



Research article

Childhood caries management in the European Union: A cross-sectional study

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ARTICLE INFO

Keywords:

Health sciences
Public health
Dentistry
Caries prevention
Childhood caries
Dental public health
Health policy

ABSTRACT

Objectives: Dental caries is one of the most widespread childhood diseases worldwide, although it is largely preventable. In Europe, there is an observable difference between caries prevalence in Eastern and Western European states. This study aimed to gather data on the characteristics of publicly financed dental preventive services for children in European Union (EU) member states.

Methods: Data on important indicators were collected through an online survey. National and international professional bodies specializing in pediatric dentistry and dental services were invited to participate in the study. Descriptive statistics and information gain were applied in the analysis to identify the strongest indicators of the availability and content of childhood caries services. Additionally, the reimbursement characteristics were examined.

Results: We received responses from 27 EU member states. The accessibility and assessment of dental preventive services among the member states vary notably. The frequency of screenings and the screened age groups differ by country and free screenings for preschool children are not common. Monitoring systems were present in only 37% of the responding countries, but brief dental interventions are available to promote caries prevention in 25 of the 27 countries. However, these interventions are mainly focused on basic oral health education. Regarding the reimbursement characteristics, we found that the amount of reimbursement is larger for higher-cost treatments targeting already developed caries than for cost-effective preventive treatments, which are less likely publicly financed.

Conclusions: The prevention of dental caries is part of oral health promotion and education efforts in the EU; unlike the treatment of already developed dental caries, the accessibility of clinical prevention services is limited and usually not free for children. Further comprehensive studies are necessary to identify key indicators for international assessment and facilitate the standardization of the screening process, thus promoting the collection of comparable data.

1. Introduction

Dental caries is one of the most prevalent noncommunicable diseases and most widespread childhood diseases worldwide. Dental caries represents a major public health issue, although it is largely preventable [1]. In our study, we cover childhood caries developing in both primary and permanent teeth of children under 18 years of age. The related preventive services and treatments for children are typically funded by public health systems in the European Union (EU) countries. Regarding primary

teeth's caries, Early Childhood Caries (ECCs) is a major issue among children under 6 years of age [2]. ECCs develops at an early age and can cause serious health conditions if it remains untreated [3]. As caries, ECC and their complications are widespread in high-income countries [4], the treatment of these issues represents an economic burden; however, there is a lack of information about their exact financial impact [5]. The available data on the effectiveness of preventive measures for caries are also limited, and reliable indicators are not widely available for children between age 0 and 18. The only available indicator to estimate the

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Received 12 October 2020; Received in revised form 27 January 2021; Accepted 1 February 2021

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burden of disease is the DMFT score (decayed, missing and filled teeth) for permanent teeth among 12-year-olds.

The WHO adopted the DMFT score for 12-year-olds as a surveillance indicator to assess dental caries. More than half of decayed teeth in the 12-year-old population in high-income countries remain untreated, and in middle-income countries, this ratio is two-thirds [4]. DMFT scores vary widely due to the lack of standardized screening methods and the range in screening frequency and throughput [6]. According to the available DMFT data, there is a considerable difference between Eastern and Western European countries [5, 7], and Figure 1 shows that some European Union (EU) member countries, including Slovakia, Croatia, Latvia, and Bulgaria, are still left behind [7]. Although a reduction in DMFT scores was observed in most developed countries over the past few years, there are groups within developed countries, e.g., children living in deprived areas, requiring special attention. Average scores can mask inequalities, especially in Eastern Europe [5, 6].

The implementation of effective caries prevention programs and screening systems can facilitate a reduction in the number of untreated decayed teeth and significantly improve health outcomes, especially for high-risk groups [4]. Since dental caries is a multifactorial disease, prevention requires a multilevel framework of intervention considering socioeconomic factors [1], public health approaches, oral health promotion and international or intersectoral collaboration [8].

Although EU countries have similar approaches and national guidelines for caries prevention, their elaboration and practical implementation show much variety due to the diversity of national healthcare systems, monitoring systems and national caries prevention policies [5]. Oral health services, including dental caries prevention, are fragmented

in many countries and are not integrated into primary health care services [3, 9]. In the EU, member countries hold primary responsibility for organizing and delivering health services and medical care. According to the Treaty on the Functioning of the European Union (Article 168), the actual role of the EU is limited within healthcare [10]. However, the EU has a role in improving preventive services, according to the White Paper of the Council of European Dentists the EU can do a lot “by supporting Member States in achieving shared objectives and tackling shared challenges, e.g. through establishing guidelines and indicators or preparing periodic monitoring and evaluation” [11]. Limited data are available for international comparison on the applied prevention methods, monitoring systems and dental preventive policies aiming caries prevention: this also applies to under 18 year-olds in the EU countries. The improvement of the overall data and knowledge base would be crucial for international assessment [5].

The objective of our study was to provide insight into caries prevention policies and services provided for children across EU member states by gathering information on 1) access to dental caries screening and preventive services, 2) the assessment of caries preventive services, 3) data registration during the dental screening process, and 4) financial aspects of preventive and operative treatments.

2. Methods

2.1. Study design

This cross-sectional, survey-based exploratory study collected information on the characteristics of public dental care for children, with a

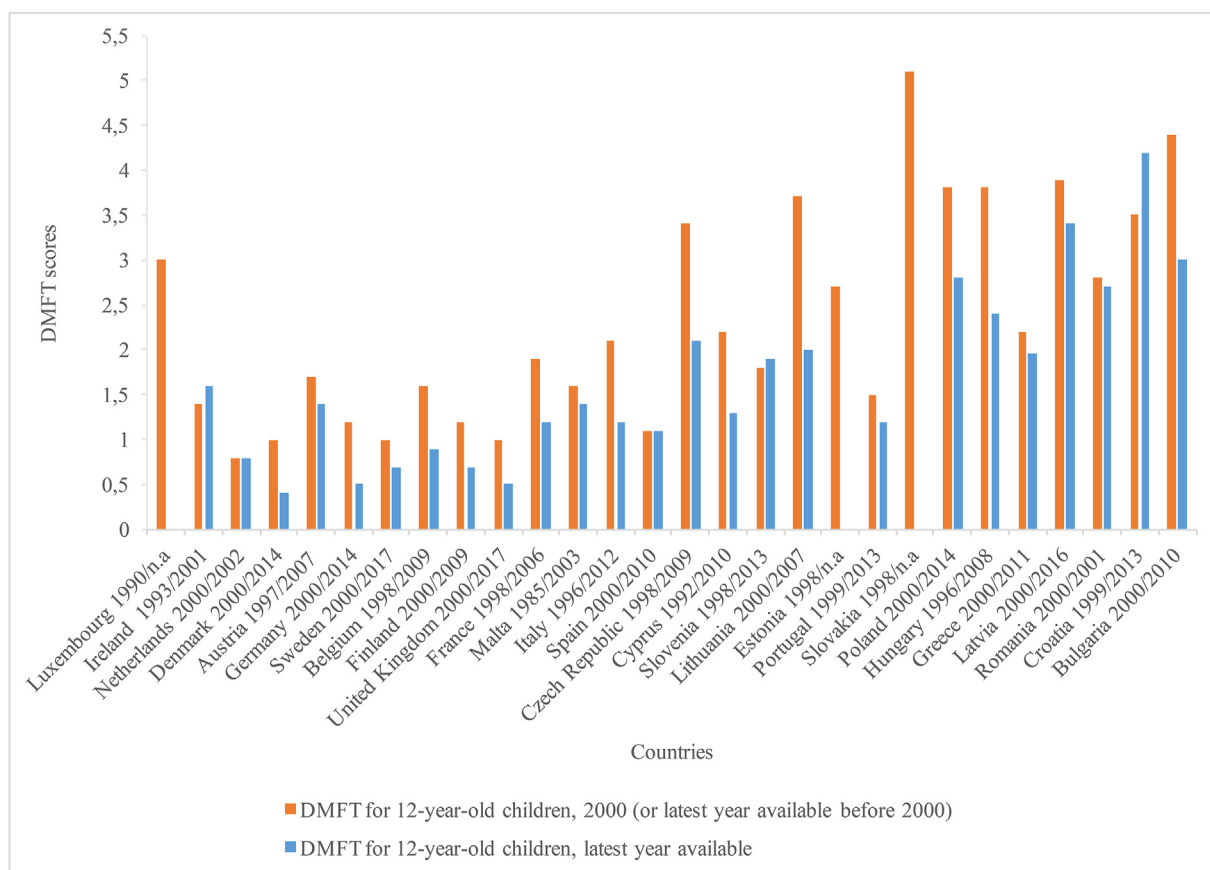


Figure 1. Comparison of DMFT score for 12-year-old children in European Union member states. Figure 1 represents the DMFT scores of the European Union (EU) member states. The list of countries based on GDP (PPS) (gross domestic product in purchasing power standard) per capita (2017), in descending order from left to right. This comparison indicates the alteration in DMFT score for 12-year-old children in the year of 2000 (or nearest year available) and the latest updates for each member state. DMFT values reduced between since 2000 in almost all EU member states. The higher GDP (PPS) is associated with lower DMFT values. Source of GDP per capita in (PPS) data: <https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=tec00114>. Source of DMFT data: <https://capp.mau.se/dental-caries/> Accessed: July 1, 2020.

special focus on national dental practice and policy in childhood caries prevention. Structural, process and outcome indicators (as presented by EGOHID, SIGN-138) [12,13] were gathered throughout the survey to help turn individual features and records into unified datasets. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines were applied [14].

2.2. Survey

The questionnaire [available online at https://evasys.unideb.hu/evasys/online.php?p=caries_policy] was anonymous, presented in English and made available online through the EvaSys survey automation suite. The questionnaire consisted of 70 closed and 6 open-ended questions, covering 5 areas: the demographic data of respondents, the organization of dental services for children, the oral health education provided for children, data recording and the reimbursement characteristics of provided treatments. The survey took approximately 15 min to complete; responses were confidential and anonymous.

2.3. Participants

The questionnaire was sent to targeted caries experts from professional institutions within the EU member states, the examined period was between July 2017 and September 2018. Potential participants were contacted through their public email addresses, and participation in this study was voluntary.

Questionnaires were sent periodically with expanded circle of included experts aiming to gather data from each EU country. We gathered data in 2 main phases: in phase 1, dental councils, pediatric dental associations and EU members of international dental associations were contacted. In case of non-responding countries, other professionals and professional bodies in academic settings were invited to participate. In phase 2, available responses were sent to the competent national authorities for validation. Submissions were received from 27 member states of the EU-28 (non-responding country was Luxembourg) in the examined period of July 2017 to September 2018.

European dental councils, members of the European pediatric dentistry societies, International Association of Paediatric Dentistry members representing a European country and at least one university with a dental school per country (preferably a pediatric dental school) received the questionnaire link to access the online survey. Additionally, if no response was received from national professional organizations or dental faculties, then orthodontic and public health departments of universities, professional regional dental associations, dental hygienists and their organizations, pediatric healthcare professionals or researchers with relevant publications in the field were invited to participate in the survey. All received responses were sent for verification to the competent authority (health or other relevant ministries) of their respective countries [15]. Such authorities were also invited to participate in the questionnaire online.

2.4. Data analysis

We included one dataset from each country in the analysis. Personal data were not collected; however, contact details were provided by some respondents to receive information about our results, and this information was destroyed after the completion of the study. If multiple responses were received from the same country, questionnaires not fully answered were excluded and the dataset, which is consistent with the literature, more coherent and more complete was included in the analysis. Nonrelevant responses, including missing answers or contradictory answers within the same survey response were excluded from the analysis. Thus, the number of 'responding countries' included in the analysis varies per question. In the open-ended questions, responses to 'your country' were included in the analysis, and other responses provided only supplementary data (e.g., the name of a database).

Descriptive statistics were applied by using Microsoft Excel 2010. We used information gain (IG) [16], a feature selection method, to determine the importance of the collected indicators. Zhao et al. [16] describe that Information Gain measures the dependence between the feature and the class label. IG is a feature weighting algorithm. Entropy measures the uncertainty [17] and IG shows the reduction of uncertainty [18]. The feature is relevant, when the information gain is high [16]. IG was calculated by using Microsoft Excel v16.45. With IG, we can analyse the difference between two selected groups. IG values are between 0-1, where 0 means full overlap with no difference, and 1 means the greatest difference between groups under examination. To help with the international assessment, countries were classified by their DMFT score for 12-year-old children, as this is so far the only internationally available indicator for children's dental health. The applied classification for countries was based on the WHO classification: very low (under 1.2), low (between 1.2 and 2.6), moderate (between 2.7 and 4.4.) and high (above 4.4). Source of DMFT data and classification [7]: <https://capp.mau.se/dental-caries/>. We assessed indicators of the questionnaire across 'very low' and 'moderate-high' DMFT groups to identify the most relevant differences among groups with IG.

We analysed the estimated reimbursement (in Euros) per performed treatments/services: (1) Preventive services include fissure sealing, topical fluoride varnish, dental hygiene treatment, oral health education, oral health screening and preventive orthodontic treatment for children (e.g. space maintainer) and (2) Operative treatments include primary tooth filling, permanent tooth filling, tooth extraction, primary tooth pulp therapy and permanent tooth root canal treatment. We assigned a score from 0 to 5 to each treatment, depending on the reimbursement value (no reimbursement for the given treatment – score 0, or treatment is reimbursed at a high value – score 5). We classified the examined treatments as 'preventive' and 'operative', and presented the weighted average score for the 'preventive' and 'operative' groups. The weighted results were calculated using Microsoft Excel by the use of weighted calculation procedures described by Bland J Martin and Kerry Sally M [19].

Our aim was to obtain information on all oral preventive policies and services in childhood. The Manual of Dental Practice 2015 emphasizes, that within the EU countries, national health insurance covers certain dental services and treatments for children [20]. To respect the national policy variations, we used the EU definition of "below the age of 18 years" when referring to children. In a majority of EU countries, 'children' are under 18 years of age [21]. We used 'childhood caries' as a general term to refer to caries experienced in childhood, until 18 years of age. As a subgroup, we paid special attention to children under 6 years of age, to gather data on Early Childhood Caries prevention. ECC, by definition, means caries in primary dentition under 71 months of age [3].

3. Results

We sent 444 invitational emails during the examined period and received 36 responses (response rate of 8.1%) from 27 member states of the EU-28 (we received no response from Luxembourg). Twenty-seven responses were included in the study, one dataset for each member state. The majority of respondents were female (55.6%), 40–59 years old (63%), and employed by a higher educational institution (51.9%). 'Dentist or dental specialist' was the most frequent title (7 respondents, 1 of them is leading dentist in paediatric dentistry), 'professor' was the second (6 respondents, 2 of them are head of department), then 'associate professor' (2 respondents), 'assistant professor' (2 respondents), 'university lecturer' (2 respondents) and 'dentists with PhD' (2 respondents). Among the 27 respondents, 4 also hold or previously held 'vice president', 'vice chair', 'chair/chairwoman' titles in professional organizations. In case of 15 countries (Belgium, Cyprus, Greece, Hungary, Italy, Ireland, Latvia, Malta, The Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, United Kingdom), it was noted by the respondents that uniformity in children's dental services and screening might not be

Table 1. Access to screening and assessment of caries preventive services in the member states of the European Union.

Function	Indicator/Data type	Countries ¹ and DMFT prevalence groups																										
		Very low (<1.2)									Low (1.2-2.6)									Moderate (2.7-4.4) and high (4.4<)								
		DK	DE	UK	SE	FI	NL	BE	ES	FR	IT	PT	CY	AT	MT	IE	SI	EL	LT	CZ	HU	EE	RO	PL	BG	LV	HR	SK
Access to screening and preventive services	Free-of-charge dental treatments provided for children ²	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Brief dental interventions available for children ³	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	School dentistry is part of the public dental care	*	*			*		*			X	*			*	*				*	X	*					X	X
	Frequency of school dental screening																											
	More often than a year			*							X									*	X					X	X	
	Yearly	*						*		X	*									X	*				X	X		
	Not every year					*				X					*	*				X					X	X		
	Screened age groups																											
	All	*								X					*					*	X					X	X	
	Selected		*			*		*		X	*			*						X	*					X	X	
	Organized dental screening available for preschool children ²	*	*		*	*	*					*						X	*	*								
	Frequency of preschool dental screening																											
	More often than a year			*			*											X		*								
	Yearly	*											*					X	*									
	Not every year					*	*											X										
	Screened age groups																											
	All	*					*											X		*								
Selected		*			*	*					*						X	*										
Effectiveness of caries preventive services	Special care available for high-caries-risk groups	*	*	*	*	*	*	*	*	*	*							*	*					*	*	*	*	
	National guideline(s) ⁴ available to standardize brief dental interventions	*	*	*	*	*	*		*	*		*			*		*						*	*	*	*	*	
	Uniformity achieved throughout the country in children caries prevention	*	*		*	*			*			*						*	*	*	*	*	*	*	*	*	*	
	Caries risk assessment applied in the country	*	*	*	*	*	*	*	*						*					*				*	*	*	*	
	Monitoring system available for children's dental screening	*	*	*	*	*	*	*	*			*	*					*		*				*	*	*	*	

Table 1 shows the indicator categories used for caries preventive services and assessment of preventive services in the European Union member states (based on the responses). Countries are presented by their most recent DMFT score, from left to right: very low, low, moderate and high DMFT. Asterisk indicates 'available', fields marked with 'X' indicates no response received or response was excluded due to contradictory responses and not included in the analysis.

EU 2-letter country codes: AT-Austria, BE-Belgium, BG-Bulgaria, CY-Cyprus, CZ-Czechia, DE-Germany, DK-Denmark, EE-Estonia, EL-Greece, ES-Spain, FI-Finland, FR-France, HR-Croatia, HU-Hungary, IE-Ireland, IT-Italy, LT-Lithuania, LV-Latvia, MT-Malta, NL-Netherlands, PL-Poland, PT-Portugal, RO-Romania, SE-Sweden, SI-Slovenia, SK-Slovakia, UK-United Kingdom, source: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Country_codes.

¹ Countries indicated by 2-letter country codes, grouped by DMFT scores. Source of DMFT data and classification: <https://capp.mau.se/dental-caries/> Accessed: July 1, 2020.

² Through the public health service.

³ Dental interventions: aiming for caries prevention, we included interventions of both in-practice (clinical) and non-practice (non-clinical) setting.

⁴ Guidelines: To standardize brief dental interventions on caries prevention for children, either in-practice or non-practice setting, e.g. on oral health instructions and promotion, health behaviour, plaque control.

Table 2. Features of oral health education in the member states of the European Union.

Function	Indicator	Countries ¹ and DMFT prevalence groups																										
		Very low (<1.2)								Low (1.2–2.6)								Moderate (2.7–4.4) and high (4.4<)										
		DK	DE	UK	SE	FI	NL	BE	ES	FR	IT	PT	CY	AT	MT	IE	SI	EL	LT	CZ	HU	EE	RO	PL	BG	LV	HR	SK
Access to oral health education as a part of brief dental interventions	Basic oral health education ²	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Education of tooth-brushing techniques ³	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
	Promotion of fluoride toothpaste	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
	Promoting awareness in dietary habits	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
	Education of parents, involving them in the oral care promotion	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
	Supervised tooth-brushing	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
	Motivation based on individual health behaviour	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
	Education of pregnant women, involving them in the oral care promotion	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
	Information about bad habits for oral health ⁴	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
	Introduction of special tooth cleaning methods, products ⁵	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			

Table 2 shows the availability of oral health education in the member states of the European Union (based on the responses), depending on 10 indicators representing the interventions provided. Asterisk indicates 'available', in individual or group setting or both. Countries are presented by their most recent DMFT score, from left to right: very low, low, moderate and high DMFT.

EU 2-letter country codes: AT-Austria, BE-Belgium, BG-Bulgaria, CY-Cyprus, CZ-Czechia, DE-Germany, DK-Denmark, EE-Estonia, EL-Greece, ES-Spain, FI-Finland, FR-France, HR-Croatia, HU-Hungary, IE-Ireland, IT-Italy, LT-Lithuania, LV-Latvia, MT-Malta, NL-Netherlands, PL-Poland, PT-Portugal, RO-Romania, SE-Sweden, SI-Slovenia, SK-Slovakia, UK-United Kingdom, source: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Country_codes.

¹ Countries indicated by 2-letter country codes, grouped by DMFT scores. Source of DMFT data and classification: <https://capp.mau.se/dental-caries/> Accessed: July 1, 2020.

² Importance of tooth-brushing, toothbrush, toothpaste.

³ Including frequency and duration of tooth-brushing, what time of the day etc.

⁴ e.g. thumb-sucking, certain types of sports.

⁵ Anything other than toothbrush and toothpaste, e.g. dental floss, mouthwash, interdental brush.

Table 3. Data registration characteristics during oral health screening in the member states of the European Union.

Function	Indicator/Data type	Countries ¹ and DMFT prevalence groups																									
		Very low (<1.2)								Low (1.2–2.6)								Moderate (2.7–4.4) and high (4.4<)									
		DK	DE	UK	SE	FI	NL	BE	ES	FR	IT	PT	CY	AT	MT	IE	SI	EL	LT	CZ	HU	EE	RO	PL	BG	LV	HR
<i>Data recorded during the oral health screening process</i>	Mandatory data report required on screening	*		*	*	*		*			*	*						*	*		*	*			*	*	
	Complete Dental Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	D – Decayed teeth	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	F – Filled teeth	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	M – Missing teeth	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Medical History (Anamnesis)		*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Children with Disabilities		*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	DMF/dmf rate – newly developed caries	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Untreated Decayed Teeth ²	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Oral Hygiene Record (plaque)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Early Childhood Caries - cavitated	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Use of Fluoride		*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Record of Referral ³		*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Dietary Factors ⁴			*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Early Childhood Caries – noncavitated	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	White Spots		*	*	*	*	*	*	*	*	*	*	*	*	*	*	X	*	*	*	*	*	*	*	X	*	*
	Sociodemographic or Geographic Markers ⁵		*		*		*	*	*		*						X							*	X		
	Salivary Flow			*			*										X							*	X		
	Microbiological Risk Factors (Streptococcus mutans)						*										X							*	X		

Our dataset represents 25 respondent countries (Latvia and Greece did not respond for recorded data). Countries are presented by their most recent DMFT score, from left to right: very low, low, moderate and high DMFT. Asterisk indicates a specific data is recorded in school children, preschool children or both, fields marked with 'X' indicates no response received or response was excluded due to contradictory responses and not included in the analysis. Poland and Austria responded 'no data', they also responded that 'there is no mandatory data report' required by a national body. All our data represents service availability for children through the public dental health provider. We did not include any form of private dental service in our research.

EU 2-letter country codes: AT-Austria, BE-Belgium, BG-Bulgaria, CY-Cyprus, CZ-Czechia, DE-Germany, DK-Denmark, EE-Estonia, EL-Greece, ES-Spain, FI-Finland, FR-France, HR-Croatia, HU-Hungary, IE-Ireland, IT-Italy, LT-Lithuania, LV-Latvia, MT-Malta, NL-Netherlands, PL-Poland, PT-Portugal, RO-Romania, SE-Sweden, SI-Slovenia, SK-Slovakia, UK-United Kingdom. Source: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Country_codes.

¹ Countries indicated by 2-letter country codes, grouped by DMFT scores. Source of DMFT data and classification: <https://capp.mau.se/dental-caries/> Accessed: July 1, 2020.

² e.g. if previously detected decayed tooth remains untreated.

³ for special needs, special dental treatments.

⁴ feeding practices, dietary habits, frequency of sugary drink, food consumption.

⁵ e.g. hard-to-reach population, children whose families live in a deprived area.

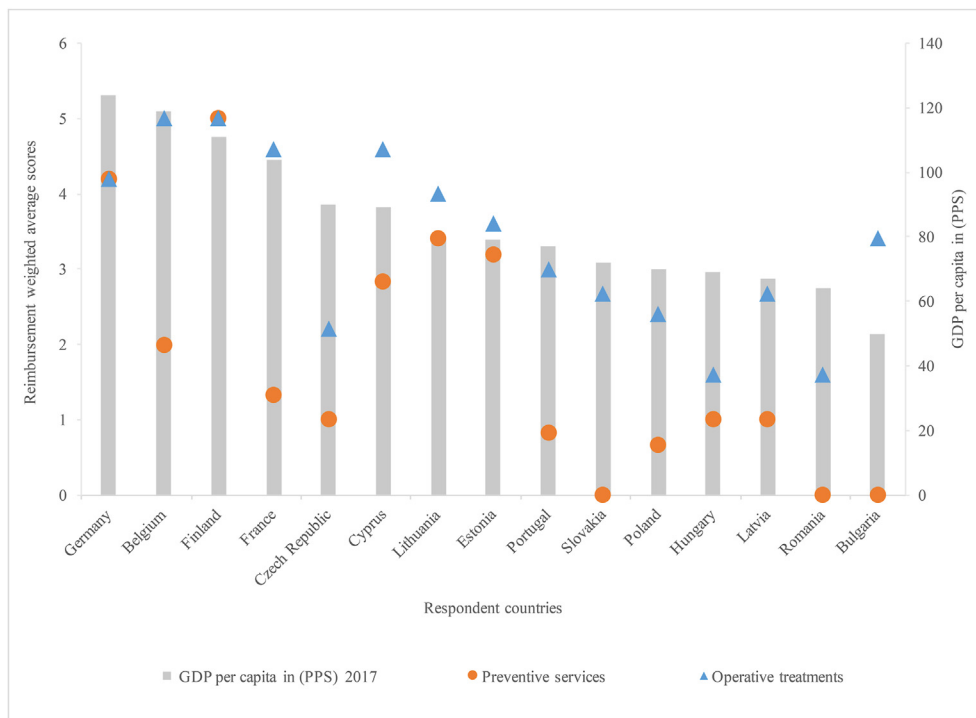


Figure 2. Reimbursement tendency estimation with scores of preventive and operative interventions. Figure 2 horizontal axis represents the responding countries, ranked from highest GDP (PPS) to lowest, from left to right. Right side vertical axis: GDP (PPS) per capita (represented by grey columns). Left side vertical axis: represents the reimbursement weighted average scores for preventive and operative treatment categories (preventive – orange spot or operative – blue triangle). Preventive services: fissure sealing, topical fluoride varnish, dental hygiene treatment, oral health education, oral health screening and preventive orthodontic treatment for children (e.g. space maintainer). Operative treatments: primary tooth filling, permanent tooth filling, tooth extraction, primary tooth pulp therapy and permanent tooth root canal treatment. The scores applied from 0–5, where 0 represents the lowest interest and smaller amount provided to reimburse the category, and 5 means the highest interest and higher amount provided to reimburse the category. Source of GDP per capita in (PPS) data: <https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=tec00114>.

achieved on a national level. Thus regional differences can occur, and in this case, our dataset might only reflect regional data.

The results are presented according to their functional purposes: 1) access to dental screening and caries preventive services, 2) the assessment of caries preventive services, 3) data registration during the dental screening process, and 4) financial aspects of dental services among the responding EU countries.

3.1. Access to dental screening and caries preventive services

We examined how children's public dental services are carried out in EU countries (Table 1) and paid special attention to discovering whether school and preschool dental screening operates as a part of publicly financed dental care. In 9 of the 23 responding EU member countries, there are established school dental screening systems as a part of public dental care. In 66.7% of the responding countries, the screening is performed at least yearly; however, such screening is usually limited to selected age groups. We also examined the availability of screening for preschool children. According to the responses, free public dental screening for preschool children was only available nationwide in 8 of the 26 responding countries. In 75.0% of the responding countries, there is at least a yearly screening; however, in 62.5% of the responding countries, only certain age groups are screened.

IG values of dental screening for preschool children (IG value 0.41) showed the highest difference between the 'very low' and 'moderate-high' DMFT groups.

According to our findings, all EU member countries provide some kind of treatment for children free of charge at a certain level: brief dental interventions (in a practice or nonpractice setting) are available to promote caries prevention in 25 of the 27 countries (Table 1). These interventions include oral health education and oral health promotion. Regarding the content of oral health education, we used 10 indicators, and the international scope is shown in Table 2. Basic oral health education and education on tooth-brushing techniques are usually included (85.2%), while supervised tooth-brushing is (66.7%) less likely to be included. Information about bad habits for oral health is only featured in 63% of the 27 countries. However, regarding the content of brief dental

interventions, our IG analysis shows that the main differences between 'very low' and 'moderate-high' DMFT groups are the provision of information about bad habits (IG value 0.38) and the promotion of awareness of dietary habits (IG value 0.26).

Among the 27 responding countries, oral health education is mostly performed by dentists (92.6%) and pediatric dentists (81.5%), but dental university students (74.1%) and dental hygienists (70.4%) also play an important role. Professional dental nurses are usually involved in oral health education in countries with 'very low' DMFT.

3.2. Assessment of caries preventive services

We used 5 indicators to assess the screening processes and estimate the reliability of preventive services (see Table 1).

Caries risk assessment is applied in 11 of the 27 countries, while children at high caries risk receive special care during dental screenings in 14 of the 27 countries. National guidelines with the aim of standardizing the delivery of brief dental interventions for caries prevention and oral health education are available in 13 of the 27 countries. Regarding whether a unified caries prevention program is implemented nationwide, uniformity has been achieved in only 12 of the 27 countries. The monitoring system for the quality assurance of children's dental screening is available in 10 of the 27 countries.

Regarding the assessment of caries preventive services, IG values of availability of monitoring systems (IG value 0.29) show the highest difference between 'very low' and 'moderate-high' DMFT groups.

3.3. Data registration during the dental screening process

A mandatory data report and the type of data collected throughout the children's oral health screening process were also studied with 19 indicators. Details of the recorded data from the 25 responding countries are shown in Table 3.

Individuals' complete dental status is registered in 92% of the 25 responding countries, and their medical history is recorded in 68%. Oral hygiene records and cavitated early childhood caries (ECC) are recorded in 56% of the responding countries. However, noncavitated ECC is

recorded in 48% of the responding countries, white spots are registered in 32%, and microbiological risk factors (e.g., the presence of *Streptococcus mutans*) are the least likely to be registered, with a rate of 8%.

With IG analysis, no single prominent indicator is detectable, but the recorded fluoride usage, oral hygiene data, newly developed caries and cavitated ECC (IG values 0.24) indicate the greatest difference between 'very low' and 'moderate-high' DMFT countries.

3.4. Financial aspects of dental services

We received data on publicly financed treatments provided for children, examining 6 preventive types of dental services and 5 operative types; the responses indicate diverse coverage. Among the preventive treatments provided, topical fluoride varnish is available for children free of charge in 70.4% of the 27 countries, fissure sealants in 74.1%, and dental hygiene treatment in 81.5%. Meanwhile, operative treatments, such as fillings for permanent teeth, are covered in 92.6% of the countries, and the rate is the same for tooth extraction. Fillings for primary teeth are covered 85.2% of the countries.

We received data on the estimated reimbursement of children's free dental treatments (in Euros, per treatment) from 15 countries. We divided the provided treatments into (1) preventive treatments and (2) operative treatments targeting already developed dental diseases.

A score from 0-5 was assigned to the estimated reimbursement per treatment, and then a weighted average of preventive and operative treatment types was measured. Reimbursement scores are presented in Figure 2.

Our findings show that treatments for already developed diseases are reimbursed at a higher price range than preventive treatments. While basic dental treatments, such as tooth extraction or fillings, are mostly provided free-of-charge, preventive dental treatments are not always part of public dental care. Responses from three countries show especially poor financing of preventive services: Slovakia, Romania and Bulgaria.

4. Discussion

There are obstacles to making comparisons across EU countries, including the limited scope of available indicators for international assessment [5]. Although there have been efforts to develop and standardize oral health indicators across Europe [12] and to identify the best practices regarding oral health prevention [5], more studies are necessary to build a reliable base of knowledge regarding national pediatric oral health promotion and caries prevention.

Due to cost pressures and increasing demand for care services, national health systems across Europe are struggling to supply universal access to essential, high-quality care while safeguarding their long-term sustainability [22]. Evidence of benefit from applied caries preventive measures are also limited, and reliable indicators are not widely available for children between age 0 and 18. Most countries reported free dental treatments for children through public health services, but the provided services differ greatly.

4.1. Main findings and their implications

1) Dental screening and dental education play a major role in promoting preventive actions (primary and secondary prevention) [23]. A total of 39.1% of the 23 countries have their system organized through the school dental screening system, although there is a perceptible discrepancy in the judgment of this matter. A number of publications have criticized the practice of dental screening in schools, saying that it does not fall under the principle of screening and that the screening process lacks standardization and has many incongruities between its goals and actual practices [24].

Contrary to the divergent opinions on school dentistry, the screening of preschool children is considered especially (and uniformly) important, as ECC can develop between birth and 71 months of age and can cause

serious health conditions and dental defects if it remains untreated [3]. Our findings support this evidence; the availability of organized screening for preschool children is a main difference between countries with 'very low' and 'moderate-high' DMFT scores, and these countries also have the highest IG value (greatest difference) overall. However, only 30.8% of the 26 responding countries provide organized screening for children under the age of 6.

Oral health education is the foundation of prevention and is provided for children in over 90% of EU countries. Although it is an effective method, it has a limited impact on dental status by itself, and it should be combined with other interventions, especially clinical prevention methods [23]. An overall focus on individual health behavior and promoting healthy dietary habits could be an opportunity to expand oral disease prevention, which is in line with our findings. Assisting lifestyle changes through health promotion can help eliminate modifiable risk factors (i.e., sugar consumption) for better oral health, according to the WHO [25].

2) Attempts have been made to standardize screening indicators, preventive services and monitoring systems between EU member states. However, these efforts have not yet been realized neither in the EU nor universally [6, 12]. The availability of national protocols, guidelines and recommendations are only available in 13 member states, for the screening process, oral health education and data recording. Many countries have only basic professional guidelines, which are the main rules available to follow. Having guidelines or national protocols that are consistent across organizations may promote the standardization of high-quality screening [12].

Our data reflect these literature findings: countries with 'moderate-high' DMFT scores are less likely to have specific guidelines, or monitoring systems for dental screening, while countries with 'very low' DMFT usually have such guidelines. The monitoring system for the screening process is available in only 37.0% of the 27 countries; thus, the data quality throughout the EU cannot be assured or can be confirmed only on a basic level.

3) Data registration has a major role in public health surveillance, which is necessary for the planning, implementation, and evaluation of national public health practices. Most of the responding countries register DMFT scores regularly as part of their dental screening process, although data reporting on children's dental screening is mandatory in only 13 of the countries. Countries with very low DMFT scores make a more extensive data record during oral health screening. Compared to countries with moderate-high DMFT scores, they are especially strong in recording the oral hygiene index, ECC (both cavitated and noncavitated) and white spots. Early detection and treatment may reduce or stop the progression of the noncavitated lesion [4]. However, noncavitated caries and white spots are not recorded routinely in most of the countries, and cavitated ECC is only recorded in 56% of the 25 responding countries. Caries risk assessment is only applied in 40.7% of the 27 responding countries, although it has an essential role in the caries management and decision-making process, especially in the prevention and treatment of ECC [3, 26]. Special care for high-caries-risk groups is only available in 14 of the 27 responding countries (51.9%); however, the recommended care path is different for high-risk groups [27]. Caries risk indicators for preschool children (as presented in Scottish guidelines [13]) were less likely to be recorded in the screening process, such as dietary factors, oral hygiene factors, microbiological risk factors and sociodemographic markers. Indicators' absence can make caries risk assessment rather difficult and limit public health surveillance.

4) The literature suggests that children's dental care is focused on the treatment of already developed caries [28], and this is in line with our findings. Regarding the amount of reimbursement for dental treatments, we used the classification of preventive and operative treatments, as nonoperative treatments would be favorable in clinical caries management [29]. Managing caries at an early stage can also prevent suffering and unnecessary treatment expenses [3], and there is strong evidence

that caries preventive services are more cost-effective than the treatment of caries [5].

Our data also indicate a trend of treatments of already developed dental diseases having higher prices yet being provided free-of-charge for children in most of the countries. Meanwhile, although preventive services are in a lower price range, are cost effective [5], and provide the strongest evidence of preventing caries [28, 30], they are less likely to be provided free-of-charge, according to our dataset. Although an association between high DMFT scores and poor reimbursement of preventive services could be speculated, such an association should be further studied. The financial framework of healthcare systems plays a role in the provision of services. In addition, fixed salaries and capitation payment for dental practitioners may result in the underprovision of treatment [31].

4.2. Strengths and limitations of the study

There is an information gap between the international caries prevention guidelines and the actual efficiency of caries prevention policies. Our unique dataset provides an overview of actual EU countries' caries prevention practices, which may facilitate the design and implementation of more effective health policies [32]. Although responses were provided by reliable sources, there were limitations throughout the data-collection process. These limitations included local regulations restricting official bodies from supplying this kind of data, public email addresses being unavailable or limited in number, and professional bodies and faculties being limited in number or only providing a general email address, in which case, the email might not be received by relevant persons. The questionnaire - consisting of a series of questions - was designed for gathering national statistical information from qualified participants. Since - although we attempted - the validity of data were not corroborated by the national authorities, a degree of reporting bias cannot be excluded. However, the results of previous questionnaires and other literature data were taken into account to determine the validity of the responses, especially in case of conflicting responses. Similarly, collected information may not be able to show the diversity of the childhood caries management in respondents' countries. This was an exploratory study, and our questions might not be relevant in all countries because of diverse national practices and variety in healthcare systems; thus, the responses might reflect the respondents' own professional practices or opinions on the matter. Additionally, some of the datasets were not fully completed, and territorial differences may exist within countries; hence, the data provided for each country might not be representative of the whole country. A number of countries provided limited financial data, resulting in less generalizable findings. Our data collection focused on public services, even though the private sector is significant and offers similar services.

Despite the above mentioned shortcomings, these results provide a very unique insightful snapshot at the time of the survey of the situation of childhood caries management in the EU member states, assessed by relevant healthcare organizations and other professionals; highlighting the need for targeted comprehensive research in this area in order to identify the most effective national strategies. Although the prevention and treatment of childhood caries are covered by public healthcare in all member states, according to the CED White Paper (CED-DOC-2019-015-FIN-E, 25 May 2019) [11] the EU has a special role in this field. As detailed by the TFEU 168, the EU can effectively contribute to prevention of chronic diseases by e.g. establishing and maintaining databases, facilitating networking [10]. We believe that in the future, EU efforts in the area of disease prevention and control should address the issue of oral health, in particular childhood caries.

5. Conclusions

There are a wide variety of guidelines and recommendations for children's dental screening, oral health education and data registry

among EU member states, yet the necessity of screening preschool children is mostly neglected. Regarding children's dental health, the only available indicator for comparison is the DMFT score, which can be insensitive to health inequalities [5]. The lack of standardized data registries, whether in data collection or across member states, results in difficulties in comparing and assessing indicators. Dental caries prevention efforts are based on oral health promotion and education. Clinical prevention services for children are limitedly accessible and not necessarily free-of-charge, unlike the treatment of already developed dental caries. Comprehensive studies are needed to identify good practices, standardize the screening process and record indicators, which would thus promote the collection of comparable data.

Declarations

Author contribution statement

Z. Bencze and O. Varga: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

G. Kovalecz, S. Márton Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

N. Mahrouseh, T. Gáll: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Funding statement

This work was supported by the GINOP-2.3.2-15-2016-00005 project. The project is co-financed by the European Union under the European Social Fund and European Regional Development Fund, as well as by the Hungarian Academy of Sciences (TK 2016-78).

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

O.V. receives a fellowship from the Hungarian Academy of Sciences (Premium Postdoctoral Research Program).

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