

# Effectiveness of Fluoridated Milk in Children's Daily Diet for the Prevention of Caries

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## Abstract

In this work, a comprehensive study of risk factors and caries infestation was carried out. The main indicators of the enamel–plaque–saliva system and the state of local immunity in preschoolers with different levels of caries health and activity were studied. The role of regular intake of fluoridated milk in the prevention of caries in children with different levels of health and activity of dental caries has been studied. The study of caries resistance, the main parameters of the cariesogenic situation, and local immunity in preschoolers with different levels of health and activity of dental caries in the dynamics of the systemic use of fluoridated milk. It is stated that in frequently and long-term ill children, the prevalence of general and local risk factors for the development of caries and the intensity of tooth damage is higher, and the caries resistance of enamel is lower than in rarely and occasionally ill children. The use of fluoridated milk in children from the age of 3 is an effective method of primary prevention of dental caries in preschoolers, however, does not completely solve the problem of prevention of caries of baby teeth. The milk fluoridation program is more effective for rarely and occasionally ill children with I degree of caries activity. For frequently and long-term ill children, both with I and III degrees of caries activity, the milk fluoridation program should be supplemented with the use of a set of additional caries-prophylactic measures.

**Keywords:** Milk, Fluoride, Caries, Children, Dentistry

## INTRODUCTION

Unfavorable socioeconomic processes in our society are accompanied by a sharp deterioration in the health of children [1, 2]. A decrease in the level of protective and adaptive mechanisms of the child's body has led to an increase in diseases of various organs and systems, weighing their course and outcomes [3, 4]. A high proportion in the structure of general childhood morbidity is the frequent incidence of acute respiratory infections in children [5, 6].

Diseases of the oral cavity organs are background diseases that significantly affect the health of children [7]. Dental caries is the most common dental disease among children and adults [8]. Common causes of the development of frequent morbidity in children and the occurrence of dental caries are the impact of adverse social factors and environmental conditions, changes in immunoreactivity in combination with the actions of other factors: the burden of genealogical, biological history, early transfer to artificial feeding, the presence of foci of chronic infection, etc. [9].

While in highly developed countries, due to the introduction of communal preventive programs, there is a decrease in the incidence of caries [10], in Russia, children and adults have a high prevalence and intensity of dental caries. In different regions, the prevalence of caries of milk teeth in children aged

three years is 45%-75%, in six years - 85%-95%, the prevalence of caries of permanent teeth in 12-year-olds is 70%-80%, in adults 35-44 years – 98%-100% [11]. In this regard, the prevention of dental caries continues to be an urgent area of research in dentistry. At the population level, programs of systemic administration of fluorides are of particular importance, the safety and effectiveness of which have been confirmed by long-term clinical observations and scientific research [12].

Milk fluoridation, as one of the alternative methods of systemic administration of fluorides, is successfully used in

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different countries, as it is acceptable to the population and is consumed by most children regularly [13]. In the production of fluorinated milk, special attention is paid to the forms of introduced fluorides (they must be bioavailable), as well as their effect on the stability of the dispersed system of milk [14, 15].

However, several issues related to clarifying the individual sensitivity of children to fluorides used for preventive purposes remain insufficiently studied. The effect of fluorides on children with different levels of health has not been studied. The effectiveness of the systemic use of fluorides in children with varying degrees of dental caries activity has not been sufficiently studied.

Thus, the study aimed to determine the effectiveness of the use of fluoridated milk in preschoolers with different levels of health and activity of dental caries to justify measures of individualized prevention of caries in children.

## MATERIALS AND METHODS

For a preliminary assessment of the prevalence and intensity of dental caries in preschoolers of Vladikavkaz before the introduction of the milk fluoridation program, an epidemiological survey of 2,045 children aged 3 and 6 years

was conducted. The overall health of the children was assessed according to the catamnesis data. We studied 1230 individual cards of children 3-6 years old who visited polyclinics in Vladikavkaz.

Risk factors for the development of dental caries in preschoolers were studied according to a survey of parents. A total of 600 questionnaires were distributed, of which 494 (82.33%) were returned and evaluated. To study the results of the milk fluoridation program, two groups were formed among organized preschoolers: "A" – preventive (children regularly consumed fluoridated milk), 195 children, "B" – comparison group (children regularly consumed regular milk), and 211 children.

The effectiveness of the milk fluoridation program was determined in children with different levels of health and activity of dental caries. In this regard, two subgroups (60 children each) were included in groups "A" and "B": 1 - children who are often and long-term ill (OLTI), 2 - children who are rarely and occasionally ill (ROI). In each subgroup, 3-year-old (30 people) and 6-year-old (30 people) children were represented, the number of boys and girls in the subgroups was the same, and the number of children with I and III degrees of caries activity was also the same (**Table 1**).

**Table 1.** Organization of research groups.

Groups	Age, years	Degree of caries activity		Total	
		I	III		
		Children	Children		
A (preventive), 195 children.	1. OLTI, 60 children.	3	15	15	30
		6	15	15	30
	2. ROI, 60 children.	3	15	15	30
		6	15	15	30
	3. ROI children with healthy teeth, 75 children.	3	-	-	75
		3	15	15	30
B (comparison), 211 children.	1. OLTI, 60 children.	3	15	15	30
		6	15	15	30
	2. ROI, 60 children.	3	15	15	30
		6	15	15	30
	3. ROI children with healthy teeth, 91 children.	3	-	-	91
Total					406

To assess the role of regular use of fluoridated milk in the primary prevention of dental caries at the individual level, a third subgroup was formed in groups A and B (**Table 1**), which included three-year-olds with healthy teeth: 75 children in the preventive group, 91 children in the comparison group (all children of the 3<sup>rd</sup> subgroups belonged to ROI since there were practically no children with healthy teeth in OLTI). In these subgroups, the dynamics of the incidence of caries were studied for three years. A total of 406 children participated in the study.

In groups of children, OLTI and ROI conducted a study of indicators in the "enamel – plaque – saliva" system before and in the dynamics of the use of fluoridated milk. In all children, the intensity of caries and the increase in the intensity of caries were determined according to the standard method. The degree of activity was determined in accordance with the criteria of Austin *et al.* [16]. To assess the cariogenic situation and caries resistance of teeth in children with I and III degrees of caries activity we studied: the indicators of enamel acid resistance (TER test) [17], enamel remineralization rate [18], oral hygiene indices [19],

salivation rate according to the method [20], pH of the oral fluid using pH meter Checker (Moscow, Russia), mineralizing potential of saliva (MPS) [21]. The state of local immunity of the oral cavity was also studied: the content of immunoglobulins (Ig) of classes G, M, and A. Studies were carried out by the immunoturbidimetric method on a photometer Microlab-200 (Berlin, Germany).

The communal level of effectiveness of the milk fluoridation program was determined based on the data of an annual survey of 6-year-olds in Vladikavkaz, before the introduction and for four years after the introduction of the program. A total of 600 children were examined.

In the process of work, a database in Microsoft Excel was used. For statistical data processing, standard mathematical statistics software packages were used using the Student's significance criterion (t) with a given degree of reliability of differences at  $t > 2$ ,  $p < 0.05$ .

## RESULTS AND DISCUSSION

The results of the study of the general health of children aged 3-6 years showed that the majority (943 people (76.7%)) had various deviations in health status and belonged to the II health group; 110 people (8.9%) had the I health group; 177 (14.4%) had the III and IV health group, and the V health group did not meet in any case. Among preschoolers of the II health group, 18.2% were a subgroup of OLTi children. ROI

children were found in all health groups and accounted for 68.2% of the total number of preschoolers surveyed.

Risk factors for dental caries in preschoolers were studied in the groups OLTi (1) and ROI (2). The study of the antenatal period of children's life showed that only 36.3% of women in group 1 did not suffer from extragenital diseases during pregnancy, in group 2 - 1.8 times more often - 65.5%. During the entire period of pregnancy, group 1 women suffered one extragenital disease in 56.9% of cases, two diseases - in 30.2%, and three or more - in 12.8%. In group 2, the incidence of diseases in women during pregnancy was lower: 78.4% had been ill once, 16.3% twice, and 5.3% three or more times. Toxicoses of the first and second half of pregnancy were more common in group 1 than in group 2 (28.8% and 22.1%, respectively).

The study of the type of feeding of a child in the first year of life showed that in group 1, the majority of children had a natural type of feeding only up to 3 months (44.8%), less often - up to 6 months (29.3%). Only 17.2% of children received breast milk before the year and 8.6% after the year. In group 2, many children received natural feeding for a longer time: 28.4% up to 3 months, 34.7% - up to 6 months, 20.3% - up to a year, and 16.5% - after a year (**Table 2**). The incidence of acute respiratory infections in group 1 was high already in the first year of life (71.1% of children have been ill 4 or more times). The number of children who had never been ill in Group 1 was less than in Group 3 - 28.9%, while in Group 2 there were the majority of such children - 60.6%.

**Table 2.** The type of feeding and the nature of diseases in children at an early age.

Factor	Factor graduation	Group 1, OLTi, 135 children	Group 2, ROI, 264 children
		%	%
Type of feeding:	age:		
	up to 3 months.	44.8	28.4**
	up to 6 months.	29.3	34.7
	up to 1 year.	17.2	20.3
Natural	1 year or more	8.6	16.5*
	Mixed	since birth	5.2
Artificial	since birth	8.8	9.5
	ARI disease in the first year of life	yes: 1-3 times	0.0
4 or more times		71.1	0.0***
ARI disease in the second and third years of life	no	28.9	60.6***
	up to 1-5 times	0.0	76.1***
The presence of a chronic disease	6 or more times	100.0	0.0***
	no	0.0	23.9***
	yes	84.4	42.8***
	no	15.6	57.2***

\* The differences between the data of groups 1 and 2 are significant,  $p < 0.05$ , \*\* -  $p < 0.01$ , \*\*\* -  $p < 0.001$ .

In the second and third years of life in group 1, 100% of children had ARI 6 or more times, in group 2 there were fewer such children: 76.1% of children had ARI 1-5 times, and 23.9% had never been ill. At the time of the survey, 84.4% of children in group 1 had from one to three chronic diseases of

internal organs, in group 2 such children were 2 times less - 42.8%.

In both groups, there were often such risk factors for the development of caries as insufficient hygienic oral care and rare visits to the dentist for preventive purposes. A total of

58.0% of children in both groups performed daily oral care. Only 34.8% of children in group 1 brushed their teeth twice a day, in group 2 – even less, 26.0%. The majority of children in group 1 visited the dentist once a year - 42.6%, or once every two years - 17.0%, in group 2 - 53.3% and 18.8%, respectively. Only 3.1% of group 1 children visited the dentist every 3 months, 37.2% - every 6 months, in group 2 - 5.8% and 22.2%, respectively.

Thus, in the OLTi group, more often than in the ROI group, preschoolers had risk factors for dental caries, both during the period of antenatal development and in the first and subsequent years of the child's life. However, in both groups of children, oral care and the frequency of visits to the dentist were insufficient.

The results of the epidemiological dental examination of children showed that the prevalence of caries of baby teeth was 61.1% (for 3 years olds) and 85.4% (for 6 years olds). In group 1 (OLTi), the prevalence of caries of milk teeth was higher than the average age indicators and indicators of group 2 (ROI): 65.4% in 3 years-olds and 90.9% in 6 years-olds of group 1 versus 56.8% and 79.3% of group 2, respectively. The intensity of caries of baby teeth in 3 years-olds was  $1.57 \pm 0.03$ , and in 6-year-olds  $4.82 \pm 0.03$ . In group 1, the intensity of dental caries was higher than the age average and was  $2.43 \pm 0.41$  in 3-year-olds and  $5.31 \pm 0.63$  in 6-year-olds, which significantly exceeded the intensity of dental caries in children of group 2 ( $1.28 \pm 0.22$  and  $3.61 \pm 0.31$ , respectively). The same patterns were found for permanent teeth. The prevalence of caries of permanent teeth in 6 years-olds was 11.1%, in group 1 – 13.2%, in group 2 – 6.3 times less (2.1%). The intensity of damage to permanent teeth in 6 years-olds was  $0.12 \pm 0.021$ , in group 1 –  $0.21 \pm 0.03$ , in group 2 – 5.2 times less ( $0.04 \pm 0.03$ ).

As a result of the study of the acid resistance of tooth enamel, it was found that in children with the I degree of caries activity in all groups, the values of acid resistance did not exceed three points and corresponded to a high level of caries resistance. In all groups of children with the III degree of caries activity, acid resistance values were 1.7 – 2 times higher ( $p < 0.05$ ) than in children with the I degree of caries activity and were in the range of 4.8-5.5 points, which corresponded to the average level of caries resistance. The

study of the rate of enamel remineralization showed that in children with the I degree of caries activity in all groups, enamel remineralization after etching occurred within three days, which reflected a high level of enamel caries resistance. In children with the III degree of caries activity, the values of the enamel remineralization rate index significantly ( $p < 0.001$ ) exceeded the corresponding indicators in children with the I degree of caries activity, the values of the enamel remineralization rate exceeded 3 days, which indicated a decrease in enamel caries resistance.

The hygienic condition of the oral cavity in most children of 3 years olds and 6 years olds with the III degree of caries activity was significantly worse than in children with the I degree of activity. The efficiency index of oral hygiene in 6 years-olds in all groups exceeded 1.7 points, which corresponded to an unsatisfactory level of hygiene.

A comprehensive analysis of the data showed that in children of the OLTi group, compared with the ROI group, a decrease in tooth enamel caries resistance and a cariesogenic situation in the oral cavity were more common. However, the most pronounced and significant changes were detected in children with the III degree of caries activity, compared with children with the I degree, both in the OLTi and ROI groups.

The results of the study of the state of local immunity showed that in the saliva of children of group 1 (OLTi), both at the age of 3 and 6, the concentration of Ig G and Ig A were significantly ( $p < 0.001$ ) higher than in children of group 2 (ROI). In children with the III degree of caries activity, the concentration of IgA exceeded the same indicator in children with the I degree of caries activity, but the differences were not statistically significant.

Thus, the level of local immunological protection of the oral cavity depended on the general health of children, while many indicators of caries resistance and the caries-induced situation in the oral cavity varied depending on the degree of caries activity.

Analysis of these indicators "enamel-plaque-saliva" after regular intake of fluoridated milk for 12 months showed that in children of the preventive group, changes in the value of TER were of a different nature (Table 3).

**Table 3.** Changes in the indicators of acid resistance of enamel (TER-test) in children after 12 months

Degree of caries activity	Age/ Inspection	Group 1 (OLTi)		Group 2 (ROI)	
		A (preventive)	B (comparison)	A (preventive)	B (comparison)
		Score, $M \pm m$	Score, $M \pm m$	Score, $M \pm m$	Score, $M \pm m$
	3 years				
I	1 insp.	$2.67 \pm 0.22$	$2.47 \pm 0.20$	$2.67 \pm 0.19$	$2.73 \pm 0.19$
	2 insp.	$2.87 \pm 0.28$	$3.27 \pm 0.26^*$	$2.47 \pm 0.33$	$3.47 \pm 0.30^*$
III	1 insp.	$5.00 \pm 0.32$	$5.40 \pm 0.32$	$5.80 \pm 0.30$	$5.00 \pm 0.20$
	2 insp.	$5.47 \pm 0.30$	$6.87 \pm 0.22^{**}$	$5.00 \pm 0.25^*$	$6.67 \pm 0.22^{**}$

6 years

I	1 insp.	2.80±0.21	2.87±0.17	3.07±0.24	2.27±0.26
	2 insp.	2.20±0.20*	2.73±0.19	3.27±0.31	2.80±0.34
III	1 insp.	5.87±0.33	3.80±0.15	5.07±0.34	5.93±0.21
	2 insp.	4.93±0.26*	4.50±0.17**	4.87±0.28	6.67±0.13**

\* Validity of differences,  $p < 0,05$ , \*\* -  $p < 0,01$ , \*\*\* -  $p < 0,001$  between the values of TER obtained at 1 and 2 inspections in the same groups of children.

In group 1, 3 years-olds with I and III degrees of caries activity tended to increase, but the differences were not significant. In all other groups, the values of TER decreased, the differences were dorsal in 3 years-olds of group 2 with III degrees of caries activity, and 6 years-old children of group 1 with I and III degrees of caries activity. In most comparison groups, the values of the TER test significantly increased, especially in 3 years-olds with III degrees of caries activity, which corresponded to a decrease in the acid resistance of the enamel.

Thus, regular consumption of fluoridated milk increased the acid resistance of tooth enamel in most children. However, this effect was not observed in 3 years-olds from the OLT I group.

The rate of enamel remineralization 12 months after the initial examination increased in the preventive group in children of 3- and 6 years-old ROI, both with I and III degrees of caries activity. The majority of children with OLT I maintained the same tendency as in all comparison groups to decrease the rate of enamel remineralization (Table 4).

**Table 4.** The change in the rate of enamel remineralization in children after 12 months.

Degree of caries activity	Age/ Inspection	Group 1 (OLT I)		Group 2 (ROI)	
		A (preventive)	B (comparison)	A (preventive)	B (comparison)
		Days, M±m	Days, M±m	Days, M±m	Days, M±m
3 years					
I	1 insp.	2.07±0.12	1.93±0.19	2.60±0.14	2.13±0.20
	2 insp.	2.66±0.22*	2.73±0.24*	2.20±0.15*	3.00±0.22**
III	1 insp.	3.33±0.13	3.07±0.24	4.02±0.23	3.53±0.14
	2 insp.	3.66±0.13	4.01±0.22**	3.43±0.13*	4.04±0.19*
6 years					
I	1 insp.	2.42±0.14	2.41±0.17	2.62±0.14	2.91±0.19
	2 insp.	2.40±0.14	2.93±0.24	2.11±0.11**	2.94±0.19
III	1 insp.	3.43±0.14	3.94±0.06	3.64±0.17	3.72±0.13
	2 insp.	3.82±0.11*	3.81±0.11	3.12±0.17*	4.04±0.19

\* Validity of differences,  $p < 0,05$ , \*\* -  $p < 0,01$  between the rate of enamel remineralization, obtained at 1 and 2 inspections in the same groups of children.

Regular consumption of fluoridated milk did not significantly affect the rate of salivation in the preventive groups. In the comparison groups, a tendency to decrease the salivation rate was revealed, however, only in children with the III degree of caries activity, did a decrease in the salivation rate to values of  $0.21±0.01$  ml/min in 3 years olds and  $0.29±0.04$  ml/min in 6 years-olds was recorded, characterizing the occurrence of a cariesogenic situation in the oral cavity.

The study of saliva mineralizing potential showed that children from preventive groups had a clear tendency to increase saliva mineralizing potential, however, the differences between the data of 1 and 2 inspections were not statistically significant. In children of all comparison groups, on the contrary, there was a tendency to decrease the mineralizing potential of saliva, which was confirmed statistically ( $p < 0,01$ ) in most children with the III degree of caries activity (Table 5).

**Table 5.** Dynamics of saliva mineralizing potential (SMP).

Degree of caries activity	Age/ Inspection	Group 1 (OLT I)		Group 2 (ROI)	
		A (preventive)	B (comparison)	A (preventive)	B (comparison)
		Score, M±m	Score, M±m	Score, M±m	Score, M±m
3 years					
I	1 insp.	2.26±0.26	2.29±0.14	2.42±0.21	2.39±0.21
	2 insp.	2.49±0.17	1.97±0.15	2.93±0.30	2.24±0.21

III	1 insp.	1.72±0.13	1.75±0.12	1.55±0.17	1.95±0.09
	2 insp.	1.84±0.10	1.33±0.11**	1.95±0.16	1.55±0.08**
	6 years				
I	1 insp.	2.03±0.16	2.24±0.14	2.82±0.24	2.17±0.08
	2 insp.	2.35±0.13	2.17±0.12	3.16±0.23	2.09±0.13
III	1 insp.	1.62±0.22	1.97±0.20	1.56±0.07	1.29±0.15
	2 insp.	1.91±0.16	1.73±0.19	1.80±0.23	1.87±0.13**

\* Validity of differences,  $p < 0.05$ , \*\* -  $p < 0.01$  between SMP, obtained at 1 and 2 inspections in the same groups of children.

When studying the hydrogen index of the oral fluid after 12 months, no significant changes in the pH value were detected in most observation groups. Only in the prophylactic group of 3 years-olds (ROI), there was a significant increase in the pH value to a safe level (from  $6.74 \pm 0.05$  to  $6.85 \pm 0.01$ ,  $p < 0.05$ ), and in the corresponding comparison group there was a decrease in the value of the indicator to a critical value (from  $6.71 \pm 0.03$  to  $6.57 \pm 0.04$ ,  $p < 0.01$ ).

Analysis of the indicators of local immunity of the oral cavity showed that in all preventive groups, the content of Ig G and Ig A significantly ( $p < 0.001$ ) decreased to the values of the physiological norm, while no positive changes were observed in the comparison groups.

The study of the development of caries in children who had healthy teeth at the age of three showed a pronounced primary caries-prophylactic effect of regular intake of fluoridated milk at the individual level. At the end of the follow-up period (after 3 years), in children of the preventive group who took fluoridated milk from the age of 3, the prevalence of caries in milk teeth was 13.1%, and the intensity was 1.4 times lower than in children who consumed regular milk, which is consistent with the data of Mariño *et al.* [22]. A similar effect was obtained in permanent teeth: after 3 years in the preventive group, compared with the comparison group, the prevalence of caries was 8.5 times, and the intensity was 4.6 times lower. The reduction in the intensity of caries of permanent teeth was 78.4%.

## CONCLUSION

The results of the studies showed that the level of the child's general health did not significantly affect the changes in most indicators in the enamel-plaque-saliva system, which is consistent with the results of other authors [23, 24]. The change in the indicators of local immunity in children who are often ill, compared with those who are rarely ill, was expressed in an increase in the content of Ig G and Ig A in the oral fluid, both in children with I and III degrees of caries activity. In children who regularly consumed fluoridated milk, in the ROI group there was an increase in the acid resistance of enamel and the rate of its remineralization, an increase in the mineralizing potential of saliva, in the OLT group there was a tendency to increase SMP. There was no significant effect of fluoridated milk intake on oral hygiene indicators, salivation rate, and pH of oral fluid in children. In children of the OLT group with I and III degrees of caries activity, regular intake of fluoridated milk led to a decrease in the content of Ig G and Ig A to values corresponding to the

physiological norm. In 3 years-olds who had healthy teeth and took fluoridated milk, after 3 years in milk teeth, the prevalence of caries was 13.1%, and the intensity was 1.4 times lower than in children who consumed regular milk. In permanent teeth, respectively, the prevalence of caries was 8.5 times, and the intensity was 4.6 times lower. Regular intake of fluoridated milk reduced the increase in caries in preschoolers with I and III degrees of caries activity. Reduction of the growth of caries of milk teeth was the greatest among 3 years-olds: in the ROI group with the I degree of caries activity – 72.1%, III – 23.3%, in the OLT group – 37.5% and 36.9%. In 6 years-olds, there was a high reduction in the growth of caries of permanent teeth: 79.4% in the OLT group, and 86.8% in the ROI group.

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