



Trends in caries experience and background factors in 3-year-old children in Poland: evidence from epidemiological surveys during 2002–2017

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ABSTRACT: The prevalence of early childhood caries and its level varies. The present study was to establish the trends in dental caries and the impact of behavioural changes on the prevalence of caries in three-year-olds in Poland within a fifteen-year period. The results of a cross sectional survey carried out on 3439 three-year-olds in 2002, 2009, and 2017 using WHO criteria for dental caries (dmft, dmft=0, dmft≥4) and the results of a questionnaire filled by their parents with data on sociodemographics, oral hygiene and dietary habits, especially their sugar intake, were assessed. The dmft/dmfs index is applied to the primary dentition and is expressed as the total number of teeth/surfaces that are decayed, missing, or filled. The Cochran-Armitage test for trend was used to assess the fraction changes in time. The Pearson correlation coefficient was used to assess the changes in dmft trends and the correlations between behavioural changes, awareness levels, and the prevalence of caries. Within the fifteen-year period minimal changes in the prevalence of early childhood caries (15% down), dmft≥4 (11.4% down) and a lower dmft (36% down) were accompanied by a better parent awareness about the causes of caries and better oral hygiene routines. Sugary beverages were no longer drunk at least once a day, however sweetened milk, cake, doughnuts, and sweet rolls were consumed more often. Being female, living in an urban area, having parents more aware about caries, consuming sugary beverages less frequently, brushing teeth twice a day, and using a fluoride toothpaste promoted lower early childhood caries. Gradually healthier teeth are linked to an increased awareness of the parents and healthier routines. A too frequent exposure to sugar promotes early childhood caries. Should the changes of dietary habits be insufficient, brushing teeth with fluoride toothpaste becomes crucial.

KEY WORDS: early childhood caries, high risk, diet, oral hygiene, pediatric dentistry

Abbreviations used in the text: ECC – early childhood caries, S-ECC – severe-early childhood caries, dmft – the total number of teeth (t) that are decayed (d), missing (m), or filled (f), dmfs – the total number of surfaces (s) that are decayed (d), missing (m), or filled (f), TNI – treatment needs index.

Introduction

Early childhood caries (ECC) is defined as the presence of one or more decayed, missing or filled tooth surfaces in primary teeth in children aged 71 months or younger. It is particularly dangerous when prevailing in the youngest children, especially shortly after primary teeth eruption. The immaturity of freshly erupted teeth promotes dynamic caries that lead to dental crown damage or pulpitis.

From ages 3 through 5, 1 or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth, or a decayed, missing, or filled score of >4 (age 3), >5 (age 4), or >6 (age 5) surfaces constitutes severe-early childhood caries (S-ECC) (AAPD 2008). The dmft/dmfs index is applied to the primary dentition and is expressed as the total number of teeth/surfaces that are decayed (d), missing (m), or filled (f). S-ECC increases the risk of new caries and may result in pain, hospitalisations and emergency room visits, physical growth and development delays, increased treatment costs, and even death (Finucane 2012). Despite a better awareness of the causes of ECC, it remains a significant health problem in many countries (Çolak et al. 2013). Its prevalence varies (Masiga and Holt 1993; Al-Hosani and Rugg-Gunn 1998; Al-Malik et al. 2001; Rajab and Hamdan 2002; Kiwanuka et al. 2004; Maj Saravanan et al. 2014; Watanabe et al. 2014); it is below 20% in some European Union countries in three-year-olds (Ferro et al. 2007; Bardsley 2013; Dental public health epidemiology programme 2013; Morgan and Monghan 2015) and much higher in others (Henkuzena et al. 2004; Szatko et al. 2004; Jodkowska et

al. 2009; Slabšinskienė et al. 2010; Begzati et al. 2011; Olczak-Kowalczyk et al. 2016).

There are few studies on ECC in three-year-olds (Szatko et al. 2004; Ferro et al. 2007; Bardsley 2013; Dental public health epidemiology programme 2013); most of them are on four- or most often on five-year-olds (Stecksen-Blicks et al. 2004; Dye et al. 2007; Lenčová et al. 2012; Zhang et al. 2016). Cross-sectional surveys on five-year-olds in the Czech Republic established that ECC declined (dmft at 3.5 in 1994 and at 2.7 in 2006) and the percentage of children with no caries increased (from 23.9% in 1994 to 42.2% in 2006) (Lenčová et al. 2012). Zhang et al. (2016) also established, after a literature review, that the overall ECC prevalence in China decreased from 77.9% between 1987 and 1994 to 56.4% between 2010 and 2013. However, two national health and nutrition surveys in the US confirmed that ECC in children between the age of two and five increased from 24.2%, in a study between 1988 and 1994, to 27.9%, in another between 1999 and 2004 (Dye et al. 2007). Still, studies in Italy in the same regions in 1985 and between 2002 and 2003 established that teeth became healthier in three- and four-year-olds (Ferro et al. 2007).

The awareness about oral healthcare in parents had also changed (Piernas and Popkin 2010; Razmienė et al. 2012; Ford et al. 2013). Many factors are said to contribute to ECC. However, little is known about the impact of healthier habits on teeth in children.

The aim of the study is to illustrate trends in dental caries and health promoting habits in three-year-olds in Poland and their impact on the prevalence of ECC within a fifteen-year period.

Material and methods

The results of cross-sectional surveys conducted in 2002, 2009, and 2017 in three-year-olds, as part of a Ministry of Health Oral Health Programme, were assessed. The surveys met the requirements of World Health Organization national pathfinder surveys with their range (number of provinces and urban and rural areas), the representativeness of samples (stratified sampling with three layers, number of patients and their sex), and the required researcher training and calibrating in order to standardise the research (WHO 1997; 2013).

The researches have been conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki. The 2002 study included 15 out of the 16 provinces; the 2009 one – seven, and the 2017 one – all provinces of Poland with different degrees of urbanisation. In 2014, 60.4% of the inhabitants lived in urban areas; in the lower Silesia province 69.4% living in urban areas; in the Mazovia province 64.2% living in urban areas; and in the Lublin province 46.3% living in urban areas. In all provinces of Poland the fluoride level in the water oscillated between 0.1 and 0.5 mg/l (Olczak-Kowalczyk et al. 2018).

The analysis of the results of epidemiological tests delivered data on the number of patients in the tested group, their place of living and sex, the percentage of patients without caries (dmft=0), the percentage of patients with dmft \geq 4, and the dmft itself and its components in every study. The dmft index is applied to the primary dentition and is expressed as the total number of teeth (t) that are decayed (d), missing (m), or filled (f). Answers with recurrent (at every study) causes of dental caries, including those to questions

testing the dental awareness of parents, oral hygiene habits of the child, their dietary habits, and access to medical care were extracted. Answers that differed in any way in the subsequent studies were excluded. Trends and levels were established for ECC, for oral health related behaviour and for the correlation between changes in behaviour and caries indexes.

The Cochran-Armitage test for trends was used in statistical analysis to assess the changes in time in fractions (percentages) of children with determined symptoms, habits, and the percentage of correct answers. The Pearson correlation coefficient was used to determine the change trend for caries indexes and the correlations between selected habits, dental awareness, and caries. Significance was set at $p < 0.05$. XLSTAT 4 and Statistica 12 were used for statistical analysis.

Results

The studies included 3439 three-year-olds; 1045 in 2002, 756 in 2009, and 1638 in 2017 (Table 1).

Table 2 presents the caries indexes and treatment needs index (TNI) in the tested three-year-olds, the dental awareness of their parents, the dietary and oral hygiene habits, and the access to dental care.

In all three studies the analysis of caries indexes established that there were more boys than girls with dmft \geq 4. There

Table 1. Number of tested three-year-olds (N) in 2002, 2009, and 2017 according to their sex and place of living (urban/rural areas)

Variable		2002	2009	2017
		Number of patients		
		1045	756	1638
Sex	Female	525	368	859
	Male	520	388	779
Place of living	Urban area	521	405	866
	Rural area	524	351	772

Table 2. Caries indexes in three-year-olds in 2002, 2009, and 2017 and the dental awareness of their parents, dietary and oral hygiene habits, and access to dental care

Parameter	2002	2009	2017	p-value	
Caries prevalence ECC (%)					
dmft=0	43.8	42.8	58.9	$p^c < 0.001$	
dmft \geq 4	32.6	30.1	20.9	$p^c < 0.001$	
Caries (mean)					
				r (P)	
dmft	2.9	2.7	1.85	-0.954 (0.194)	
dt	2.8	2.61	1.70	-0.948 (0.206)	
mt	0	0	0.02	0.885 (0.309)	
ft	0.1	0.06	0.13	0.462 (0.695)	
Treatment needs index (TNI) (ft/ft+dt)	0.03	0.02	0.08	0.801 (0.408)	
Parent awareness about oral health (% of correct answers)					
Children should regularly go for dental check	90	86.9	97.5	$p^c < 0.001$	
Snacking promotes caries	66	70.5	73.2	$p^c < 0.001$	
Too much sugar causes caries	92	94.3	96.3	$p^c < 0.001$	
Fluoride products are healthy	70	71.4	74.3	$p^c < 0.001$	
Deciduous teeth do not require the same care as permanent teeth	66	82.3	86.1	$p^c < 0.001$	
Caries spreads from deciduous to permanent teeth	63	64	61.2	$p^c = 0.296$	
Dietary habits (% of affirmative answers)					
One or more times a day	sweetened tea	48	65.4	34.9	$p^c < 0.001$
	sugary sodas	12	7.6	2.7	$p^c < 0.001$
	sweetened milk	23	27.5	29.2	$p^c < 0.001$
	cake, doughnuts, sweet rolls	10	21.8	12.5	$p^c < 0.001$
Diet with limited amounts of sugar	69	84.3	80.8	$p^c < 0.001$	
Child eats sweets once a week	2	1.6	8.4	$p^c < 0.001$	
Hygiene habits (%)					
Child's teeth are brushed by an adult	17	21.6	38.9	$p^c < 0.001$	
Teeth are brushed using a toothbrush and toothpaste	87	95	99.5	$p^c < 0.001$	
Use of fluoride toothpaste	56.7	66.5	52.0	$p^c = 0.002$	
Child brushes teeth at least twice a day	25	50.1	53.0	$p^c < 0.001$	
Dental care (%)					
Child has never been to the dentist	62	46	52.4	$p^c < 0.001$	

p^c – Cochran-Armitage test for trend; r – the Pearson correlation coefficient.

dmft index – the total number of teeth (t) that are decayed (d), missing (m), or filled (f).

TNI – treatment needs index.

ECC – early childhood caries.

were 0.8% more boys without caries than girls in only 2002 (Fig. 1).

In 2009 and 2017 there were more girls with $dmft=0$. Girls had lower mean $dmft$ than boys (0.1 less in 2009 and 0.3 less in 2017) (Fig. 2).

It was established that the percentage of three-year-olds without caries was higher in urban than in rural areas (Fig. 3).

There was a 0.5% difference between urban areas in the studies in 2002 and 2009 and a 1.6% difference between rural areas in 2002 and 2009 and a 14.6% difference in 2017 in urban areas and 15.1% in rural areas. $Dmft$ in children living in urban areas were 0.2 lower in 2002, 0.5 lower in 2009, and 0.4 lower in 2017 (Fig. 4). Urban areas had a lower percentages of three-year-olds with

$dmft \geq 4$ than rural areas (Fig. 3). The differences were: 4.6% in 2002, 4.7% in 2009, and 4.5% in 2017.

The changes related to parent awareness, dietary and hygiene habits, and more frequent dental check-ups seemed positive. Only the changes in the answer to the question “caries spreads from deciduous to permanent teeth” was not statistically significant ($p^c=0.296$) (Table 2). According to the percentages of correct answers in 2002 and 2017, the number of parents of three-year-olds aware of the necessity of caring about deciduous teeth decreased by 1.8%. The number of people aware of the fact that snacking promoted caries had increased by 7.2%; that of those aware of the benefits of using fluoride products by 4.3%; that of those aware of the benefits of regular dental check-

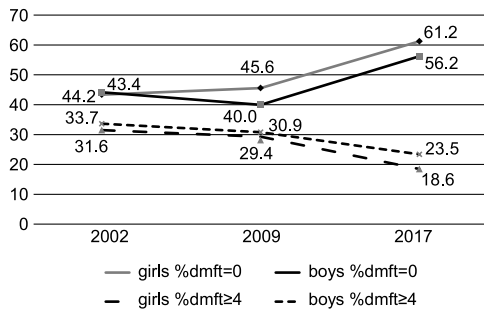


Fig. 1. The percentage of three-year-old girls and boys without caries ($dmft=0$) and with caries ($dmft \geq 4$) in 2002, 2009, and 2017

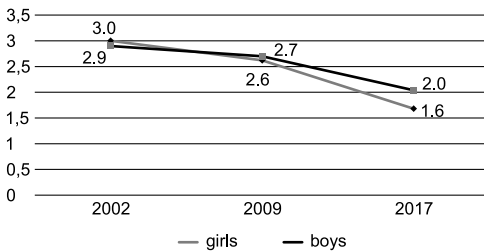


Fig. 2. The mean value of $dmft$ in girls and boys in 2002, 2009, and 2017

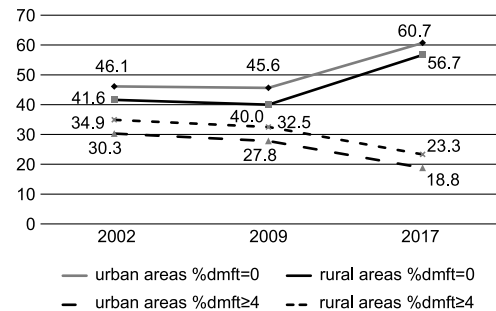


Fig. 3. The percentage of three-year-olds without caries ($dmft=0$) and with caries ($dmft \geq 4$) living in urban/rural areas in 2002, 2009, and 2017

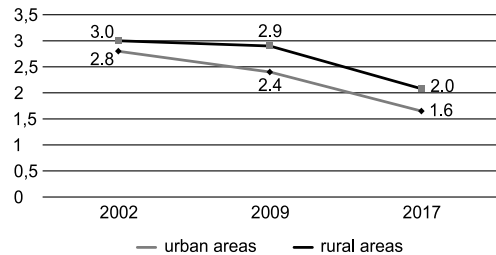


Fig. 4. Mean value of $dmft$ in three-year-olds living in urban or rural areas in 2002, 2009, and 2017

Table 3. Pearson correlation coefficient assessing the impact of the changes in the parent awareness about oral health and the related behaviour on ECC indexes

Parameter	ECC %	dmft \geq 4	dmft	dt
Parent awareness about oral health				
Children should regularly go for dental checkups	-0.973	-0.881	-0.892	-0.900
Frequent snacking promotes caries	-0.750	-0.894	-0.883	-0.875
Too much sugar causes caries	-0.814	-0.936	-0.927	-0.920
Fluoride products are healthy	-0.928	-0.992	-0.989	-0.986
Deciduous teeth require the same care as permanent teeth	-0.602	-0.787	-0.772	-0.760
Caries spreads from deciduous to permanent teeth	0.954	0.844	0.857	0.866
One or more times a day				
sweetened tea	0.852	0.690	0.707	0.719
sugary sodas	0.853	0.958	0.952	0.946
sweetened milk	-0.672	-0.839	-0.826	-0.816
cake, doughnuts, sweet rolls	0.368	0.117	0.140	0.158
Attempts to limit sugar intake	-0.245	-0.486	-0.465	-0.449
Child eats sweets once a week	-0.99*	-0.967	-0.973	-0.977
Child's teeth are brushed by an adult	-0.968	-0.99*	-0.99*	-0.99*
Teeth are brushed using a toothbrush and toothpaste	-0.739	-0.887	-0.876	-0.867
Use of fluoride toothpaste	0.785	0.599	0.618	0.632
Child brushes teeth at least twice a day	-0.533	-0.733	-0.716	-0.703
Dental care				
Child has never been to the dentist	0.059	0.314	0.291	0.274

dmft index – the total number of teeth (t) that are decayed (d), missing (m), or filled (f).

ups by 7.5%. The percentage of children drinking sweetened tea and sugary sodas at least once a day had decreased. However, the percentage of children eating cake, doughnuts, and sweet rolls and drinking sweetened milk had increased.

Table 3 presents the impact of the behavioural changes on ECC in three-year-olds, using Pearson correlation coefficient.

Discussion

A comparison of the results of three-year-olds from 2002, 2009 and 2017 indicated that the prevalence of ECC and dmft \geq 4 had decreased. The differences were not statistically significant, however the percentage of children without caries increased by 2.7% and the percent-

age of children with dmft \geq 4 decreased by 3.1% within the fifteen-year period. A similar analysis of two studies within an eighteen-year period conducted on three-year-olds in Italy established that there was a higher percentage of children without caries; in 1985 58.2% of children did not have caries, in 2002 and 2003 that number was at 86.7% (Ferro et al. 2007). In Lithuania ECC and dmft increased (ECC from 71.1% to 81.9%) in four-year-olds between 2000 and 2010 (Razmienė et al. 2012). In Poland the dmft decreased by 1.0 in children within the fifteen-year period. However, the number of teeth with caries remained the main dmft component; in 2002 it represented 96.5% of dmft, in 2009 96.6%, and in 2017 91.9% (Szatko et al. 2004; Olczak-Kowalczyk et al. 2018). The dif-

ferences were not statistically significant, most probably because few studies were analysed. However, the correlations for dmft and dt were strongly negative. In Italy children's dmft decreased from 2.2 to 0.5 within a seventeen-year period (+1.83) (Ferro et al. 2007).

There were also some small but positive improvements in the treatment of deciduous teeth caries and of its complications. In 2002 and 2009 the average number of teeth lost because of caries equalled zero (Szatko et al. 2004; Jodkowska et al. 2009). In 2017 there were children who had their teeth removed because of caries. The treatment needs index (TNI) also doubled within the fifteen-year period, although it still remained low. Other studies also referred to considerable negligence in deciduous teeth caries treatment in young children. In Latvia the ratio between the mean number of filled teeth and dmft (ft/dmft x 100) was 28% in 2000 three-year-olds (Henkuzena et al. 2004). The care index (%) was at 2.8% in three-year-olds and at 4.0% in four-year-olds in China between 2005 and 2009 (Zhang et al. 2016).

During the fifteen-year period ECC and dmft \geq 4 were less frequent in girls; both also decreased more considerably in girls (ECC by 17.1% and dmft \geq 4 by 13.1%) than in boys (by 12.8% and 10.2% respectively). Data on the correlation between ECC and sex varied; in many studies it was established to be non-existent (Mohebbi et al. 2006; Nobile et al. 2014; Toutouni et al. 2015). In Latvia the prevalence of dental caries was higher in boys than in girls (Henkuzena et al. 2004). In Kosovo there was no statistically significant correlation between ECC in three-year-olds and their sex, however, more five-year-old girls had caries than boys the same age (Begzati et al. 2011). In Po-

land lower caries in girls within the fifteen-year period seemed to indicate a correlation between caries and patient sex.

Not only are ECC and dmft \geq 4 was lower in children living in urban areas, but also the percentage of children without caries is higher there. For both rural and urban areas decrease of the percentage of children with dmft \geq 4 was similar between years 2002 and 2017 (11.6% vs. 11.5%). Differences between the prevalence of ECC in urban and rural areas still exist in certain countries. In China ECC was higher in rural areas (63.5%) than in urban areas (59.5%) (OR=1.08, 95% CI:1.02–1.14) (Zhang et al. 2016). However, Levin et al. (2010), who studied urban-rural differences in caries in five-year-olds, established that children in rural areas and on the outskirts of urban areas had healthier teeth than those living in urban areas (Levin et al. 2010).

ECC is a multifactorial disease. Its risk factors are also sociodemographic (such as a lower education level and lower socioeconomic status), poor dietary habits (especially the exposure to sugar), and poor hygiene (Wang 1996; Al-Hosani and Rugg-Gunn 1998; Al-Malik et al. 2001; Rajab and Hamdan 2002; Kiwanuka et al. 2004; Steckslen-Blicks et al. 2004; Szatko et al. 2004; Poutanen et al. 2006; Psoter et al. 2006; Tinanoff et al. 2009; Christensen et al. 2010; Slabšinskienė et al. 2010; Turska-Szybka et al. 2011; Prakash et al. 2012; Maj Saravanan et al. 2014; Nobile et al. 2014; Watanabe et al. 2014; Wulaerhan et al. 2014). In the present studies, the teeth of three-year-olds grew gradually healthier, which was accompanied by a better parent awareness and healthier habits. However, every fifth parent still was not aware of the fact that frequent snacking and no fluoride prevention increased the

risk of caries; more than 30% of parents did not understand the correlation between deciduous and permanent teeth caries; and 40% of parents served their children sweetened tea at least once a day. The percentage of children who had their teeth brushed by their parents increased by 21.9%, that of children whose teeth were brushed at least twice a day by 28.0%. However, the oral hygiene level remained poor. The assessment of the correlation confirmed that the impact of parent awareness about oral health and of healthier habits, i.e. frequent fluoride toothpaste use, brushing teeth at least twice a day, and limiting sweetened beverage intake, was significant. Although there was no statistically significant correlation between the other assessed parameters, their change indexes, including parent awareness, their attempt to limit sugar intake, and having teeth brushed by an adult, were high. There was a statistically significant negative correlation between parent awareness about the necessity of caring about deciduous teeth the same way as about permanent teeth and $dmft \geq 4$, and their awareness about regular dental check-ups made ECC less frequent. A Chinese study confirmed that more aware parents/guardians ($OR=0.74$; $95\%CI:0.60-0.90$) could prevent ECC (Wulaerhan et al. 2014).

Therefore, educating parents and motivating them to change their habits was one of the main preventive measures for the youngest children. An increased parent awareness about the influence of frequent snacking had a statistically significant impact on the number of teeth with caries and a lower sweetened beverage intake had a positive statistically significant impact on $dmft$. However, the consumption of sweetened milk, cakes, doughnuts, and sweet rolls increased.

There were highly negative correlations between sweetened milk and ECC. Good dietary habits in childhood are crucial not only to prevent caries. That is also the time when future dietary habits and preferences are formed (Birch et al. 2007; Prakash et al. 2012). There were few studies on the changes in dietary habits in young children (Piernas and Popkin 2010; Ford et al. 2013). The US national representative surveys (between 1989 and 1991, 1994 and 1998, 1994 and 1998, and 2003 and 2006) on food intake in children showed two- to six-year-olds snacked more frequently and therefore consumed more calories (Piernas and Popkin 2010). That tendency was confirmed in a 2007 and 2008 study (Ford et al. 2013). According to Slining et al. (2013) the intake of sweetened beverages got lower after 2004. However, Fox et al. (2010) established that about 85% of two- and three-year-olds consumed sweetened beverages, desserts, or snacks at least once a day. In the present studies, the intake of sweetened milk, cake, doughnuts, and sweet rolls had significantly increased within the fifteen-year period. However, the consumption of sugary sodas had decreased.

The presented correlation between the impact of healthier hygiene habits and ECC indexes confirmed the importance of brushing teeth at least twice a day and using fluoride toothpaste in order to prevent ECC. In China, where an important number of three-year-olds had ECC (ECC: 65.5% and S-ECC: 33.8%), as much as 73.9% of children did not brush their teeth on a regular basis (Zhang et al. 2016). That study confirmed the impact of regular tooth brushing on ECC prevention ($OR=0.44$; $95\%CI:0.60-0.90$). Among preschool children aged six to 71 months in Nigeria, ECC prevailed in

24.1% of children brushing their teeth twice a day and in 75.9% of those not brushing their teeth regularly (Olatosi et al. 2015). That was also confirmed by an Indian study (Prakash et al. 2012). The comparison of dental caries prevalence and oral hygiene skills in four-year-olds in Lithuania established that the percentage of children with caries decreased when teeth were brushed regularly (from 89.0% to 83.3%). S-ECC (OR=29.16; 95%CI:6.49–191.03) increased significantly when teeth were not brushed in three-year-olds (Slabšinskienė et al. 2010).

There is a global consensus that regular use of fluoride toothpaste is crucial to prevent caries. Fluoride toothpastes were the main reason for the dramatic decline in caries in the last decade of the 20th century. Daily tooth brushing with fluoride toothpaste in three to six year olds was established to significantly reduce the prevalence of caries (Holttta and Alaluusua 1992; Schwarz et al. 1998). In the afore-quoted Nigerian study, children who had their teeth cleaned with glycerine were 17.7 times more likely to develop ECC comparing to those who used fluoride toothpaste (OR=17.7; 95%CI:3.0–103.7) (Olatosi et al. 2015). An Indian study (0.7 ml/l fluoride concentration in drinkable water) on 1 500 children aged eight to 48 months established that the use of fluoride toothpaste significantly decreased caries prevalence, most probably reflecting parent awareness (Prakash et al. 2012). However, in Lithuania, the use of fluoride toothpaste did not significantly decrease the risk of S-ECC in three-year-olds (OR=0.89; 95%CI:0.46–1.72) (Slabšinskienė et al. 2010).

The present study was limited because there were few studies to assess

(N=3). Data (such as $dmft \geq 4$ in studies conducted in 2002 and 2009) was insufficient. Percentages in some studies were reported to the nearest integer and in others to the tenth of percentage. The standard deviations were reported along with the mean for caries indexes in last studies, but in other studies only the mean was reported. The questions in the subsequent surveys were different. Last but not least, the complete data were available only in 2017, while data from 2002 and 2009 were aggregate. The unit subjected to statistical analyses was a year of survey not an individual subject. The lack of raw information made it impossible to apply multivariate statistical methods. However, it does not change the fact that it was possible to analyse factors affecting the parameters of dental caries in 3-year-old children. The fact that the same methodology was used to assess caries prevalence and its severity is one of its advantages.

Conclusions

The presented analysis reflects a gradual improvement in oral health in young children, correlated with parent awareness and healthier habits. A too frequent exposure to sugar is the main reason why ECC remains frequent. Insufficient changes in dietary habits are compensated by regular tooth brushing using fluoride toothpaste.

Authors' contributions

ATS conceptualized and designed the study. UK coordinated and supervised data collection, participated in the analytical framework for the study. DG performed the final data analyses.

JT participated in the analytical framework for the study, drafted the manu-

script. DOK conceptualized and designed the study, critically reviewed and revised the manuscript for important intellectual content. All authors approved the final manuscript as submitted.

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Conflict of interest

The authors have no conflicts of interest to disclose.

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