Urinary Fluoride Excretion in Children Drinking Fluoridated School Milk in Thailand

Prathip Phantumvanit[1], Sawalee Sangkheaw[2], Puangtong Lekfuengfu[3], Kornkamol Niyomsilp[4]

Thailand

Summary:

Objective: **To compare urinary fluoride concentration and excretion for children drinking fluoridated milk with that of children drinking non-fluoridated milk and to check whether total fluoride intake, when fluoridated milk is used for caries prevention in Thailand, does not exceed accepted standards. Methods: Eight-hour urinary collections were carried out in 31, 44 and 40 children aged 4, 6 and 8 years in fluoridated milk drinking school and 41, 32 and 30 children in non-fluoridated milk drinking school. Urine was collected during 2 periods: 7.30-10.00 a.m. and 10.00 a.m.-3.30 p.m. at baseline and after 6, 12 and 24 months. The children drank 200 ml milk at 10.00 a.m. In the control group the milk was not fluoridated; in the test group, 200ml milk contained 0.5 mg fluoride.**

Results: **The average excreted urinary fluoride per hour in the morning in children aged 4 and 8 years in test group remained similar to those of control group, whereas those in the afternoon samples in every age group in test group were significantly higher than that of control group. In children aged 4, 6 and 8 years, the average urinary fluoride per hour in the morning at baseline was 9.0±4.87, 10.5±5.17 and 10.4±4.38 g/hr and after the fluoridated milk was 13.8±8.05, 17.6±9.57 and 17.6±8.35 g/hr, respectively ($p>0.05$). But the mean urinary fluoride per hour in the afternoon was 3 times significantly ($p<0.05$) higher as 26.9±10.82, 28.3±16.23 and 29.1±12.30 g/hr, in children aged 4, 6 and 8 years, when compared with the baseline data as 9.0±4.62, 9.8±5.64 and 10.3±5.46 g/hr respectively.**

Conclusion: **The average total excreted urinary fluoride per hour in children in all age groups, after launching the fluoridated milk project, indicated that they received fluoride at the optimum and safety level. Further study should be done to investigate the bioavailability of fluoride from milk and the corresponding fluoride excretion in young children in more detail for more precise estimations of total fluoride intake.**

Keywords: **urinary fluoride, fluoridated milk, caries prevention**

Introduction:

Fluoridated milk was first introduced as a possible dental caries prevention medium in 1953. Its caries-prevention effect of fluoridated milk has been demonstrated in many studies [1, 2]. As caries experience (dmft) in 6-year-old children in Bangkok metropolitan, the capital of Thailand, in 2001 was as high as 4.9 and the tap water contains only 0.1-0.2 mg F/l [3], a study using milk fluoridation was considered to be useful. The Thailand milk fluoridation program started in 2000 with a demonstration community scheme in Bangkok, with over 14,000 children, age 4-11 year, drinking fluoridated school milk each school

[1] Associate Professor, Faculty of Dentistry, Thammasat University Rangsit Campus, Patumthani 12121, Thailand
[2] Dr, Division of Dental Health, Bangkok Metropolitan Administration, Bangkok 10500, Thailand
[3] Dr, Department of Health, Ministry of Public Health, Nonthaburi 11000, Thailand
[4] Dr, Department of Health, Ministry of Public Health, Nonthaburi 11000, Thailand

day [4]. Each carton contains 0.5 mg of fluoride, as sodium fluoride, dissolved in 200 ml of milk.

With this advent of a new fluoride source, it is very important to get data relating to its safety and its effectiveness in caries prevention [5]. The WHO (1994) suggests that, before and during fluoride supplement programmes, monitoring be performed to ensure that ingestion of fluoride from all sources by the children participated is at the suitable level [6].

Urine is the main excretion route for ingested fluoride, so fluoride excretion via urine is considered as a good indicator of fluoride intake in children and adults who have been in a steady state of fluoride intake for at least six months or rather one year [7, 8].

Evaluation of 24-hour urine collections in a given population is optimal for assessments of urinary fluoride excretion. However, it is hard to obtain complete urine collection over the entire 24-hour period. Urine collection with total duration of 8 hours is preferable if collection is performed at school under supervision [9]. The fractional urinary excretion of fluoride (FUEF) during the first 7 hour after ingestion of the fluoride dose and the integrated 24-hour were not significantly different (28.5% and 30.7% respectively) [10]. Thus, 8-hour urine samples were collected in the present study.

Aim of this study was to compare urinary fluoride concentration and excretion in children drinking fluoridated milk with that of children drinking non-fluoridated milk, thus deriving a comparative measure of safety for fluoridated milk schemes in Thailand.

Materials and Methods:

The target population in the fluoridated milk scheme was pre-school and primary school children (aged 4-6 and 7-11 year old at the beginning of the scheme) in Bangkok. The scheme involved approximately 14,000 children in 8 public and 6 private schools. One public and one private school in the scheme were selected for the test group by simple random sampling. The control group sample consisted of children drinking non-fluoridated milk in one public and one private school which was considered in the same caries experience and socioeconomic status with test school.

Consent to collect the urinary samples at school was obtained from the Department of Health, and the parents of the children were asked to give their written informed consent.

Before launching the fluoridated milk scheme (at baseline) urine samples were collected at school from 210 and 239 children at three different age groups (4, 6 and 8 years old at the beginning) in test and control group, respectively. The dropout rate was 45-55% in test and control groups which was due to consistently 3-4 urine collections in each child at the period of 1-2 years. After the program was implemented for twelve months, only 44 and 40 children 6 and 8 years age groups were included in the data analysis in test group; whereas the control group was 32 and 30 children respectively. In the 4 years age group the urine collection was run up to 24 months, therefore only 31 and 41 children were included in the test and control groups. In test group, the use of fluoridated dentifrice in children aged 4, 6 and 8 year was 96%, 97.5% and 97.5% respectively, comparable with those in the control group as 100%, 93.5% and 88.2% respectively.

Teachers and children were informed about the objective and urine collection procedure by a meeting in order to obtain cooperation and accuracy in urine collection in advance. On the day before urine collection, questionnaires were sent to parents and children to record the time of last voiding of the bladder at home on the following day. The children in the test group

had received fluoridated milk every school day (around 190 days/year) and definitely on the day before the urine sample were taken.

Urine collection was based on time-controlled urinary collection, 8-hour collection period and supervised by 4 trained health workers for one kindergarten class per day and two trained health workers for one primary school class per day.

Two separate urine collection were carried out; low fluoride period or morning sample and high fluoride period or afternoon sample, after drinking fluoridated milk. Urine sample was brought for fluoride analysis within 24 hours. Fluoride concentration of urine samples were determined using a fluoride ion selective electrode (Orion model 9609 BN) connected to an Orion model 940 digital pH/mV meter.

Data were analyzed by using SPSS version 10.0 software programme. Statistical test of comparing between groups at baseline was made by applying Student t-test. Statistical test of comparing between groups of the control and test group were made by applying repeated measure ANOVA. Statistical test of comparing within group were made by applying Bonferroni test. An alpha value of $p<0.05$ was selected as the indicator for statistical significance.

Results:

Children 4 years old age group:

Table 1 shows the average collection duration, urinary flow rate, urinary fluoride excretion and fluoride concentration in children aged 4 years in the test and control groups. At baseline, the average morning collection duration (range of the averages 2.60-3.68 h), morning urinary flow rate (range of the averages 18.38-30.88 ml/h), urinary fluoride excretion and fluoride concentration were similar among test and control group ($p>0.05$).

From 4 collections in test and control group, the morning collections extend over 2.60-3.68 h and last for 4.11-5.72 h in the afternoon. In the morning and afternoon samples, the urinary flow rate varied between 18.38-30.88 and 17.89-34.97 ml/h. When comparing the average collection duration and urinary flow rate both in the morning and afternoon, the differences between test and control group were not statistically significant but some differences within test and control group were statistically significant.

In the morning samples, the average excreted fluoride per hour and fluoride concentration in children aged 4 years in test and control group did not differ statistically. The average morning excreted fluoride per hour after 6 and 12 month implementation in test group is higher than that of baseline ($p<0.05$).

In the afternoon samples, the average excreted fluoride per hour and fluoride concentration in children aged 4 years in test and control group differed significantly. After drinking fluoridated milk, afternoon samples in test group had significantly increased urinary fluoride excretion more than 2-3 times from 9.0±4.62 at baseline to 22.1±986 at 24 months period and 31.8±10.62 g/hr at 12 months. Similarly, the urinary fluoride concentration had increased significantly from 0.5±0.27 at baseline to 1.2± 0.63 at 24 months and 1.5± 0.59 mg/l at 6 months period. On the other hand, the fluoride excretion in the afternoon samples of control group was not significant different ($p>0.05$), from 11.6±7.43 at baseline to 17.8±12.97 g/hr, or fluoride concentration from 0.4±0.21 at baseline to 0.6±0.55 mg/l, at 6 months period.

Children 6 years old age group:

The durations of collection were similar to those in the 4 year old children and no notable differences occurred (Table 2).

In the morning samples, the average urinary excreted fluoride per hour and flu-

Table 1. Urinary fluoride excretion in children aged 4 years \
(n = 31 and 41 in test and control groups respectively)

Variables		Test Group				Control Group				Difference between group[1]
		Baseline	6 mos	12 mos	24 mos	Baseline	6 mos	12 mos	24 mos	
Duration (hr)										
morning	Mean	3.6[a,b,c]	3.1[d]	2.6	2.8	3.7[a,b]	2.9[e]	2.7[f]	3.4	0.143
	SD	0.50	0.57	0.58	0.75	0.59	0.61	0.60	0.76	
afternoon	Mean	4.5[b,c]	4.5[d,e]	5.0[f]	5.7	4.1[a,b,c]	5.1[d]	5.4[f]	4.8	0.427
	SD	0	0.11	0.22	0.51	0.38	0.54	0.27	0.77	
Urinary flow rate (ml/hr)										
morning	Mean	18.4	19.1	26.2	23.7	20.5[c]	20.2[e]	22.4[f]	30.9	0.512
	SD	10.91	12.30	16.92	16.31	10.33	13.75	16.49	19.69	
afternoon	Mean	19.8	21.6	26.8	21.7	30.8[c]	35.0[d,e]	24.9	17.9	0.072
	SD	10.40	14.88	16.17	13.67	19.46	19.72	14.68	9.76	
Amount F excreted (µg/hr)										
morning	Mean	9.0[b,c]	10.7[d]	16.7	13.9	9.4[a]	15.3	12.0	11.8	0.688
	SD	4.87	6.49	9.57	7.10	6.78	9.55	5.64	8.06	
afternoon	Mean	9.0[a,b,c]	26.5	31.8[f]	22.1	11.6[a]	17.8	12.7	9.0	0.000
	SD	4.62	12.02	10.62	9.82	7.43	12.97	5.84	3.92	
F concentration (mg/l)										
morning	Mean	0.6	0.6	0.7	0.7	0.5[a]	0.9[d,e]	0.6[f]	0.5	0.379
	SD	0.43	0.30	0.39	0.36	0.38	0.57	0.27	0.23	
afternoon	Mean	0.5[a,b,c]	1.5	1.4	1.2	0.4[b,c]	0.6	0.6	0.6	0.000
	SD	0.27	0.59	0.48	0.63	0.21	0.55	0.28	0.29	

1 Significance of the difference between test and control group (repeated measure ANOVA)
Difference within group
a = Difference between baseline and 6 mos
b = Difference between baseline and 12 mos
c = Difference between baseline and 24 mos
d = Difference between 6 and 12 mos
e = Difference between 6 and 24 mos
f = Difference between 12 and 24 mos

Table 2. Urinary fluoride excretion in children aged 6 years (n = 44 and 32 in test and control \
group respectively)

Variables		Test Group			Control Group			Difference between groups[1]
		Baseline	6 mos	12 mos	Baseline	6 mos	12 mos	
Duration (hr)								
morning	Mean	3.2[b]	3.1	3.0	3.4[a,b]	2.8[c]	3.1	0.988
	SD	0.50	0.60	0.63	0.63	0.61	0.64	
afternoon	Mean	4.9[a,b]	5.3[c]	5.5	4.7[a,b]	5.9[c]	5.6	0.092
	SD	0.07	0.52	0.23	0.43	0.46	0.56	
Urinary flow rate (ml/h)								
morning	Mean	19.6	21.4	26.1	22.4	19.3	20.9	0.467
	SD	11.81	15.00	16.37	16.10	5.60	9.12	
afternoon	Mean	18.8[a,b]	26.1	27.0	21.1	23.9	22.4	0.456
	SD	10.02	16.12	12.01	12.14	15.93	11.06	
Amount F excreted (µg/hr)								
morning	Mean	10.5[a,b]	16.4	18.7	9.3[a,b]	14.3	12.9	0.015
	SD	5.17	8.68	10.47	3.97	6.04	4.56	
afternoon	Mean	9.8[a,b]	27.4	29.2	9.6[a]	14.6	11.6	0.000
	SD	5.64	10.25	22.21	4.32	7.37	6.31	
F concentration (mg/l)								
morning	Mean	0.6[a]	0.9	0.8	0.5[a]	0.7	0.7	0.012
	SD	0.30	0.38	0.37	0.26	0.20	0.28	
afternoon	Mean	0.6[a,b]	1.2	1.1	0.5[a]	0.7	0.5	0.000
	SD	0.30	0.54	0.52	0.18	0.35	0.20	

1 Significance of the difference between test and control group (repeated measure ANOVA)
Difference within group
a = Difference between baseline and 6 mos, b = Difference between baseline and 12 mos, c = Difference between 6 and 12 mos

oride concentration in children aged 6 years in test group was statistically higher than those in control group ($p=0.015$, 0.012, respectively). In test and control group, the average morning excreted fluoride per hour after 6 months and 12 months implementation was higher than that of baseline ($p<0.05$). In test and control group, fluoride concentration after 6 month implementation was also higher than that of baseline significantly ($p<0.05$).

In the afternoon samples, the average urinary excreted fluoride per hour and fluoride concentration in children aged 6 years in test and control group differed significantly ($p<0.0001$). After drinking fluoridated milk, afternoon samples in test group had significantly increased urinary fluoride excretion almost 3 times, from 9.8±5.64 at baseline to 27.4±10.25 at 6 months and 29.2±22.2 g/hr at 12 months. Similarly, the urinary fluoride concentration had increased significantly from 0.6±0.30 at baseline to 1.2±0.54 at 6 months and 1.1±0.52 mg/l at 12 months period. On the other hand, the fluoride excretion in the afternoon samples of control group was increased but not significant different ($p>0.05$), from 9.6±4.32 at baseline to 14.6±7.37 g/hr, or fluoride concentration from 0.5±0.16 at baseline to 0.7±0.35 mg/l, at 6 months period.

Children 8 years old age group:

Table 3 shows that durations were similar to those in the groups aged 4 and 6. Urinary flow averages (range 19.73-28.74) were not consistently higher than those at age 4 or 6 years.

In the morning samples, the overall average urinary excreted fluoride per hour and fluoride concentration in children aged 8 years were similar among test and control group ($p > 0.05$). In test and control group, the average morning excreted fluoride per hour after 6 and 12 month implementation was higher than that of baseline ($p<0.05$). In test group, fluoride concentration after 6 and 12 month implementation was higher than that of baseline ($p<0.05$). In control group, only fluoride concentration after 6 month implementation was higher than that of baseline ($p<0.05$).

In the afternoon samples, after drinking the fluoridated milk, samples in test group had significantly increased urinary fluoride excretion more than 2-3 times from 10.3±5.46 at baseline to 26.1±11.19 at 6 months and 32.1±13.42 g/hr at 12 months. Similarly, the urinary fluoride concentration had increased significantly from 0.5±0.23 at baseline to 1.1±0.41 at 6 months and 1.3±0.46 mg/l at 12 months period. On the other hand, the fluoride excretion in the afternoon samples of control group was also increased but not significant different ($p>0.05$), from 9.3±4.56 at baseline to 13.6±9.59 g/hr, or fluoride concentration from 0.4±0.19 at baseline to 0.6±0.29 mg/l, at 12 months period.

Discussion:

In spite of the fact that urinary fluoride excretion is regarded as a reliable indicator of fluoride intake, few studies have been performed involving collection and analysis of 24 h urine samples. This is mainly due to the difficulties involved in collection of 24 h urine samples from large groups of subjects [11]. However fluoride is rapidly excreted after intake with the peak within 2 hours [8]. The average FUEF value obtained using 24-h calculation does not differ from the corresponding 7-h average value significantly [10]. To obtain the values of urinary fluoride excretion related parameter on the basis of statistically meaningful samples, so 8-hour urine collection method was selected in this study.

According to the experimental design used in the present study, fluoridated milk was drunk at 10.00 a.m., the time between breakfast and lunch, when the stomach was empty. The hypothesis that fluoride

Table 3. Urinary fluoride excretion in children aged 8 years \
(n = 40 and 38 in test and control group respectively)

Variables		Test Group			Control Group			Difference between groups[1]
		Baseline	6 mos	12 mos	Baseline	6 mos	12 mos	
Duration (h)								
morning	Mean	3.5	3.5	3.6	3.5 [a,b]	3.0 [c]	3.2	0.011
	SD	0.53	0.60	0.90	0.50	0.67	0.63	
afternoon	Mean	4.8[a]	5.3[c]	5.1	4.8 [a,b]	5.9[c]	5.6	0.000
	SD	0.23	0.31	0.64	0.20	0.21	0.51	
Urinary flow (ml/h)								
morning	Mean	25.0	24.1	22.4	24.8	28.7	27.3	0.103
	SD	11.33	11.01	10.11	12.82	11.79	11.36	
afternoon	Mean	19.7[b]	24.4	27.5	23.0	25.3	23.5	0.963
	SD	7.56	10.15	13.05	11.99	10.50	9.97	
Amount F excreted (μg/hr)								
morning	Mean	10.4[a,b]	16.8	18.5	11.7[a,b]	18.1	17.2	0.721
	SD	4.38	8.39	8.32	4.96	7.75	8.74	
afternoon	Mean	10.3[a,b]	26.1[c]	32.1	9.3[a]	16.0	13.6	0.000
	SD	5.46	11.19	13.42	4.56	7.70	9.59	
F concentration (mg/l)								
morning	Mean	0.4[a,b]	0.7[c]	0.9	0.5[a]	0.7	0.7	0.263
	SD	0.20	0.25	0.41	0.22	0.35	0.32	
afternoon	Mean	0.5[a,b]	1.1	1.3	0.4[a,b]	0.6	0.6	0.000
	SD	0.23	0.41	0.46	0.19	0.20	0.29	

1 Significance of the difference between test and control group (repeated measure ANOVA)
Difference within group
a = Difference between baseline and 6 mos, b = Difference between baseline and 12 mos, c = Difference between 6 and 12 mos

bioavailability is lessened when fluoride is ingested with milk is controversial [12, 13, 14, 15] and has no importance for the present results because urine was collected over 5 hours after fluoride ingestion.

The average excreted fluoride per hour in children in all age groups, before launching the fluoridated milk project, varied between 9.0±4.87 and 10.5±5.17 g/hr. These observations are in agreement with those of WHO provisional standards [9] (Table 4). Villa et al reported urinary fluoride value in 48 Brazilian children aged 4-5 years who consumed low fluoride in water (0.04-0.08 mgF/l) excreted average fluoride of 9.5 g/hr (10) which is comparable with the water fluoride in Bangkok (0.1-0.2 mgF/l). The average total excreted fluoride per hour in children in all age groups, after launching the fluoridated milk project, are consistent with those of provisional standards of WHO guideline [9].

It is interesting to note that the data from the control group, non fluoridated milk, in all age groups (Table 1, 2 and 3), did show the higher urinary fluoride excretion in the morning urine after 6, 12 and 24 months, in comparison with the baseline data, which might be due to that the parents of control group were informed about the fluoride study prior to the permission for urine collection in their children. This might have some impact on the increased fluoride use for caries prevention in their children such as fluoridated toothpaste in this control group thus demonstrated higher urinary fluoride excretion in this study.

In the test group, the fluoride excretions and concentrations were similar after 6, 12 months; all respective comparisons resulted in non-significant differences. This means that despite fluoride supple-

Table 4: Comparison of the urinary fluoride excretion per hour in children, according to age group and fluoride intake, with WHO provisional standards

Children age group	Fluoride excretion per hour (μg/hr)			
	24-hour collection*	Peak after main meal*	Test group †	
			morning	afternoon
Age 3-5 years:				
Low fluoride intake	7-12	8-13	9.0±4.87	9.0±4.62
Optimal fluoride intake	15-20	18-27	13.8±8.05	26.9±10.82
Age 6-7 years:				
Low fluoride intake	8-13	10-15	10.5±5.17	9.8±5.64
Optimal fluoride intake	20-25	24-36	17.6±9.57	28.3±16.23
Age 8-9 years:				
Low fluoride intake	-	-	10.4±4.38	10.3±5.46
Optimal fluoride intake	-	-	17.6±8.35	29.1±12.30
Age 10-14 years:				
Low fluoride intake	9-14	12-18	-	-
Optimal fluoride intake	25-34	30-48	-	-

*Provisional standards for urinary fluoride excretion and concentrations in: Guidelines for monitoring of renal fluoride excretion in community preventive programmes on oral health. WHO, 1999 (9).

+ the value from this study, the figures were mean±SD from baseline data in the first line and from fluoridated milk data in the second line, at 4, 6 and 8 years age groups.

ments taken with the school milk for up to 12 months, there was no fluoride accumulation in the bones sufficient to increase the level of fluoride excretion.

The urinary flow rates observed in children aged 4 and 6 years in this study were consistent with the previously reported values in Australia, Sri Lanka and England. It had been shown that 16 children aged 3-5 years had urine output as 537 ml in 24 hours or 22.38 ml/hr in winter and 485 ml in 24 hrs or 20.20 ml/hr in summer, in Australia study [16]. Urine output in 53 children aged 4 years in Sri Lanka was 449 ml in 24 hrs or 18.71 ml/hr whereas those in 43 children aged 4 years in England was 504 ml in 24 hrs or 21 ml/hr [7].

The present study of children aged 4 and 6 years might be comparable with a study of 24-hr urinary fluoride excretion in children aged 2-6 years in Jamaica where fluoride concentration in drinking water was less than 0.25 mg F/l [17]. Before and after the introduction of fluoridated salt (250 mg/kg salt), the average total excreted fluoride per hour (14.3 and 30.3 g/hr) was slightly higher than those of the present study. When comparing with the Bulgarian preschool children who ingested 1 mg fluoride in 200 ml of fluoridated milk in the morning, the average excreted fluoride rate per hour in the morning was 37 g/hr after drinking fluoridated milk or 6.37 times of that of the control group, who did not get fluoridated milk or other forms of fluoride, at the same period (5.8 g/hr) [18]. While the average urinary excreted fluoride rate per hour in the afternoon, after drinking 0.5 mg in 200 ml at 10.00 a.m., in children aged 4 years in this study was almost 3 times of the baseline (from 9.0±4.87 to 26.9±10.82 g/hr), which was quite similar in other age groups of 6 and 8 years old children in this study as well.

Marthaler et al.(1995) studied fluoride excretion in children aged 10 years in Zurich (1983) and 10-13 years in Canton of Glarus. The urinary collections lasted during 6-7 hours at school and were divided into 2 periods; morning and afternoon. The

30 children in Zurich using domestic fluoridated salt containing the insufficient level of 90 gF/g excreted 8.6, 13.5 and 9.7 g/hr in the morning, afternoon and whole period, respectively. Whereas the fluoride excretion from 32 children in Canton of Glarus, using 250 gF/g fluoridated salt, were 18.5, 31.2 and 21.7 g/hr respectively [19]. This demonstrated that afternoon urinary fluoride excretion was significantly higher than morning and night urinary fluoride excretion which was confirmed in this study that the afternoon urinary fluoride excretion, after milk fluoridation, was also significantly higher than the morning urine...

Not only the urinary excretion rate in children aged 8 years in this study agrees fairly well with those from Zurich and Canton of Glarus [19], but also with those from one group of Strabourg children aged 10-14 years who consumed 250 gF/g fluoridated salt with every meal and with those from the other group of Strabourg children taking a daily supplement of 1.0 mg fluoride [5]. The data from this study confirms the useful biomarker of urine sample for the fluoride intake from consuming fluoridated milk in several age groups of children similar to other forms of fluoride intake such as water fluoridation or salt fluoridation from previous studies. Moreover, the application of 8-hrs urine collection for urinary fluoride excretion in this study can reflect well of the fluoride intake which is comparable with other studies from 24-hrs and 7-hrs urinary fluoride and will be more practical for further urinary fluoride study in the future.

This study also affirms the safety dose of 0.5 mg fluoride from fluoridated milk in school children age 4, 6 and 8 years in the Thai milk fluoridation scheme from the urinary fluoride excretion in comparison with the data of the similar age groups from other means of optimal fluoride intake such as water fluoridation and salt fluoridation.

Conclusion:

In conclusion, the morning urine in children which was prior to drinking either fluoridated milk in test group or non-fluoridated milk in control group, demonstrated slightly increased of fluoride excretion from baseline in both test and control groups with no different in the 3 age groups, 4, 6 and 8 years old children. In the control group, the increased urinary fluoride excretion in the morning urine samples was not different from the afternoon urine, after consuming non-fluoridated milk in all age group.

The average excreted fluoride per hour of afternoon urine samples, after drinking fluoridated milk, in every age groups in test group were 3 times significantly higher than that of control group which reflected the fluoride intake from fluoridated milk. The overall average urinary excretion of fluoride per hour in children in the 3 studied age groups, after launching the fluoridated milk project, indicated that they received fluoride at the optimum and safety level.

Further study should be done to investigate the bioavailability of fluoride from milk and the individual FUEF in young children in more detail for more precise estimations of total fluoride intake.

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