Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2022 Jun 12; 10(D):260-266.
https://doi.org/10.3889/oamjms.2022.9560
eISSN: 1857-9655
**Category:** *D - Dental Sciences*
***Section:*** *Pedodontics and Preventive Dentistry*



# The Correlation Between the DMFT of the 15-year-old Children and the Concentration of Fluoride in Drinking Water from the East Region of the Republic of Macedonia

Vesna Ambarkova[1]*, Olga Kokoceva-Ivanovska[1], Natasha Stavreva[2], Jovan Ambarkov[3], Tomo Karakamcev[4]

*[1]Department of Pediatric and Preventive Dentistry, Faculty of Dental Medicine, Saints Cyril and Methodius University, Skopje, Republic of Macedonia; [2]Department of Dental Prosthetics, Faculty of Dental Medicine, Saints Cyril and Methodius University, Skopje, Republic of Macedonia; [3]Undergraduate Student, Faculty of Medicine, Saints Cyril and Methodius University, Skopje, Republic of Macedonia; [4]Department of Dental and Endodontic Diseases, Faculty of Dental Medicine, Saints Cyril and Methodius University, Skopje, Republic of Macedonia*

**Edited by:** Sasho Stoleski
**Citation:** Ambarkova V, Kokoceva-Ivanovska O, Stavreva N, Ambarkov J, Karakamcev T. The Correlation Between the DMFT of the 15-year-old Children and the Concentration of Fluoride in Drinking Water from the East Region of the Republic of Macedonia. Open Access Maced J Med Sci. 2022 Jun 12; 10(D):260-266. https://doi.org/10.3889/oamjms.2022.9560
**Keywords:** Dental caries; School children; Drinking water; Fluoride; DMFT index; Oral epidemiology
***Correspondence:** Vesna Ambarkova, Department for Preventive and Pediatric Dentistry, Faculty of Dentistry, University Ss. Cyril and Methodius, Skopje, Republic of Macedonia. E-mail: vesna.ambarkova@gmail.com
**Received**: 26-Mar-2022
**Revised:** 31-May-2022
**Accepted:** 02-Jun-2022

**Funding:** This research did not receive any financial support
**Competing Interests:** The authors have declared that no competing interests exist


**Abstract**

**AIM:** The aim of this study is to determine the correlation between the DMFT index of 15-year-old children from the east region and the concentration of fluoride in drinking water from the populated areas where children live.

**METHODS:** In the examination, 414 children were enrolled, out of seven central secondary schools from four bigger cities from east region, at which the DMFT index was determined. The children live in six different cities and 51 different villages. Fifty-seven water samples were taken from the examined area to determine the fluoride concentration using the electrochemical method using the pH/ISE meter-Thermo-Orion with a special F-electrode (Thermo Orion Ion Plus Fluoride Electrode) at the Institute for public health. Spearman's method was used to determine the correlation between the specified variables.

**RESULTS:** The total number of children in the examined sample was 414, out of which 226 (54.6%) were male and 188 (45.4%) were female. The prevalence of caries free children was 9.4%. SiC index was 10.22. The average DMFT index in this group of children was 5.77 with a standard deviation of ± 4.02. Maximum concentration of fluorine in drinking water of 0.99 ppmF was determined in the village Raslovci, and 0.87 ppmF in the village Star Karaorman, while the minimum (0.07 ppmF) in the village Dvorishte and (0.10 ppmF) in the village Grad. Correlation of the DMFT index in 15-year-old children from the east region and the concentration of fluorine in the drinking water has a negative, indirect correlation, with the value of the coefficient R = −0.27.

**CONCLUSION:** The correlation between the DMFT index and the concentration of drinking water is a negative, indirect correlation, and statistically, this correlation is highly significant ($p < 0.05$).

## Introduction

Oral diseases with their specificity are a significant public health problem in each country, primarily due to their prevalence, their impact on individuals and society, as well as the high cost of their treatment. According to the World Health Organization (WHO) on the morbidity characteristics of the entire globe in recent decades, oral pathology, and especially dental caries and periodontal disease, are the third most common diseases [1]. The foundations for a unified representation of the prevalence and incidence of dental caries in children were laid by the World Health Organization (WHO) in 1965, when it developed a system for monitoring the state of oral health in children aged 6, 12, and 15 years.

Providing the evidence-based information about the rates of caries experience and associated factors are very important for every country, which take care about the oral health of its whole population. Detection of changes in the risk factors that cause dental caries and modifying these risk factors may provide great potential in the establishment of the national preventive strategies within countries from the Balkan region and elsewhere. Dental caries is a significant public health problem in each country, primarily due to its prevalence, its impact on individuals and society, as well as the high cost of its treatment. The previous epidemiological studies showed that 59% of children at the age between 12 and 19 years have caries experience in their permanent teeth [2].

In 1803, Morichini D finds fluoride in an elephant fossil tooth. It was the first sign that fluoride was associated with tooth resistance. The link between fluoride and the prevention of dental caries dates back to the 1930s when in several endemic regions in the southwestern United States, the existence of so-called colorful teeth has been discovered among the local population by dentist McKay FS. Only these colorful teeth have been left without caries [3].

In the past 70 years various forms of fluoride products have been used for the prevention of dental caries and in many different ways fluoride can be delivered, by water fluoridation, milk fluoridation, gels, fluoride toothpastes, varnishes, and mouth rinses. Fluoridated water reduces the incidence of caries by 40–50% on primary and 50–60% on permanent dentition [4].

The countries around the world that still used water fluoridation include Brazil, USA, Malaysia, Australia, Canada, Chile, Hong Kong, Israel, Singapore, Spain, Vietnam, Ireland, Argentina, South Korea, New Zealand, Guatemala, Peru, Panama, and others [5]. EU countries where fluoridation is still practiced today are Ireland, Great Britain, Spain, and Poland. The majority of countries have decided to discontinue water fluoridation or continue this activity in only small part of population. Only around 10% of Spanish population receive artificially fluoridated water. However, even considering that all people in these countries would receive fluoridated water, they would make up < 6% of the total world population. Only few countries from Europe, within which are Austria, France, Germany, and Switzerland fluoridate the salt used for cooking [6].

The decision to implement a water fluoridation program relies upon an understanding of the population's oral health behavior (e.g., use of fluoride toothpaste), the availability and uptake of other caries prevention strategies, their diet and consumption of tap water and the movement/migration of the population. There is insufficient evidence to determine whether water fluoridation results in a change in disparities in caries levels across SES socio-economic status [7].

Water fluoridation has never been performed in the Republic of Macedonia. In the research conducted by Kolevska *et al*. found that the highest average values of fluoride in the groundwater were found in Pelagonija, Ovchepolie, Povardarje, and in some spring waters in the mountains Belasica and Osogovo [8]. In the research conducted by Kolevska *et al*., the highest average values of fluoride in the groundwater was found in Pelagonija, Ovchepolie, Povardarje, and in some spring waters of Belasica and Osogovo. She notes that in most of these cases these are very small springs intended for water supply of settlements that are declining in population and with unfavorable age structure of population (reduced number of children) [8]. The natural sources which contain fluoride are usually of small or very small capacity. These springs are mainly located in eastern Macedonia where there is a triangle with geological composition of erupted rocks and where a significant number of examined waters have a concentration close to the optimal (municipalities of Kumanovo, Kocani, Stip, Radovish, Strumica, and St. Nikole) [8].

In the past there were three endemic fluorotic areas (Kumanovo, Veles, and Prilep region) throughout the Republic of Macedonia. Carchev *et al*. in 1992 conducted a study to determine the relationship between fluoride in drinking water and caries frequency in endemic areas and others control settlements [9]. Drinking water in the Republic of Macedonia, especially those consumed in larger cities, contain fluoride concentrations usually <0.2 mg/L [8], [10], [11].

After measuring 200 samples of drinking water from 147 settlements, Ambarkova confirm that drinking water mostly contains low amounts of fluoride in the Republic of Macedonia (‹0.3 mg F/L) According to the number of inhabitants and the type of spring, most of the population of the Republic of Macedonia are now supplied with drinking water from groundwater from carbonates springs [12].

The aim of this study is to determine the correlation between the DMFT index of 15-year-old children from the east region and the concentration of fluoride in drinking water from the populated areas where children live.

## Materials and Methods

The sample for the present cross-sectional study was 412 school children from 1st year of 7 secondary schools, suited in four cities from the Eastern region. The data for this cross-sectional study were collected between 2013 and 2014. Based on the information from the Macedonian National Institute of Statistic [13] there are approximately 7172 students attending 13 secondary schools in this region. There are 505 secondary school students in Delčevo, within which 131 are at first grade, while from 2.745 secondary school students in total from Kočani city, 446 are at 1st year of secondary school [14].

The clinical part of the examination consisted of obtaining the DMFT of the 15-year old children in accordance with the basic criteria for assessment of oral and dental health and the need for rehabilitation, which is recommended by the World Health Organization (WHO, 2013). We estimate the intensity of dental caries according to the generally accepted Klein-Palmer index "DMF," which is a set of decayed, missing, and filled teeth. The examinations were carried out by two dentists in accordance with the recommendations stemming from the basic criteria for assessment of oral and dental health recommended by the WHO [15].

The 15-year-old children who were included in the examination were from the following seven secondary schools in the eastern region: Sergej Mihajlov, Dimitar Miraschiev, Nikola Nechtenin from Shtip city, Gosho Vikentiev, Ljupcho Santov from Kochani city, Metodi Mitevski Brico from Delcevo, and Koco Racin from Sveti Nikole city. Permission for the study was obtained from the school authorities, who sought and obtained consent from the parents of the

children concerned. Ethical approval was obtained from the Ministry of Health. The cluster sampling was used because it was more economical and the research was not funded. All classes (adolescents) from these secondary schools were included in the investigation.

By 15 years the permanent teeth have been exposed to the oral environment for 3 to 9 years. The assessment of caries prevalence in adolescents may therefore be relevant. Data were collected by means of clinical examinations in daylight using plain dental mirrors and probe, which took place in a dental office with the subject seated on the chair. Two calibrated dental examiners conducted the dental examination and the clinical part of the form was filled in by two other trained dentists (kappa values for inter-examiner reliability was 0.85). No radiograph was taken.

The determination of F-concentration was performed using a special pH/ISE meter-Thermo-Orion produced by ORION and a Special F-electrode (Thermo Orion Ion Plus Fluoride Electrode) for detecting the traces of fluorine. For the chemical analysis, 10% TISAB Aluminon was used.

### *Statistical analysis*

The descriptive methods for displaying quantitative variables were used in the form of percentage and frequency distribution. For statistical analysis of DMFT scores to access the oral health among secondary school children, the SPSS 13.0 for Windows (Statistical Package for Social Sciences) for statistical computing was used. For the determination of the correlation between certain variables, Spearman Rank Order Correlation was used. For the level of significance, the value of $p < 0.05$ was taken.

## Results

In the eastern region, 414 children aged 15 years were analyzed, of which 226 (54.6%) are males and 188 (45.4%) are females. The ethnic structure is dominated by 398 (96.1%) children of Macedonian nationality. Regarding the place of residence, 267 (64.49%) children are from urban areas, while the remaining 147 (35.51%) children originate from rural areas in the territory of the east region (Table 1).

Among the research population of 15 year old children, 308 (74.4%) were diagnosed with dental caries, of which the largest number 64 (15.5%) had two decayed teeth. Out of 414 examined children, 90 (21.7%) children underwent tooth extraction, dominated by a group of 43 (10.4%) with one extracted tooth (Figure 1). One hundred and fifty-five children from the whole group are without filled teeth, 155 (37.4%), while two hundred and fifty-nine children 259 (62.6%) are with filled teeth. Fifty-nine children with two filled teeth are most often registered 59 (14.25%) (Figure 2). Descriptive statistics of the number of carious, extracted, and filled permanent teeth in the group of 15-year-old children from the east region are presented in Table 2.

The median of the analyzed parameters shows that half of this group of examinees have more than 3 carious teeth, more than 2 teeth removed, and more

**Table 1: Distribution of children in relation to the gender, nationality and place of living**

| | N = 414 | % |
|---|---|---|
| Gender | | |
| Male | 226 | 54.59% |
| Female | 188 | 45.41% |
| Nationality | | |
| Macedonian | 398 | 96.13% |
| Turks | 8 | 1.93% |
| Roma | 8 | 1.93% |
| Place of living | | |
| Town | 267 | 64.49% |
| Village | 147 | 35.51% |
| Name of town/village | | |
| Ss. Nikole | 58 | 14.01% |
| Shtip | 55 | 13.28% |
| Delcevo | 81 | 19.56% |
| Kochani | 71 | 17.15% |
| Vinica | 1 | 0.24% |
| Probishtip | 3 | 0.72% |
| Orizari | 6 | 1.45% |
| Selce | 2 | 0.48% |
| Radanje | 2 | 0.48% |
| Star Karaorman | 3 | 0.72% |
| Karbinci | 3 | 0.72% |
| Dolni Balvan | 1 | 0.24% |
| Tri cesmi | 2 | 0.48% |
| Erdjelija | 4 | 0.97% |
| Dvorishte | 1 | 0.24% |
| Milino | 1 | 0.24% |
| Gorobinci | 1 | 0.24% |
| Grad | 5 | 1.21% |
| Shtamer | 5 | 1.21% |
| Gabrovo | 2 | 0.48% |
| Vrtislavci | 1 | 0.24% |
| Trabotivishte | 4 | 0.97% |
| Virce | 3 | 0.72% |
| Razlovci | 2 | 0.48% |
| Zvegor | 7 | 1.69% |
| Poleto | 1 | 0.24% |
| Chiflik (Delcevsko) | 1 | 0.24% |
| Obleshevo | 14 | 3.38% |
| Burilchevo | 1 | 0.24% |
| Morodvis | 2 | 0.48% |
| Chiflik (Kochani) | 6 | 1.44928 |
| Gorni Podlog | 5 | 1.20773 |
| Mojanci | 3 | 0.72% |
| Sokolarci | 6 | 1.45% |
| Ziganci | 2 | 0.48% |
| Spanchevo | 7 | 1.69% |
| Chesinovo | 2 | 0.48% |
| Nivichani | 1 | 0.24% |
| Trkanje | 10 | 2.41% |
| Grdovci | 1 | 0.24% |
| Zrnovci | 7 | 1.69% |
| Lipec | 1 | 0.24% |
| Sasa (Delcevsko) | 3 | 0.72% |
| Preseka | 1 | 0.24% |
| Teranci | 2 | 0.48% |
| Dulica | 1 | 0.24% |
| Jakimovo | 1 | 0.24% |
| Pantelej | 2 | 0.48% |
| Kuchichino | 1 | 0.24% |
| Blatec | 1 | 0.24% |
| Turija | 1 | 0.24% |
| Beli | 1 | 0.24% |
| Gradec | 1 | 0.24% |
| Peklani | 2 | 0.48% |
| Dolni Podlog | 1 | 0.24% |
| Polaki | 1 | 0.24% |
| Mustafino | 1 | 0.24% |

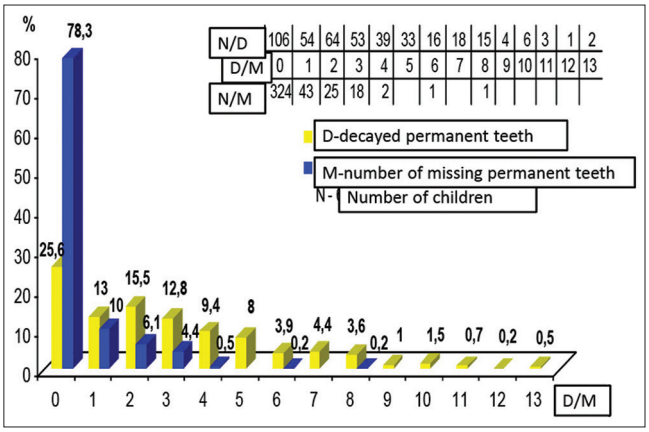


*Figure 1: Distribution of children in relation to the number of decayed and missing teeth*

than 3 filled teeth. The highest maximum value (19) is recorded in the number of filled teeth (Table 2).

The value of the DMFT index of permanent teeth in the group of 15-year-old children from the Eastern region is shown in Table 3 and ranges from 0 to 21 with an average value of 5.77 ± 4.02.

The distribution of caries, extracted and filled teeth, depending on the gender of the children at the age of 15 years from the east region, is presented in Table 4. The presence of dental caries is more common among the female children (77.7% vs. 71.7%), extracted teeth are also more frequently registered in female children (25.5% vs. 18.6%) and they also more often than boys have filled teeth (70.2% vs. 56.2%). The tested differences in the number of carious, extracted and filled teeth, depending on the gender of the subjects in this group, show statistical significance difference only in the distribution of filled teeth (p = 0.003).

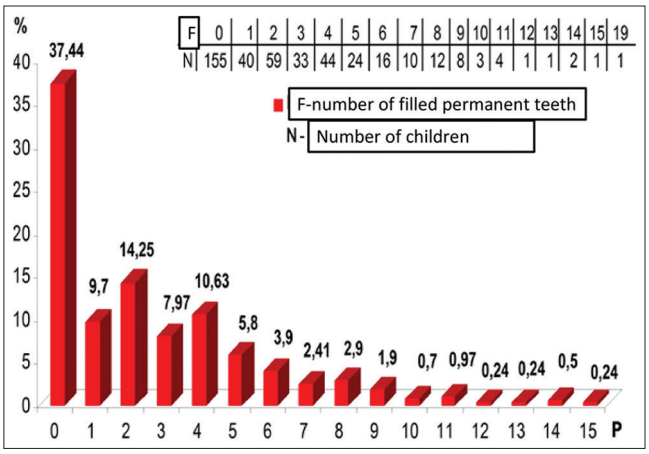


*Figure 2: Distribution of the children in relation to filled permanent teeth*

In the eastern region, female adolescents aged 15 years, significantly more often than male, have a dental intervention for filling of the teeth (Table 4).

**Table 2: Descriptive statistic/number of permanent teeth**

| Descriptive Statistics - (number of permanent teeth N = 2388) | | | | |
|---|---|---|---|---|
| Variable | N (%) | Median | min-max | lower–upper quartiles |
| D–decayed teeth | 1171 (49.04) | 3.0 | 1.0–13.0 | 2.0–5.0 |
| M–missing teeth | 169 (7.07) | 2.0 | 1.0–8.0 | 1.0–2.0 |
| F–filled teeth | 1048 (43.89) | 3.0 | 1.0–19 | 2.0–5.0 |

The gender of the 15-year-old children from the east region has a highly significant impact on the value of the DMFT index (p = 0.003).

**Table 3: Descriptive statistic/DMFT index of permanent teeth**

| Descriptive statistics - DMFT (index of permanent teeth) | | | | | | |
|---|---|---|---|---|---|---|
| Variable | N | Mean ± SD | 95% confidence interval of means | Min-max | Median | Lower–upper quartiles |
| DMFT | 414 | 5.77 ± 4.02 | 5.38–6.16 | 0–21.0 | 5.0 | 3.0–8.0 |

The average DMFT index in the group of male adolescents is 5.04 ± 3.77, while in the group of female adolescents, the DMFT index has an average value of 6.65 ± 4.14 (Table 5).

**Table 4: Distribution of decayed, missing, and filled permanent teeth in relation to gender**

| Variable | Gender | |
|---|---|---|
| | Male (n%) | Female (n%) |
| D –decayed of permanent teeth | | |
| Caries free | 64 (28.32%) | 42 (22.34%) |
| Decayed | 162 (71.68%) | 146 (77.66%) |
| Pearson Chi-square: 1.92 df = 1 P = 0.16 | | |
| M –-missing permanent teeth | | |
| Without missing teeth | 184 (81.42%) | 140 (74.47%) |
| With missing teeth | 42 (18.58%) | 48 (25.53%) |
| Pearson Chi-square: 2.91 df = 1 P = 0.09 | | |
| F –filled permanent teeth | | |
| Without filling | 99 (43.81%) | 56 (29.79%) |
| With filling | 127 (56.19%) | 132 (70.21%) |

Pearson Chi-square: 8.61 df = 1 P = 0.003* *P < 0.01.

Table 6 shows the values of the fluoride concentration in drinking water in relation to the place of living.

**Table 5: Descriptive statistic of DMFT index of permanent teeth/ gender differences**

| Descriptive statistics - DMFT (index of permanent teeth) | | | | | | |
|---|---|---|---|---|---|---|
| Variable gender | N | Mean ± SD | 95% confidence interval of means | Min-max | Median | Lower–upper quartiles |
| Male | 226 | 5.04 ± 3.77 | 4.54–5.53 | 0.0–21.0 | 5.0 | 2.0–8.0 |
| Female | 188 | 6.65 ± 4.14 | 6.05–7.24 | 0.0–21.0 | 6.0 | 4.0–9.0 |

Mann–Whitney U Test Z = 4.06, P = 0.00005** P < 0.01.

There is a negative, indirect correlation with the value of the coefficient R = −0.27 (Figure 3) between the value of the DMFT index of 15 years old children as a dependent variable and the concentration of fluoride in drinking water in the east region as an independent variable. This means that these two variables are changing inversely, and that by increasing the concentration of fluoride in drinking water, the value of the DMFT index decreases and vice versa, smaller values of the DMFT index are obtained if the concentration of fluoride in the drinking water is higher. And statistically this correlation is confirmed as highly significant, that is, highly significant (p < 0.01) (Figure 3).

**Table 6: Distribution of the concentration of fluorine in drinking water in relation to the place of living**

| Place of living | Concentration of F in water |
|---|---|
| Ss.Nikola | 0.2624 |
| Shtip | 0.4700 |
| Delcevo | 0.3100 |
| Kochani | 0.4500 |
| Vinica | 0.1300 |
| Probishtip | 0.2000 |
| Orizari | 0.4500 |
| Radanje | 0.2070 |
| Star Karaorman | 0.8723 |
| Karbinci | 0.6420 |
| Dolni Balvan | 0.5643 |
| Tri Chesmi | 0.4700 |
| Erdjelija | 0.3200 |
| Dvorishte | 0.0690 |
| Milino | 0.3390 |
| Gorobinci | 0.1670 |
| Grad | 0.1000 |
| Stamer | 0.1900 |
| Trabotivishte | 0.1800 |
| Virce | 0.2900 |
| Razlovci | 0.9930 |
| Zvegor | 0.1300 |
| Poleto | 0.1300 |
| Chiflik (Delcevsko) | 0.1300 |
| Obleshevo | 0.4093 |
| Gorni Podlog | 0.4500 |
| Mojanci | 0.4500 |
| Sokolarci | 0.2640 |
| Ziganci | 0.5240 |
| Spancevo | 0.3280 |
| Cheshinovo | 0.3520 |
| Trkanje | 0.4500 |
| Grdovci | 0.4500 |
| Zrnovci | 0.4500 |
| Sasa (Delcevsko) | 0.1110 |
| Blatec | 0.1240 |
| Beli | 0.4500 |
| Dolni Podlog | 0.4500 |

## Discussion

The prevalence of dental caries in this secondary school-based cross-sectional study was 90.6%, out of which 49.04% adolescents had decayed teeth, while only 7.07% had missing teeth and 43.89% had their teeth filled. The average DMFT index in the group of adolescents was 5.77 ± 4.02. There was large difference of dental caries experience between gender, with all indicators (decayed, missed, and filled teeth). The average DMFT index within female was 6.65, while within male 5.04.

The prevalence of dental caries in our study was higher than in many developed countries like England, Wales and Northern Ireland and Brazil [16], [17] and some developing countries like India [18], but our results were very similar to countries like Republic of Moldova, Chile, Russia, and Romania [19], [20], [21], [22].

The mean DMFT (5.77 ± 4.02) and SiC (10,22) observed within 15 years olds from the Republic of North Macedonia were a little bite lower that among 15-year-olds from Bosnia and Herzegovina, which have mean DMFT index of 7.6 (SD ± 4.1) and SiC of 9.2 (SD ± 1.2) [23]. Our results are similar to the results obtained by Lalic (mean DMFT index = 5.84) conducted in Belgrade among 15-year old children [24].

Exposure to fluoridated water or non-fluoridated water could be in conjunction with other sources of fluoride: Fluoride toothpastes, taking fluoridated salt, fluoride intake through food, and beverages. School time is a period when habits are permanently formed and when health and educational measures are of the greatest benefit [25]. We must convince children that the health of mouth and teeth are a mirror of overall health of the body and that the health could not be complete with the absence of oral health.

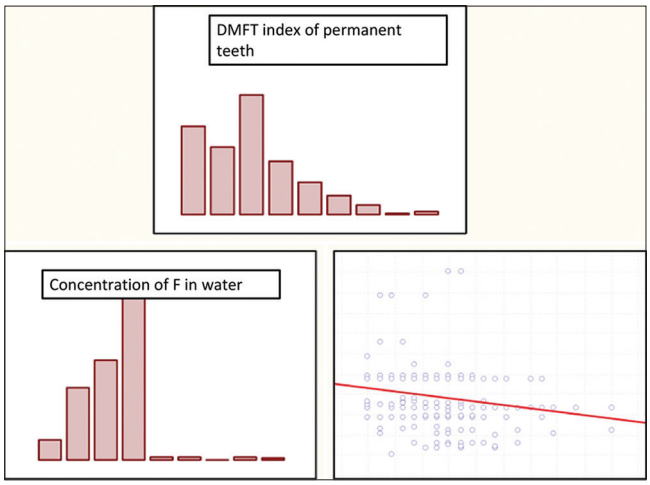


*Figure 3: Correlation – DMFT index of permanent teeth/concentration of fluorine in drinking water. Spearman rank order correlations $R = -0.267$, $p < 0.05$*

Children at the age of 15 are in puberty and during that period their physical appearance is important to them which can be used to motivate them to take care of their oral health. The optimal fluoride level in oral environment that would minimize the manifestation of caries and fluorosis should be determined on an individual level, thus, having in mind the systematic (endogenous) uptake of fluorides, as well as the influence of potential usage of local fluorides in the form of supplements [12].

Nutrition is part of the daily life of every living creature, even man, which affects not only the oral but also the health in general. Caries risk is directly associated with the frequency and amount of carbohydrate intake, especially taking in mind the time intervals between meals [26].

As early as 1979, Tavciovski and his associates, examining the national pathology from a dental aspect in the vicinity of the Stip city and noticed that there was an inversely proportional dependence of the carious process and the concentration of fluoride in the drinking water [27].

It has been known for many years that a lack of regular oral hygiene habits plays a significant role in the development of caries. Children's oral health can be influenced by parents' attitudes and behavior toward oral health, as well as their own oral health of parents [28], [29].

A National Caries Preventive Program starts to be implemented from 2007 until nowadays by 142 calibrated pediatric dentists in the Republic of

Macedonia [30]. They work according to the standards of the WHO, and after the privatization of the dental sector, pediatric dentists and dentists who work with children within their schools continued to work as a preventive teams in the frame of public health.

Low or high levels of fluoride intake cause disease, while only the optimal amount of fluoride intake has a protective effect. The low amount of fluoride in drinking water (<0.5 mg F/l) is one of the most important predisposing factors for dental caries [31]. Amounts of fluorine in drinking water greater than 2 mg F-/l cause dental and over 10 mgF-/l cause bone fluorosis [32]. It has been established that in our climate zone the optimal amount of fluoride in drinking water have to be 1 mg F-/l [33]. It is, therefore, important to know the concentrations of fluoride in our environment (in food, air, and drinking water).

According to the fact that occlusal surfaces have the highest participation in DMFT index between children, in 2007 all preventive teams started the process of sealing the occlusal fissures and pits of first permanent molars right after their eruption at all school children at first grade (born in 2001) in all regions of our country. Taking in mind that our group of 15 year old children are at first grade of secondary school (born in 1998) were not covered by the preventive measures that began to be implemented in our country. Let's hope that the oral health condition of this group of children will improve in the future by implementing the following measures: mechanical and chemical control of dental plaque, application of fluoride (systemic and topical), control of sugar intake, sealing of fissures and pits and education and motivation for keeping oral health.

The limitations of the present study were that some important factors that influence fluorine intake were not taken into consideration, for example, drinking water quantity (it was very important to influence the actual intake of fluorine from water), fluorine concentrations in food and toothpaste, because, food fluorine and toothpaste fluorine should be used to adjusted when take the statistically analysis. Furthermore, in our present study, some important factors that influence children's DMFT were not taken into consideration, for example, family economic income, parents' education, soft drink consumption, personal brushing habits, and so on.

## Conclusion

Dental caries experience was seen to be high among secondary school children (first grades) in Eastern Region of the Republic of Macedonia. The high prevalence of dental caries within 15 years old children from Eastern region is probably due to their poor oral hygiene. The correlation between the DMFT index and the concentration of drinking water is a negative, indirect correlation, and statistically, this correlation is highly significant ($p < 0,05$). We hope that with the implementation of the National strategy for the prevention of oral diseases the state of oral health in all children from the Republic of Macedonia in the future will be improved.

## References


1. Kidd E. Essentials of Dental Caries: The Disease and its Management. 3rd ed. United Kingdom: OUP Oxford; 2005.
2. Dye BA, Tan S, Smith V, Lewis BG, Barker LK, Thornton-Evans G, *et al*. Trends in Oral Health Status: United States, 1988-1994 and 1999-2004. Vital Health Stat 11. 2007;248:1-92. https://doi.org/10.3886/icpsr04010
   PMid:17633507
3. Meiers P. Fluoride Research in the 19th and Early 20th Century. Available from: https://www.fluoride-history.de [Last accessed on 2021 Oct 25].
4. Aoun A, Darwiche F, Al Hayek S, Doumit J. The fluoride debate: The pros and cons of fluoridation. Prev Nutr Food Sci. 2018;23(3):171-80. https://doi.org/10.3746/pnf.2018.23.3.171
   PMid:30386744
5. Pollick HF. Salt fluoridation: A review. J Calif Dent Assoc. 2013;41(6):395-7, 400-4.
   PMid:23875431
6. The State of Oral Health in Europe Report, Commissioned by the Platform for Better Oral Health in Europe Dr. Reena Patel, Dental Advisor. United States: Better Oral Health; 2012.
7. Iheozor-Ejiofor Z, Worthington HV, Walsh T, O'Malley L, Clarkson JE, Macey R, *et al*. Water fluoridation for the prevention of dental caries. Cochrane Database Syst Rev. 2015;2015:CD010856. https://doi.org/10.1002/14651858.cd010856.pub2
   PMid:26092033
8. Kolevska L, Filjanski P, Cvetkoska T, Gjorgjev D, Mitrikeska M. Fluoride content in drinking water from SR Macedonia. Mac Med Review. 1985;3-4:103-6.
9. Carcev M, Gjorgev D, Neceva LJ, Docevska V, Filjanski P. Fluoride in drinking water and dental caries frequency in endemic areas of Macedonia. Mac Dent Review. 1992;16(1):51-7.
10. Ambarkova V, Topitsoglou V, Iljovska S, Jankulovska M, Pavlevska M. Fluorine content of drinking water in relation to the geological-petrographical formations from FYROM. Balk J Stom. 2007;11(3):163-6.
11. Ambarkova V, Topitsoglou V, Iljovska S, Carcev M. Natural fluoridated drinking water from the republic of Macedonia. Mac Dent Review. 2005;29(3-4):177-82.
12. Ambarkova V. Comparative Study between Oral Health and Natural Fluorinated Drinking Water in Certain Regions of the Republic of Macedonia. Doctoral Dissertation, Egypt: Skopje, Republic of Macedonia, Faculty of Dentistry, University SS. Cyril and Methodius, 2015. https://doi.org/10.17113/ftb.55.02.17.4991
13. Primary, Lower Secondary and Upper Secondary Schools at the end of the school year 2012/2013. Statistical Review: Population and Social Statistics. United States: United Nations Statistics Division; 2013.
14. Ambarkova V, Panova O. Dental caries experience among 15-years old children in the Southeast region of the Republic of

Macedonia. Oral Health Dent Manag. 2015;14(6):353-60.

15. World Health Organization. Oral Health Surveys, Basics Methods. 5th ed. Geneva: World Health Organization; 2013.
16. Vernazza CR, Rolland SL, Chadwick B, Pitts N. Caries experience, the caries burden and associated factors in children in England, Wales and Northern Ireland 2013. Br Dent J. 2016;221(6):315-20. https://doi.org/10.1038/sj.bdj.2016.682
    PMid:27659635
17. Xavier A, Carvalho ES, Bastos RS, Caldana ML, Damiance PR, Bastos JR. Impact of dental caries on quality of life of adolescents according to access to oral health services: A cross sectional study. Braz J Oral Sci. 2016;15(1):1-7. https://doi.org/10.20396/bjos.v15i1.8647090
18. Sukhabogi JR, Parthasarathi P, Anjum S, Shekar B, Padma C, Rani A. Dental fluorosis and dental caries prevalence among 12 and 15-year-old school children in Nalgonda district, Andhra Pradesh, India. Ann Med Health Sci Res. 2014;4(3):S245-52. https://doi.org/10.4103/2141-9248.141967
    PMid:25364597
19. Bilder L, Stepco E, Uncuta D, Aizenbud D, Machtei E, Bilder A, *et al*. The pathfinder study among schoolchildren in the Republic of Moldova: Dental caries experience. Int Dent J. 2018;68(5):344-7. https://doi.org/10.1111/idj.12392
    PMid:29696641
20. Giacaman RA, Bustos IP, Bazán P, Mariño RJ. Oral health disparities among adolescents from urban and rural communities of central Chile. Rural Remote Health. 2018;18(2):4312. https://doi.org/10.22605/rrh4312
    PMid:29656652
21. Gorbatova AM, Gorbatova LN, Grjibovski AM. Dental caries experience among 15-year-old adolescents in north-west Russia. Int J Circumpolar Health. 2011;70(3):232-5. https://doi.org/10.3402/ijch.v70i3.17824
    PMid:21703127
22. Tudoroniu C, Popa M, Iacob SM, Pop AL, Năsui BA. Correlation of caries prevalence, oral health behavior and sweets nutritional habits among 10 to 19-year-old cluj-napoca romanian adolescents. Int J Environ Res Public Health. 2020;17(18):6923. https://doi.org/10.3390/ijerph17186923
    PMid:32971957
23. Markovic N, Muratbegovic AA, Kobaslija S, Bajric E, Selimovic-Dragas M, Huseinbegovic A. Caries prevalence of children and adolescents in Bosnia and Herzegovina. Acta Med Acad. 2013;42(2):108-16.
    PMid:24308391
24. Lalić M, Krivokapić M, Janković-Bukva B, Aleksić E, Gajić M, Banković D. Influence of oral health related behavior on oral health of adolescents in Belgrade. Serb Dent J. 2013;60(2):76-84. https://doi.org/10.2298/sgs1302076l
25. Mishra A, Pandey RK, Chopra H, Arora V. Oral health awareness in school-going children and its significance to parent's education level. J Indian Soc Pedod Prev Dent. 2018;36(2):120-4. https://doi.org/10.4103/jisppd.jisppd_1172_17
    PMid:29970627
26. Gondivkar SM, Gadbail AR, Gondivkar RS, Sarode SC, Sarode GS, Patil S, *et al*. Nutrition and oral health. Dis Mon. 2019;65(6):147-54. https://doi.org/10.1016/j.disamonth.2018.09.009
    PMid:30293649
27. Tavchiovski I, Rafajlovski R, Stevanovic M, Kedevov P, Stojanovski J, Nikov B. Multiple examination of the ratio between dental caries and fluoride concentration in drinking water. Mac Dent Review. 1979;3(4):209-14.
28. Abu-Gharbieh E, Saddik B, El-Faramawi M, Hamidi S, Basheti M, Basheti M. Oral health knowledge and behavior among adults in the United Arab Emirates. Biomed Res Int. 2019;2019:7568679. https://doi.org/10.1155/2019/7568679
29. Tolvanen M, Lahti S, Miettunen J, Hausen H. Relationship between oral health-related knowledge, attitudes and behavior among 15-16-year-old adolescents: A structural equation modeling approach. Acta Odontol Scand. 2012;70(2):169-76. https://doi.org/10.3109/00016357.2011.600722
    PMid:21793645
30. National Strategy for Prevention of Oral Diseases in Children from 0 to 14 Years of Age in the Republic of Macedonia for the Period from 2008 to 2018. Ministry of Health. Skopje: Republic of Macedonia; 2007.
31. World Health Organization. Guidelines for Drinking-water Quality. 4th ed. Geneva: World Health Organization; 2011. Available from: https://www.who.int/water_sanitation_health/publications/2011 [Last accessed on 2021 Oct 25].
32. Keesari T, Pant D, Roy A, Sinha UK, Jaryal A, Singh M, *et al*. Fluoride geochemistry and exposure risk through groundwater sources in Northeastern parts of Rajasthan, India. Arch Environ Contam Toxicol. 2021;80(1):294-307. https://doi.org/10.1007/s00244-020-00794-z
    PMid:33388840
33. Ambarkova V, Jankulovska M, Kocubovski M, Guguvcevski LM. Determining the optimal concentration of fluoride in drinking water from the republic of Macedonia. J Interdiscipl Med Dent Sci. 2016;4:199.