: (1) children not living with their parents; (2) history of allergy to fluoride varnish; (3) current use of medications that interact with fluoride; (4) prior application of fluoride varnish for less than six months; (5) presence of dental diseases requiring treatment; and (6) lack of parental consent.

Two sampling lists were prepared, including rural communes and urban wards in Phu Ly city. From each list, two communes or wards were randomly selected, resulting in four study sites (two rural and two urban). In each selected area, one preschool was randomly chosen. The selected schools were comparable in terms of student characteristics, educational conditions, infrastructure, and teaching staff. A list of eligible children from the four schools was then compiled. Children were assigned to either the intervention group (fluoride varnish application combined with basic oral health education) or the control group (basic oral health education only). Each group included children from one rural school and one urban school.

A total of 430 children were enrolled, including 208 in the intervention group and 222 in the control group. At the 6-month follow-up, 420 children were reassessed (97.7%; 202 intervention and 218 control). At the 12-month follow-up, 414 children were reassessed (96.3%; 200 intervention and 214 control). All losses to follow-up were due to children transferring to other schools.

Intervention procedure

Children in the intervention group received supervised toothbrushing instruction at school, and toothpaste was directly provided by a dentist. Fluoride varnish was applied according to the manufacturer's instructions. A volume of 0.4 mL was used for the entire dental arch. The varnish was applied evenly to all tooth surfaces using a single-use cotton applicator, avoiding contact with soft tissues. The application procedure lasted approximately 3–4 minutes. Children were instructed not to eat or brush their teeth for two hours after application. Parents were informed about temporary tooth discoloration associated with 5% sodium fluoride varnish. Both intervention and control groups received basic oral health education using visual materials.

Data measurement

Dental caries status was assessed based on caries classification (D0–D3), onset time, extent of caries, and changes before and after intervention. A Diagnodent KaVo 2190 laser device was used following the manufacturer's instructions, using the Di

index. Caries assessment, including early lesions, was based on the International Caries Detection and Assessment System (ICDAS) criteria [10]. ICDAS classifies caries into six codes ranging from sound tooth structure to extensive cavities with visible dentine.

Diagnodent scores ranged from 0 to 99 and were categorized into four ECC levels. D0 indicated no caries (Di index 0–13). D1 represented mild caries (Di index 14–20). D2 indicated moderate caries (Di index 21–29). D3 reflected severe caries (Di index ≥30). The decayed, missing, and filled teeth (dmft) index was used to record the total number of affected primary teeth. Assessments were conducted at baseline, 6 months, and 12 months.

Statistical analysis

Data were entered using Epidata 3.1, cleaned, and linked across time points using individual identification codes. Statistical analysis was performed using STATA 14.0. Descriptive statistics were used to summarize frequencies, percentages, means, standard deviations, and ranges. The chi-squared test and Kruskal–Wallis test were applied to compare caries prevalence between groups and over time. The effectiveness of the intervention was evaluated using a generalized estimating equations (GEE) regression model, which accounted for repeated measurements over time. Statistical significance was set at $p < 0.05$.

Ethical approval

The study was conducted in accordance with ethical standards approved by the Ethics Committee of Hanoi University of Public Health (Code: 229/2020/YTCC-HD3). Participation was voluntary. Parents were fully informed about the study objectives and procedures and were invited to provide written informed consent before any data collection was conducted. All personal information was coded and used solely for research purposes to ensure confidentiality. Participants did not receive financial incentives, and no costs were incurred for pediatric oral health examinations. Both parents were provided with an information sheet and were required to sign the consent form for their child's participation.

RESULTS

At baseline, a total of 430 children were included in the analysis. Among them, 59.0% (n = 254) were boys, and 63.3% (n = 272) lived in urban areas. As shown in Table 1, before the intervention, the prevalence of primary early childhood caries (ECC) was 71.2% in the intervention group and 80.2% in the control group. After 6 months, ECC prevalence decreased to 66.8% in the intervention group but increased to 86.6% in the control group. After 12 months, ECC prevalence further decreased to 62.0% in the intervention group, whereas it continued to increase to 89.2% in the control group. The change in ECC prevalence in the control group between baseline and 12 months was statistically significant across demographic subgroups ($p < 0.05$).

Table 1. Rate of primary tooth decay in children before and after intervention

Group	Baseline		After 6 months			After 12 months		
	n	(%)	n	(%)	p*	n	(%)	p**
Total								
Intervention group	148	71.2	135	66.8	0.34	124	62.0	0.05
Control group	182	80.2	188	86.6	0.07	190	89.2	**0.01**
p-value	**0.03**		**<0.01**			**<0.01**		
Gender								
Male								
Intervention group	96	74.4	87	69.6	0.39	81	65.9	0.14
Control group	103	82.4	110	89.4	0.11	115	92.7	**0.01**
p-value	**0.12**		**<0.01**			**<0.01**		
Female								
Intervention group	52	65.8	48	62.3	0.65	43	55.8	0.20
Control group	79	77.5	78	83.0	0.33	75	84.3	0.23
p-value	0.08		**<0.01**			**<0.01**		
Living location								

Group	Baseline		After 6 months			After 12 months		
	n	(%)	n	(%)	p*	n	(%)	p**
Rural								
Intervention group	72	80.9	65	77.4	0.57	60	72.3	0.18
Control group	63	85.1	65	91.6	0.23	65	92.9	0.14
p-value	0.48		**0.02**			**<0.01**		
Urban								
Intervention group	76	63.9	70	59.3	0.47	64	54.7	0.15
Control group	119	77.8	123	84.3	0.16	125	87.4	**0.03**
p-value	**0.01**		**<0.01**			**<0.01**		

** compared between rates at baseline and after 6 months; ** compared between rates at baseline and after 12 months*

As presented in Table 2, the prevalence of ECC at levels D1 and D2 in the intervention group decreased gradually from 71.2% at baseline to 65.8% after 6 months and 62.5% after 12 months. In contrast, in the control group, the prevalence of ECC at levels D1–D2 increased from 78.4% at baseline to 87.9% after 12 months. The increase observed in the control group was statistically significant ($p < 0.05$). At both 6 and 12 months, the prevalence of ECC levels D1–D2 in the intervention group was significantly lower than in the control group ($p < 0.05$).

Table 2. Rates of ECC level D1, D2 in children before and after intervention

Group	Baseline		After 6 months			After 12 months		
	n	(%)	n	(%)	p*	n	(%)	p**
Total								
Intervention group	148	71.2	133	65.8	0.25	125	62.5	0.06
Control group	178	78.4	186	85.3	0.06	188	87.9	**0.01**
p-value	0.08		**<0.01**			**<0.01**		
Gender								
Male								
Intervention group	96	74.4	85	68.0	0.26	80	65.0	0.11
Control group	101	80.8	108	87.8	0.13	113	91.1	**0.02**
p-value	0.22		**<0.01**			**<0.01**		
Female								
Intervention group	52	65.8	48	62.3	0.65	45	58.4	0.34
Control group	77	75.5	78	82.1	0.26	75	83.3	0.18
p-value	0.15		**<0.01**			**<0.01**		
Living location								
Rural								
Intervention group	72	80.9	64	76.2	0.45	59	71.1	0.13
Control group	64	86.5	65	91.6	0.33	64	91.4	0.35
p-value	0.34		**0.01**			**<0.01**		
Urban								
Intervention group	76	63.9	69	58.5	0.39	66	56.4	0.24
Control group	114	74.5	121	82.3	0.10	124	86.1	**0.01**
p-value	0.06		**<0.01**			**<0.01**		

** compared between rates at baseline and after 6 months; ** compared between rates at baseline and after 12 months*

Similarly, Table 3 shows that the prevalence of ECC level D3 in the intervention group decreased from 43.3% at baseline to 34.7% after 6 months and 31.0% after 12 months, with statistically significant reductions over time ($p < 0.05$). In contrast, the prevalence of ECC level D3 in the control group increased markedly from 62.1% at baseline to 83.2% after 12 months ($p < 0.05$). At all time points, the prevalence of ECC level D3 was significantly lower in the intervention group than in the control group ($p < 0.05$).

Table 3. Rate of ECC level D3 in children before and after intervention

Group	Baseline		After 6 months			After 12 months		
	n	(%)	n	(%)	p*	n	(%)	p**
Total								
Intervention group	90	43.3	70	34.7	0.07	62	31.0	**0.01**
Control group	141	62.1	157	72.0	**0.03**	178	83.2	**<0.01**
p-value	**<0.01**		**<0.01**			**<0.01**		
Gender								
Male								
Intervention group	61	47.3	46	36.8	0.09	43	35.0	0.05
Control group	82	65.6	91	74.0	0.15	106	85.5	**<0.01**
p-value	**<0.01**		**<0.01**			**<0.01**		
Female								
Intervention group	29	36.7	24	31.2	0.47	19	24.7	0.10
Control group	59	57.8	66	69.5	0.09	72	80.0	**<0.01**
p-value	**0.01**		**<0.01**			**<0.01**		
Living location								
Rural								
Intervention group	45	50.6	39	46.4	0.59	31	37.4	0.08
Control group	43	58.1	53	74.7	**0.04**	63	90.0	**<0.01**
p-value	0.34		**<0.01**			**<0.01**		
Urban								
Intervention group	45	37.8	31	26.3	0.06	31	26.5	0.06
Control group	98	64.1	104	70.8	0.22	115	79.9	**<0.01**
p-value	**<0.01**		**<0.01**			**<0.01**		

** compared between rates at baseline and after 6 months; ** compared between rates at baseline and after 12 months*

Table 4 presents changes in the decayed, missing, and filled teeth (dmft) index. In the intervention group, the mean dmft score decreased from 3.69 (SD = 3.83) at baseline to 3.45 (SD = 3.72) after 6 months and to 3.07 (SD = 3.40) after 12 months ($p < 0.04$). In contrast, in the control group, the mean dmft score increased from 5.73 (SD = 4.88) at baseline to 7.81 (SD = 4.92) after 12 months ($p < 0.05$). The increase in the control group between baseline and 12 months was statistically significant across demographic subgroups ($p < 0.05$).

Table 4. Decayed, Missing, and Filled Teeth index in children before and after intervention

Group	Baseline		After 6 months			After 12 months		
	Mean	(SD)	Mean	(SD)	p*	n	(%)	p**
Total								
Intervention group	3.69	3.83	3.45	3.72	0.52	3.07	3.40	**0.04**
Control group	5.73	4.88	6.82	5.03	**0.02**	7.81	4.92	**<0.01**
p-value	**<0.01**		**<0.01**			**<0.01**		
Gender								
Male								
Intervention group	3.95	3.72	3.66	3.63	0.53	3.28	3.26	0.14
Control group	5.85	4.66	6.95	4.88	**0.03**	8.02	4.62	**<0.01**
p-value	**<0.01**		**<0.01**			**<0.01**		
Female								
Intervention group	3.27	4.00	3.10	3.86	0.80	2.73	3.60	0.38
Control group	5.59	5.17	6.64	5.23	0.16	7.52	5.31	**0.01**
p-value	**<0.01**		**<0.01**			**<0.01**		
Living location								

Rural								
Intervention group	4.01	3.55	3.96	3.59	0.93	3.51	3.28	0.33
Control group	4.82	3.70	6.24	4.17	**0.03**	7.06	3.90	**<0.01**
p-value	0.16		**<0.01**			**<0.01**		
Urban								
Intervention group	3.45	4.03	3.08	3.78	0.47	2.76	3.46	0.16
Control group	6.17	5.32	7.10	5.38	0.14	8.17	5.32	**<0.01**
p-value	**<0.01**		**<0.01**			**<0.01**		

** compared between rates at baseline and after 6 months; ** compared between rates at baseline and after 12 months*

Multivariate regression analysis showed that, after adjusting for time, sex, and place of residence, the intervention was significantly associated with a reduced risk of ECC. Children in the intervention group had a 67% lower risk of overall ECC compared with those in the control group (OR = 0.33; 95% CI: 0.21–0.51). For ECC levels D1–D2, the risk in the intervention group was 0.37 times that of the control group (OR = 0.37; 95% CI: 0.25–0.57; $p < 0.01$). For ECC level D3, the intervention reduced the risk by 79%, with an odds ratio of 0.21 (95% CI: 0.14–0.30; $p < 0.01$). In addition, children who received the intervention had a mean dmft score that was 2.67 points lower than that of children in the control group ($\beta = -2.67$; 95% CI: −3.48 to −1.87; $p < 0.01$).

Table 5. Effectiveness in improving primary tooth decay in children before and after intervention

Characteristics	Overall				Early dental caries (D1, D2)				Late dental caries (D3)				Decayed, Missing, and Filled Teeth index			
	OR	95%CI		p-value	OR	95%CI		p-value	OR	95%CI		p-value	Coef.	95%CI		p-value
Group																
Control	1				1				1				-			
Intervention	0.33	0.21	0.51	<0.01	0.37	0.25	0.57	<0.01	0.21	0.14	0.30	<0.01	-2.67	-3.48	-1.87	<0.01
Time																
Baseline	1				1				1				-			
After 6 months	1.07	0.93	1.24	0.34	1.07	0.91	1.25	0.40	0.94	0.79	1.12	0.51	0.31	0.18	0.46	<0.01
After 12 months	1.04	0.88	1.24	0.70	1.05	0.87	1.27	0.64	1.00	0.82	1.23	0.96	0.50	0.31	0.71	<0.01
Gender																
Female	1				1				1				-			
Male	0.66	0.44	1.01	0.06	0.68	0.45	1.02	0.06	0.64	0.45	0.92	0.02	-0.80	-1.65	0.53	0.07
Living location																
Rural	1				1				1				-			
Urban	0.50	0.31	0.80	<0.01	0.49	0.31	0.77	<0.01	0.90	0.62	1.29	0.55	0.28	-0.49	1.05	0.48
	R^2 =0.101 ; p<0.001				R^2 =0.092 ; p<0.001				R^2 =0.126 ; p<0.001				R^2 =0.091 ; p<0.001			

DISCUSSION

This study provides additional evidence on the effectiveness of fluoride varnish in the prevention of early childhood caries (ECC) among preschool children in Vietnam. The results demonstrated that regular application of 5% sodium fluoride (NaF) varnish over a 12-month period significantly reduced both the prevalence and severity of ECC, as well as the dmft index, compared with oral health education alone. These findings highlight the preventive value of fluoride varnish in a population with a high burden of dental caries.

The observed reduction in ECC prevalence and severity in the intervention group is consistent with findings from previous studies conducted in different countries and settings [11, 12]. Studies in Vietnam and other Asian countries have reported similar protective effects of fluoride varnish on both primary and permanent teeth [13, 14]. Evidence from systematic reviews and meta-analyses further supports these results, showing substantial reductions in caries incidence following regular fluoride varnish application [6]. Together, these findings confirm that fluoride varnish is an effective intervention for caries prevention across diverse populations and caries risk levels.

Several mechanisms may explain the beneficial effects observed in this study. Fluoride varnish provides a high concentration of fluoride that adheres to tooth surfaces, allowing prolonged fluoride release and sustained contact with enamel. This process enhances remineralization of early carious lesions and increases enamel resistance to acid attacks from cariogenic bacteria [7]. In young children, whose enamel is more porous and susceptible to demineralization, this prolonged fluoride exposure is particularly important. In addition, fluoride varnish reduces bacterial metabolism and acid production, thereby slowing the progression of existing lesions and preventing the formation of new caries.

Beyond its biological effectiveness, fluoride varnish has practical advantages that support its use in preschool settings. The application procedure is simple, quick, and non-invasive, requiring minimal equipment and limited cooperation from children. Unlike other preventive measures, such as pit and fissure sealants, fluoride varnish does not require strict moisture control and can be applied even during tooth eruption. These characteristics make fluoride varnish especially suitable for large-scale, school-based or community-based prevention programs targeting young children [15].

The integration of fluoride varnish application with oral health education likely contributed to the positive outcomes observed in the intervention group. Oral health education improves caregivers' knowledge and awareness, encourages healthy behaviors such as regular toothbrushing with fluoride toothpaste, and promotes early dental care seeking. School-based education programs provide an effective platform to reach both children and parents, particularly in settings where access to dental services is limited. Reducing ECC at an early age is important not only for improving immediate oral health and quality of life but also for lowering the risk of caries in permanent teeth later in childhood.

Despite these strengths, several limitations should be acknowledged. First, the study was conducted in a single province, which may limit the generalizability of the findings to other regions of Vietnam with different socioeconomic or cultural characteristics. Second, although efforts were made to control for key confounding factors, unmeasured variables such as dietary habits, home oral hygiene practices, and parental education may have influenced the outcomes. Third, the study focused solely on fluoride varnish and did not compare its effectiveness with other preventive or therapeutic approaches, such as sealants or silver diamine fluoride. Future studies with broader geographic coverage, longer follow-up periods, and comparative designs are needed to further inform national oral health policies.

CONCLUSION

In summary, this study demonstrated that regular application of 5% NaF fluoride varnish significantly reduced the prevalence, severity, and progression of early childhood caries among preschool-aged children. Fluoride varnish is a safe, effective, and practical preventive measure that can be easily implemented in school and community settings. When combined with oral health education, fluoride varnish represents a promising public health strategy for reducing the burden of ECC in young children and for improving long-term oral health outcomes.

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