Scientific Research Report

Caries Prevalence and Severity for 12-Year-Old Children in Latvia

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ARTICLE INFO

Article history:
Available online 30 October 2020

Key words:
Caries prevalence
Epidemiology
Oral health
Latvia

ABSTRACT

Objectives: To study caries prevalence/severity in 12-year-old children in Latvia and potential risk indicators.

Methods: A cross-sectional oral-health national survey of 12-year-old children was conducted in 2016. A nationally representative stratified-cluster probabilistic sample of 2,138 pupils in 92 schools was selected. Children were examined by seven calibrated examiners (kappa inter-examiner, intra-examiner scores of 0.71–0.77, 0.81–0.97, respectively) at school. Enamel-non-cavitated decay (D_1), enamel cavitation (D_3), dentine cavitation (D_5), missing (M) or filled (F) status at the tooth (T)/surface (S) levels were evaluated, and decayed, missing, and filled (DMF) index scores for severity, along with the Significant Caries Index (SiC), were calculated. An associated caries factor questionnaire was completed by participants.

Results: The prevalence of caries was 98.5% for D_1MFT, 79.7% for D_3MFT, and 71.9% for D_5MFT. The means (standard deviations) for severity were 9.2 (5.3) for D_1MFT, 3.3 (3.0) for D_3MFT, and 2.4 (2.4) for D_5MFT, and 5.6 (2.1) for the SiC. Indicators associated with a lower risk of caries (D5MFT) were irregular dental visits (prevalence odds ratio POR = 0.45, 95% confidence interval (CI): 0.36, 0.56) and irregular use of mouthwashes (POR = 0.73, 95% CI: 0.60, 0.89).

Conclusions: We found a high caries prevalence and severity in 12 year-old children in Latvia. Although the WHO target for 2010 (D_5MFT ≤ 3) is met, the values for caries prevalence (D_5MFT > 0 = 71.9%) and severity (D_5MFT = 2.5) in 12-year-old Latvian children are higher than the European averages (D_5MFT > 0 = 52%, D_5MFT = 1.1).

Introduction

Dental caries in 12-year-olds have undergone a large decline in prevalence, about 90%, between the 1970s and 1990s. This decline has been most pronounced in the US and Scandinavia.[1] During the 1990s, Europe changed, with several countries recovering their sovereignty. This has led to differences in socioeconomic aspects and health indicators. Oral health is a key indicator of those differences. A study in nine European countries found that 52% of 11–13-year-olds had tooth decay, and there is inequality in the distribution of the severity of dental conditions.[2] This inequality has been more pronounced in countries that have undergone changes in their economic systems. For example, there are differences between the old West German states and newly formed German states.[3] While the global prevalence of dental caries seems to be decreasing,[4] in some countries it seems to be increasing,[5] particularly those in the former Soviet bloc.[6]

Latvia is a Baltic republic that gained its independence from the USSR in 1991, joined the European Union in 2004 and the Organisation for Economic Co-operation and Development (OECD) in 2016. Few national epidemiological studies on children's oral health have been conducted in Latvia. For instance, the International Study of Oral Health in 1993 revealed that all age groups in the Latvian population had severe caries.[7] This high severity was still found in

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https://doi.org/10.1111/idj.12627

12-year-old children in 2000, as shown by the Decayed, Missing, and Filled Surface (DMFS) index at the enamel (D_1) level, D_1MFS = 19.9, and at the cavitated lesions (D_3) level, D_3MFS = 10.5.[8]

The high prevalence of caries detected in local studies may have several explanations. A study on children aged 11–13 years in 27 European countries conducted to determine the prevalence of caries and risk indicators found that the most common risk factors were low use of fluoride toothpaste and high consumption of snacks and sugary drinks.[9]

In Latvia, few studies included a risk indicator analysis and those studies did not examine the whole territory of Latvia.[10–13] Those studies only used univariate methods to assess risk factors, instead of multivariate analyses, which provide a clearer picture.

Hence, there is a paucity of epidemiological data on the prevalence and associated factors of dental caries in Latvia. Also, recent reviews have detected a gap in the information available about the detail of the caries component in epidemiological studies.[1] For this reason, the Centre for Disease Prevention and Control (CDPC) of Latvia launched a national study to assess the oral health status of 12-year-old children in Latvia. Thus, the present study sought to assess the prevalence and severity of dental caries and associated factors among a nationally representative sample of 12-year-old schoolchildren in Latvia and discuss them in the European context.

Methods

The research protocol was approved by the Ethics Committee of Rīga Stradiņš University (No.1/17.12.15.) on November 26, 2015.

Study design

A cross-sectional study was conducted in 2016 in Latvia. This report follows the recommendations of the STROBE guidelines[14] for observational studies.

Setting

According to 2011 statistics, Latvia has 2,070,371 inhabitants[15] with a wide ethnic diversity including Latvian 61.8%, Russian 25.6%, Belarusian 3.4%, Ukrainian 2.3%, Polish 2.1%, Lithuanian 1.2% and others 3.6%.[16] The population is distributed across 110 municipalities and 9 large cities, with the greatest concentration of people being found in and around the port and capital city of Riga; small agglomerations are scattered throughout the rest of the country. The urban population is 68.1% of the total population. The literacy rate is 99.9% and school life expectancy is 16 years. The gross domestic product (GDP) per capita is USD15,594 (EU average = USD33,715)[17] and the health expenditure is 5.9% of the GDP[16] (EU average = 7.1%).[18] The professionally active dentist density is 1.15 per 1,000 inhabitants (OECD average = 1.02).[19] The approximate population of 12-year-olds was 11,028 in 2016.[20] There is no water fluoridation in Latvia. The government sponsors preventive measures (hygiene instruction, removal of dental plaque or calculus, and application of F-gel or F-varnish) for every child, which is provided by a dentist or hygienist once annually; for 7- and 12-year-old children these procedures are available twice a year.

Participants

Only 12-year-olds were included. Participants were recruited from 92 out of 487 schools that had courses for 12-year-olds. The protocol with the stratified sampling details is available at the Centre for Disease Prevention and Control of Latvia.[21] The number of schools sampled in each particular stratum was proportional to the average number of pupils in that stratum.

Parents or caregivers received information about the study and an informed consent form, delivered to the children by their teachers. After clinical examinations and completion of the questionnaires, every child received an information letter, which included a caries risk assessment and information about their oral health. The participating children or parents did not receive any incentive for participation.

Data sources/measurement

At baseline, after giving consent, examiners interviewed children and requested that they complete a questionnaire regarding use of dental services, oral health habits, diet, and socioeconomic variables. In this study, the prevalence (experience) and severity of dental caries were measured.

The questionnaire of associated factors was designed through a pilot study and two versions were created, in Russian and Latvian, and back translations were done to check for consistency between languages. Nine examiners were trained by a previously trained ICDAS evaluator, through a program consisting of three photo training and theoretical sessions and three clinical sessions with patients examined exclusively for the calibration over two months. The intra-examiner agreement calculation was made within a month. Those evaluators with kappa intra- or inter-examiner scores of <0.7 were removed, leaving seven examiners. Operational coordination took two months, plus one month of calibration and then three months of measurements of the children in the schools.

The caries measurement was done with the simplified ICDAS-II criteria,[22] with codes 1–2 as D_1, then 3–4 as D_3 and 5–6 as D_5 to make an equivalence with the modified WHO criteria[23,24]. Caries prevalence (D not equal to zero) and severity was found according to the Decayed, Missing, and Filled (DMF) index scores for lesions at the thresholds of the enamel (D_1), cavitated enamel (D_3), and cavitated dentine (D_5) levels, with the addition of missing or filled teeth due to caries (D_1MFT, D_3MFT, D_5MFT). Children were judged caries experience-free when the sum of D_1MFT, D_3MFT or D_5MFT was zero. The Significant Caries Index (SiC) was calculated,[25] as follows: individuals are sorted according to their D_5MFT values; the third of the population with the highest caries score is selected and the mean D_5MFT for this subgroup is calculated – this value constitutes the SiC Index. In addition, teeth exhibiting fissure sealants, whether complete or incomplete, were also recorded.

The demographic information and putative associated factors were collected using the aforementioned questionnaire.

Variables

Dental caries

All examiners were trained by an experienced dentist. This included theory and clinical training, with slides and patients not included in the research. Seven trained and calibrated dentists (inter-examiner kappa 0.71–0.77 and intra-examiner kappa 0.81–0.97 at the D_1 threshold) performed the clinical examinations. A supervised pre-examination toothbrushing was required of all participants. The pupils were clinically examined on school premises on mobile examination tables (RESTPRO® Classic-2; RESTPRO, Riga, Latvia). The dental examinations were performed with the use of artificial light, size 5 plane dental mirrors and CPI (Community Periodontal Index of Treatment Needs) probes for caries evaluation, while cotton rolls were used for moisture control. No air drying was applied. Detection and assessment of the carious lesions were based on visual examination and no probing was used. Also, no x-rays were taken.

Associated factors

All the putative associated factors were selected from currently available epidemiological evidence.[26] These possible associated factors include frequency of dentist visits, dental hygienist visits, and toothbrushing. The research participants' socioeconomic status (SES) was measured according to the Family Affluence Scale (FAS).[27] This was developed by the World Health Organization (WHO) as a measure of family wealth and comprises four items: parental car ownership ['Does your family own a car, van, or a truck?' (0, 1, 2)], sharing or not sharing a bedroom ['Do you have your own room?' (1, 0)), number of holidays per year ['During the past 12 months, how many times did you travel away on holiday with your family?' (0, 1, 2, 3)), and having computers at home ['How many computers does your family own?' (0, 1, 2, 3)]. The composite FAS score was calculated for each adolescent by adding the four items (ranging from 0–9) and further categorised into low (0–5), medium (6–7) and high (8–9).[27] Data for all of these variables were provided by the participants. We included questions about dental flossing and dental mouthwash. The questionnaire covered the consumption of different foods. The amount of added sugar was estimated and divided into high or low consumption levels according to the amount recommended by the WHO, assuming 35 g for men and 25 g for women.[28] For liquids, it was considered a risk if they added additional sugar to hot drinks or if the cold drinks contained sugar. More details can be found in the study protocol.[21]

Bias

Incomplete or illegible questionnaires were not used. Ten percent of the participants were re-evaluated to check the consistency of the records. Issues were found in fewer than 1% of the records.

Study size

To assess the national prevalence, we considered a population of 12,000 children 12 years of age.[15] We estimated a prevalence of 80% at D_5MFT.[8] The sample was a stratified cluster sample based on region of residence and language (Latvian or minority schools) to ensure ethnic diversity. Sampling for probability proportional to size was used to select the schools. Then participants were randomly selected via a sample procedure in R software[29] without replacement until the desired number of participants was obtained. We used the formula described by Bennet et al.[30] A final minimal sample size of 1,960 participants with an average of 20 per school was required to be 95% certain that our estimate of prevalence was within 5% of the true population value (i.e. a relative error of 0.05/0.80 = 0.0625). This sample size made it possible to detect ten possible associated factors with a prevalence odds ratio (POR) of >1.25 with a Type I error = 0.05 and power = 0.8.[31] Deliberate over-sampling was performed to account for an expected attrition of 40% in participants; hence, we planned to invite 3,500 children. After stratified school selection, 92 schools with 3,598 sixth-grade pupils were included in the sample.

Statistical methods

Data were tabulated and cleaned using a Google form and spreadsheet, then exported to the R software[29] for statistical analysis. Descriptive tables and graphs were constructed for dental caries prevalence. The differences between proportions were analysed using the proportions test and the differences between means using the *t*-test or ANOVA followed by Tukey's test. The associated factors were selected based on the available literature and the remaining collected factors were used to adjust the final model.[32] In order to determine the caries associated factors, the prevalence odds ratios (POR) with 95% confidence intervals (CIs) were calculated and regression models were used to find statistically significant ($P < 0.05$) factors. The clinical significance was set for any factor with a POR whose 95% CI lower limit was >1. A generalised linear model for binomial distribution was used to evaluate putative associated factors. The outcome variable was D_5MFT > 0. All these associated factors were dichotomised in binary values, where '0' describes a situation with no or very insignificant association, and '1' describes a situation where associated factors are present or are extremely significant. Thus, a positive value can be interpreted as the presence of a factor positively associated with caries history for the cavitated dentine (D_5MFT) threshold. Those factors whose POR 95% CI limits were outside 1 were considered to be associated with the response variable.

Results

Participants

From the selected sample of 3,598 pupils, we examined 2,713 (response rate = 75.4%). We did not include in the survey and did not perform a clinical examination for 430 children who

were absent from school during our visit, for 380 children whose parents refused their participation, and for 75 pupils who refused participation themselves. Of those 2,713 examined, 31 questionnaires were incomplete and were not included in the data analysis. In addition, 544 were of different ages (one was 10 years old, 63 were 11, 453 were 13, 24 were 14 and 3 were 15). This led to the final sample for data analysis of 2,138 12-year-old schoolchildren.

Descriptive data

The study sample consisted of 2,138 children (girls 48.2%). Of the children surveyed, 77.7% lived in urban areas and 21.3% had a low SES-FAS. The demographic characteristics of the participants are provided in Table 1.

Outcome data

Caries prevalence

The proportion of children with caries experience was 98.5% (95% CI: 97.8, 98.9) for the D_1MFT threshold, 79.7% (95% CI: 77.9, 81.4) for D_3MFT, and 71.9% (95% CI: 69.9, 73.8) for D_5MFT. Details by gender, region, area and SES are shown in Table 1.

The highest caries prevalence at D_3MFT was measured in the Latgale region (85.4%). The Riga (75.97%) and Kurzeme (76.47%) regions showed the lowest levels of caries prevalence at the D_3 threshold.

Caries severity

The caries severity at the tooth and surface levels by gender is shown in Table 2. No evidence of a difference in caries severity by gender was found (*t*-test, $P > 0.05$).

The caries severity in 12-year-old children per tooth by region is shown in Table 3.

No evidence of a difference in caries severity between regions was found (ANOVA, *P*-value > 0.05). The details of DMFT and SiC caries severity means (SDs) by region are shown in Table 3.

The teeth least affected by caries were the mandibular incisors, whereas first mandibular molars were the most affected by caries, with percentages of $D_1 = 53.9$, $D_3 = 15.7$, $F = 9.9$ and $M = 0.8$, followed by first maxillary molars, with percentages of $D_1 = 50.2$, $D_3 = 15.0$, $F = 7.6$ and $M = 0.2$. The details are provided in Figure 1.

The SiC index was calculated at the following values: 15.9 at the D_1 level, 7.0 at the D_3 level, and 5.5 at the D_5 level. The details of SiC by gender are shown in Table 2 and by region in Table 3. No evidence of difference by gender or region was found (ANOVA, *P* values > 0.05). It was found that on average 6.6% of the children examined had sealants in 0.14 teeth.

Caries associated factors

The generalised linear model of associated factors is shown in Table 4. The baseline risk of D_5MFT > 0 is POR = 3.25 (95% CI: 2.42, 4.36). The factor most associated with the D_5MFT > 0 outcome was living in a rural area (POR = 1.58, 95% CI: 1.23, 2.03). Indicators associated with less risk for a history of caries (D_5MFT) were declaring less than one visit per year to the dentist (POR = 0.45, 95% CI: 0.36, 0.56) and irregular use of mouthwashes (POR = 0.73, 95% CI: 0.60, 0.89). The adjusted model shows a R^2 MacFadden of 0.033, with a specificity of 29.6% and sensitivity of 84.5%, resulting in an accuracy of 35.8%.

Discussion

In the present study, the first national and probability-based caries prevalence study in Latvia, we found a high prevalence and severity of caries in 12-year-old children. There has been a significant reduction in the prevalence of dental caries in 12-year-olds in Western European countries, but dental caries

Table 1 – Demographic characteristics of the participants

	n (%)			%		
	Female	Male	Total	D_1MFT > 0	D_3MFT > 0	D_5MFT > 0
Overall	1,031 (48.2)	1,107 (51.8)	2,138 (100.0)	98.5	79.7	71.9
Gender						
Female				98.6	81.4	74.0
Male				98.3	78.2	70.0
Region						
Kurzeme	145 (50.2)	144 (49.8)	289 (13.5)	95.2	76.5	73.7
Latgale	157 (53.4)	137 (46.6)	294 (13.8)	98.3	85.4	73.8
Pieriga	198 (47.9)	215 (52.1)	413 (19.3)	99.3	80.6	71.2
Riga	292 (45.3)	353 (54.7)	645 (30.2)	99.8	76.0	66.4
Vidzeme	86 (42.6)	116 (57.4)	202 (9.4)	97.5	80.7	79.7
Zemgale	153 (51.9)	142 (48.1)	295 (13.8)	98.3	83.7	76.3
Area						
Rural	223 (46.8)	253 (53.2)	476 (22.3)	98.7	86.6	78.6
Urban	808 (48.6)	854 (51.4)	1,662 (77.7)	98.4	77.8	70.0
SES-FAS						
Low	221 (48.5)	235 (51.5)	456 (21.3)	98.5	83.8	75.2
Medium	619 (47.9)	673 (52.1)	1,292 (60.4)	98.3	78.8	71.6
High	191 (49.0)	199 (51.0)	390 (18.2)	99.0	78.2	69.2

D_1, non-cavitated lesion; D_3, enamel cavitated lesion; D_5, dentine-cavitated lesion; FAS, Family Affluence Scale; SES, socioeconomic status.

Table 2 – Caries severity and sealant presence in 12-year-old Latvian children by gender (means, SD)

	Overall (n = 2,138)	Female (n = 1,031	Male (n = 1,107)	t-test P value
SiC	5.6 (2.1)	5.5 (1.9)	5.7 (2.2)	0.216
By tooth				
D_1T	5.9 (4.3)	5.7 (4.2)	5.9 (4.3)	0.228
FT	2.0 (2.2)	2.1 (2.1)	1.9 (2.3)	0.085
D_3T	0.9 (1.3)	0.9 (1.3)	0.9 (1.4)	0.300
D_5T	0.4 (1.1)	0.4 (1.0)	0.4 (1.1)	0.612
MT	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)	0.392
D_1MFT	9.2 (5.4)	9.2 (5.3)	9.2 (5.5)	0.950
D_3MFT	3.4 (3.0)	3.5 (2.9)	3.2 (3.1)	0.105
D_5MFT	2.5 (2.5)	2.5 (2.4)	2.4 (2.6)	0.164
By surface				
D_1S	12.6 (10.5)	12.3 (9.9)	12.9 (11.0)	0.110
FS	3.2 (4.1)	3.3 (3.4)	3.1 (4.3)	0.594
D_3S	1.0 (1.6)	1.0 (1.6)	1.0 (1.6)	0.726
D_5S	0.6 (2.0)	0.6 (1.8)	0.7 (2.1)	0.287
MS	0.1 (0.8)	0.1 (0.9)	0.1 (0.7)	0.546
D_1MFS	17.6 (13.2)	17.2 (12.1)	17.9 (14.1)	0.235
D_3MFS	5.0 (5.6)	4.9 (5.3)	4.9 (5.9)	0.845
D_5MFS	4.0 (4.9)	3.9 (4.6)	3.9 (5.2)	0.915
Sealants				
Sealants	0.1 (0.7)	0.2 (0.7)	0.1 (0.7)	0.710

D_1, non-cavitated lesion; D_3, enamel cavitated lesion; D_5, dentine-cavitated lesion; F, filled; M, missing; S, surface; SiC, Significant Caries Index; T, tooth.

Table 3 – Caries severity (means, SD) in 12-year-old Latvian children by region

Index	Region					
	Kurzeme	Latgale	Pieriga	Riga	Vidzeme	Zemgale
D_1T	7.7 (3.4)	7.1 (3.4)	5.2 (5.1)	4.9 (4.3)	2.9 (2.3)	4.1 (3.5)
D_3T	0.9 (0.7)	1.0 (1.4)	1.2 (1.4)	1.2 (1.4)	0.4 (0.9)	0.3 (1.5)
D_5T	0.3 (1.5)	0.3 (0.7)	0.5 (0.9)	0.2 (1.0)	0.6 (1.1)	0.7 (1.0)
FT	1.9 (2.2)	1.8 (2.4)	2.0 (2.1)	2.3 (2.1)	2.8 (2.9)	2.0 (2.0)
MT*	0.0 (0.2)	0.0 (0.1)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)
D_1MFT	10.9 (4.9)	10.2 (5.1)	9.0 (5.8)	8.7 (5.4)	6.7 (4.0)	7.0 (4.7)
D_3MFT	3.2 (2.8)	3.1 (3.0)	3.7 (2.8)	3.8 (3.0)	3.9 (3.3)	3.0 (3.1)
D_5MFT	2.3 (2.6)	2.1 (2.5)	2.5 (2.3)	2.5 (2.4)	3.5 (3.0)	2.7 (2.3)
SiC	5.7 (2.1)	5.6 (2.2)	5.5 (2)	5.5 (2.1)	6.2 (2.3)	5.4 (1.6)

D_1, non-cavitated lesion; D_3, enamel cavitated lesion; D_5, dentin-cavitated lesion; F, filled; M, missing; SiC, Significant Caries Index; T, tooth.

* The mean for MT for all regions is 0.021.

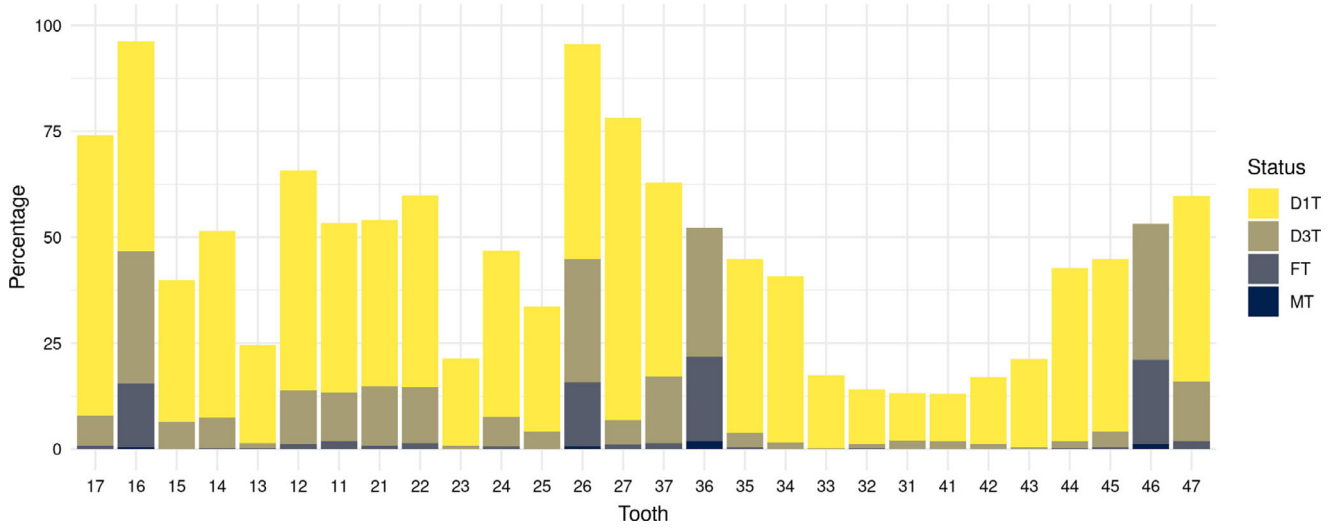

Fig. 1 – Caries status per tooth (T) in 12-year-old children, Latvia. D_1, enamel caries; D_3, dentine or cavitated caries; FT, filled tooth; MT, missing tooth.

Table 4 – Associated factors for caries history in 12-year-old children, Latvia

Predictor for $D_5MFT > 0$	Estimate	SE	Z	P	95% Confidence Interval		
					POR	Lower	Upper
Intercept	1.18	0.15	7.85	<0.01	3.25	2.42	4.36
Less than one visit per year to the dentist	−0.80	0.11	−7.06	<0.01	0.45	0.36	0.56
Less than one visit per year to the hygienist	0.00	0.11	0.01	0.99	1.00	0.81	1.24
Lack of regular toothbrushing	0.42	0.35	1.21	0.23	1.52	0.77	3.01
Lack of regular flossing	0.04	0.11	0.38	0.71	1.04	0.85	1.28
Irregular use of mouthwash	−0.32	0.10	−3.16	0.00	0.73	0.60	0.89
Diet high in sugar	0.11	0.11	1.05	0.29	1.12	0.91	1.38
Liquids high in sugar	−0.14	0.12	−1.14	0.26	0.87	0.69	1.11
Lower socioeconomic status level (FAS)	0.23	0.13	1.80	0.07	1.25	0.98	1.61
Residence in a rural area	0.46	0.13	3.60	<0.01	1.58	1.23	2.03

Estimates represent the log odds of 'D_5MFT = Yes' vs. 'D_5MFT = No'. Regression results with the prevalence odds ratio (POR) and 95% confidence interval. The outcome variable is the caries history at D_5MFT level. D_5MFT, index for Decayed, Missing, and Filled Teeth at the level of dentine cavitation.

is still the most common oral health problem worldwide. Table 5 provides the comparison of our results in the European context based on the WHO caries criteria (D_5MFT). This study has some limitations. The use of the simplified ICDAS-II criteria allowed us to compare our results with other national studies. However, the fact that we did not use strict drying to detect ICDAS-II category 1 lesions suggests that our study underestimates the prevalence of non-cavitated lesions. Also, using a questionnaire to identify probable factors associated with dental caries is a task that proved to be more complex and less reliable than we anticipated. While there are numerous studies on the assessment of risk factors in preschool children,[33] there is little evidence for adolescents.[34] Ideally, in the future a questionnaire can be standardizes for use in epidemiological studies of caries risk in adolescents and adults. On the other hand, this study follows the proposal of Patel et al.[35] to improve the reporting on caries prevalence to enable valid comparison between studies. This is why we detail the different threshold levels of caries diagnoses. Caries prevalence and severity are lower in most countries around the world; however, half of the world's population currently suffers from untreated caries and other severe dental diseases.[1] Here, 94.6% of the children evaluated had at least one non-cavitated enamel lesion (D_1), presenting an opportunity for non-invasive treatment rather than allowing them to progress to the traditional stages of dental intervention.[36] Some of these interventions are proximal[37] and occlusal sealants.[38] We found that 6% of the children evaluated had dental sealants. By comparison, 55% of children in Portugal have sealants.[39] Although Latvia lacks fluoridated drinking water and there are no plans to implement it, the creation of a school for dental hygienists suggests that there is an opportunity to increase the coverage of preventive interventions. The severity of dental caries in 12-year-old Latvian children meets the WHO[40] goal of 3.0, with a D_5MFT value of 2.5. It is worth comparing this value with Estonia's 2.8 in 2003 and with Lithuania's average of 1.9 in 2011,[41] since these countries share a common history and are similar in size, population, and ethnic diversity. The fact that only 6.6% of the children examined have sealants is evidence of the lack of implementation of caries prevention strategies. This could explain why the D_5MFT index is above the 2015 European average, which was 1.81.[42]

Table 5 provides a comparative display of D_5MFT for Latvia with other countries.

Considering the high prevalence of caries, the statistical model was insensitive to detecting associated factors. This implies that the entire population of 12-year-olds should be treated as being at high risk of dental caries. A cross-sectional study allows only for the exploration of associated factors and risk indicators that might explain the observed prevalence of caries.

There are limitations to consider when evaluating the effect of possible associated factors. In the first place, the design of the study does not allow the temporality of the association to be established.[43] Another possible limitation is that some explanatory variables were obtained through a questionnaire in which respondents stated whether, for example, they frequently used mouthwash, while other variables, such as rurality, were obtained via official records. This might help explain some unexpected results. On the one hand, reporting irregular dental visits seems to be associated with a protective caries indicator. This could be because patients who have no need to go to the dentist may have better cavity-related oral health than those who require frequent dental visits. This result is similar to that found by the Cochrane systematic review which reports that there is no evidence to support or refute the practice of encouraging patients to attend dental check-ups at 6 month intervals.[44] Also, the result that children who report irregular use of mouthwash have a POR between 0.60 and 0.89 could be because we did not ask what type of mouthwash it was. Thus, for example, there is evidence from systematic reviews showing a protective effect of fluoride-based mouthwashes,[45] while there is no clinical evidence showing a protective effect for mouthwashes containing chlorhexidine[46] or essential oils.[47] On the other hand, it is curious that the socioeconomic index is not a factor associated with caries risk, but living in a rural area is. The fact that there are non-biological factors, e.g. rurality, associated as indicators of caries is consistent with other reported outcomes.[48] Considering the cross-sectional design of our study, it would be risky to propose any mechanism, so future research should clarify why there is an

Table 5 – Prevalence and severity of dental caries in 12-year-old children from selected countries with studies since 2009, with the exception of Estonia (2000-2003) and France (2006) for comparison. Ordered by decreased D_5MFT and colored according to the mean value of severity and prevalence.[54]

Country	D_5MFT	Year D_5MFT data	Caries free % (D_5)	Year Caries free data
Croatia	4.2	2015	46.8	2011
Albania	3.7	2011		2011
Macedonia	3.5	2013		2013
Romania	3.4	2011	32.9	2011
Montenegro	3.4	2006		2006
Latvia (this study)	3.4		20.3	
Bulgaria	3.0	2010		2010
Poland	2.8	2014		2014
Estonia	2.8	2003	42.2	2000
Moldova	2.7	2018	22.5	2018
Russia	2.5	2008	16.6	2008
Czechia	2.1	2010		2010
Belarus	2.1	2009		2009
Lithuania	1.9	2011	33.1	2011
Slovenia	1.9	2013		2013
Greece	1.5	2011	29.0	2012
France	1.2	2006	31.0	2006
Portugal	1.2	2014	53.0	2017
Italy	1.2	2012		2012
Switzerland	0.9	2011	63.0	2011
Belgium	0.9	2010		2010
Spain	0.8	2019	60.4	2019
UK	0.8	2013	62.6	2012
Sweden	0.8	2011		2011
Finland	0.7	2009		2009
Netherlands	0.6	2006		2006
Germany	0.4	2016	78.0	2019
Denmark	0.4	2014	46.0	2010

association between living in rural areas and increased caries history. Using a questionnaire to identify probable factors associated with dental caries is a task that proved to be more complex and less reliable than we anticipated and it would be helpful if in the future a questionnaire can be standardised for use in epidemiological studies of caries risk in adolescents and adults.

In contrast to many studies showing the association between tooth decay and sugar consumption,[49] our model did not confirm this association in the children examined. Unlike other studies,[50] we found no association between a diet high in sugars or carbohydrates and cavities, but this lack of association could be a cross-sectional design artefact.[51] These associated factors should be considered only as explanatory, given that the main limitation of the cross-sectional design is establishing causality.[51] Likewise, the fact that the prevalence is high and the population is homogeneous in terms of its habits renders the exploration of putative associated factors difficult. This suggests that a risk-based approach would not make much sense in Latvia; on the contrary, the entire population of 12-year-olds should be considered at high risk of caries. Future prospective longitudinal risk studies should clarify this situation.

Overall the results indicate that caries severity in Latvia has decreased in comparison with the data collected in 1993 and 2001,[52] and both caries prevalence and severity are lower than what was noted in some specific Latvian regions in 2009.[13] The oral health status of 12-year-old children in Latvia could be interpreted as follows: while public health has shown remarkable progress in Latvia since independence from the USSR,[53] these advances are not reflected in oral health. The presence of a high proportion of non-cavitated lesions indicates that there is an opportunity for non-invasive interventions to stop the progression of non-cavitated lesions in the future.

In conclusion, we found a high caries prevalence and severity of dental caries in 12 year-old children in Latvia. Although the WHO target for 2010 ($D_5MFT \leq 3$) has been met, the caries prevalence ($D_5MFT > 0 = 71.9\%$) and severity ($D_5MFT = 2.5$) in 12-year-old Latvian children are higher than the European averages ($D_5MFT > 0 = 52\%$, $D_5MFT = 1.1$). Therefore, there is an opportunity to implement evidence-based interventions to decrease the prevalence and severity of dental caries in children in Latvia.

Acknowledgements

We wish to thank the Ministry of Health and the Ministry of Education and Science of the Republic of Latvia for their kind support and cooperation. Also, we are grateful to all the schools involved, their principals and teachers, as well as the sixth-grade pupils of the 2015/2016 study year and their parents for their support and participation in this study.

Author contributions

IM designed the study, wrote the study protocol, carried out the calibration, assessments, data cleaning and wrote the first draft and the final manuscript. AB participated in preparing the study protocol and the final manuscript. ES participated in writing the study protocol, obtained the research funds and monitored the study throughout. AS participated in writing the final manuscript. SU performed the statistical analysis and wrote the final manuscript. All authors discussed the results, implications and commented on the manuscript at all stages. All authors approved the final version of the manuscript.

Funding

This research was funded by the Centre for Disease Prevention and Control of Latvia, procurement No. SPKC2015/26, contract No. P/2015-89.

Ethical approval

This study was approved by the Ethics Committee of Rīga Stradiņš University (No.1/17.12.15.) on November 26, 2015. The passive parental informed consent was used – parents were asked to sign and return the informed consent form if they refused their child's participation in the study.

Conflicts of interest

The authors have no conflicts of interest to declare.

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