

# Low district economic performance presents strong oral health determinant in preschool children: country level analysis

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## Research article

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# Abstract

**Background:** Having in mind that macro level factors such as social, political and economic determinants strongly impact occurrence of chronic NCDs, it might be beneficial to enlarge scarce level of data on the influence of these factors on children's oral health. The aim of the present study was to test association between macro level factors and oral health in a nationally representative sample of preschoolers involving all preschooler's age groups from the beginning to compulsory Preschool Preparatory Program.

**Method:** Oral health data derived from cross sectional study involving nationally representative sample of preschool children. Dependent, oral health variables included prevalence of primary teeth caries, untreated caries, and caries on permanent first molars. Data on macro level factors included regional information on economic, population, and healthcare factors: population density, density of physicians and dentists, district share in national gross domestic product (GDP), social and health care expenditures, local self-government budget, employment rate in public, private and agricultural sector. In order to have nationally representative sample we used stratified cluster sampling method proposed by World Health Organization.

**Results:** Final sample included 1665 preschoolers aged 36 to 91 months. Observed prevalence of ECC was 57.8%. Of these, 90.4% had untreated caries. Furthermore, 11.1% of examined preschoolers already had lesions on permanent first molar. All ECC related oral health outcomes were statistically significantly associated with regional social economic indicators – poor oral health was more frequently observed in regions and districts with lower economic performance.

**Conclusions:** The results of this study displayed first nationally representative data on prevalence of primary teeth caries in preschool children. Noteworthy findings confirmed highly statistically significant association of economic macro level factors with prevalence of primary teeth caries, untreated caries, and caries on permanent first molars. Upstream preventive interventions especially targeted at population living in districts with lower economic indicators might seem as most appropriate strategy.

## 1 Background

Chronic non-communicable diseases (NCDs) include oral disease as they share the same etiology; this means that tackling similar risk factors might improve both general and oral health in pediatric population [1]. Although, NCDs are mostly preventable, yet their prevalence is steadily rising globally, representing a health burden [2]. Having in mind that macro level factors such as social, political and economic determinants strongly impact occurrence of chronic NCDs, it might be beneficial to enlarge scarce level of data on the influence of these factors on children's oral health [3]. This might enable designing proper oral health prevention strategies, that might benefit general health too.

Although plethora of studies imply strong influence of microlevel factors on children oral health [4], only few studies analyzed influence of macro level factors - El Tantawi et al. highlighted upstream approach in addressing risk factors associated with poor oral health in preschoolers – higher dentist and physician

density contributed to better oral health data, and countries with stronger economies had higher frequency of early childhood caries (ECC) [5]. Markovic et al. in their recent study on a national representative sample of preschoolers aged 36 to 71 months of age showed weak association between macro level healthcare factors, economic performance and early childhood caries profile on a country level in Serbia, suggesting additional research on a larger scale sample so the results could be confirmed [6]. However, it is important to emphasize “think globally – act locally” concept by adapting public health analysis and interventions to local population characteristics and needs. Therefore, we involved in new analysis all preschooler’s age groups from the beginning to final year of preschool education (representing compulsory Preschool Preparatory Program), ensuring both large scale sample and wide coverage.

## 2 Method

The aim of the present study was to determine the association between macro level factors and oral health of freshly erupted primary first molars in preschool children. The null hypothesis behind this paper was that primary teeth caries in a nationally representative sample of preschool children in Serbia would not be associated to district economic and healthcare data.

The method used, involving study design, sampling method, independent variables, data sources, study size, and statistical methods followed the same methodological protocol reported by Markovic et al.[6].

This study was approved by the Ethical Committee of University of Belgrade School of Dental Medicine (reference number 36/10), Ministry of Health Republic of Serbia, management of primary health care centers and of kindergartens. Also, parents or legal guardians of all participant were informed about study purpose and methods and they consented to participating in the study.

### 2.1 Setting

In correspondence with European Union Nomenclature of Territorial Units for Statistics (NUTS), Serbia is subdivided into 4 statistical territorial units (that correspond to NUTS level 2 – regions of the country), and 24 districts (that correspond to NUTS level 3) [7]. There are 8 districts in western region – Šumadija and Western Serbia, 9 in Southern and Eastern Serbia, 7 in northern region called Vojvodina and 17 municipalities in the City of Belgrade (**Table 1**) [8]. Although NUTS geocode standards are regulated by European Union for member states in detail, NUTS subdivision corresponds to administrative division within Serbia used for statistical purposes.

### 2.2 Participants

Study sample comprised preschool children attending public kindergartens in Serbia, and involved children from 36 months of age who started preschool education until up to 91 months in preschoolers

who attend compulsory Preschool Preparatory Program [9].

## 2.3 Variables

Dependent variables were describing oral health of the participants:

- **Experience of primary teeth caries in preschool children** – percent of children having at least one primary tooth surface decayed, filled or at least one missing tooth due to caries.
- **Prevalence of untreated primary teeth caries in preschool children** – percent of children with at least one cavitated caries lesion affecting at least one primary tooth surface, secondary caries and caries sequels.
- **Prevalence of permanent first molars caries in preschool children** – percent of children affected with cavitated or non-cavitated lesion on freshly erupted permanent first molars.

## 3 Results

Final sample included a total of 1665 children. Caries experience in primary dentition was present in more than half of enrolled sample (57.8%,  $n = 962$ ). A high majority of participants had untreated caries on primary teeth (90.4%). Lesions on permanent first molar was observed in 11.1% of preschoolers.

Physician and dentist density were similar in all Serbian regions – only physician density was statistically significantly associated with occurrence of caries on permanent first molar ( $p = 0.005$ ) (Tables 3, 4, and 5).

Statistical analysis discovered that prevalence of primary teeth caries experience and were significantly ( $p < 0.01$ ) higher in rural and peri-urban locations (62.3% in both groups), compared to urban areas (53.1%). Also, untreated caries in primary teeth was more frequent in rural and peri-urban locations (56.6% and 59.3%, respectively) compared to urban sites (46.4%). Table 2 displays prevalence of caries experience in primary teeth, untreated caries, and caries in permanent first molars according to analyzed districts. Furthermore, statistical analysis showed significantly lower prevalence of primary teeth caries experience, untreated caries, and caries on permanent first molars in the capital district respect to other analyzed areas ( $p < 0.01$ ).

Primary teeth caries was significantly associated with regional economic situation: preschoolers with primary teeth caries, compared to healthy children, lived in districts with  $\approx 2.3\%$  lower share in national GDP, 9 € lower social and health care expenditures per inhabitant, 28 inhabitants per  $\text{km}^2$  lower population density, 15 € lower local self-government funding per inhabitant, and 1% higher employment rate in private sector (Table 3).

Caries treatment was also statistically significantly associated with regional social economic indicators - children with untreated primary teeth caries, compared to healthy children, lived in districts with  $\approx 2\%$

lower share in national GDP, 22 inhabitants per km<sup>2</sup> lower population density, and almost 1% higher employment rate in private sector (Table 4). Although no statistically significant difference was found, district social and health care expenditures were 5 € per inhabitant lower in children with untreated primary teeth caries compared to healthy children (Table 4). However, when total of district social and health care expenditures was compared, the results confirmed that preschoolers with untreated caries compared to preschoolers with healthy teeth were living in districts with total of 23 million € lower district social and health care expenditures in total.

Table 5 shows that oral disease affecting permanent first molars was significantly associated with regional social economic indicators - children with caries on permanent first molars, compared to healthy children, lived in districts with 8 inhabitant per one physician lower physician density, almost 25 € per inhabitant lower social and health care expenditures, 56 inhabitants per km<sup>2</sup> lower population density, 30 € lower local self-government funding per inhabitant, and 1.5% higher employment rate in private sector.

## 4 Discussion

This is the first study to present the prevalence of primary teeth caries in the nationally representative sample of preschool children in the Republic of Serbia using reliable and repeatable Basic Method for Oral Health Surveys by World Health Organization [10]. Primary teeth caries was detected in more than a half of examined preschoolers (57.8%) while less than 10% of all primary teeth caries lesions were treated. Also, 11% of children already had visible lesion on freshly erupted primary first molar.

This is the first study that strongly connected healthcare and economic macro level factors with poor oral health outcomes in preschoolers on country level –primary teeth caries prevalence, untreated caries and occurrence of disease on permanent first molars were more frequently observed in regions with lower economic performance: lower district share in national GDP, lower social and health care expenditures per inhabitant, lower population density, lower local self-government budget per inhabitant, and higher employment rate in private sector.

Current literature emphasizes the need to control and combat oral disease, recognizing public health importance, worldwide high prevalence and increased treatment costs [11]. However novel results displayed that reaching for the drill might not be the best approach in improving preschoolers oral health [12]. Having in mind the fact that UN recognized social determinants of health such as living conditions, wealth distribution, poverty, economy, politics, strongly impact occurrence of NCDs [1], when it comes to prevention strategies, there is a need for careful planning starting with understanding the problem, followed by gathering data on epidemiological profile and risk factors [13]. The results of this study contribute to highlighting social and economic determinants of preschooler's oral health emphasizing the need for appropriate efficient and cost-effective National Oral Health Program that would answer the population needs and target subgroups who are most at risk [14].

National level oral health analysis is crucial step before implementing adequate preventive programs and designing the appropriate framework for interventions to bettering the oral health [15]. National level data provide more precise information and correlation between observed oral health and macrolevel data without usual confounders that might obscure results in international analysis such as: differences in national level income, healthcare, political and different welfare systems, genetic and cultural characteristics of inhabitants. For example, Bernabe et al. investigated national income and inequalities among 22 of 50 richest countries revealing that income inequality was better determinant of health compared to national income per inhabitant when country reaches higher level of economic development [16]. Serbia is a middle-income country located in South Eastern Europe – having in mind our results, it might be beneficial to analyze in further international investigations how income inequalities, besides national income, affects children oral health separately in countries belonging to same income categories.

The role of family physicians and pediatric dentists is significant in providing primary health care, dietary, and oral hygiene advices to young children and bettering both their general and oral health [17]. Global data showed that number of health professionals represent strong determinant of oral health – higher ECC prevalence and absence of data on ECC prevalence was observed in countries with lower physician and dentist density [5]. The universal health coverage in Serbia covers pediatric dental care, with public funds through Health Insurance Fond which is financed via obligatory salary social taxes from employees [18]. However, although Serbia officially has UHC, we have witnessed one of the most obvious decreases in dentist density, from approximately 867 inhabitants per one dentist in 1980 to about 977 inhabitants per one dentist in 2012 [19]. Unfortunately, the Statistical Office of the Republic of Serbia official data from 2018 shows further deterioration of circumstances in public oral health sector considering that one dentist now covers  $4588.2 \pm 308.1$  inhabitants in average (ranging from 3922 inhabitants per one dentist in the southern part of western Serbian region to 4927 inhabitants per one dentist in central Serbia) [8]. The shortage of dentists with high prevalence of oral disease, might explain high frequency of untreated caries, and why despite similar district dentist and physician density, Serbian preschoolers have poor oral health. Destabilization of health system due to economic crises and lowering family incomes affected citizen's health leading to poor health and creating utilization gap, providing mostly urgent treatments [20]. The political and economic collapse in the region of South Eastern Europe during last decade of previous century also disabled management of Serbian National Oral Health Prevention Program (1996–2000) [21, 22]. Unfortunately, due to difficulties in financing, the second attempt to implement oral health prevention program from 2009 to 2015 was also compromised [23, 24]. Interestingly, our results discovered that preschoolers with poor oral health were living in districts with higher employment rate in private sector. But, having in mind that people working in private sector are usually not members of pre-paid health schemes, the possible explanation might be that they used to visit private dentists, due to logistics (longer office hours, closer to home, shorter waiting list, etc.) [25]. This means more out of pocket expenditures for families and creating risk for poor oral health and untreatment in families with financial difficulties.

Observed high standard deviation in population density among regions might be explained with country centralization having nine times higher population density in the capital compared to southern region (522 vs 58 inhabitants per km<sup>2</sup>); the capital also had 2.5 times higher GDP per inhabitant, higher employment rate, higher local self-government funding per inhabitant, and higher expenditures for social and health care in the capital compared to other regions [8]. Using the relevant WHO method that involved 17 randomly chosen locations from different NUTS 3 and NUTS 2 levels and obtaining adequate distribution regarding urban, peri-urban and rural areas, study sample might be considered nationally representative involving all subgroups that might display differences in the disease level and data availability.

Although this study provided valuable information on association of economic and health care factors with primary preschoolers' oral health, potential limitations of the study should be considered when interpreting the results.

First, having in mind that present study is cross sectional, the timing of the results it displays might not be the same if observed over period.

Second, the age limit for the early childhood caries definition is up to 71 months of age, and this is the study sample in most studies analyzing preschooler's oral health. But from the public health point of view it is important to include all preschoolers in Serbia from 36 months of age who started preschool education until up to 91 months in preschoolers who attend compulsory Preschool Preparatory Program. The oldest age group in public kindergartens in Serbia (71 to 91 months of age) is considered especially important from public health aspect, since it covers 95% of population aged 5.5 to 7 years of age (on the other hand, preschool education for 3 to 5.5 year-olds covers 47–48% of children in Serbia) [9]. Furthermore, this is the last year in kindergarten, involving compulsory general health, oral health examinations and vaccination visits before entering primary school.

Third, all examinations were performed without dental unit – in kindergartens, scoring dmft (DMFT) index, which means that some non-cavitated caries lesions might be overlooked. This method is recommended by the WHO as the most suitable method in epidemiological field examinations and feasible for gathering population data [10]. In order to have the widest possible coverage, the examiners were instructed to detect any cavitated or non-cavitated caries lesions if observed [26].

Finally, the calibration procedure did not involve patients since parents of participants did not approve exhausting examination with examiners from 17 locations during calibration procedure. Therefore, we organized the calibration workshop involving case studies, photographs and item by item examples that gathered all examiners from all cites. In order to improve consistency, consensus was achieved since the project team leader and participants reviewed all the answers.

Besides having data on nationally representative and regional oral health outcomes in preschool children (primary teeth caries prevalence, untreated primary teeth caries and caries on permanent first molars), oral health awareness and psychosocial impact of ECC might be influenced by the economy indicators.

Therefore, further efforts should aim analyzing these variables via adequately designed questionnaire to determine oral and general health behaviors in order to implement the most appropriate and cost-effective preventive strategy.

Having in mind significantly higher caries frequency in older preschoolers compared to younger preschoolers, and furthermore, considering that every 10th child starts the school with already obvious lesion on the freshly erupted first molar, early preventive intervention even before beginning of kindergarten and involving building bridges between health professionals might be the best answer. Furthermore, implementation of preventive programs during preschool period, encouraging caregivers to apply everyday healthy habits [27], especially targeted at population living in districts with lower economic indicators seems a cost-effective strategy.

Efficient combat against NCDs, involving oral disease, includes implementing a proper strategy that should be based on insight into clear and unique definition of the problem and assessing epidemiological data in order to be efficient. Understanding non-communicable nature of oral disease and changing dental professionals' mindset from "drill and fill" strategy to upstream preventive interventions, might enable improving oral health in generations of children who would grow into adults with good health – because there is no good health without oral health.

## **5 Declaration**

### **5.1 Ethics approval and consent to participate**

This study was approved by the Ethical Committee of University of Belgrade School of Dental Medicine (reference number 36/10), Ministry of Health Republic of Serbia, management of primary health care centers and of kindergartens. Informed and written consent was obtained from parents or legal guardians of all participant before the children's examinations.

### **5.2 Consent for publication**

Non applicable.

### **5.3 Competing interests**

The authors declare that they have no financial nor non-financial competing interests.

### **5.4 Funding**



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## 5.5 Authors' contributions

DM conceptualized and designed the study, developed study methods, collected data on macro level factors, planned analysis, conducted the analysis and interpretation of data, drafted the initial manuscript, and reviewed and revised the manuscript. AV designed the study, collected data, conducted the data analysis, critically reviewed and revised the manuscript for important intellectual content. RV, TP, and IS contributed to the collection of macro level and disease prevalence data, they were involved with the data analyses, and reviewed and revised the manuscript for important intellectual content. GC developed study methods, designed data collection and data analysis, critically reviewed and revised the manuscript for important intellectual content. All authors approved the final version of the manuscript.

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## 6 Availability Of Data

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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## Tables

**Table 1.** Schematic presentation of European Union Nomenclature of Territorial Units for Statistics (NUTS), applied for Republic of Serbia.

Statistical territorial units (NUTS )2	Districts (NUTS 3)	
Central (Sumadija) and Western Serbia	1. Kolubara	1. Rasina
	2. Macva	2. Raska
	3. Moravica	3. Sumadija
	4. Pomoravlje	4. Zlatibor
Southern and Eastern Serbia	1. Bor	1. Pirot
	2. Branicevo	2. Podunavlje
	3. Jablanica	3. Toplica
	4. Nisava	4. Zajecar
	5. Pcinje	
Northern region (Vojvodina)	1. Middle Banat	1. South Backa
	2. Northern Banat	2. Srem
	3. South Banat	3. Western Backa
The capital (City of Belgrade)	City of Belgrade with 17 municipalities: Barajevo, Čukarica, Grocka, Lazarevac, Mladenovac, Novi Beograd, Obrenovac, Palilula, Rakovica, Savski Venac, Sopot, Stari Grad, Surčin, Voždovac, Vračar, Zemun, Zvezdara.	

**Table 2.** Prevalence of primary teeth caries experience, untreated primary teeth caries and caries in permanent first molar according to districts.

	Primary teeth caries experience  n (%)	Untreated primary teeth caries prevalence  n (%)	Permanent molar caries prevalence  n (%)
Capital District	217 (51.8)	200 (92.1)	7 (5.4)
District 1	122 (67.0)	119 (97.5)	5 (6.8)
District 2	66 (66.0)	63 (95.5)	6 (14.3)
District 3	93 (45.8)	57 (61.3)	8 (13.1)
District 4	113 (61.7)	102 (90.2)	14 (15.6)
District 5	135 (65.2)	129 (95.6)	7 (9.7)
District 6	131 (65.2)	123 (93.9)	17 (22.1)
District 7	85 (50.0)	77 (90.6)	4 (5.8)
TOTAL	962 (57.8)	870 (90.4)	68 (11.1)

**Table 3.** Regional social economic indicators regarding primary teeth caries in preschoolers.

	Participants Caries Free (mean $\pm$ SD)	Participants Caries Experience (mean $\pm$ SD)	Total (mean $\pm$ SD)	p
District share in national GDP (%)	13.1 $\pm$ 16.9	10.8 $\pm$ 15.7	11.8 $\pm$ 16.3	<0.01
Physician density (# inhabitants per 1 physician)	389.8 $\pm$ 77.8	394.9 $\pm$ 76.3	392.8 $\pm$ 76.9	0.15
Dentist density (# inhabitants per 1 dentist)	4605.7 $\pm$ 286.9	4575.4 $\pm$ 322.3	4588.2 $\pm$ 308.1	0.35
Social and health care expenditures per inhabitant (€)	224.6 $\pm$ 62.1	215.2 $\pm$ 58.7	218.6 $\pm$ 60.4	<0.01
Population density (# inhabitants per km <sup>2</sup> )	199.9 $\pm$ 205.1	171.8 $\pm$ 189.5	183.7 $\pm$ 196.7	<0.01
Employment rate in private sector (%)	17.6 $\pm$ 4.9	18.6 $\pm$ 4.9	18.2 $\pm$ 4.9	<0.01
Local self-government funding per inhabitant (€)	344.5 $\pm$ 117.2	329.3 $\pm$ 109.6	335.7 $\pm$ 113.1	0.03

**Table 4.** Regional social economic indicators in regard to untreated primary teeth caries in preschoolers.

	Participants Caries Free (mean $\pm$ SD)	Participants Caries Experience (mean $\pm$ SD)	Total (mean $\pm$ SD)	p
District share in national GDP (%)	12.7 $\pm$ 16.7	10.9 $\pm$ 15.7	11.8 $\pm$ 16.3	<0.01
Physician density (# inhabitants per 1 physician)	392.3 $\pm$ 77.0	393.1 $\pm$ 76.9	392.8 $\pm$ 76.9	0.53
Dentist density (# inhabitants per 1 dentist)	4604.4 $\pm$ 281.8	4573.3 $\pm$ 329.7	4588.2 $\pm$ 308.1	0.71
Social and health care expenditures (€)	222.0 $\pm$ 62.1	216.1 $\pm$ 58.7	218.6 $\pm$ 60.4	0.12
Population density (# inhabitants per km <sup>2</sup> )	194.9 $\pm$ 202.3	173.4 $\pm$ 190.9	183.7 $\pm$ 196.7	<0.01
Employment rate in private sector (%)	17.7 $\pm$ 4.8	18.6 $\pm$ 4.9	18.2 $\pm$ 4.9	<0.01
Local self-government funding per inhabitant (€)	341.1 $\pm$ 116.2	330.8 $\pm$ 109.9	335.7 $\pm$ 113.1	0.39

**Table 5.** Regional social economic indicators in regard to presence of caries on permanent first molar before school.

	Participants Caries Free (mean $\pm$ SD)	Participants Caries Experience (mean $\pm$ SD)	Total (mean $\pm$ SD)	p
District share in national GDP (%)	10.7 $\pm$ 15.7	6.7 $\pm$ 11.5	10.3 $\pm$ 15.3	0.66
Physician density (# inhabitants per 1 physician)	362.3 $\pm$ 45.5	370.9 $\pm$ 37.1	363.2 $\pm$ 44.7	<0.01
Dentist density (# inhabitants per 1 dentist)	4585.8 $\pm$ 303.3	4637.8 $\pm$ 301.6	4591.5 $\pm$ 303.3	0.10
Social and health care expenditures per inhabitant (€)	216.6 $\pm$ 57.8	193.9 $\pm$ 46.8	214.4 $\pm$ 57.0	<0.01
Population density (# inhabitants per km <sup>2</sup> )	170.3 $\pm$ 190.1	114.2 $\pm$ 139.9	164.1 $\pm$ 185.9	0.05
Employment rate in private sector (%)	18.2 $\pm$ 4.8	19.5 $\pm$ 3.4	18.4 $\pm$ 4.7	0.02
Local self-government funding per inhabitant (€)	333.1 $\pm$ 107.9	302.5 $\pm$ 87.2	329.7 $\pm$ 106.2	<0.01