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Dental disease prevention in children of different ages in the Zakarpattia region

Yan Duhanchik*

Senior Lecturer
Uzhhorod National University
88000, 3 Narodna Sq., Uzhhorod, Ukraine
https://orcid.org/0000-0002-9058-4729

Edita Dyachuk

Senior Lecturer
Uzhhorod National University
88000, 3 Narodna Sq., Uzhhorod, Ukraine
https://orcid.org/0009-0003-7251-5732

Mykola Bilyschuk

PhD in Medical Sciences, Associate Professor
Ivano-Frankivsk National Medical University
76000, 2 Halytska Str., Ivano-Frankivsk, Ukraine
https://orcid.org/0009-0006-9586-9148

Abstract. The study aimed to characterise the dental health status of the child population in Zakarpattia region and identify practical ways to optimise preventive care among children. The study was conducted in January-June 2025 at the Dental Department of the Rakhiv District Hospital, a municipal non-profit enterprise in the Zakarpattia region. The analysis covered 240 children aged 6-15 and involved a clinical and analytical approach combining examination, questionnaires and statistical analysis of the relationships between behavioural and clinical indicators of dental health. The results of the study showed that the average caries intensity index increased from 2.12 in the 6-8 age group to 4.36 in adolescents aged 12-15, accompanied by a deterioration in hygiene status from 1.49 to 2.06. The index was dominated by decayed teeth: 1.50 in younger children, 2.58 in middle-aged children, and 3.02 in older children, reflecting late treatment. Girls had better results (3.22 vs 3.69 in boys) and a higher frequency of regular tooth brushing (77% vs 69%). Territorial analysis revealed a gap: the caries level was 2.84 in urban children and 3.92 in mountain children, with worse hygiene indicators (2.07 vs 1.61). Only 47% of urban children underwent preventive examinations, compared to 32.6% in mountain communities. A negative correlation was found between hygiene behaviour and caries ($r = -0.62$), confirming the key role of behavioural factors in maintaining health. The obtained results indicated that the dental health of children in Transcarpathia is influenced by age, gender, behavioural habits and territorial conditions, while the effectiveness of prevention remains insufficient due to the uneven participation of schools, families and medical services in the hygiene education system. The practical significance of the study results is determined by the possibility of using the data by local health authorities, school medical services and family doctors to plan regional programmes for caries prevention and hygiene education for children

Keywords: hygiene; health; caries; fluoride toothpaste; tooth brushing; behavioural factors; remote mountain villages

INTRODUCTION

Dental diseases in children are among the most common non-infectious pathologies affecting the overall health, quality of life and harmonious development of a child. According to the World Health Organization [1], approximately 3.5 billion people worldwide have experienced oral diseases during their lifetime, which highlights their

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*Corresponding author

significance as a global public health problem. Border regions of Ukraine, in particular the Zakarpattia region, are characterised by complex geographical conditions, socio-economic heterogeneity, insufficient coverage by preventive programmes and limited access to specialised care. This combination of factors contributes to late visits to the dentist, irregular oral hygiene control, and low effectiveness of preventive measures, which creates the conditions for the early development of dental lesions. Untreated pathological processes in children lead to chronic pain, chewing and speech disorders, sleep disorders, reduced food adaptation and cognitive activity, and, over time, to the formation of persistent infectious foci and an increased burden on the healthcare system, determining the need for systematic prevention and clinical monitoring of the dental health of the child population.

Global approaches to the prevention of dental diseases in children have demonstrated a transition from a purely therapeutic model to a preventive and educational one, integrated into the public health system. The concept of "Federation Dentaire Internationale Vision 2030", presented by M. Glick & D.M. Williams [2], defined the prevention of dental diseases in children as an element of the basic rights of the child to health and emphasised the need for equal access to primary care and continuous monitoring, which is of particular importance for peripheral regions. At the same time, the authors noted that personnel, financial and organisational barriers hindered the integration of dental health into public policy priorities. A meta-analytic review by P. Akera *et al.* [3] demonstrated that school interventions combining hygiene education, nutrition control and access to preventive measures reduced the incidence of caries even in resource-limited settings. The researchers also found that without the support of the healthcare system, the effect of such programmes was short-lived. A study by T. Bramantoro *et al.* [4] confirmed that the inclusion of a dental component in the educational process from preschool age increased the effectiveness of prevention, while formal models without systematic hygiene control did not provide sustainable results.

Ukrainian studies have shown that the prevention of dental diseases in children in Ukraine remains fragmented and depends mainly on local initiatives. A clinical study by O.V. Sheshukova *et al.* [5] established those interactive educational activities, in particular dental performances for younger schoolchildren, improved hygiene skills and increased adherence to prevention. At the same time, the authors noted that such programmes did not have regulatory status and were not scaled up, which indicated the lack of a sustainable preventive infrastructure. An analysis of dental care provision conducted by V.D. Chopchyk *et al.* [6] revealed a shortage of material and technical resources and demonstrated uneven access to examinations for children, especially in small settlements. It was emphasised that this resource imbalance had transformed into clinical inequality, increasing the proportion of late referrals. V.A. Grokhotov *et al.* [7] showed that the lack of a single standard for preventive monitoring of children's risk groups made it difficult to ensure the proper quality of dental services. The researchers emphasised that without the creation of an integrated model, prevention in border regions, particularly in the Zakarpattia region, remained situational.

Socio-economic and behavioural factors determine the cumulative risk of dental pathology in childhood and necessitate regionally adapted prevention models. A study conducted by M.E. Northridge *et al.* [8] found that limited access to dental care, geographical remoteness and financial barriers caused persistent differences in children's health. The study demonstrated that these inequalities were systemic in nature and reproduced across generations, exacerbating the social vulnerability of the child population. As noted by O.S. Almajed *et al.* [9], the low socioeconomic status of the family directly affected the availability of hygiene products and the quality of children's nutrition. The study emphasised that it was social determinants that determined long-term differences in the prevalence of caries and complications. O.V. Sheshukova *et al.* [10] demonstrated that stressful social conditions, in particular the consequences of armed conflicts, were associated with early caries development and an increase in the frequency of inflammatory processes. The scientists emphasised that social instability is a powerful risk factor for children's dental health. According to the results of a study by O.S. Pavlenkova & L.F. Kaskova [11], organised educational groups were an effective environment for the formation of sustainable hygiene habits in children. The researchers noted that the duration of the effect of such programmes depended on the regularity of pedagogical support and intersectoral interaction between the education and healthcare systems.

Despite numerous international and national studies in the field of preventive dentistry, there is still no comprehensive assessment of age, behavioural and socio-economic factors influencing the dental health of children in the mountainous regions of the Zakarpattia region. The study aimed to assess the dental health of children of different age groups in Transcarpathia and to justify directions for improving preventive measures aimed at reducing the prevalence of dental lesions. To achieve this goal, the following tasks were set: to establish the prevalence of dental diseases among children of different age groups; to analyse the level of hygiene knowledge and behavioural risk factors; to develop recommendations for improving the effectiveness of preventive programmes among the child population in mountainous areas.

MATERIALS AND METHODS

The study was clinical and analytical in nature and was conducted between January and June 2025 at the Dental Department of the Rakhiv District Hospital, a municipal non-profit enterprise in Zakarpattia region. The facility serves both the population of the city of Rakhiv and residents of surrounding remote mountain villages (Yasinya, Bohdan, Kvasy, Bilin, Dilove, etc.), which ensured diversity in the sample in terms of place of residence, living conditions, and access to preventive care. This approach covered the geographical, socio-economic and infrastructural characteristics of the region that potentially affect the dental health of children. The choice of the period January-June was due to the representativeness of visits at this time of year, when there is a stable flow of patients after the winter and spring holidays, as well as no seasonal decline in attendance, which is typical for the summer months. This made it possible to minimise time fluctuations in indicators and ensure the objectivity of the results.

The study involved 240 children aged 6 to 15 who visited a paediatric dentist for preventive or therapeutic treatment. Patients were divided into three age groups: younger (6-8 years), middle (9-11 years), and older (12-15 years). The lower age limit of 6 years was selected as this is the age at which the temporary dentition is replaced by permanent teeth, the first permanent molars are formed, and thus the basis of the child's dental status is established. This is the age at which it is advisable to conduct systematic monitoring of dental health for the early detection of caries in permanent teeth. The upper limit of 15 years corresponds to the completion of the formation of the permanent dentition and the period of stabilisation of hygiene habits, which can be used to assess the cumulative effect of preventive measures and behavioural habits. To ensure the representativeness of the sample, stratification was conducted not only by age but also by gender and geographical characteristics. This approach covered children living in the city of Rakhiv and surrounding settlements, as well as in remote mountain villages, which differ in terms of access to dental care. A summary of the sample characteristics was provided in Table 1.

Table 1. Characteristics of the sample of children included in the study (n = 240)

Age group (years)	Total, n (%)	Boys, n	Girls, n	City / adjacent areas, n	Remote mountain villages, n
6-8 (young)	78 (32.5%)	38	40	29	49
9-11 (middle)	82 (34.2%)	38	44	36	46
12-15 (older)	80 (33.3%)	38	42	37	43
Total	240 (100%)	114	126	102 (42.5%)	138 (57.5%)

Source: compiled by the authors

The sample included children aged 6-15 who had lived permanently in the Rakhiv region for at least three years and had no significant somatic or mental disorders. Children with acute infectious diseases at the time of examination, as well as those with systemic, metabolic or hereditary disorders that could affect the condition of hard tooth tissue, were excluded from the study. The clinical examination was conducted according to the World Health Organization methodology [12], which provides a standardised approach to assessing the dental status of children. To determine the intensity of the carious process, the DMF index (a measure of caries intensity reflecting the sum of decayed, extracted and filled teeth) was used, which was calculated using formula (1):

$$DMF = D + M + F, \quad (1)$$

where D – number of decayed teeth (Decayed), M – number removed due to caries (Missing), F – number of filled teeth (Filled).

The DMF index was used similarly for temporary occlusion. Oral hygiene was assessed using the Oral Hygiene Index-Simplified (OHI-S) in the Green-Vermillion (1964) modification, which reflects the level of cleanliness of tooth surfaces in terms of the presence of soft plaque and tartar. The index was calculated using formula (2):

$$OHI\text{-}S = DI\text{-}S + CI\text{-}S, \quad (2)$$

where *DI-S* (Debris Index Simplified) – indicator of soft plaque quantity, and *CI-S* (Calculus Index Simplified) – indicator of tartar quantity.

The assessment was conducted on six index teeth, determined based on the international dental numbering system: 16 – first upper right molar, 11 – central upper incisor, 26 – first upper left molar, 36 – first lower left molar, 31 – central lower incisor i 46 – first lower right molar (all permanent teeth). If one of the specified teeth was missing, the assessment was performed on its symmetrical antagonist. Each vestibular or lingual surface was assessed on a four-point scale: 0 – clean surface, 1 – plaque or tartar covers no more than one-third of the surface, 2 – one to two-thirds, 3 – more than two-thirds of the surface. After calculating the average values of DI-S and CI-S, the total OHI-S index was obtained, which was interpreted as good (0-1.2), satisfactory (1.3-3.0) or unsatisfactory (over 3.0) oral hygiene.

To analyse the behavioural aspects of dental risk formation, a questionnaire was developed and adapted to the research objectives. The questionnaire contained 15 questions concerning the frequency and duration of tooth brushing, the use of additional hygiene products, eating habits, the level of awareness of prevention, and the regularity of visits to the dentist (Table 2). The survey was conducted during the appointment after the clinical examination; in younger age groups (6-8 years), the answers were recorded by parents or legal representatives, and in middle and older age groups (9-15 years), the children themselves answered under the supervision of the researcher. Of the 240 participants, 228 (95.0%) completed the questionnaire, ensuring a high level of representativeness of the behavioural data.

Table 2. Structure of the questionnaire for assessing behavioural factors of dental risk

No.	Content of the question	Answer options
1.	Teeth cleaning frequency	2 times per day – 1; 1 time – 0.5; rarer – 0
2.	Teeth cleaning duration	> 2 min – 1; 1-2 min – 0.5; < 1 min – 0
3.	Use of additional hygiene products	Yes – 1; No – 0
4.	Frequency of sweets consumption	Rarer – 1; several times per week – 0.5; every day – 0
5.	Mouthwash after eating	Always – 1; sometimes – 0.5; never– 0
6.	Use of fluorinated paste	Yes – 1; no – 0; not aware – 0.5
7.	Frequency of dentist visits	1 time per 6 months – 1; 1 time per year – 0.5; only if pain is present – 0
8.	Caries treatment experience	No – 1; Yes – 0

Table 2. Continued

No.	Content of the question	Answer options
9.	Preventive recommendations	Yes – 1; No – 0
10.	School visits by dentists/information about oral hygiene	Yes – 1; No – 0
11.	Self-assessment of knowledge level	High – 1; average – 0.5; low – 0

Source: compiled by the authors

A scoring system was used to quantitatively assess the responses: preventative favourable responses were scored as 1 point, neutral responses as 0.5 points, and risky responses as 0 points. The total score was interpreted as a high level of preventive behaviour (⩾11 points), satisfactory (6-10 points) or low (<6 points). This system facilitated the objectification of self-assessment of hygiene habits and the comparison of risk profiles between age groups and geographical subgroups (urban and remote villages). To assess the effectiveness of preventive measures, questionnaire results were aggregated according to three structural components: family, school and medical. Questions concerning personal hygiene, use of fluoride toothpaste, frequency of tooth brushing and eating habits characterised the family component. Questions regarding preventive visits, receiving recommendations, and treatment experience reflected the medical component. Schoolchildren's awareness and teachers' participation in educational activities formed the school component. The effectiveness of each area was assessed on an expert scoring scale from 0 to 3 points, where 0 meant no implementation of the measure, 1 – occasional implementation, 2 – partial or irregular implementation, and 3 – systematic and regular implementation. For each component, an average integral score was calculated, which characterised the overall level of participation in preventive activities. The level of effectiveness was stratified as low for values <1.5 points, medium for values between 1.5 and 2.4 points, and high for values – ⩾2.5 points.

The obtained data were subjected to descriptive and variational statistics with the determination of mean values (M) and standard deviations (SD). The analysis was performed using Microsoft Excel 2021 and IBM SPSS Statistics 26.0. The Kolmogorov-Smirnov test was used to check the normality of the distribution. Statistical relationships between behavioural factors and clinical indices were assessed using the χ^2 criterion, Student's t-test (for parametric data) and Mann-Whitney U test (for non-parametric data). Correlations were determined using Pearson's coefficient (r). The level of statistical significance was set at $p < 0.05$.

The study was conducted in accordance with the principles of the Declaration of Helsinki [13] on ethical standards for medical research involving human subjects and the American Sociological Association [14] code of ethics, which regulates the rules of voluntary participation, confidentiality, and processing of personal data during surveys. The participation of children and their legal representatives was voluntary. All parents signed a written informed consent form for the examination and use of aggregated data for scientific purposes. A limitation of the study was that it covered only one district of the Zakarpattia region, which limits the possibility of generalising the results for the entire population of children in the region.

RESULTS

Age, gender and geographical characteristics of children's dental status. The results of the clinical examination of children in the Zakarpattia region showed significant age, gender and territorial differences in dental status, reflecting both biological patterns of development and socio-economic characteristics of the region. To assess these differences, a comparative analysis of indicators by age, gender and geographical groups was conducted, the results of which are presented in Table 3.

Table 3. Age, gender and geographical characteristics of children's dental status (n = 240)

Children group	n	DMF (M ± SD)	OHI-S (M ± SD)	Component D	Component F	Component M
6-8 years, boys	38	2.24 ± 0.25	1.55 ± 0.10	1.62 ± 0.18	0.41 ± 0.07	0.21 ± 0.04
6-8 years, girls	40	2.00 ± 0.23	1.43 ± 0.09	1.38 ± 0.17	0.47 ± 0.06	0.15 ± 0.03
Young group total	78	2.12 ± 0.24	1.49 ± 0.09	1.50 ± 0.17	0.44 ± 0.06	0.18 ± 0.03
9-11 years, boys	38	3.72 ± 0.27	1.91 ± 0.12	2.74 ± 0.20	0.61 ± 0.08	0.37 ± 0.05
9-11 years, girls	44	3.46 ± 0.25	1.78 ± 0.11	2.42 ± 0.18	0.78 ± 0.09	0.26 ± 0.04
Middle group total	82	3.58 ± 0.26	1.84 ± 0.11	2.58 ± 0.19	0.70 ± 0.08	0.31 ± 0.04
12-15 years, boys	38	4.55 ± 0.30	2.16 ± 0.14	3.20 ± 0.22	0.88 ± 0.10	0.47 ± 0.06
12-15 years, girls	42	4.18 ± 0.28	1.97 ± 0.13	2.83 ± 0.21	1.01 ± 0.11	0.34 ± 0.05
Older group total	80	4.36 ± 0.29	2.06 ± 0.13	3.02 ± 0.22	0.95 ± 0.10	0.40 ± 0.05
City and adjacent areas	102	2.84 ± 0.22	1.61 ± 0.10	1.92 ± 0.16	0.69 ± 0.08	0.23 ± 0.04
Remote mountain villages	138	3.92 ± 0.29	2.07 ± 0.14	2.63 ± 0.21	0.72 ± 0.09	0.57 ± 0.07

Note: DMF – caries intensity index, which reflects the sum of decayed (D), filled (F) and missing (M) teeth in permanent or temporary dentition; OHI-S – simplified oral hygiene index according to Green-Vermillion, which assesses the degree of contamination of tooth surfaces; M – mean value; SD – standard deviation

Source: compiled by the authors

Caries intensity indicators showed a gradual increase with age, from 2.12 ± 0.24 in the younger group (6-8 years) to 4.36 ± 0.29 in the older group (12-15 years). This increase reflects the cumulative effect of lesions associated with prolonged exposure to cariogenic factors, the main ones being irregular hygiene, excessive sugar consumption and lack of preventive check-ups. At the same time, component F (filled teeth) increased slightly with age, indicating some

improvement in access to treatment for adolescents, but component D (decayed teeth) remained dominant in the index structure at 1.50 in the younger group, 2.58 in the middle group, and 3.02 in the older group. This indicates that most children sought dental care only at the stage of already formed caries, without the prevention stage. At the same time, there was a deterioration in hygiene (OHI-S: 1.49 → 2.06), which can be attributed to a decrease in parental control and an increase in children's independence in oral care.

Girls in all age groups demonstrated better dental health. Their average caries intensity was lower (3.22 ± 0.25) compared to boys, which may indicate a greater willingness to visit the dentist even for minor symptoms. Social expectations, parenting models, and parents' awareness of the aesthetic aspects of oral health may also have contributed to girls' preference for prevention. Thus, female gender in this age group acts as a conditional protective factor against severe lesions, confirming the role of a combination of behavioural and sociocultural aspects in the formation of dental risk.

The most noticeable differences were found between urban children and those living in remote mountain villages. The DMF index among mountain residents was 3.92 ± 0.29 compared to 2.84 ± 0.22 among urban children ($p < 0.01$), and the OHI-S index was 2.07 ± 0.14 compared to 1.61 ± 0.10, respectively. This difference indicates a clear territorial gradient in dental health. The main reasons are limited transport accessibility to dental clinics, a shortage of paediatric dentists, a low level of preventive measures in schools, and reduced availability of hygiene products. In many mountain villages, preventive examinations are performed sporadically, and children only visit the dentist in case of pain. As a result, the proportion of component D and the number of extracted teeth increase (M = 0.57 ± 0.07 compared to 0.23 ± 0.04 in urban areas). This indicates late referral for dental care, low effectiveness of preventive measures, and the prevalence of a symptomatic treatment model among the child population in mountainous areas.

Thus, the data obtained showed that the dental health of children in the Zakarpattia region is influenced by a combination of factors, including age, gender, behaviour, and geography. The most vulnerable group was middle and high school boys from remote mountainous areas, who combine poor hygiene habits with limited access to medical care. The results highlighted the need to develop tailored prevention programmes for mountainous regions, involving schools, local health workers and parents, as well as ensuring regular monitoring of the dental health of the child population.

Hygienic behaviour and preventive habits of children of different ages and genders. The results of the survey revealed the level of hygienic behaviour among children of different ages, genders and places of residence, as well as differences in preventive habits. Considering both individual (age and gender) and territorial factors was used for a comprehensive analysis of the social aspects of dental culture formation among the child population of the Zakarpattia region. The summarised data are presented in Table 4, which reflects the frequency of basic preventive actions, the level of use of fluoridated toothpastes, additional hygiene products and the regularity of preventive visits to the dentist.

Table 4. Hygiene behaviour and preventive habits of children of different ages, genders and places of residence (n = 228)

Age group (years)	n	Regular brushing of teeth twice a day, %	Use of fluorinated paste, %	Additional hygiene products (mouthwash, dental floss), %	Regular preventive visits to the dentist (≥1 time/year), %	Average score for preventive behaviour (0-10), M ± SD
6-8 years, boys	36	57.0	50.0	16.7	25.0	8.7 ± 2.6
6-8 years, girls	38	63.0	58.0	23.0	31.0	9.3 ± 2.3
Young group total	74	60.0	54.1	19.7	28.0	9.0 ± 2.4
9-11 years, boys	36	70.0	65.0	27.0	32.0	9.8 ± 2.4
9-11 years, girls	42	78.0	72.0	40.0	40.0	10.5 ± 2.1
Middle group total	78	74.0	68.3	34.1	36.0	10.2 ± 2.3
12-15 years, boys	36	80.0	73.0	39.0	43.0	10.7 ± 2.3
12-15 years, girls	40	90.0	84.0	56.0	54.0	12.0 ± 2.1
Older group total	76	85.0	78.3	47.0	48.0	11.4 ± 2.1
City/adjacent areas	97	76.5	76.5	39.8	47.1	11.1 ± 2.3
Remote mountain villages	131	63.0	63.0	27.3	32.6	9.8 ± 2.7

Note: M – mean value; SD – standard deviation
Source: compiled by the authors

The results demonstrated an age-related trend in the development of preventive behaviour. The proportion of children who regularly brushed their teeth twice a day gradually increased from 60.0% in the 6-8 age group to 85.0% among children aged 12-15. A similar trend was demonstrated in the use of fluoride toothpaste, from 54.1% to 78.3%. This indicates that as children get older, they become more responsible in matters of personal hygiene and become more conscious. This is possibly related to the development of self-control, increased cognitive activity and expansion of the information field, which provides access to knowledge about hygiene.

Gender analysis revealed consistent differences between boys and girls. In all age groups, girls demonstrated higher rates of regular hygiene practices and were more likely to use fluoride toothpaste and additional hygiene products. On average, 77% of girls brushed their teeth twice a day, compared to 69% of boys. Girls also used mouthwash or dental floss more often (40% vs 27%), indicating a more developed hygiene culture. These differences are due not

only to individual behavioural characteristics, but also to socio-cultural and educational factors, in particular, parenting models, the level of parental awareness, and school approaches to the formation of aesthetic norms. In many families, girls are more encouraged to be neat and aesthetically well-groomed, which reinforces their commitment to hygienic practices. At the same time, boys showed greater variability in behavioural habits: among them, there were more cases of irregular tooth brushing, skipping evening care and insufficient use of fluoride toothpaste. This trend can be explained not only by personal characteristics of hygiene control, but also by less focus on aesthetic norms of behaviour, lower levels of pedagogical reinforcement of hygiene habits in the family and at school, as well as weaker involvement of boys in educational programmes on healthy lifestyles.

In terms of age groups, there was a gradual increase in the average score for preventive behaviour: from 9.0 ± 2.4 in the younger group to 11.4 ± 2.1 in the older group. This indicates an increase in hygiene literacy and responsibility. Younger schoolchildren mostly performed hygiene procedures under the supervision of their parents and often skipped evening tooth brushing. Children of middle school age (9-11 years) have already demonstrated a certain stability of skills, but only 36% of them visited the dentist for preventive care at least once a year. The highest rates were recorded among older children: 48% underwent regular preventive examinations, and almost half used additional hygiene products.

Significant territorial differences revealed the systemic influence of the socio-economic environment on the formation of a preventive culture. In urban areas or settlements close to them, children demonstrated significantly better results in all criteria. The proportion of children who brushed their teeth regularly twice a day was 76.5% among urban schoolchildren and only 63.0% among residents of mountainous areas. The difference in the use of fluoride toothpaste was more than 13%, and in the use of additional hygiene products, more than 12%. The average score for preventive behaviour was significantly higher among children in urban areas (11.1 ± 2.3) compared to those living in remote communities (9.8 ± 2.7). These differences indicate that place of residence is one of the key predictors of hygiene behaviour. Lower scores among children from mountain villages can be explained by several factors: difficult access to dental clinics, lower income levels of families, limited availability of hygiene products, and less awareness of the significance of prevention.

The level of school involvement in developing preventive skills are also substantial: in mountainous areas, such activities are sporadic, while in urban schools, informational lectures, meetings with dentists, or thematic classes on oral hygiene are held more frequently. Preventive visits to the dentist remained an uncommon practice among all groups, but there were significant differences between geographical clusters. Almost half of urban children (47.1%) underwent a preventive examination at least once a year, while among residents of mountain communities, this figure did not exceed 32.6%. In the younger age group, such visits were mostly initiated by parents, while in the older age group, the motivation of the child prevailed. However, even among adolescents, visits to the dentist were not systematic, which indicates an insufficient culture of preventive care.

The obtained data indicate that the hygienic behaviour of children in the Zakarpattia region is formed unevenly under the influence of age, gender, and socio-geographical factors. The differences identified between the groups not only reflect varying levels of access to dental services but also demonstrate the influence of the social environment on the development of a culture of prevention. The most vulnerable remain younger schoolchildren, especially boys from mountainous areas, who have low levels of hygiene skills combined with limited access to dental care. This risk structure requires targeted intervention at the level of local educational and medical programmes, with an emphasis on early hygiene education, raising parental awareness and creating conditions for regular preventive screening in groups of children.

The relationship between clinical indicators and behavioural risk factors. To assess the relationship between the clinical condition of the oral cavity and the hygienic behaviour of children, a correlation analysis was performed, which determined the strength and direction of statistical relationships between the main indices of dental status (DMF, OHI-S) and the level of preventive activity, assessed by questionnaire scores. Figure 1 shows the dynamics of correlation coefficients in three age groups, which demonstrated a gradual strengthening of the inverse relationship between behavioural and clinical indicators with increasing age of children.

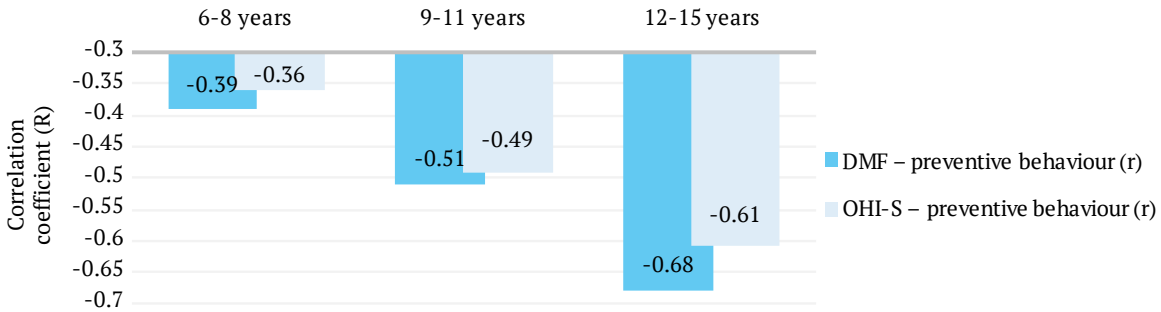

Figure 1. Correlations between clinical indicators (DMF, OHI-S) and preventive behaviour in children of different ages
Note: r – correlation coefficient, reflecting the strength and direction of the statistical relationship between clinical indicators and the level of preventive behaviour
Source: compiled by the authors

The results demonstrated that in the younger age group (6-8 years), the relationship between preventive behaviour and clinical indices was weak (r = -0.39 for DMF; r=-0.36 for OHI-S). This is attributed to the fact that the hygiene skills of children of this age are still developing, and the performance of daily procedures is largely controlled by parents. At this age, the clinical condition of the oral cavity is determined mainly by family factors such as care, eating habits and the level of awareness of adults, rather than the child's own behaviour. In the middle age group (9-11 years), the strength of correlations increased to r = -0.51 (DMF) and r = -0.49 (OHI-S), indicating the formation of stable hygiene habits and the beginning of a conscious attitude towards one's own dental health. Children of this age are already more likely to perform hygiene procedures on their own, and the regularity of brushing their teeth and using fluoride toothpaste is directly reflected in a decrease in the level of caries intensity and contamination of tooth surfaces. The most pronounced correlations were observed among adolescents (12-15 years old), where the coefficients reached r = -0.68 for DMF and r = -0.61 for OHI-S ($p < 0.01$). This indicates that in older school age, preventive behaviour becomes the leading factor that directly determines the clinical condition of teeth and gums. Teenagers who regularly performed hygiene procedures had significantly lower rates of tooth decay and better oral hygiene. The strengthening of the connection with age reflects the transition from external control to internal motivation, i.e., hygienic behaviour transforms from a habit supported by adults to a conscious element of the individual lifestyle. The generalised indicator for the entire sample confirmed the existence of a stable inverse relationship between clinical indices and the level of preventive activity: r = -0.62 for DMF and r = -0.58 for OHI-S ($p < 0.01$). Therefore, as the questionnaire score for preventive behaviour increases, the intensity of caries decreases and oral hygiene improves.

Interpretation of these results showed a clear trend: at a younger age, the clinical condition of teeth is determined mainly by environmental and social factors, while in adolescence, individual behaviour is primary. This pattern confirms the significance of early formation of hygienic habits and systematic preventive education of primary school children, which provides the basis for stable dental health in adolescence. Thus, the analysis showed that behavioural risk factors are closely related to clinical indicators of dental status. The strengthening of this relationship with age indicates the growing role of personal responsibility in maintaining oral hygiene. This highlights the need to move from occasional educational activities to systematic programmes for the formation of a culture of hygiene among children and adolescents in the region.

Assessment of the effectiveness of existing preventive measures and directions for their improvement. The effectiveness of existing prevention programmes was assessed based on the results of a questionnaire, which made it possible to determine the extent to which various social institutions (the family, school and medical institutions) are involved in shaping children's hygiene habits. To systematise the data, a comparative analysis of the level of implementation of the main areas of prevention within these three components was conducted (Table 5).

Table 5. Cross-sectional assessment of the effectiveness of preventive measures among children in Zakarpattia region (rated on a scale of 0-3)

Prevention	Family	School	Medical personnel
Hygiene education	1.5	1.5	2
Screenings	1	0.5	2.5
Hygiene skills control	1.2	1	2
Information basis	1.8	1.5	1.8
Access to hygiene products	1.3	1	1.5

Source: compiled by the authors

As shown in Table 5, the highest level of effectiveness of preventive measures was recorded in the medical sector, particularly in the areas of preventive examinations (2.5 points) and hygiene education (2.0 points). This demonstrated the central role of medical professionals in maintaining children's dental health, as they have the professional knowledge and diagnostic tools and can provide practical demonstrations of proper oral care. However, such activities are mainly concentrated in urban polyclinics, while in mountainous areas the participation of medical personnel is sporadic due to staff shortages, the remoteness of settlements and a lack of resources. As a result, the prevention efforts of medical institutions are not systematic and are often limited to treatment episodes when children already have clinical signs of caries.

The family link demonstrated an average level of effectiveness (1.3-1.8 points) with a predominance of information support (1.8 points) and hygiene education (1.5 points). Parents remain the primary agents of prevention, as they are the ones who shape their children's daily hygiene habits and monitor their implementation. However, the effectiveness of this influence varies significantly depending on the family's education, income and access to dental information. Rural and mountainous areas are characterised by less awareness of the role of fluoride, the correct duration of tooth brushing and the need for preventive visits, which is often combined with an underestimation of the problem of caries in deciduous teeth. At the same time, in families with higher socioeconomic status, parents are more probable to provide their children with quality hygiene products, which is reflected in lower caries intensity rates. Thus, the family is potentially a significant resource for prevention, but its effectiveness is limited by unequal access to information and material resources.

According to the assessment results, the school level proved to be the weakest (average effectiveness level of 0.5-1.5 points). The indicators are particularly low in the areas of preventive examinations (0.5 points) and hygiene

skills monitoring (1.0 points), which indicates a lack of systematic cooperation between educational institutions and medical services. In most schools, preventive activities are limited to one-off thematic lectures or "Health Days", without practical skills training and regular feedback. This creates a gap between the informational and behavioural levels of students' knowledge: they are aware of the benefits of dental care, but do not always follow the recommendations in practice. Another problem is the lack of an integrated monitoring system: schools do not keep records of preventive measures, do not record children's participation in hygiene programmes, and do not have a mechanism for interacting with local clinics. In most cases, the initiative depends on the enthusiasm of individual teachers or school medical workers, which reduces the consistency of such actions.

To systematise prevention in the educational environment, it is advisable to create a regulatory and organisational framework. It is recommended to develop a single set of regulations, the School Dental Prevention Programme, which will define the minimum scope of preventive measures, their frequency and the persons responsible for them. The programme should be integrated into the curricula for the subjects "Fundamentals of Health" and "Human Biology", and methodological support should be provided to teachers through participation in training courses organised jointly with medical specialists. It would be effective to create interdisciplinary teams consisting of a school doctor or nurse, a class teacher and a representative of the local dental service. This could provide not only regular lectures but also monitoring of hygiene and motivational talks with children and parents. It is also advisable to introduce a unified electronic database of school preventive measures, which can be used to monitor the implementation of programmes, evaluate their effectiveness and ensure feedback between schools and medical institutions.

The overall assessment of the three prevention components showed an average score of 1.5 points, which corresponds to a partially systemic level of functioning. The most critical area remains access to hygiene products, where all three components showed the lowest scores (1.3-1.5 points). This reflects a lack of social support programmes that would provide children in remote areas with free oral care kits. In addition, there is a lack of public information campaigns aimed at changing attitudes towards prevention as a daily necessity rather than a formal requirement. The results showed that the prevention system lacks a unified coordination framework. Families, schools and medical institutions operate separately, without a unified mechanism for information exchange and without clear algorithms for joint action. This disconnect reduces the effectiveness of even the best initiatives and leads to a loss of results at the stage of interagency interaction. To remedy the situation, it is advisable to create a unified regional strategy for dental prevention in children, which will include joint monitoring, standardised hygiene education programmes, a calendar of preventive examinations and an electronic record-keeping system.

Improvements can be achieved through cross-sectoral integration. Schools should become centres for regular hygiene monitoring, where teachers record children's participation in preventive programmes and coordinate cooperation with doctors. Medical staff should provide training for teachers and parents in basic oral health care skills, conduct outreach lectures and preventive examinations. Families should reinforce these skills through daily practice and positive reinforcement. A promising direction could be the creation of a regional digital platform called "Healthy Smile Zakarpattia", which would combine interactive educational modules, a system of reminders about preventive examinations, and the possibility of remote consultations with a dentist. For mountainous areas, it would be advisable to introduce mobile dental teams consisting of a doctor, hygienist and nurse, who would conduct examinations and lectures in schools twice a year, provide children with toothbrushing kits and demonstrate proper hygiene techniques. At the same time, mobile hygiene education programmes should be introduced to spread knowledge among parents even without the physical presence of specialists. Such steps will contribute to the formation of a unified preventive environment and reduce geographical disparities. Thus, a comprehensive assessment has shown that improving the effectiveness of dental prevention is only possible if a coordinated three-component system of "medicine-school-family" is created. Implementation of this system will help to establish a sustainable culture of hygiene, reduce the prevalence of caries among children, and lay the foundation for maintaining the dental health of the population of the Zakarpattia region in the long term.

DISCUSSION

The results of the clinical and questionnaire survey were used to comprehensively assess the dental health of children in the Zakarpattia region and determine the impact of behavioural, social and geographical factors. The analysis showed that the prevalence of caries and the level of oral hygiene have clear age, gender and territorial differences. Older children demonstrated improved preventive behaviour and lower caries intensity, while younger age groups showed higher dental risk. Gender differences were evident in the more consistent hygiene behaviour of girls, which is consistent with known psychological characteristics of self-organisation in the field of health.

The data obtained demonstrated distinct age and gender differences in the dental status of children. The DMF index increased from 2.12 ± 0.24 in the 6-8 age group to 4.36 ± 0.29 in adolescents aged 12-15, accompanied by a deterioration in hygiene status (from 1.49 to 2.06). A similar pattern was found by H. Das *et al.* [15], who proved that the increase in DMF among schoolchildren decreased by an average of 28% only under conditions of systematic school education, while with episodic programmes, the indicator remained consistently high. These data confirmed that the gradual increase in caries intensity observed in Transcarpathia was associated with insufficient consistency of preventive measures. R. Abbasova *et al.* [16] noted that the introduction of basic preventive methods (hygiene, fluoride prophylaxis) in early childhood reduced DMF by 25-30%, which is consistent with the trend towards higher values in older children in the study. T. Vaičiūnas *et al.* [17] showed that the average DMF level in post-Soviet countries was 3.8-4.0, which is close to the data obtained (3.92 in mountainous areas) and indicated the influence of similar socio-economic conditions. The study emphasised that it is

the lack of preventive infrastructure that is the key factor in regional differences, which was confirmed by the results of the study in Zakarpattia. Contrary to the conclusions of M. Glick *et al.* [18], which reported a downward trend in caries among children in highly developed countries thanks to nationwide strategies, the results obtained showed consistently high DMF and OHI-S scores in the mountainous regions of Ukraine. This indicated that without the integration of preventive programmes into the primary education and family medicine systems, it is impossible to overcome age-related accumulation of lesions.

Gender analysis revealed a stable advantage for girls in all clinical indicators: the average DMF was 3.22 ± 0.25 compared to 3.69 ± 0.28 in boys, and OHI-S 1.63 ± 0.10 versus 1.96 ± 0.12. This pattern is consistent with the data of F. Mlenga & E.G. Mumghamba [19], concluding that in Malawi, the frequency of regular tooth brushing among girls was 15-20% higher, and the DMF index was 0.5-0.7 points lower, which was explained by a greater adherence to preventive habits. Similar results were presented in a study by K.Y. Chandregowda *et al.* [20], where among children aged 6-10 years, the rate of twice-daily tooth brushing among girls reached 81.4%, while among boys it was only 64.9%. The difference directly correlated with lower caries intensity among girls. In contrast, A. Hemandez-Vasquez *et al.* [21] found no significant gender differences among children under 12 years of age in Peru, emphasising that in the absence of educational or social gaps, the influence of gender becomes insignificant. A study by K. Boustedt *et al.* [22] showed that systematic school hygiene education and individual preventive consultations can eliminate gender differences in the prevalence of early caries, reducing the incidence of lesions by 30%. The gender differences identified in the Transcarpathian region confirmed the universal mechanism of hygiene discipline formation: more consistent preventive measures among girls are accompanied by lower DMF and OHI-S scores, while boys remain a group at increased behavioural risk, especially in rural and mountainous areas.

Territorial analysis demonstrated a significant gap between urban children (DMF = 2.84 ± 0.22; OHI-S = 1.61 ± 0.10) and residents of mountain villages (DMF = 3.92 ± 0.29; OHI-S = 2.07 ± 0.14), indicating a pronounced socio-geographical gradient in dental health. A similar pattern was observed by R. Sava-Rosianu *et al.* [23], determining that the average DMF score among rural schoolchildren in Romania was 0.9 higher than among urban schoolchildren, which directly correlated with family income and access to preventive examinations. The results confirmed that in the mountainous regions of Transcarpathia, there is a similar relationship between social status and hygiene indicators, in particular, OHI-S above 2.0. A study by G. Tortora *et al.* [24] showed that children from peripheral communities in Italy had 35% worse hygiene indicators compared to their urban peers. The authors highlighted the lack of dental programmes in small settlements, which correlates with Ukrainian data. E. Štefanová *et al.* [25] found that in Slovakia, less than 40% of children underwent annual preventive examinations, which was accompanied by an increase in the average DMF to 4.1, which corresponds to the results for mountain schools in Transcarpathia (DMF = 3.92). A.R. Mareddy *et al.* [26] proved that even in socially vulnerable groups, regular use of electric or manual toothbrushes reduces DMF by 20-25%, which emphasised the importance of accessibility to hygiene products in mountainous areas. The territorial imbalance in dental status established in Transcarpathia reflects not only medical but also socio-economic determinants of health, which require targeted preventive interventions in remote communities.

Correlation analysis demonstrated a gradual strengthening of the inverse relationship between preventive behaviour and clinical indices with increasing age of children ($r = -0.39 \rightarrow -0.68$ for DMF; $r = -0.36 \rightarrow -0.61$ for OHI-S), reflecting a transition from external control to conscious self-regulation. According to L.F. Moghaddam *et al.* [27], behavioural factors determined about 60% of the variability in dental status, and among adolescents with high preventive scores, the DMF index was 1.5 units lower, confirming a similar trend in the Transcarpathian sample. As shown by I. Ciumeico *et al.* [28], the level of parental education directly correlated with the formation of children's hygiene habits: in families with higher education, the frequency of regular tooth brushing exceeded 80%, while in illiterate families it was only 52%. The study noted that short educational interventions for parents helped reduce the average DMF by 25%, confirming the significant impact of family educational resources on children's dental health. According to the results of A. Buckeridge *et al.* [29], parental choice of high-quality fluoride toothpastes was associated with lower DMF and OHI-S scores in children, and the difference between groups with different levels of education reached 1.2 units for DMF, confirming the importance of family awareness. According to the conclusions of Â.D. Nora *et al.* [30], sociodemographic determinants, in particular income level and place of residence, accounted for up to 40% of the difference in dental status between urban and rural children. The study demonstrated that low parental education levels in rural communities were a key predictor of high DMF scores, consistent with trends observed among children in the mountainous regions of Zakarpattia. A study by M. Recalde *et al.* [31] showed that short-term school prevention programmes reduced DMF by 15-20% by increasing children's knowledge and motivation, confirming the effectiveness of systematic learning in forming sustainable hygiene habits. This is also consistent with the data from M. Levkiv *et al*. [32], which emphasises the importance of educational strategies in shaping adolescents' oral hygiene behaviour. The results showed that the behavioural component is the leading factor in maintaining dental health in adolescence.

The assessment of the effectiveness of preventive measures showed an average integral level of 1.5 points, with the highest scores in the medical sector (2.5 points) and the lowest in schools (0.5-1.0 points). A study by J. Szöke & P.E. Petersen [33] demonstrated that in Central European countries where school prevention programmes operated without medical support, the average DMF level remained at 4.0, while under conditions of integration it decreased by half. L.F. Kaskova *et al.* [34] found that in European countries with unified state prevention programmes, the average DMF among 12-year-old children was 2.1, while in countries without coordinated prevention, it exceeded 4.0. The study also noted that the introduction of national monitoring systems made it possible to reduce

the proportion of untreated caries by almost 40%, which is fully consistent with the need to unify approaches within the regional system of Transcarpathia. N. Cenzato *et al.* [35] showed that territorial disparities in dental prevention directly reflect structural inequalities in the health care system, and that in rural areas, the effectiveness of hygiene programmes was 35% lower. The researchers also emphasised that in areas with low funding, the lack of dental education in schools led to an increase in the incidence of caries among children, confirming the relevance of similar trends in the mountainous areas of Transcarpathia. V. Bolchis *et al.* [36] demonstrated that the implementation of regionally adapted preventive programmes in Romania contributed to a 22% reduction in the average DMF among children aged 11-14. The study proved that the efficiency of these programmes increased when local communities, schools, and primary healthcare providers got involved, which shows that a comprehensive approach is needed for mountainous regions in Ukraine.

Summarising the results, the study determined that the dental health of children in the Zakarpattia region is determined by a combination of age, behavioural and territorial factors. With increasing age, there was an increase in the intensity of caries and a deterioration in hygiene, while a high level of preventive behaviour was accompanied by better clinical indicators. Girls and urban children showed more favourable results, confirming the influence of the social environment and established hygiene habits. The patterns identified are consistent with the results of other scientific studies, which also demonstrated the key role of preventive activities, educational programmes and cross-sectoral interaction in maintaining children's dental health.

CONCLUSIONS

A study of age, gender and regional characteristics of children's dental status showed a clear trend towards an increase in caries intensity with age: the average DMF index increased from 2.12 ± 0.24 in the 6-8 age group to 4.36 ± 0.29 among adolescents aged 12-15, accompanied by a deterioration in hygiene (OHI-S = 1.49 → 2.06). The dominance of component D in the index structure indicated late referral for dental care, while the proportion of filled teeth increased only in older children. The gender differences found (DMF = 3.22 ± 0.25 in girls versus 3.69 ± 0.28 in boys) indicated more developed hygiene discipline among girls. The territorial gap between urban children (DMF = 2.84 ± 0.22; OHI-S = 1.61 ± 0.10) and residents of mountain villages (DMF = 3.92 ± 0.29; OHI-S = 2.07 ± 0.14) confirmed the influence of socio-economic and infrastructural factors on dental health.

The results of the study of hygienic behaviour showed a pronounced age-related dynamic in the formation of preventive habits: regular brushing of teeth twice a day increased from 60% in children aged 6-8 to 85% in the 12-15 age group, the use of fluoride toothpaste from 54.1% to 78.3%, and the average score for preventive behaviour increased from 9.0 ± 2.4 to 11.4 ± 2.1. Girls demonstrated consistently higher hygiene activity (77% vs 69% among boys), indicating gender differences in behavioural patterns. Territorial differences (76.5% of urban children brushed regularly, compared to 63.0% of rural children) indicated limited access to hygiene products and information support in remote communities. The data confirmed that hygiene behaviour is influenced by age, gender and social environment.

Correlation analysis showed a statistically significant inverse relationship between preventive behaviour and clinical indicators: the correlation strength for DMF increased from r = -0.39 in the younger group to r = -0.68 in the older group, and for OHI-S from r = -0. 36 to r = -0.61 ($p < 0.01$). This indicated that as the level of hygienic activity increased, the intensity of caries decreased, and the condition of the oral cavity improved. The strengthening of the relationship with age demonstrated a transition from external parental control to conscious personal responsibility, which determines the need for early formation of sustainable preventive habits.

An assessment of the effectiveness of existing preventive measures revealed an average implementation level of 1.5 points on a three-point scale, with the highest scores in the medical sector (up to 2.5 points) and the lowest in schools (0.5-1.0 points). The family link provided partial information support (1.8 points) but did not have sufficient consistency in monitoring hygiene skills. The weakest component was the school, where preventive measures were sporadic. These results indicated the fragmentation of the preventive system and the need for a unified regional model of "medicine-school-family" that integrates educational, clinical and social components. For further research, it is advisable to expand the geography of the sample to include several areas with different levels of urbanisation and to evaluate the long-term effectiveness of integrated preventive programmes using digital monitoring tools.

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Профілактика стоматологічних захворювань у дітей різного віку на території Закарпатської області

Ян Дуганчик
Старший викладач
Ужгородський національний університет
88000, пл. Народна, 3, м. Ужгород, Україна
https://orcid.org/0000-0002-9058-4729

Едіта Дячук
Старший викладач
Ужгородський національний університет
88000, пл. Народна, 3, м. Ужгород, Україна
https://orcid.org/0009-0003-7251-5732

Микола Білищук
Кандидат медичних наук, доцент
Івано-Франківський національний медичний університет
76000, вул. Галицька, 2, м. Івано-Франківськ, Україна
https://orcid.org/0009-0006-9586-9148

Анотація. Метою дослідження було охарактеризувати стан стоматологічного здоров'я дитячого населення Закарпатської області та визначити практичні шляхи оптимізації профілактичної роботи серед дітей. Дослідження проводилось у січні-червні 2025 року на базі Стоматологічного відділення Комунального некомерційного підприємства «Рахівська районна лікарня» Закарпатської області, охоплювало 240 дітей віком 6-15 років і передбачало клініко-аналітичний підхід із поєднанням обстеження, анкетування та статистичного аналізу взаємозв'язків між поведінковими та клінічними показниками стоматологічного здоров'я. Результати дослідження засвідчили, що середній показник карієс-інтенсивності зростав із 2,12 у віковій групі 6-8 років до 4,36 у підлітків 12-15 років, що супроводжувалося погіршенням гігієнічного стану від 1,49 до 2,06. У структурі індексу переважали зруйновані зуби – 1,50 у молодших, 2,58 у середніх і 3,02 у старших дітей, що відображає пізнє звернення за допомогою. Дівчата мали кращі результати (3,22 проти 3,69 у хлопців) і вищу частоту регулярного чищення зубів (77 % проти 69 %). Територіальний аналіз показав розрив: у міських дітей рівень карієсу становив 2,84, у гірських – 3,92, із гіршими показниками гігієни (2,07 проти 1,61). Лише 47 % міських дітей проходили профілактичні огляди, у гірських громадах – 32,6 %. Виявлено зворотний зв'язок між гігієнічною поведінкою та карієсом (r=-0,62), що підтвердив ключову роль поведінкових чинників у збереженні здоров'я. Отримані результати свідчать, що стоматологічне здоров'я дітей Закарпаття формується під впливом віку, статі, поведінкових звичок і територіальних умов, а ефективність профілактики залишається недостатньою через нерівномірність участі школи, сім'ї та медичної ланки у системі гігієнічного навчання. Практичне значення полягає у можливості використання даних місцевими органами охорони здоров'я, шкільними медичними службами та сімейними лікарями для планування регіональних програм профілактики карієсу та гігієнічного навчання дітей

Ключові слова: гігієна; здоров'я; карієс; фторована паста; чищення зубів; поведінкові чинники; віддалені гірські села