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Dental service utilization and costs before and after introduction of fluoride gel application for preschool children in Taiwan

Shu-Fen Chen, Herng-Ching Lin*

Taipei Medical University, School of Health Care Administration, 250 Wu-Hsing St., Taipei 110, Taiwan

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ABSTRACT

Objective: To examine dental service utilization and costs before and after the introduction of fluoride gel application for preschool children in Taiwan.
Methods: This study used claim data for 101,314 preschool children aged ≤5 years. The study sample was divided into two groups: children who received fluoride gel application in dental clinics in 2004 as the study group, with children who visited dental clinics in 2004 but did not receive fluoride gel applications as our control group. A difference-in-difference methodology was employed to compare change in the number of dental-visits and relative dental expenditures before and after fluoride gel application for the study group alongside change over the same time period for the control group.
Results: We found that after fluoride gel application, the total number of dental-visits, caries treatments and pulpitis treatments all increased at slower rates for the study group compared to the control group. Similar patterns were found on dental expenditures.
Conclusion: Fluoride gel application is associated with a slower rate of growth in the number of visits for the treatment of dental disease and lower dental care expenditures for preschool children.

1. Introduction

Issues of oral health in children revolve principally around dental caries. Early Childhood Caries (ECC) is defined as dental decay among children ≤5 years of age [1], and it is this group's most common chronic dental disease [2]. ECC can develop as soon as teeth erupt, but its treatment is the most prevalent unmet health need in US children [3]. It is estimated that almost 19% of children aged 2–5 years meet the criteria for ECC in the United States [4]. Decay in primary dentition can result in severe health conditions including failure to thrive [5,6], speech impediments and reduced quality of life [7]. In addition, tooth decay not only affects overall health; its ramifications include children's hours lost from school and parents' hours lost from work [8]. Furthermore, while ECC is a predictor of decay in permanent teeth [9], and has serious implications for adulthood [7,10], thus early intervention can translate into significant cost savings for dental care for preschool-aged children [11–13].

A previous study showed that ECC prevalence in Taiwan was 5% among 2-year-old children, and ECC prevalence increased to 89% among 6 year olds [14]. Since ECC represents a significant financial and societal burden in Taiwan, a new nationwide public dental health policy was initiated in July 2004. This new policy provides free preventive fluoride gel applications twice a year for children under 5 years old, with intervals no shorter than 180 days. Preventive programs, which are conducted by licensed dentists, include applying fluoride gel and providing information about oral hygiene to parents at dental clinics or hospital dental departments.

During recent decades, topically applied fluoride gels have been widely used in prevention programs in schools in many countries. Furthermore, substantial reduction in

* Corresponding author. Tel.: +886 2 2736 1661x3613; fax: +886 2 2378 9788.
E-mail address: henry11111@tmu.edu.tw (H.-C. Lin).

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caries increases through application of fluoride gel has been reported, and the treatment effect increased when the frequency and intensity of gel application increased [15]. However, the economic implications of fluoride gel application for preventing early childhood caries have been less clear.

The government-run, single-payer national health insurance scheme in Taiwan, the National Health Insurance (NHI), was initiated in year 1995. Since NHI enrollment is mandatory for all Taiwan citizens, more than 96% of the Taiwanese population of 23 million is now enrolled. Furthermore, 94.45% of total dental clinics are NHI-contracted and dental health providers who contract with the NHI can provide fluoride gel application and can claim 500 NT$ compensation from NHI for each fluoride gel application [16]. By using this nationwide population-based data from Taiwan over a 3-year period, we examined dental service utilization and costs before and after the introduction of fluoride gel application for preschool children in Taiwan.

2. Research methods

2.1. Database

This study uses national dental claim data obtained from the National Health Insurance Research Database (NHIRD) of the NHI, published by Taiwan's National Health Research Institute (NHRI) from January 2003 to December 2005. The NHIRD covers all inpatient and outpatient medical benefit claims. Each claim record has ICD-9-CM codes for one principal operation procedure, one principal diagnosis, and up to four secondary diagnoses, along with the details of the care provided, patient demographics and provider characteristics.

Annual information about the population size of cities/counties in Taiwan was abstracted from the Taiwan-Fukien Demographic Fact Book published by the Taiwan Ministry of the Interior [17]. The data on the number of dentists in each city/county was obtained from the Taiwan Department of Health. Since the NHIRD released secondary data protects patient anonymity for research purposes, the study was exempt from full review by the Internal Review Board (IRB) after consulting with the Director of the IRB of our university.

2.2. Study sample

In Taiwan there were 1,526,867 children ≤5 years of age in 2004. The study group consisted of all preschool children aged ≤5 years old who received fluoride gel application from dental clinics or hospital dentistry departments between 1 July and 31 December, 2004. There were a total of 50,657 eligible patients (3.3% of the whole population in this age group). During the same period, there were 172,980 preschool children aged ≤5 years who visited dental clinics or hospital dentistry departments without receiving fluoride gel applications. We have randomly selected 50,657 from the 172,980 preschool children (one for every one in the study sample), matched with the study group in terms of gender, age ($0 \le \text{age} < 2$; $2 \le \text{age} < 3$; $3 \le \text{age} < 4$ and $4 \le \text{age} \le 5$) and geographic region (northern, central, southern and eastern Taiwan) as our control group. Ultimately, a total of 101,314 preschool children were included in our study.

2.3. Empirical specification

Our analysis uses a difference-in-difference methodology or a pre–post design with a control group. We compare the change (or difference) in the variables of interest (utilization of dental services and costs) before and after fluoride gel application for the study group to change over the same period for the control group. In a difference-in-difference framework, any trend affecting the study and control groups equally will be removed from consideration and the resulting net difference should be purely the effect of fluoride gel application.

Table A1 and Fig. A1 illustrate the difference-in-difference methodology. Suppose $x1$ and $x2$ measure average dental utilization during the periods before and after the fluoride gel application; $c1$ and $c2$ measure average dental utilization for the same periods in the control group. Δx measures the change in average dental utilization as a result of the fluoride gel application and other trend factors. Δc measures the change in average dental utilization as a result of only trend factors. The difference between Δx and Δc thus removes the changes in average dental utilization that are caused by the trend effects, isolating the pure effect of fluoride gel application. Our analysis is based on the following empirical specifications:

$$\begin{aligned} Y = {} & \text{a} + \beta 1\ \text{fluoride gel application} + \beta 2\ \text{time period} \\ & + \beta 3\ \text{fluoride gel application} \times \text{time period} \\ & + (\beta 4\ \text{gender} + \beta 5\ \text{age} + \beta 6\ \text{region} + \beta 7\ \text{urbanization} \\ & + \beta 8\ \text{number of dentists}) \\ & + \varepsilon \text{ and the coefficient } (\beta 3) \text{ of the interaction term} \\ & \times (\text{fluoride gel application} \times \text{time period}) = (\Delta \text{x} - \Delta \text{c}) \end{aligned}$$

2.4. Variables of interest

Utilization and costs of dental services that occurred during the study period were treated as dependent variables. The costs were the aggregate of all itemized charges in NT$ (New Taiwan dollars at the average exchange rate in 2004 (US $1 = NT $33) for services and disposables billed to the Bureau of National Health Insurance. Dental services utilization and costs were categorized according to three conditions: treatment procedures for dental caries (ICD-9-CM code 521.00), treatment procedure for pulpitis (ICD-9-CM code 522.00) and treatment for other conditions. The dummy variable of fluoride gel application is equal to 1 when the children received fluoride gel application between 1 July and 31 December, 2004. The dummy variable for the time period is equal to 1 when the utilization and costs of dental services were accrued within 1 year after the date of fluoride gel application for children in the study group or within 1 year of the first dental-visit since 1 July, 2004 for children in the control group. The difference-in-difference estimate of the impact of fluoride

Table 1
Basic sample characteristics—between 1 July and 31 December, 2004.

	Study group (n = 50,657)		Control group (n = 50,657)		Total (n = 101,314)		p-Value
	n	%	n	%	n	%	
Gender							1.000
Female	24,935	49.22	24,935	49.22	49,870	49.22	
Male	25,722	50.78	25,722	50.78	51,444	50.78	
Age							1.000
Age < 2	1,879	3.71	1,879	3.71	3,758	3.71	
2 ≤ age <3	8,783	17.34	8,783	17.34	17,566	17.34	
3 ≤ age < 4	17,504	34.55	17,504	34.55	35,008	34.55	
4 ≤ age ≤ 5	22,491	44.40	22,491	44.40	44,982	44.40	
Urbanization level							<0.001
1 (highest)	16,707	32.98	13,794	27.23	30,501	30.11	
2	20,112	39.70	18,596	36.71	38,708	38.21	
3	7,370	14.55	8,992	17.75	16,362	16.15	
4	5,243	10.35	6,423	12.68	11,666	11.51	
5	101	0.20	334	0.66	435	0.43	
6	432	0.85	1,074	2.12	1,506	1.49	
7 (lowest)	692	1.37	1,444	2.85	2,136	2.10	
Geographic region							1.000
Northern	23,109	45.62	23,109	45.62	46,218	45.62	
Central	19,236	37.97	19,236	37.97	38,472	37.97	
Southern	7,099	14.01	7,099	14.01	14,198	14.01	
Eastern	1,213	2.39	1,213	2.39	2,426	2.39	

Note: Study group: received fluoride gel application; control group: did not receive fluoride gel application.

gel application is captured by the interaction term fluoride gel application × time period. It measures differences in dental service utilization and costs before and after fluoride gel application for the study group as compared to changes in the control group.

Data on patient characteristics, including gender, age, geographic region, place of residence by urbanization level, and the number of dentists according to city/county of residence per 10,000 people, were collected. Preschool children were originally grouped into the five age categories, $0 \le \text{age} < 1$; $1 \le \text{age} < 2$; $2 \le \text{age} < 3$; $3 \le \text{age} < 4$; $4 \le \text{age} \le 5$. However, there were few children between 0- and 1-years old, and between 1- and 2-years old, thus we combined these two groups into one group, $0 \le \text{age} < 2$.

Geographic regions consisted of northern, central, southern and eastern Taiwan. Urbanization levels for cities/counties were stratified into seven classifications (from 1 indicating the most urbanized to 7 indicating the least urbanized). All 316 cities/counties in Taiwan were then stratified into the seven levels based upon a composite score obtained by calculating population density (people/km^2), population ratio of people with university education or above (%), population ratio of people over 65 years (%), population ratio of agricultural workers (%) and the number of physicians per 100,000 people [18]. Since tap water in Taiwan is not fluoridated, urbanization and geographic location were not correlated with fluoride exposure. We took urbanization and geographic location into consideration in this study for the adjustment of possible difference in medical access between areas.

2.5. Statistical analysis

The SAS 8.2 (SAS Institute, Cary, NC) statistical package was used to perform analysis of the data. Descriptive statistical analyses including frequency, percentage, mean, and standard deviation were performed for all identified variables. Chi-square tests were employed to examine the distribution of demographic characteristics between the study and control groups. Paired t-tests were also conducted to compare the difference in dental service costs and utilization before and after fluoride gel application in the study group, and to compare the difference in dental service costs and utilization before and after the first dental-visit for the control group, between 1 July and 31 December, 2004. Then a multivariable regression employing difference-in-difference was performed to assess the independent association between fluoride gel application and dental service costs and utilization after adjusting for gender, age, geographic region, residential urbanization level and the number of dentists per 10,000 in the patient's city/county of residence. A two-sided p-value of less than or equal to 0.05 was considered to be statistically significant.

3. Results

Table 1 shows basic demographic characteristics for 101,314 dental patients in our analytical sample who were ≤5 years old, as a whole and separately, according to fluoride gel application status. Of the total sample, about 51% were males. Approximately 44% of the total sample was in the 4–5-year-old age group. The distribution according to level of urbanization indicated the majority was located in communities situated at urbanization levels 1 and 2. The χ^2 tests show that there were significant relationships between fluoride gel application and urbanization level ($p < 0.001$).

Prior to fluoride gel application, the average number of dental-visits for caries per person/year in the study group was higher than in the control group (1.08 vs. 0.41,

respectively), nevertheless, after fluoride gel application, the mean number of visits for dental caries in the study group was lower than that of the control group (1.87 vs. 2.62, respectively) (Table 2). Furthermore, growth in the number of dental-visits for caries was smaller for the study group than for the control group (0.79 vs. 2.21, respectively). Similar patterns were observed with dental-visits for pulpitis treatment and total dental-visits in general. In the study group, dental-visits for pulpitis increased only by 0.22, from 0.20 to 0.42 per person/year. Meanwhile, dental-visits for treating pulpitis in the control group increased by 0.65, from 0.12 to 0.77 per person/year. Finally, the increase in the number of overall dental-visits for the study and control groups was 1.77 and 3.69, respectively.

Prior to fluoride gel application, the average cost of treating caries per person/year in the study group was higher than that in the control group (NT$ 1512 vs. NT$ 520, respectively), but this pattern was reversed after fluoride gel application (NT$ 2366 and NT$ 3466 in the study and control groups, respectively), and the growth in costs associated with dental caries was smaller for the study group than for the control group (NT$ 854 compared to NT$ 2946, respectively). In addition, after fluoride gel application, patients in the study group spent NT$ 306 more on average for the treatment of pulpitis, whereas patients in the control group spent NT$ 838 more on average for pulpitis procedures. The impact of fluoride gel application on costs associated with dental-visits in general is even more significant. Prior to fluoride gel application, the average cost of dental-visits for all conditions per person/year was higher for the study group (NT$ 1945) than for the control group (NT$ 668), but this reversed after fluoride gel application (NT$ 3310 vs. NT$ 4730 for the study and control groups, respectively). The growth in costs associated with dental-visits for all conditions was likewise smaller for the study than for the control group (NT$ 1365 compared to NT$ 4062).

In Tables 3 and 4, regression analysis confirms the impact of fluoride gel application on dental service utilization and cost. As shown in Table 3, after adjusting for patient demographic characteristics, the coefficients of the interaction terms for the treatment of dental caries, pulpitis and total dental service utilization are statistically significant and negative; fluoride application was associated with the reductions of 1.42, 0.43, and 1.92 in treatments for dental caries, pulpitis and total dental utilization, respectively. In addition, age, urbanization level, and geographic region were significantly related to total dental service utilization. More total dental service utilization was observed as children got older. Generally speaking, the higher the urbanization level of the city/county, the more total utilization of dental services was found. The highest total dental service utilization by geographic region was in the South. Although no statistically significant difference was observed by gender for dental services in general, dental treatment for caries was significantly lower among males than among females, but significantly higher rates of dental treatment for pulpitis was found among males.

As shown in Table 4, regression analysis confirms the impact of fluoride gel application on dental costs was similar to its impact on dental service utilization. Com-

Table 2
Average dental utilization and costs for selected categories of service before and after fluoride gel application or first dental-visit.

Variable	Study group ($n = 50,696$)				Control group ($n = 50,696$)			
	Before[a] mean (S.D.)	After[b] mean (S.D.)	Diff[c] mean (S.D.)	Paired t-tests p-value	Before[a] mean (S.D.)	After[b] mean (S.D.)	Diff[c] mean (S.D.)	Paired t-tests p-value
Dental utilization (number of visits)								
Dental caries	1.08 (1.70)	1.87 (2.25)	0.79 (2.57)	<0.001	0.41 (1.15)	2.62 (3.57)	2.21 (2.35)	<0.001
Pulpitis	0.20 (0.66)	0.42 (1.05)	0.22 (1.13)	<0.001	0.12 (0.47)	0.77 (1.61)	0.65 (1.44)	<0.001
Other dental treatments	0.23 (0.59)	1.00 (1.40)	0.77 (1.37)	<0.001	0.08 (0.34)	0.91 (1.72)	0.83 (1.30)	<0.001
Total	1.51 (2.23)	3.28 (3.51)	1.77 (3.58)	<0.001	0.61 (1.45)	4.30 (3.57)	3.69 (3.45)	<0.001
Cost								
Dental caries	1512 (2681)	2366 (3210)	854 (4003)	<0.001	520 (1527)	3466 (3680)	2946 (3652)	<0.001
Pulpitis	347 (1382)	652 (1808)	306 (2168)	<0.001	123 (647)	961 (2351)	838 (2230)	<0.001
Other dental treatments	86 (328)	292 (601)	206 (644)	<0.001	25 (165)	303 (585)	278 (644)	<0.001
Total	1945 (3426)	3310 (4355)	1365 (5162)	<0.001	668 (1927)	4730 (4542)	4062 (5225)	<0.001

Note: S.D. = standard deviation.
[a] Means before fluoride gel application or within 365 days prior to the first dental-visit.
[b] Means after fluoride gel application or within 365 days after the first dental-visit.
[c] Means after − before.

Table 3
Multivariable regression difference-in-difference estimates of the impact of fluoride gel application on dental service utilization.

Variable	Utilization			
	Dental caries	Pulpitis	Other treatments	Total
Intercept	−0.59***	−0.31***	−0.11***	−1.00***
Fluoride gel application				
Control group (reference group)				
Study group	0.77***	0.14***	0.15***	1.05***
Time period				
Before (reference group)				
After	2.23***	0.66***	0.75***	3.65***
Interaction term				
Fluoride gel application × time period	−1.42***	−0.43***	−0.06*	−1.92***
Gender				
Female (reference group)				
Male	−0.05***	0.07***	−0.04***	−0.03
Age (years)				
Age < 2 (reference group)				
2 ≤ age < 3	0.64***	0.13***	0.07***	0.84***
3 ≤ age < 4	1.19***	0.32***	0.09***	1.62***
4 ≤ age ≤ 5	1.26***	0.41***	0.15***	1.81***
Urbanization level				
1 (highest) (reference group)				
2	−0.03**	0.02	−0.05***	−0.05***
3	−0.12***	0.01	−0.09***	−0.21***
4	−0.08***	0.00	−0.15***	−0.20***
5	−0.07	0.01	−0.14***	−0.21**
6	−0.34***	0.03*	−0.13***	−0.45***
7 (lowest)	−0.25***	−0.05**	−0.13***	−0.42***
Geographic region				
Northern (reference group)				
Central	−0.09***	0.04***	0.17***	0.13***
Southern	0.04***	0.08***	0.09***	0.20***
Eastern	−0.06*	0.06***	0.04***	0.05*
Number of dentists/10,000 residents	0.01***	−0.01***	0.01***	<0.01

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

pared to the control group, dental costs for the study group were higher on average. After fluoride treatment, there was a statistically significant reduction in expenditures for the treatment of dental caries, pulpitis, other dental conditions and for dental treatments in general. Fluoride application was associated with the reductions of NT$ 2092, NT$ 532, NT$ 72, and NT$ 2697 per person/year, for dental caries, pulpitis, other procedures and total dental-visits, respectively. In addition, age, urbanization level, geographic region and dentists per 10,000 residents by each city/county were significantly related to dental expenditures. More total dental expenditures were observed as children got older. Generally speaking, the higher the urbanization level of the city/county, the more dental expenditures were found.

4. Discussion

The importance of primary and secondary preventive care, such as vision, hearing, and oral screening, which should be conducted before children enter school, is well recognized [19,20], furthermore, the earlier the preschool children use preventive dental care, the fewer dentally related costs the NHI program will incur [13]. According to the Guidelines of the American Academy of Pediatric Dentistry, all children should have their first dental-visit before the age of 12 months and should continue to visit dentists every 6 months subsequently [21]. Preventive dental programs have been instituted in schools in many countries in accordance with these guidelines during recent decades. Furthermore, topical application of fluoride has been widely used, and statistically significant caries-inhibiting effect of fluoride gel application has been documented by various controlled trial studies [15]. Taking advantage of the preventive dental care policy introduced for preschool children in Taiwan, we employed a difference-in-difference methodology to assess the impact of fluoride gel application on the number of dental-visits and dental cost in the preschool population in Taiwan.

The main finding of this study was the significant association between the protective effect of fluoride gel application and the dental utilization and cost. After adjusting for gender, age, urbanization level, geographic region and the number of dentists per 10,000 people, we found

Table 4
Multivariable regression difference-in-difference estimates of the impact of fluoride gel application on dental-visit costs.

Variable	Costs			
	Dental caries	Pulpitis	Others	Total
Intercept	−944***	−382***	−52***	−1377***
Fluoride gel application				
Control group (reference group)				
Study group	1142***	253***	54***	1448***
Time period				
Before (reference group)				
After	2848***	965***	255***	4068***
Interaction term				
Fluoride gel application × time period	−2092***	−532***	−72***	−2697***
Gender				
Female (reference group)				
Male	−28**	33***	−2	3
Age				
Age < 2 (reference group)				
2 ≤ age < 3	978***	228***	11	1218***
3 ≤ age < 4	1384***	435***	32***	1850***
4 ≤ age ≤ 5	1590***	552***	92***	2233***
Urbanization level				
1 (highest) (reference group)				
2	−101***	−8	−26***	−135***
3	−272***	−24**	−37***	−332***
4	−254***	−45***	−45***	−345***
5	−220***	−66	−32**	−318***
6	−515***	−58**	−38***	−610***
7 (lowest)	−466***	−140***	−52***	−657***
Geographic region				
Northern (reference group)				
Central	85***	182***	57***	325***
Southern	107***	95***	38***	240***
Eastern	−59*	98***	44***	82*
Number of dentists/10,000 residents	21***	−8***	2***	15***

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

that total dental service utilization and total costs increased more slowly for the study group. A similarly lower rate of increase was found for caries treatment and pulpitis treatments in the year following fluoride gel application. These findings are in line with a previous study that found children receiving fluoridated drinking water were less likely to receive dental treatment than children in a control group, and they also had lower dental treatment costs compared to the children in the control group [22].

The effects of fluoride application, whether by professionals or through self-application, on reducing caries treatment has been well documented [15], with an up to 20% reduction in caries incidence reported [23]. A previous meta-analysis study of the caries-inhibiting effect of fluoride treatment reported a mean prevention fraction of 22% among highly caries-active children [24]. Our study found a significantly lower number of dental-visits for caries treatment (1.42 less), for pulpitis treatment (0.43 less) and significantly lower numbers of total dental-visits per preschool child (1.92 less); furthermore, NT$ 2092, NT$ 532, and NT$ 2697 were saved on caries treatment, pulpitis treatment and total dental costs, respectively, for each preschool child per year in the study group. That children in the study group had significantly more dental-visits and higher dental costs before fluoride gel application than the control group did, suggests the study group children were at higher risk of dental disease. However, studies have indicated that the earlier children develop dental caries, the more susceptible they are to carries in the future [9,25,26]. Therefore, given that the study group is likely facing a higher risk for developing caries, it seems significant that the average number and cost of dental-visits after fluoride gel application are nonetheless significantly lower for the study group than for the control group. Thus, we believe that the fluoride gel treatment itself may contribute to the slower rate of growth in the need for dental care among children under 5 years old.

Assessment of children's dental condition and education provided about oral hygiene knowledge by dentists when performing fluoride gel application may also account for the decreasing growth in numbers of dental-visits and costs, in addition to fluoride gel application itself. When participating in the fluoride gel application program, parents receive counseling from dentists on children's oral

hygiene and diet. Moreover, participation in the program means a higher chance of detecting dental disease in its early stages, preventing further worsening of the condition. The increasing severity of untreated dental disease secondary to postponing care necessitates more extensive and costly treatments. Through early detection, significant financial savings can be made. For example, a study conducted in Iowa found that although only 5% of the dental care related to the Medicaid-participating children treated for ECC in hospitals or ambulatory care settings, up to 25–45% of all funds allocated for dental resources were consumed by those children [11]. Similar results were also reported in Washington State. In that study, 19% of pediatric dental emergencies were related to ECC; of those, more than half involved children ≤3.5 years of age [12]. These studies emphasize that early prevention can decrease health care costs.

4.1. Limitations

Since this study is not a controlled trial, our results must be viewed with caution. First of all, children in the study group had significantly more dental-visits and higher dental costs before fluoride gel application than the control group did, which suggests the study group children were at higher risk of dental disease, and therefore the effect of fluoride gel application was probably greater than it would be for an average group of children.

Second, data for preventive dental care paid out-of-pocket or not covered by the NHI program were not collected for this study. However, out-of-pocket preventive dental care, such as fluoride tablets and the application of sealants, is uncommon in Taiwan, so the proportion of preschool children with parents paying out-of-pocket for preventive dental care should be quite small. Finally, although we tried to include every important variable, restrictions inherent to administrative databases mean we were not able to access parents' characteristics, such as maternal age, educational level, and socioeconomic status. However, since we employed the difference-in-difference method in our study, we believe those variables would not influence our results greatly.

4.2. Policy implications

These findings have significant policy implications. The majority of preschool children who saw dentists went mostly for restorations, especially for the treatment of dental caries and pulpitis. Nevertheless, according to the data extracted from the NHIRD, only 23% of preschool children utilized the preventive dental care program from July to December 2004. This is probably a result of limited and ineffective government promotion of the program resulting in the lack of parental awareness of this fluoride gel application policy for preschool children. This low utilization rate can be overcome through several measures. First of all, preschool kindergartens, news media, and most importantly, pediatricians can raise parental awareness of the significance of preventive dental care for preschool children. Because Taiwan's National Health Insurance Program provides well-baby care for children aged 0–7 years old, every eligible child is entitled to a total of nine well-baby/child care visits, making pediatricians the type of physician preschool children are most likely to come across. This puts pediatricians in a position to address the importance of oral health through anticipatory guidance, informing parents about the preventive dental care policy, and to refer high-risk children to dentists [27]. Second, it normally requires more time for dentists to treat young children and not all dentists have the skills and equipment to provide care for young children. Thus providing dentists with training in providing care to young children should increase access to preventive dental care, particularly for very young children.

5. Conclusion

In conclusion, our findings underscore the potential impact of preventive dental interventions. We found that early provision of preventive dental services is associated with a slower rate of growth in the number of dental-visits for the treatment of dental disease and lower dental care costs for preschool children for dental caries, pulpitis and other procedures. These findings have significant policy implications; we hope that these results will help to mobilize the dental profession in Taiwan to support preventive dental services, especially for preschool children. In the future, more research is needed to examine this effect over a longer period of time in order to evaluate the long-term impact of fluoride application as part of preventive dental service for preschool children.

Conflict of interest

None declared.

Appendix A

See Table A1 and Fig. A1.

Table A1
The difference-in-difference methodology.

	Before	After	Difference (after − before)
Study group (received fluoride gel application)	$x1$ (dental cost or utilization before fluoride gel application)	$x2$ (dental cost or utilization after fluoride gel application)	$\Delta x = x2 - x1$
Control group (did not receive fluoride gel application)	$c1$ (dental cost or utilization before the first dental-visit)	$c2$ (dental cost or utilization after the first dental-visit)	$\Delta c = c2 - c1$
Difference-in-difference			$\Delta x - \Delta c = (x2 - x1) - (c2 - c1)$

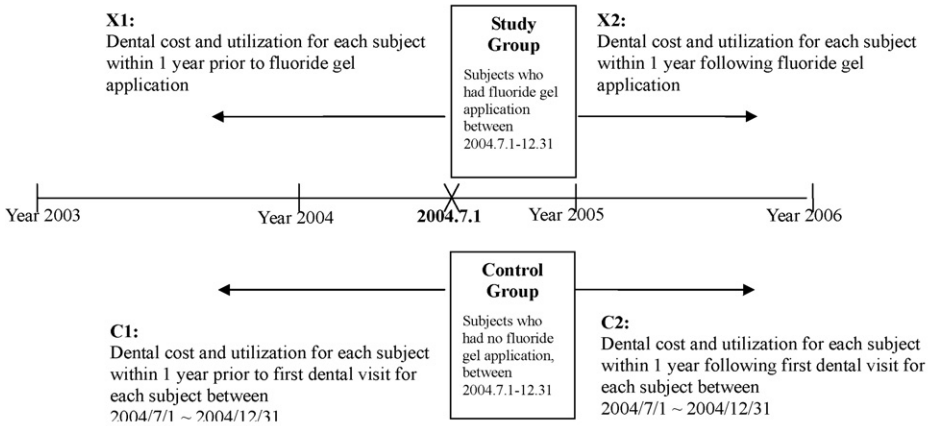

Fig. A1. The difference-in-difference methodology.

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