

SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PhD)

**The burden and prevention of childhood caries in
the European Union**

by Zsuzsa Bencze, DMD, MSc

Supervisor: Orsolya Varga, MD, ML, PhD



UNIVERSITY OF DEBRECEN
DOCTORAL SCHOOL OF HEALTH SCIENCES

DEBRECEN, 2021

The burden and prevention of childhood caries in the European Union

By Zsuzsa Bencze DMD, MSc

Supervisor: Orsolya Varga MD, ML, PhD

Doctoral School of Health Sciences, University of Debrecen

Head of the **Examination Committee:** György Paragh PhD, DSc
Members of the Examination Committee: Balázs Ádám PhD
Lajos Biró PhD

The Examination is held online and starts at 8:00 a.m. on 26th of April, 2022.

Head of the **Defense Committee:** György Paragh PhD, DSc
Reviewers: Judit Nemes PhD
Balázs Sándor PhD
Members of the Defense Committee: Balázs Ádám PhD
Lajos Biró PhD

The PhD Defense is held online and starts at 10:00 a.m., on the 26th of April, 2022.

Publicity is provided online. If you wish to participate, please indicate it in a message sent to the email address: jenei.tibor@med.unideb.hu by 2:00 p.m. on the 25th April, 2022 latest. After the deadline, it is no longer possible to connect to the PhD defense due to technical reasons.

INTRODUCTION

Dental caries represents a major burden worldwide with an impact on quality of life and also represent an economic burden. According to the Global Burden of Disease (GBD) database, the rate of years lived with disability (YLDs) globally per 100,000 population is 14.37 for caries of deciduous teeth among the under 5 age group. For children 5-14 year-old, this rate is 19.58 for caries of permanent teeth. Based on data from the United States, caries is the single most common chronic disease among children, appears 5 times more often than asthma. However, dental caries is a largely preventable disease, this is why public health efforts play an important role. Early detection is crucial in prevention: innovative methods and materials in the area of diagnosis and treatment of caries can make the caries management processes more effective. The treatment of caries and its consequences also have an economic impact, however, there is limited information available to estimate the exact financial burden for the cost of illness or even for the cost of treatment.

Early childhood caries

Early childhood caries (ECC) can appear from birth to 6 years of age, and can progress rapidly. Unfortunately, ECC often left untreated, leading to preventable hospitalization and surgical treatments, thus having an impact also on the families' life. Caries in the primary dentition can result in a higher risk of caries in the permanent teeth as well.

Indicators

Successful prevention programs would be necessary to prevent the caries development and progression. To implement successful prevention programs and public health measures, it would be crucial to have available metrics to estimate the burden and identify indicators, for

national and international assessment. Standardizing these indicators would also make international comparison possible.

The World Health Organization (WHO) adopted the DMFT (decayed, missing and filled teeth) score for 12-years-old children which is the only internationally available indicator for surveillance of dental caries. However, this screening method is not standardized and thus there is wide variety among European countries regarding this score (e.g frequency and examined age-groups). According to these available data, more than half of decayed teeth remains untreated in high-income countries. In case of middle-income countries, this rate is even worse: two thirds of the 12-year-old population have untreated caries. Eastern and Western European countries also differ from each other regarding their DMFT score: there is an observable difference between these countries. Another concern regarding national DMFT scores is that the applied average scores can mask inequalities, especially in Eastern European countries

Vulnerable groups and risk factors

Caries preventive methods and effective prevention programs can reduce the number of untreated decayed teeth and for high-risk groups it is especially crucial. Caries is a multifactorial disease, and it is necessary to target all possible levels, when planning effective prevention programs. Public health measures are essential to reach the whole population, especially given that socioeconomic factors play an important role in caries experience.

Diet, especially the amount of sugar intake plays an important role in the development of caries. Tooth-brushing frequency and efficiency, or the type of clinic (public or private) can also have an effect on the caries experience

Risk factors include, but not limited to:

- microbiological risk factors
- diet (e.g. sugar consumption)

- frequent sugary food consumption associated with higher caries experience .
- sugar sweetened beverages also contribute to more severe ECC in children
- infant feeding methods and trends can also correlate with ECC experience
- environmental risk factors
- socioeconomical risk factors also strongly correlate with higher ECC experience
 - Socioeconomic status can be a strong indicator for dental caries
 - The mother's level of education or low family income also correlate with the experience of ECC .

Caries management

Regarding the treatment options of dental caries, the minimally invasive dentistry plays an important role. The FDI also supports the minimal intervention approach over the restorative treatments. Patient education, follow-up and monitoring, topical fluoride and plaque-control should be part of this preventive approach. The role of oral microbiome although evidence-backed, is not commonly used in the clinical dental practice.

The FDI also encouraging governments in a policy statement to promote oral health education and widening the understanding of oral diseases among the population, e.g. through national health policies.

Although the organization of the healthcare system and health promotion strategies are mostly determined and regulated on a state level in the European Union, the EU has an important role regarding prevention of chronic diseases, as presented in the CED White paper. Good practices among European countries are also identified and described, but their incorporation into preventive strategies and their clinical implementation are very diverse within the EU.

The WHO emphasizes the role of surveillance regarding these chronic diseases and that the right dietary habits can reduce caries risk, and especially the sugar intake plays an important

role. Several approaches are being used to tackle sugar-related caries, such as taxing refined sugars, but it is hardly applied in the EU.

Regarding the ECC, the education of parents or caregivers on the proper dental hygiene and dental health is essential to reduce ECC. The FDI recommends that governments in every country to develop systems to monitor preschool children's dental caries experience from age 0 to 5.

Data availability

Only comparable data among countries is the DMFT, but its use in studies is also criticized. Dental screenings would be an ideal place for data collection, but still data collection is not unified, thus the acquired data is not necessarily comparable.

There are initiatives to standardize data collection, however, they are not yet part of the common practice (see EGOHID project - European Global Oral Health Indicators Development).

Risk assessment

Tools are available for caries risk assessment (CRA) to support the decision making process for dentists, but CRA models are not widely or routinely used among member states.

Although Geoffrey Rose pointed out in 1985 that preventive interventions addressing individuals exclusively with high risk of disease will have limited impact on population health, they have important roles. The use of innovative products to combat diseases is central element of individual based prevention programs.

Demand for novel technologies

New medical solutions, techniques and methods are crucial to keep the applied processes up-to-date or make the available processes more effective. Patents are used to protect an innovation and the patent-holders can enjoy the benefits of exclusivity.

Innovations and patenting features in the field of dentistry are also relevant in observing the trends of research activity and focus of interest in the main areas e.g. diagnostics and treatment.

OBJECTIVES

The project had 3 objectives:

1) to analyze the innovation trends in the area of ‘childhood caries’ by performing a patent analysis and to analyse the European countries’ role in patenting and research.

2) to analyze the burden of ECC for children under 5-year old, focusing on both recent years and trends over a longer period of time. The correlation between the ECC burden and environmental factors and sugar consumption were also analysed through an ecological study

3) to reveal caries management practice and prevention policies for children in the EU member states, with an online survey involving caries expert from the EU countries and reporting the results in accordance with STROBE guidelines.

MATERIALS AND METHODS

1. Assessing novel technological solutions addressing caries: a patent analysis

For the patent analysis, we collected patents and patent applications from the patent database, Orbit Intelligence. Orbit-Questel is a leading patent licensor, providing patents translated to English. The keywords were selected by using Medical Subject Headings (MeSH) database.

We searched in titles, abstracts and claims of the patent documents. The final set of patents included to the analysis was defined manually, and all applicable patents were selected, regarding all aspects of primary teeth and their carious lesions, focusing on prevention, diagnosis and treatment. Among the selected patents, we used a classification based on the specificity of the patents: 1) Specific patents – specifically related to the treatment, diagnostic of prevention of primary teeth caries 2) Generic patents –loosely related to the primary teeth caries prevention, diagnostic or treatment

2. Assessing burden and risk factors of childhood caries: an ecological study

To estimate the burden of caries experience in children and analyse the connection with its risk factors, we gathered relevant data from three public databases:

1) GBD database: we extracted data on the burden of disease for children under 5 years old (disease: caries of deciduous teeth). This database provides disease burden estimation internationally and it is beneficial for international comparison.

2) EUROSTAT: Eurostat is the statistical office of the European Union, which publishes high quality statistics and indicators at European level, allowing for comparisons between countries and regions. European Union Statistics on Income and Living Conditions (EU-SILC) provides informative data on social inequality and poverty, which are shown to have an impact on caries experience in children.

3) Food and Agriculture Organization of the United Nations (FAO): The analysed data was a food balance item, 'aggregated items of sugars and sweeteners'. This type of data is closely related to sugar consumption and it is used to estimate the sugar consumption, since no international database on sugar consumption available.

The GBD 2019 data was presented between the 1990 and 2019 time period. The examined indicator was the YLDs. The year of 2019 was described in details, and childhood caries incidence, prevalence and YLDs rate was analysed for children under 5 years old to identify trends over time. The EU countries' ecological variables were examined along with the sugar consumption data and YLDs (ECC burden) rate for children under 5 years old. Annual means (SD) were calculated to show the variability of the data in the examined time-frame (2014 - 2019), annual means were defined and compared, then absolute and relative differences were defined. Sugar consumption-related data was calculated for the time period from 2014 to 2017, due to the specific data-availability

We analysed the changes in both the dependent and also the independent variables during the examined time period - between 2014 and 2019 -, the differences (both absolute and relative) were defined by the application of two-sample t-tests.

Linear regression analyses: We analysed the possible correlation between the chosen inequality indicators and the burden of disease of ECC (YLDs rate) for the time period of 2014 to 2017, because the available data for sugar consumption was limited to 2014-2017 annual data.

3. Assessing childhood caries prevention, treatment and management: a cross-sectional study

In this cross-sectional study an exploratory research was carried out. Since no appropriate data collection or similar questionnaire were available, we developed a unique (anonymous) online survey to collect comparable data for international assessment on the followings: 1) demographic details of the responding person, 2) management and structure of dental health services for children, 3) oral health education available for children under the age of 18, 4) data registry of the result of dental screening, 5) financing details of the provided services.

We gathered information on the management of publicly financed dental services for children under the age of 18, and our scope was to discover the dental practice and its regulatory policies in every countries in the EU, aiming to identify the characteristics of childhood caries prevention. Indicators were selected based on the international guidelines (EGOHID project, SIGN-138). Selected professionals with experience and knowledge in caries prevention were invited to complete the survey online. Our focus was to gather as reliable data as possible, therefore we contacted professional dental institutions and councils and at least one dental school in each EU country.

One submitted survey per country was included in the analysis. We used descriptive statistics to analyse the data collected through the survey. Information gain (IG) is a feature selection method and it was used to determine the importance of the collected indicators and to detect the difference between two previously defined groups. For this purpose, we used the classification provided by WHO for the DMFT scores:

- Very low: DMFT score below 1.2
- Low: DMFT score is in range of 1.2 - 2.6
- Moderate: DMFT score is in range of 2.7 - 4.4
- High: DMFT score is above 4.4

A scoring method was used to classify the data extracted from the survey's reimbursement details. Based on the reimbursement value, we assigned a score (values from 0 to 5) to each examined service or treatment. The weighted average was calculated from the service/treatment scores and we classified the examined services and treatment as preventive or operative.

RESULTS

1. Assessing novel technological solutions addressing caries: a patent analysis

Observed trends in patenting

First, we defined 61 matching patents for our analysis. Second, we defined groups for classification of these patents, and their percentage to compare them to the total number of selected patents:

- 1) Patents especially related to children under 6 years of age: 39%
- 2) Patents for children above 6 years of age – but still having primary teeth: 43%
- 3) Patents not exclusively related to children's primary teeth, and could also be used for adult: 18%

The largest portion was specific to primary teeth and their caries management.

We also categorized the selected patents regarding their function: prevention-related (37 patents), diagnosis-related (8 patents) and treatment-related (16 patents) categories.

Legal status of the patents

The legal status of the patents are the following:

- 1) Granted: 27%
- 2) Pending: 19%
- 3) Dead: 54%

A patent family is 'Granted', if at least 1 member of the patent family is granted. When there is no available 'granted' patent in the family, then it is called 'Pending'. 'Dead' patents are no longer in-force. It means that they might have been expired, revoked or lapsed.

Patenting timeline and territorial differences

In 1931, the first patent became available regarding primary teeth or caries management of primary teeth. From 1990, there was a perceptible intensification of patenting activity. 2001 was the most productive year for innovations (with 18 available patents) regarding primary teeth or caries management of primary teeth.

China has the most first filing patent families, 24. The second largest number is for the United States, which has 8. Russia and the former Soviet Union is the third on the list. The European Patent Office has 6 patents, and also these patents are not recent.

Prevention-related patent activity: Activity is observable throughout the examined period of time. From 2004, there was an increase in the number of patents. China owns the most patents in this field, with 17 patents.

Diagnostic-related patent activity: Patents in this field are from 1997 to 2018. This was the least active category in patenting (only 8 patents). Russia has the most patents in this field of innovation.

Treatment-related patent activity: Activity was accelerated in 2001, with the highest number of patents in 2016. China owns the most patents in this field.

Patented innovations

Innovation from the 'Prevention' category include different types of mouthwashes, toothpastes with antibacterial effect, and also specific toothpastes for children, e.g. edible toothpaste, enriched with vitamins and calcium, special toothbrushes, oral hygiene tools for babies. Diagnostic innovations: microbiological tools, such as *Streptococcus mutans* diagnosis method, remote dental systems, using telehealth for screenings of schoolchildren. The 'Treatment' category usually includes inventions in the field of fillings, prosthetic, surgical or endodontic interventions patented filling materials, excavator tool, dental matrix band, and also crowns and tooth extraction tools and methods, toothache treatments or remedies.

2. Assessing burden and risk factors of childhood caries: an ecological study

Estimation of burden of the ECC disease among children under 5-years-old

Analyzing the available data for the year of 2019, the following results are found among EU countries:

- Incidence rate (per 100,000): 43,686

Highest in Poland and lowest in the United Kingdom.

- YLDs rate (per 100,000): 11.5

Highest in Romania, and lowest in the UK

- prevalence (%): 41.4

Highest among boys in Lithuania, Latvia and Poland, lowest in the UK and Denmark.

Analysis of the long term data for YLDs rate from 1990 to 2019

The YLDs rate of caries of primary teeth per 100,000 population for children under the age of 5 shows a trend : constantly higher YLDs rates can be observed during the examined time-period for certain countries.

Two main groups can be identified over time:

- 1) Countries with constantly higher YLDs rate (these countries are Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia)
- 2) Countries with lower YLDs rate, which could be higher on an intermittent basis.
Increasing values can be detected in Belgium, Sweden (2005, 2006), France, Spain (2006, 2007), Germany and Italy (2015), Denmark, Greece, Sweden (2017).

YLDs rate of ECC and its risk factors – comprehensive analysis

Descriptive statistics

Changes over time were analysed for the time period between 2014 and 2019.

Although the following changes were not considered significant, they were observable during the examined period of time:

Increased:

- The mean (SD) YLDs rate (per 100,000) has increased during this time by 6.6%
- Sugar consumption has increased during this time
- increase in GDP per capita (in PPS) was also observable

Decreased:

- proportion of risk of poverty has decreased
- degree of urbanization has decreased
- population of children under 5 years-old was also lower

Regression analyses

Due to the limited data availability on sugar consumption, we could analyse this type of data in the time period from 2014 to 2017. The following findings were observed:

With univariate models:

- between at risk of poverty rate and YLDs rate there was a positive significant association
- between GDP per capita (in PPS) and YLDs rate we could find an inverse association
- the degree of urbanization and YLDs rate was also inversely associated

With multivariate models:

- sugar consumption and YLDs rate was significantly associated
- between GDP per capita (in PPS) and YLDs rate there was also a positive association, showing that the increase of GDP associated with the decrease in the YLDs rate (by 0.11 years)
- degree of urbanization and YLDs rate was also significantly associated according to the analysis: 1% increase was associated with the decrease of YLDs rate of 0.15 years.
- there was no observable effect of poverty on the YLDs rate

3. Assessing childhood caries prevention, treatment and management: a cross-sectional study

As a result of the online survey, we got responses from 27 countries of the EU. The non-respondent member state was Luxembourg.

It was emphasized by the majority of the respondents (15), that regarding the publicly provided preventive dental services for children, no uniformity is achieved in the country, thus regional

differences might have an impact on the results and the responses might show approaches from the region what the respondent represents.

Accessibility of caries preventive services

Dental screening

Regarding publicly financed school dental screenings, we received 23 responses and this type of screening is provided in 9 countries, and offered at least once a year in the majority of the responding countries (66.7%), however, only certain age groups are included and it is not provided to every schoolchildren every year.

For pre-school children, screening is offered in only 8 countries in the EU among the 26 respondent countries. Where this type of screening is provided, it is mostly performed at least once a year (75%), but among the respondents, the majority does not include all age groups are included in this type screening (62.5%), thus this service is not available annually for the children.

Oral health services and education

Our analysis shows, that almost all EU countries make brief dental interventions available for children. These interventions aim to provide dental health education and oral health promotion. The base of these interventions is teaching toothbrushing techniques, as it is provided in 85% of the respondent countries. The second most important indicator is the supervised tooth brushing (67%), the third likely included educational theme is to present bad habits for oral health and providing information on the negative effects of these habits (63%).

Assessment of available services

We got responses from 27 countries for these questions of the survey and the results are following:

- Children, who belong to the high caries risk groups receive special attention or care during the dental screening procedure in 52% of the respondent countries
- National guidelines or recommendations aiming to standardize the oral health education process and brief dental interventions are available in 48% of the respondent countries
- Uniformity is obtained on a national level regarding the caries prevention programs and their implementation in 44% of the respondent countries
- The application of caries risk assessment methods is available in 41% of respondent countries
- To ensure the quality of caries preventive services, monitoring system is available in 37% of the respondent countries.

IG analysis: The analysis showed the greatest difference between the groups of low and moderate-high DMFT scores in the availability of monitoring systems (0.29).

Data collection characteristics

We analysed the features of the data report process during the children's publicly provided dental screening. We got replies from 25 EU member states.

- The complete dental status is usually recorded: 92%
- Medical history: 68%
- Oral hygiene record: 56%
- Cavitated ECC: 56%

The following indicators are less likely to be recorded:

- Noncavitated ECC: 48%
- White spots: 32%
- Microbiological risk factors: 8%

Reimbursement features

We created two treatment groups to discover the financial burden and also the likelihood of reimbursing the given preventive and operative treatments.

The following treatments are available free-of charge in the marked rates of the responding 27 countries:

- topical fluoride varnish (preventive): 70%
- fissure sealants (preventive): 74%
- dental hygiene treatment (preventive): 82%
- permanent tooth filling (operative): 93%
- tooth extraction (operative): 93%
- primary tooth filling (operative): 85%

Our scoring method showed that the estimated reimbursement value of operative treatments are higher than the preventive treatments'. Most of these operative treatments also available for children with no charge (e.g. fillings, extractions), but preventive treatments are not as accessible free-of-charge for children, not always part of the routine public dental health care.

DISCUSSION

Innovation and novel technologies (such as antimicrobial peptides, probiotics) would be very important in tackling the caries disease, since the burden what caries represents is huge, not only for the families and children but also for the healthcare systems. The practical effectiveness of these novel technologies (such as remineralization agents) regarding caries prevention and treatment, were already examined and confirmed by Chen and Wang. Although the examined innovations were relatively new (only 20% have expired by 2018), the overall number of patent families (61) regarding children's dental health is very low. Especially considering, that for dental implants there are over 23000 patents (FamPat), and most of them is very recent. Most of the examined patents were focused on prevention, which is an important finding, since caries preventive services represent an important part of caries management, as highlighted by professional organizations. Regarding the leading participants of the patent landscape, China dominates the caries prevention and treatment sectors of the patents we analysed, The European region represents an insignificant role in all the three areas: prevention, diagnosis or treatment, as it only owns 4 patents over the examined long period of time. This can reflect the trends in research and development and suggest that the area of childhood caries is considered low-priority for both the academic research and corporate players.

While the number of patent applications are increasing, the different medical fields do not share equal parts on these applications. The childhood caries management and primary teeth might represent only a small portion of the market, but the disease can have a serious impact on the quality of life and permanent teeth.

We also found that the burden of caries in primary teeth among under 5-year-old is increasing. Furthermore, during the longitudinal analysis of ECC burden over time, inequalities were observed between eastern and western European countries. In eastern Europe, the estimated

burden was constantly higher than the western states. This finding reflects previous results, where ECC was found to be more frequent in the eastern countries of Europe, and less frequent in countries with more developed economy. According to the WHO, 80% of 5-6 year-old children should be caries-free by 2020. This goal has not been met by most of the EU countries and eastern European countries are even farther from this milestone. Inequality also present within the EU countries and socioeconomic factors are good indicators to identify the disparities. People with lower socioeconomic status are more vulnerable. The disease burden estimation might not be correct for these vulnerable groups within countries, as the average can mask the disparities. There is a correlation between higher GDP and lower ECC rate, which means that in economically developed countries the ECC rate will decrease. Thus, higher GDP may contribute to the reduction of YLDs rate as well.

Higher sugar intake and growth in ECC rate is widely studied and confirmed. Assessing its correlation with the income level, this association was the strongest in case of middle-income countries. With multivariate analysis, it was observed that the sugar intake on the population level was correlated with the increased rate of YLDs. Study of European countries also shown, that children and adolescents usually consume more sugar and sweeteners than the internationally recommended maximum amount. There is a complex relationship between socioeconomic indicators (including level of education) and the experience of caries and ECC, since children of mothers with lower level of education are more prone to consume a poor diet, have a higher sugar intake or less likely engage in positive health behavior, such as attend regular dental check-ups or treatments at the dentist.

As socioeconomic factors might play an important role in caries risk. The importance of proper diet in caries prevention and dental surveillance is also emphasized by the WHO. Such indicators could provide valuable, comparable data for international assessment. However, collecting EU data on caries risk indicators or preventive dental services is challenging. The

number of available indicators are limited and the lack of standardization also represent a barrier. Good practices for prevention are also identified, but their implementation in the different preventive strategies and services show a large variety within the EU. Although basic dental treatments and services are available for children free-of-charge, these services and their reimbursement is different among EU member states.

We found that the school dental screening is available in 39% of the responding 23 countries. Dental screening and education about oral health represent the base for dental caries prevention, although the school dental screening itself sometimes is criticized for not being standardized. Pre-school dental screening, however, is considered crucial in preventing severe consequences of ECC. This is in line with our findings, since the availability of organized dental screening for pre-school children was associated with a great difference in IG between countries with low vs- moderate-high DMFT score. Unfortunately, among the 26 respondent countries, 31% marked that this type of screening is provided.

Established and implemented standards for screening and preventive procedures would be important to provide consistency and may contribute to higher screening quality. Standardization of caries preventive services, monitoring and recorded indicators are still not achieved among EU member states. Our findings support this: only 13 of the respondent countries marked that national guidelines are available for the processes of screening, data collection, or even oral health education. Furthermore, EU countries with higher DMFT scores are usually less likely to have monitoring systems implemented for the screening procedure or less likely provide specific guidelines for the preventive and educational processes. Overall, monitoring is only available in 37% of the respondent countries (27) and this can contribute to lower quality of reported data.

Data registration is necessary for proper monitoring of processes and develop efficient public health policies and preventive strategies. The EU member states with lower DMFT scores

usually perform better at data record, they record oral hygiene index or white spots (initial caries) more often than countries with higher DMFT scores. Although DMFT data usually part of the register, the early signs of caries, such as ‘white spots’ are less likely recorded. However, early detection of caries, especially initial caries, which is reversible, has a very important role in preventing caries progression. Furthermore, even cavitated ECC is not widely recorded. It would be essential to identify children with higher caries risk, as they might have different needs, and this should be reflected in the provided care path. Still, the risk assessment is used in only 52% of the countries. Other important indicators for the children under 6 years old, such as dietary patterns or oral hygiene index, sociodemographic characteristics are emphasized, but less likely recorded thus making the caries risk assessment challenging.

Regarding the financial characteristics of provision of dental services, we found that treatments for the developed diseases are usually in a higher price-range, compared to preventive interventions. However, these operative treatments are mainly provided for children at no cost, while lower cost preventive services are less likely to be provided free-of-charge. Prevention would be crucial, as these services are cost effective: early detection and treatment are both reduce costs and suffering, and according to the literature, they proved to be evidence-based interventions regarding dental caries prevention. There is a lack of data regarding the effectivity of preventive efforts, with no standardized indicators and proper monitoring systems. These would be crucial for effective public health policies and successful caries management strategies.

Among the limitations of our patent analysis, we understand that although patent analysis is available to assess available patents, the clinical usefulness or market success cannot be evaluated through patent landscape analysis, and also not all inventions are granted. Regarding our ecological study, there was only a limited time-period (2014-2017) available for analysis due to lack of relevant data, and ECC is applicable for children under 6 years old, while we

could only select the ‘under 5’ age group for analysis from the database. There is a complex relationship between the socioeconomic factors and ECC, and challenges include that key data might not be available or the national data might mask social differences within countries, and data collection procedure can be different for the countries. One of the limitations of the cross-sectional study that data collection is challenging, due to the limited number of professional organizations to reach out to, or local regulations on data availability and provided responses might only be relevant locally, not for the whole country. Furthermore, validity of responses cannot be evaluated.

-

MAIN FINDINGS

Innovations would have a crucial role in the caries management process, in all prevention, diagnosis and treatment areas for children. Through the patent landscape analysis, our findings showed that given the very few patent families (61) over the examined 87 years, the research field of ‘caries in the primary dentition’ is neglected and also majority (54%) of the examined patents were ‘Dead’. The most neglected area was the ‘diagnosis’, regarding children’s dental caries. The role of the EU in this field of innovation was quite small and a low research interest might be speculated.

The burden of dental caries for children under 5-years old (ECC among under 5 year old) is detectable in Europe and shows a divided EU, both for the year of 2019 and through longitudinal analysis: there are considerable differences between Eastern and Western European countries, since Eastern European countries have constantly higher YLDs rates. Limited international data are available for the risk factors of ECC. Analysing the available data, we observed that the sugar consumption is increasing, and so does the YLDs rate among under 5-year-olds and we could confirm with multivariate model that these were significantly associated. We also found through univariate model, that higher GDP was associated with lower YLDs rate. The role of sugar and GDP in caries experience is confirmed and socioeconomic factors impact the burden of ECC, but both local and international initiatives would be necessary to identify and protect the vulnerable groups of population and effectively target them with future policy actions.

We found that the screening process shows large variety among EU states, both regarding screening frequency and screened age-groups. Although main guidelines exists, their interpretation is different in the countries. Pre-school children’s screening is widely supported by professional organizations and we found that it represents one of the differences between countries with low and moderate-high DMFT score, yet our data show it is only provided in

30% of the respondent countries. Basic education on oral health is usually provided for children, but clinical preventive services are not necessarily available for children free-of-charge, even though they are cost-effective. Meanwhile, treatments of already developed caries are in a higher price-range, still more likely provided free-of-charge. Since the focus is mainly on treatment of disease, rather than comprehensive prevention programs, relevant indicators could help evaluate current practice and strategies. The dental screening process and preventive services could also be improved with reliable, internationally available indicators and monitoring systems.



Registry number: DEENK/528/2021.PL
Subject: PhD Publication List

Candidate: Zsuzsa Bencze

Doctoral School: Doctoral School of Health Sciences

List of publications related to the dissertation

1. **Bencze, Z.**, Kovalecz, G., Marton, S., Gáll, T., Mahrouseh, N., Varga, O.: Childhood caries management in the European Union: a cross-sectional study.
Heliyon. 7 (2), 1-10, 2021.
DOI: <http://dx.doi.org/10.1016/j.heliyon.2021.e06198>
2. **Bencze, Z.**, Mahrouseh, N., Andrade, C. A. S., Kovács, N., Varga, O.: The Burden of Early Childhood Caries in Children under 5 Years Old in the European Union and Associated Risk Factors: an Ecological Study.
Nutrients. 13 (2), 1-12, 2021.
DOI: <http://dx.doi.org/10.3390/nu13020455>
IF: 5.717 (2020)
3. **Bencze, Z.**, Fraihat, N., Varga, O.: Patent Landscape Analysis of Dental Caries in Primary Teeth.
Int. J. Environ. Res. Public Health. 16 (12), 1-8, 2019.
DOI: <http://dx.doi.org/10.3390/ijerph16122220>
IF: 2.849





UNIVERSITY of
DEBRECEN

UNIVERSITY AND NATIONAL LIBRARY
UNIVERSITY OF DEBRECEN

H-4002 Egyetem tér 1, Debrecen

Phone: +3652/410-443, email: publikaciok@lib.unideb.hu

List of other publications

4. Fraihat, N., Madae'en, S., **Bencze, Z.**, Herczeg, A., Varga, O.: Clinical Effectiveness and Cost-Effectiveness of Oral-Health Promotion in Dental Caries Prevention among Children: systematic Review and Meta-Analysis.
Int. J. Environ. Res. Public Health. 16 (15), 1-33, 2019.
DOI: <http://dx.doi.org/10.3390/ijerph16152668>
IF: 2.849

Total IF of journals (all publications): 11,415

Total IF of journals (publications related to the dissertation): 8,566

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

15 December, 2021



ACKNOWLEDGEMENTS

First and foremost, I would like to thank my supervisor, Dr. Orsolya Varga for her continuous support in my academic endeavours, her expert guidance, patience and encouragement, that helped me throughout my PhD work.

I would like to appreciate Prof. Dr. Róza Ádány and Prof. Dr. Margit Balázs for giving me the opportunity to carry out my research at the Department of Public Health and Epidemiology, Faculty of Medicine, University of Debrecen.

My appreciation also extends to my colleagues and those involved in the publications, Nóra Kovács, Nour Mahrouseh and Tibor Gáll for their assistance and tireless work and Dr. Gabriella Kovalecz and Dr. Sándor Márton, who supported my research with their valuable comments and suggestions.

I would like to thank my family, especially my husband, Roland Harangozó for his help and continuous support, and my mother, sister and friends for their constant support and encouragement.