COUNTRY PROFILE OF THE EPIDEMIOLOGY AND CLINICAL MANAGEMENT OF EARLY CHILDHOOD CARIES

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PUBLISHED IN: Frontiers in Public Health

frontiers Research Topics

ISSN 1664-8714
ISBN 978-2-88963-808-6
DOI 10.3389/978-2-88963-808-6

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COUNTRY PROFILE OF THE EPIDEMIOLOGY AND CLINICAL MANAGEMENT OF EARLY CHILDHOOD CARIES

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Citation: Folayan, M. O., Sabbah, W., El Tantawi, M., Ramos-Gomez, F., eds. (2020). Country Profile of the Epidemiology and Clinical Management of Early Childhood Caries. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88963-808-6

Table of Contents

frontiers in Public Health

EDITORIAL
published: 30 April 2020
doi: 10.3389/fpubh.2020.00141

Editorial: Country Profile of the Epidemiology and Clinical Management of Early Childhood Caries

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Keywords: early childhood caries, prevalence, policy, structural determinant, elimination, sustainable development goal

Editorial on the Research Topic

Country Profile of the Epidemiology and Clinical Management of Early Childhood Caries

Early childhood caries (ECC) is the presence of decayed (cavitated and non-cavitated), filled and missing teeth due to caries, affecting the primary dentition in children less than 72 months old (1). It is the most common non-communicable disease in children (2) and a global endemic problem with those socially disadvantaged (ethnic minorities, immigrants, those of low socioeconomic status or from resource-limited settings) being most affected. The negative impact of ECC on the quality of life, growth, social development, and neurodevelopment of affected children makes it ethically imperative that public epidemiological and clinical management of ECC improves (3). Whether treated or not, ECC is a high-risk factor for caries in the first permanent molar, as highlighted by Songur et al. in this topical issue. Four other manuscripts in this special issue emphasize the urgency of addressing the endemic ECC problem. Musinguzi et al. highlighted that the prevalence of ECC in rural Uganda was 48.6% in 3–5-year-olds, and Castillo et al. showed it was as high as 76.2% in 3–5-year-olds in Peru. Also, Pierce et al. reported a prevalence of 98% in some parts of Canada, and Amalia et al. reported a prevalence of 100% in South Kalimantan, Indonesia.

Twenty years after establishing the definition of ECC, we know a lot more about ECC prevention and management (4), but we still know little about cost-effective integrated management of ECC that can control the disease using life course approaches appropriate for various cultural settings. The World Health Organization guidance document (2) promotes integration of oral healthcare into existing primary care systems. In this special issue, Villalta et al. describe how an integrated primary care model improved the knowledge and attitudes of caregivers regarding child oral health care, and Castillo et al. discuss policies, taxes, and guidelines on ECC management and labeling of food sugar content that are addressing the huge ECC problem in Peru.

Policies and taxes are strong tools for addressing structural barriers and enhancing actions for disease control, as we have learnt from tobacco control programs (5). Increased availability of ECC data will help improve the design and implementation of context-specific public oral health responses to control the disease through which we can learn about effective public health ECC control responses. The epidemiological profiles of ECC in Canada (Pierce et al.), Indonesia (Amalia et al.), Israel (Shmueli et al.), and Peru (Castillo et al.) that were presented in this issue add to our understanding of the risk factors for ECC.

Edited and reviewed by:
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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *13 February 2020*
Accepted: *03 April 2020*
Published: *30 April 2020*

Citation:
Folayan MO, El Tantawi M, Ramos-Gomez F and Sabbah W (2020) Editorial: Country Profile of the Epidemiology and Clinical Management of Early Childhood Caries. Front. Public Health 8:141. doi: 10.3389/fpubh.2020.00141

Eradication—the permanent reduction of global incidence of ECC to zero—seems ambitious at the present time. However, elimination—the sustained reduction of ECC incidence to zero or levels defined by global oral health authorities—seems possible. Countries such as Finland (0.3%), Nigeria (2.7%), Kuwait (3.0%), Japan (3.9%), Tanzania (5.2%), and Sweden (6.0%) with low ECC prevalence for 0 to 2-year-old children; and Denmark with a low prevalence of 6.3% for 3 to 5-year-old children (6) may serve as global learning centers on best practices for ECC elimination.

The sparse evidence on structural determinants of ECC risk will limit efforts for ECC elimination. For ethical reasons, randomized clinical trials that might answer critical questions on structural determinants of ECC cannot be conducted; thus, the causal pathways for a multitude of inter-related factors for ECC can only be modeled (7). In this issue, Markovic et al. provide ecological data from Serbia, which suggests that structural factors like social and health care expenditures, unemployment rates, population density, and availability of physicians and dentists are determinants of the prevalence and treatment of ECC. Joury provided data suggesting that the risk for ECC in Syria increased during war and crisis, which is contrary to findings of historical studies that found a decrease in caries during war and crisis (8).

When the elimination of ECC becomes the focus of public oral health response for children under the age of 6 years (9), the World Health Organization will have to refine its targets, including setting global goals for ECC (10). Also, indicators to measure achievement should set elimination goals for 0 to 2-year-old children separate from those for 3 to 5-year-old children as emerging evidence suggests that the epidemiological profile and risk factors for ECC for the two age groups differ (6). In addition, goals and interventions for eliminating ECC should recognize that those most vulnerable to the disease are the less privileged who may be left behind if right-based interventions are not developed (11). Sadly, the populations at increased risk for ECC are likely to have no data on ECC available (6).

The 11 articles published in this topical issue provide information that can help inform policy development, policy review, and program design for the control of, and possible elimination of ECC. They contribute to our understanding of what we can modify to attain goal 3.1 of the Sustainable Development Goal for children below 6 years by 2030. The articles also provide evidence on parent-targeting interventions that can be effective (Al-Batayneh et al.; Razeghi et al.; Villalta et al.). Despite all we know about ECC, we still need more data like these published in this issue, to enable planning for control and possible elimination of ECC.

AUTHOR CONTRIBUTIONS

MF developed the first draft of the manuscript. ME, FR-G, and WS revised and made intellectual contributions to the subsequent drafts. All authors approve of the final version of the manuscript and for its submission.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

MINI REVIEW
published: 09 October 2019
doi: 10.3389/fpubh.2019.00280

Epidemiology and Clinical Management of Early Childhood Caries in Israel

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Aim: The aim of the present review is to describe the current status of early childhood caries (ECC) in Israel in aspects of epidemiology, prevention, and management.

Methods: PubMed search was performed using the words caries, children, Israel. Demographic data was collected from the Israeli Central Bureau of Statistics.

Results: The decayed, missing, and filled teeth index was 2.72 in 1992 and 2.56 in 2016. The proportion of restored teeth has increased. A number of preventive programs are ongoing but a general preventive program is lacking at the national level. From 2010, every child in Israel is eligible to receive free dental treatment.

Conclusion: The gaps in understanding of the epidemiological profile of ECC in Israel is a call for more research conduct on ECC in the country.

Keywords: caries, prevalence, early childhood, prevention, Israel

OPEN ACCESS

Edited by:
Morenike Oluwatoyin Folayan, Obafemi Awolowo University, Nigeria

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *07 May 2019*
Accepted: *18 September 2019*
Published: *09 October 2019*

Citation:
Shmueli A, Moskovitz M, Halperson E, Ram D and Fux-Noy A (2019) Epidemiology and Clinical Management of Early Childhood Caries in Israel. Front. Public Health 7:280. doi: 10.3389/fpubh.2019.00280

INTRODUCTION

Israel is a relatively small country with a population of almost 9 million people, located in the Middle East. The population is diverse with about 6.6 million Jews and 1.9 million Arabs. Since the establishment of the State of Israel in 1948, Jewish persons from around the world have immigrated to the country. According to the published registry, Israel's population at the end of 2016 was 8.63 million people of which 2.8 million (aged 0 to 17 years) are children. This is about 33% of the population of which 71.3% are Jews, 25.7% are Arabs (Muslims, Christians, and Druze), and 3% are of other backgrounds (1). Children under age 14 years comprise 28.2% of the population (1). This item is high compares to the population distribution in western countries but relatively low in comparison to Israel's neighboring countries. Percentage of children is higher in the northern and southern parts of Israel. Places where children constitute more than half of the population typically belong to religious population (1).

Israel's relatively small population comprises diverse ethnic groups. These subpopulations have specific socio-demographic and cultural characteristics that may affect the tendency to develop caries in general and early childhood caries in particular. There are some population groups for example the ultra-orthodox Jews that are characterized by large families (more than 4 children per family). In these communities the dental awareness is sometimes low, and many children are referred to dental treatment under sedation or general anesthesia due to their young age and complexity of treatment.

In 1981, water fluoridation was started in Israel. The first fluoridation station was in the capital city, Jerusalem. Despite the significant decline in caries prevalence and severity, which was attributed to water fluoridation, and despite the recommendations of public health experts, the

Israeli Minister of Health decided to discontinue public water fluoridation in 2014. The reasons to this step were concerns about the influence of fluoride on general health. Israel is located in the hot region of the Middle East and there is substantial shortage of natural water. Most of the water (about 80%) that will be provided in the coming years will be from water desalination. The implication is that most of the water in Israel will not be fluoridated.

Public debates and discussions are ongoing regarding water fluoridation. The dental professional advisors recommended the minister of health to add fluoride to the drinking water, the current minister of health is willing to do so, hopefully, the problem will be resolved soon, in favor of the dental health of Israeli children (2). The current review describes the status of ECC in Israel, prevention and treatment modalities.

EPIDEMIOLOGY OF EARLY CHILDHOOD CARIES (ECC)

There are only a few surveys on ECC conducted in Israel. This is due to difficulties such as the lack of accessibility to a large representative sample of children younger than 5 years, since the compulsory school enrolment begins at this age ("Israeli compulsory education")[1] Examining very young children in Mother-and-Child Health Centers raises biases because this population does not necessarily reflect the general population. To absence of a national survey on ECC contributes to the challenges with planning for prevention and early detection of this disease.

The findings of a national survey of 5-year-old children were published in 1992 (3). The sample of 767 children were recruited from 25 kindergartens around the country and examined using World Health Organization (WHO) criteria. No radiographs were taken. The mean decayed, missing and filled teeth (dmft) were 2.72 for children aged 5 to 6 years, and the prevalence of caries was 58.7%. No differences were found between genders or between urban and rural populations (3).

Another survey was performed in Ashkelon, a peripheral but large city (above 100,000 residents) in southern Israel (4). Of the 182 5-year-old children examined in that survey, 57% had caries. The mean dmf (t) was 2.08 + 2.64. An interesting finding of this survey was that the f component of the dmft was 0, which means that these children were not treated (4). Children at the lower end of the socio-economic scale showed high rates of severe early childhood caries. Populations that are predominantly low on the socio-economic scale are Bedouins, Ultra-Orthodox Jews, refugees from Africa and immigrants. These populations are characterized by low income and a high number of children. According to the Israeli national insurance institute, 463,300, families in Israeli were of low socio—economic level in 2016, among them 842,300 children (5). In 2007, a survey among 5-year-olds in 28 of 70 local authorities providing school dental services reported that 64.7% of children had tooth decay, with an average dmft of 3.31 (6).

Livny et al. (7), by using visual caries detection method, examined 102 Bedouin children for caries, using the World Health Organization (WHO) (1997) criteria. The children were aged 12 to 36 months from the Jahalin tribe, a previously nomadic tribe dwelling on the eastern outskirts of Jerusalem. White spot lesions were not recorded as caries. The investigators reported severe early childhood caries in 17.6% of the children. The prevalence of early childhood caries was significantly associated with older children's age (25 to 36 months), larger family size, and mother's lower education level and poorer dental appearance. The average number of children per family in that study was 4.6 and the maximum was 13. The researchers assumed that in a large family, it is more difficult for the parents to provide optimal healthcare according to each child's needs, including healthy feeding and oral hygiene practice (8).

In attempting to understand the prevalence trends of caries in Israel, and specifically ECC, Sgan-Cohen et al. (9) compared average defs (decayed extracted filled surfaces) and dmfs among first-grade children in south-west Jerusalem. According to municipality records, the neighborhoods surveyed represent the lower middle class. The examinations were conducted in 1983, 1992, and 2005, in accordance with the 1977 WHO's recommendations. Data indicated a consistent decline in disease severity: a reduction in the defs from 13.95 to 8.09 and 5.07 in 1983, 1992, and 2005, respectively.

In 2016, Natapov et al. (10) published a survey of 6 year-old-children residing in 23 local authorities that were randomly selected nationwide. Although Ecc is defined as caries before age six. Trends can be learned from this data about the caries experience of this children in their early years of life. The children were examined according to the WHO Oral Health Survey Methods 4th edition protocol. Of 1,210 children examined, 61.7% had dental decay and only 38.3% were caries free. The mean dmft was 2.56: d−1.41 (teeth with untreated caries), f = 1.15 (teeth damaged by decay and restored); no teeth were missing due to caries. The prevalence of dental caries was rather consistent, an average of over 2 teeth were affected per child. In this survey, the f component was higher than previously reported, especially in the Jewish sector, yet still lower in the Arab sector.

EARLY CHILDHOOD CARIES PREVENTION PROGRAMMES

The Impact of Free Access to Toothbrush and Toothpastes on Early Childhood Caries Incidence

A study was conducted to assess the impact of access to free toothbrushes and toothpastes on the incidence of ECC in 1,500 6-month-old infants recruited from Mother-and-Child Health Centers over a 2-year period. At age 2.5 years, 596 of the 1,500 children were examined. The early childhood caries prevalence

[1]The Israeli compulsory education law. Available online at: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&ved=2ahUKEwip0eeBp8PkAhUFa1AKHabqBE0QFjAEegQIAxAC&url=http%3A%2F%2Fedu.gov.il%2FDocuments%2Flimudchova.doc&usg=AOvVaw0fn3bowWd59V_cDnVqL4lB.

was 15.3%. No difference in caries prevalence was found between children whose parents received the study intervention and those whose parents did not. The proportion of children who brushed twice daily was 13.9%, while 26.8% of the children did not brush at all. Eighty-one percent of the parents reported that their children went to bed at night with a bottle. Among children who drank sugar-sweetened beverages, the prevalence of early childhood caries was significantly higher than among those who drank milk or natural juice (18.8 vs. 8.9%). The study highlighted that tooth brushing might not be the only nor optimal public health response for early childhood caries in Israel (8).

Community Health Education, Bottle-Feeding Practices and Tooth Brushing Behavior of Infants in Jerusalem

In this quasi-experimental study designed to compare the impact of a structured health education programme on infant's bottle feeding and tooth brushing behavior, parents of 727 children aged 6 to 12 months from Mother-and-Child Health Centers in Jerusalem were recruited (8). Parents in the intervention group received structured health education information over the telephone, and half were randomized to receive fluoridated toothpaste and tooth brushes. The control group received did not receive an organized educational intervention. Six months into the study, parents in the control group reported a 32.5% increase in tooth brushing for infants, compared to baseline. Tooth brushing frequency increased by 45.1% for infants of parents who received toothpaste and toothbrushes, by 43.7% for infants whose parents received health education information only, and by 60.4% for infants whose parents received health education, toothpaste, and toothbrushes ($P = 0.0002$) (8). Modification of bottle-drinking practices in this programme was unsuccessful. The study therefore recommended that free distribution of toothpaste and toothbrushes, in conjunction with a structured oral health education programme to parents of infants, is effective in promoting good oral hygiene practices (11).

The Impact of a Prenatal Infant Oral Health Programme Implemented Through Baby Clinics

In 2003, members of the Pediatric Dentistry Department of the Hadassah School of Dental Medicine initiated a Baby Clinic in Jerusalem, based on the Brazilian concept of prenatal prevention. The objective of the project was to describe the implementation and outcome of a prenatal infant oral health programme that focused on pre- and post-natal oral health education for parents, and caries prevention in their first-born babies. The intervention commenced in late pregnancy and continued until the child reached age 3 years. Twenty-four, 30-min long prenatal power-point dental education lectures were delivered to 300 young, first-time parents to be, from the 8 to 9th month of pregnancy. Participants attended the "Course for Birth Preparation" at the Hadassah Hospital, Jerusalem. Lectures were given by pediatric dentists. The lectures emphasized the relation between the mother's oral health and the oral health of the expected baby, and provided recommendations about feeding and oral habits for the expected baby. Parents were invited to bring their babies for the first visit when their first tooth erupted or between ages 6 and 12 months. A brochure containing a summary of the information from the lecture was distributed at the first or second follow-up visit, to provide parents the opportunity to review the information at home and share it with other family members or friends who did not attend the lectures.

At each recall appointment, the young parents received anticipatory guidance for prevention of dental disease, and brushing instructions were demonstrated in the child's mouth, using the "lift the lip technique." Follow-up visits were recommended according to a protocol, based on individual caries risk assessment: low risk, every 6 months; medium risk, every 4 months; and high-risk babies, every 2 months. For the high-risk group, the teeth at risk were treated with fluoride varnish. A "dental home" was also achieved for the participating families. The intervention significantly reduced the incidence of early childhood caries. By the first visit, 70% of the 137 parents who attended already brushed their children's teeth. The incidence of early childhood caries was 2.9% over the 3 years of the study, a figure significantly lower ($p < 0.001$) than the 15.3% reported by Livny and Sgan-Cohen (12).

Caries Risk Assessment Tool and Prevention Protocol for Public Health Nurses in Mother-and-Child Health Centers, Israel

In Israel, Mother-and-Child Health Centers provide free preventive services for pregnant women and children by public health nurses. A caries prevention program in health centers started in 2015. Nurses underwent special training regarding caries prevention. A customized Caries Risk Assessment Tool and Prevention Protocol for nurses, based on the tool implemented by the American Academy of Pediatric Dentistry, was introduced. A two-step evaluation was conducted, which included a questionnaire and in-depth phone interviews. Of 46 health centers included in the study, 28 returned a completed questionnaire. Most nurses believed that oral health preventive services should be incorporated into their daily work. In the in-depth phone interviews, nurses stated that the integration of the program into their busy daily schedule was realistic and appropriate. The lack of a specific dental module for managing computerized data was mentioned as an implementation difficulty (13).

EARLY CHILDHOOD CARIES TREATMENT

The National Health Insurance Scheme

Pediatric dental service was not part of the national health services until June 2010. Prior to this date, dental services such as dental examination, preventive treatments and pediatric dental treatments were not provided by the Ministry of Health. Access to dental services was limited, especially for underprivileged populations and those living in the peripheral districts of the country. The June 2010 legislation of the National Health

Insurance for children under age 8 years affords access, for every preschool child, to preventive and operative care, which was usually provided by general dental practitioners. The service is operated by four health maintenance organizations that provide all the other public medical healthcare services. The service includes the provision of all operative dentistry needs of children in the public healthcare service and operating referral centers. At such centers, very young children are usually treated under conscious sedation or general anesthesia. Specialists in pediatric dentistry generally provide the care (14).

CONCLUSION

The prevalence of early childhood caries in Israel has not changed much over the years. According to the latest survey, treated caries are more prevalent in children than in the past but dmft is still relatively high. Particular emphasis on preventive measures are needed, especially in underprivileged populations.

AUTHOR CONTRIBUTIONS

All authors have made substantial contributions to the conception and design of the work, the acquisition, analysis, or interpretation of data for the work, and have made substantial contributions to the drafting the work and revising it critically for important intellectual content. All authors approved the final version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

REVIEW
published: 12 November 2019
doi: 10.3389/fpubh.2019.00328

The Burden of Early Childhood Caries in Canadian Children and Associated Risk Factors

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Introduction: Early childhood caries (ECC) is any caries in the primary dentition occurring in children under the age of six. ECC is common in many population groups in Canada.

Objective: The purpose of this review was to describe the burden of ECC in Canada, the prevalence and associated risk factors for ECC, and its impact on childhood health based on the existing published literature.

Methods: A review was conducted to assess published Canadian studies on ECC identified through searches of electronic databases. Databased searched included PubMed, Medline, Cinahl, and the library catalog of the University of Manitoba. Known publications on ECC that were not identified by the electronic search were also considered. Only the studies that reported the prevalence of ECC or caries in preschool aged children were considered. In-depth assessments were restricted to those studies that employed logistic regression analysis to investigate relationship between ECC and risk factors or nutritional status and quality of life.

Results: A total of 36 studies were identified that related to ECC in Canadian children. Overall, 27 related to prevalence and 12 reported on risk factors, four related to the association between severe ECC and nutritional health and well-being, while only one related to the oral microbiome composition. Published studies reveal that the prevalence of ECC can be as high as 98% in some parts of Canada. Commonly identified risk factors include age, sex, socio-economic status, parental beliefs, family characteristics, debris/plaque, enamel hypoplasia, and behavioral (oral health or feeding behaviors) tendencies.

Conclusions: Current literature reveals that many Canadian children are affected by ECC. The development of ECC appears to be strongly associated with social determinants of health including low household income and the level of parental education or employment status. Associations were also observed between ECC and the child's age at first dental visit and parental beliefs about child's oral health. Children with enamel hypoplasia are also at significantly greater odds for experiencing caries. Future research should include assessments of developmental defects of enamel to better understand the association between enamel hypoplasia and ECC.

Keywords: early childhood caries (ECC), Canada, preschool child, risk factors, nutritional status, burden of caries

OPEN ACCESS

Edited by:
Morenike Oluwatoyin Folayan, Obafemi Awolowo University, Nigeria

Reviewed by:
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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *02 May 2019*
Accepted: *24 October 2019*
Published: *12 November 2019*

Citation:
Pierce A, Singh S, Lee J, Grant C, Cruz de Jesus V and Schroth RJ (2019) The Burden of Early Childhood Caries in Canadian Children and Associated Risk Factors. Front. Public Health 7:328. doi: 10.3389/fpubh.2019.00328

INTRODUCTION

Decay involving the primary dentition in children younger than 6 years of age is termed Early Childhood Caries (ECC) (1). ECC is a multifactorial chronic disease, which is influenced by biomedical factors such as diet, the oral microbiome, tooth integrity and by underlying social determinants of health (1, 2). This includes low socioeconomic status (SES), parental education, maternal nutrition, and psychosocial issues (3–5).

Numerous young Canadian children experience significant oral health problems, particularly ECC. This is especially true for First Nations, Inuit and Metis children, recent refugees and immigrants (i.e., newcomers), those living in low SES households, and children from geographically remote regions of the country (6–12). It is now well-established that up to 90% of children in some northern and remote Indigenous communities are affected (13–15). Usually, urban children are considered low-risk for caries, but there is also data available that signify that ECC is prevalent in disadvantaged urban communities in Canada (11, 16, 17). The challenge is that those most at risk for ECC are often those with the greatest barriers in accessing oral health care services.

Although national data on the true prevalence of ECC is missing, as children <6 years of age were not included in the Canadian Health Measures Survey, ECC continues to be a problem in Canada today (3, 18). One reason is due to the failure of previous interventions of being able to address successfully the underlying causative biomedical, behavioral, and social factors known to contribute to the development of caries (12).

If left untreated, early childhood caries advances to a more rampant form of disease, which further leads to malocclusions, abscess and pain. This situation is further compounded by the fact that there are long waiting lists for operative treatment in hospitals (19, 20). Furthermore, Severe Early Childhood Caries (S-ECC) among young children can negatively impact oral health related quality of life, nutritional status and growth (12, 21–23). There is also a growing body of evidence that the reoccurrence of dental caries and relapse following restorative dental treatment under general anesthesia is high (24–26).

In the absence of national prevalence data, national rates of pediatric dental surgery to treat ECC under general anesthesia can serve as a proxy measure (3, 27). National data reveals that the rate of dental surgery for ECC is 12.1 per 1,000 children and is recognized as the most common surgical procedure performed in preschool children at most Canadian hospitals (3, 28). This report also found that children from rural regions had rates of dental surgery to treat ECC 3.2 times higher than rates of urban-dwelling children (31.2 per 1,000 vs. 9.8 per 1,000) (3).

Due to potential for ECC to affect childhood growth and development and the associated treatment costs, the prevalence and etiology of ECC must be examined more closely to inform clinical management, policy, and prevention activities. The purpose of this review was to describe the burden of ECC in Canada, particularly its prevalence, associated risk factors, and its impact on childhood health and well-being based on the existing literature.

METHODS

Electronic databases were searched to identify all Canadian published studies on ECC. The search strategy by Schroth and Grant informed our work for this current review and provided a recent listing of relevant publications (18). Keywords (used alone and in various combinations) were: baby, babies, Canada, Canad*, caries, cavities, cavit*, child, "dental caries," "dent* and cavit*," "early childhood caries," ECC, infant, preschool*, "severe early childhood caries," S-ECC, and toddler. The search terms were used for title, abstract, and where possible full text. As the term and case definition for early childhood caries was adopted in 1998 (29), the literature search was limited to sources published in the English language spanning from 1990 to 2019. Databases searched included PubMed, Medline, Cinahl, Scopus, Cochrane Library, and the Library Catalog of the University of Manitoba. Similar search strategies were used to identify web resources using the Google search engine. Known publications on ECC that were not identified by the electronic search were also considered.

For the purpose of this review, ECC was defined according to American Academy of Pediatric Dentistry's case definition (1). Studies were included if they involved children <72 months of age, involved Canadian children and either focused on ECC, reported the prevalence of caries in the primary dentition (i.e., ECC, dmft > 0, dmfs >0), examined the risk factors for ECC, investigated the associated microbiome with modern techniques, or discussed associations between ECC and nutritional status and well-being. Studies relating to parental reported ECC were not included (27, 30). In depth assessments were restricted to those studies that employed logistic regression analysis to investigate the relationship between ECC and risk factors or nutritional status and quality of life. Studies exploring the oral microbiome were also reviewed in detail.

Common risk factors for ECC investigated by Canadian studies were identified with variables grouped into 15 overarching categories: childhood age, sex, SES, community of residence, family characteristics, ethnicity, parental beliefs, prenatal nutrition, child behaviors, feeding behaviors (e.g., bottle-feeding and breastfeeding), dental history, enamel hypoplasia, tooth debris score, fluoride exposure, and oral health behaviors (e.g., brushing habits). SES risk factors included any demographic characteristics relating to the level of parental education and annual household income. Family characteristics encompassed variables related to the family size or composition and whether the caregiver had legal custody of the child.

RESULTS

A total of 36 published Canadian studies were identified and reviewed in detail; 27 reporting prevalence, 11 reporting associated risk factors following logistic regression analyses, six exploring associations with nutrition and well-being, and one involving the oral microbiome (**Table 1**). Twenty-one of the studies reviewed were cross-sectional in nature, seven were case-control studies, three were randomized control trials, three were retrospective chart reviews, and two studies employed a prospective cohort design. A total of 14 studies involved

TABLE 1 | Published studies on early childhood caries among pre-school children in Canada over 29 years.

Study	Region of Canada	Population	Type of study	Age	Prevalence of ECC (%)	Reported risk factors using multiple logistic regression
Williams and Hargreaves (31)	Edmonton, Alberta	Urban Asians	Cross-sectional	2 years old 3–4 years old 5 years old	0 28 62	No
Harrison and Davis (32)	British Columbia (1988 Survey)	First Nation	Cross-sectional	5 Years old	87.5 in 1988 89.7 in 1980	No
Young et al. (33)	Keewatin region, Northwest Territories	Inuit	Cross-sectional	0–2 years old 3-5 years old	50–100, depending on community	No
Weinstein et al. (34)	Edmonton, Alberta	Urban Caucasian and diverse ethnic	Cross-sectional	Mean age = 19 months	25	No
Harrison et al. (35)	Vancouver, British Columbia	Urban Vietnamese	Cross-sectional	3–74 months <18 months ≥18 months	 0 79.5	No
Harrison and Wong (17)	Vancouver, British Columbia (1996 follow-up)	Urban Vietnamese (Intervention Group Control group)	Cross-sectional and intervention study	22.1 ± 5.0 months 22.7 ± 5.8 months	6.2 intervention 57.1 comparison	No
Peressini et al. (36)	District of Manitoulin, Ontario	First Nation	Cross-sectional	3 years old 5 years old	67 78	No
Lawrence et al. (14)	Northern Ontario	First Nation	Cross-sectional	2 years old 3 years old 4 years old	91.8 S-ECC-–81.9 97.7 S-ECC–95.8 100 S-ECC–94.7	No
Schroth and Moffatt (13)	Garden Hill First Nation, Manitoba	First Nation	Cross-sectional	3–5 years old	98.9	No, but did undertake multiple regression for deft score
Schroth et al. (10)	Rural South-western Manitoba	Caucasian	Cross-sectional	36–48 months	44 S-ECC–21	Yes
Schroth et al. (16)	Winnipeg (South Point Douglas), Thompson, Norther First Nation, Roseau River First Nation, Manitoba	Diverse urban and First Nations children living on reserve	Cross-sectional	<1–5 years old <1 year old 1 year old 2 years old 3 years old 4 years old 5 years old Winnipeg (South Point Douglas) Thompson Northern First Nation Roseau River First Nation	53.6 7.1 30.4 54.7 78.1 78.3 84.2 43.3 51.4 58.6 56.5	No
Clarke et al. (21)	Toronto, Ontario	Ethnically heterogeneous children with S-ECC	Cross-sectional	2–6 years of age	N/A All children recruited had S-ECC.	No

(Continued)

TABLE 1 | Continued

Study	Region of Canada	Population	Type of study	Age	Prevalence of ECC (%)	Reported risk factors using multiple logistic regression
Harrison et al. (37)	Hartley Bay, British Columbia	First Nations (Base Line Group)	Cross-sectional	Pre-kindergarten children	69 (baseline)	No
Schroth et al. (38)	Winnipeg (South Point Douglas), Thompson, Norther First Nation, Roseau River First Nation, Manitoba	Diverse urban and First Nations children living on reserve	Cross-sectional	<72 months of age	Previously reported in Schroth et al. (16)	Yes
Harrison et al. (39)	Surrey, British Columbia	South Asian immigrants enrolled into a randomized trial of motivational interviewing	Randomized controlled trial (RCT)	6–18 months (baseline) Intervention group Control group	 1.6	No, but did undertake Poisson regression for dmfs
Schroth and Cheba (40)	Winnipeg and surrounding area in southern Manitoba	Ethnically heterogeneous	Retro-spective chart review	1-5 years old <23 months 2 years old 3 years old 4 years old 5 years old	71 47 56 67 75 78	Yes
Tiberia et al. (41)	Five Pediatric dental practices in Canada—British Columbia, Ontario, Prince Edward Island	77% Caucasian, 7% First Nation, 8% Asian	Cross-sectional survey	Mean age 3.05 years 1–5 year olds 1–2 year olds	 74.5 S-ECC—65.7 72.7 S-ECC—57.6	Yes
Leake et al. (42)	Inuvik Region, Northwest Territories	Predominantly Inuit	Cross-sectional	2–5 years old 2 years old 3 years old 4 years old 5 years old	62.5 29 53 67 69	Yes, but this was undertaken for their own case definition for S-ECC
Valencia-Rojas et al. (43)	Toronto, Ontario	Children in care of the Children's Aid Society of Toronto (Maltreated Children)	Retro-spective chart review	2–6 years old 2–3 years old 4–6 years old	57.6 50.0 63.9	Yes
Werneck et al. (44)	Toronto, Ontario	Portuguese speaking immigrants from Portugal or the Azores, Brazil, Angola, or Mozambique	Case-control	≤ 48 months of age	35	Yes
Lawrence et al. (45)	Sioux Lookout Zone (SLZ) and Thunder Bay, Ontario	First Nations children in SLZ and primarily non-Indigenous comparison group in Thunder Bay	RCT	6 months to 5 years old Baseline: SLZ control SLZ fluoride varnish intervention Thunder Bay intervention	 68.9 72.7 15.7	Yes

(Continued)

TABLE 1 | Continued

Study	Region of Canada	Population	Type of study	Age	Prevalence of ECC (%)	Reported risk factors using multiple logistic regression
Lawrence et al. (46)	Sioux Lookout Zone (SLZ) and Thunder Bay, Ontario	First Nation	Cross-sectional	<6 years of age SLZ	95.9 (2001) 94.6 (2002) 70.6 (2003) 89.1 (2004) 93.8 (2005)	No, but did undertake Poisson regression
				3–5 year olds Thunder Bay Kindergarten	37.7 (2003/04) 40.3 (2004/05) 36.8 (2005/06)	
				All	31.1 (2003/04) 35.2 (2004/05) 31.2 (2005/06)	
		Primarily non-aboriginal		Non-Indigenous living off-reserve	73.8 (2003/04) 81.6 (2004/05) 79.4 (2005/06)	
Schroth et al. (47)	South-western Manitoba	Hutterite Colonies	Cross-sectional	6–71 months	53 S-ECC– 42.4	Yes
Harrison et al. (48)	Nine Cree communities in northern Quebec	First Nations	RCT	Children of mothers who had recently given birth	Control group 76% (100/131) Treatment group 65% (72/110) Overall, 0.71	
Schroth et al. (49)	Winnipeg and surrounding southern Manitoba	Ethnically Heterogeneous	Case-control	Mean age 43.8 months 16–71 months of age	N/A Children were recruited based on whether or not they had S-ECC	Yes
Schroth et al. (23)	Winnipeg, Manitoba	Ethnically Heterogeneous	Case-control	Mean age 40.8 <72 months of age	N/A Children were recruited based on whether or not they had S-ECC	Yes
Schroth et al. (22)	Winnipeg, Manitoba	Ethnically Heterogeneous	Case-control	Mean age 40.8 <72 months of age	N/A Children were recruited based on whether or not they had S-ECC	Yes
Schroth et al. (50)	Winnipeg (93%) and surrounding rural Manitoba (7%)	Expectant mothers from vulnerable populations. 90% Canadian Aboriginal (First Nation, Metis, or Inuit)	Prospective cohort	Infants < 24 months of age	23– when restricted to cavitated enamel lesions 36–when white spot lesions are included S-ECC-–23	Yes
Schroth et al. (51)	Winnipeg (South Point Douglas), Thompson, Northern First Nation, Roseau River First Nation, Manitoba	Cross-sectional follow-up study evaluating the Healthy Smile Happy Child Initiative	Cross-sectional	Children ≤ 71 months of age	52 S-ECC-–38.6	Yes

(Continued)

TABLE 1 | Continued

Study	Region of Canada	Population	Type of study	Age	Prevalence of ECC (%)	Reported risk factors using multiple logistic regression
Amin et al. (9)	Edmonton, Alberta	African Communities (90% originated from North eastern Africa; 9.7% from West Africa)	Cross-sectional	21–72 months old	63.7 (untreated ECC)	No
Poon et al. (52)	British Columbia (Province Wise)	Kindergarten children 4–6 years of age	Retro-spective cohort	Children between the ages of 4 and 6 years old	38.9 (2006/07) 36.7 (2009/10)	No
Davidson et al. (53)	Winnipeg, Manitoba	Ethnically heterogeneous	Case-control	24–71 months old	N/A Children were recruited based on whether or not they had S-ECC	No, but did undertake multiple linear regression for BMI that included S-ECC as a covariate
El Azrak et al. (11)	Winnipeg, Manitoba	Children from Newcomer families	Cross-sectional	<72 months of age	45.5 S-ECC−31.3	Yes
Agnello et al. (54)	Winnipeg, Manitoba	First Nation or Metis.	Case-control	<72 months of age	N/A Children were recruited based on whether or not they had S-ECC to look at the microbiome	No
Deane et al. (55)	Winnipeg, Manitoba	Ethnically heterogeneous	Case-control	40.8 † 14.1 months	N/A Children were recruited based on whether or not they had S-ECC	No, but did undertake multiple linear regression for PTH levels that included S-ECC as a covariate
Grant et al. (56)	Winnipeg, Manitoba	Children with S-ECC receiving treatment under general anesthesia	Prospective cohort	≤6 years of age	N/A Children with S-ECC were specifically recruited.	No, but multiple linear regression undertaken for early childhood oral health impact scale scores

Indigenous children (i.e., First Nations, Inuit, or Metis), six included children of newcomers (immigrants and refugees) to Canada, and 11 were with ethnically diverse populations.

Among the entire number of studies reviewed, only 14 incorporated multiple logistic regression into their analysis to investigate the presence of any significant relationships between ECC and several associated variables (**Table 2**). Eleven of these studies focused their analysis on risk factors that may contribute to the onset of ECC, while three examined how severe forms of ECC are associated with underlying nutritional status of affected children.

Overall, the prevalence of ECC in the literature reviewed ranged between 0 and 98.9% (**Table 1**). Many of the identified publications involved preschool children from Manitoba (n = 16). As seen in **Table 1**, the prevalence of ECC appears to be high among Indigenous children, often affecting 85% of children or more. Prevalence was also considerably high among children from newcomer communities reaching as high as 79.5%.

Among the 27 studies reviewed that reported on the prevalence of ECC, seven also reported the prevalence of S-ECC. The average rates of S-ECC are lower than that of ECC, however, prevalence of S-ECC still varied greatly depending on the communities and participants involved (range: 21–95.8%). In one First Nation community, the prevalence of S-ECC among Indigenous children ranged from 81.9 to 95.8%. By contrast, the prevalence of S-ECC from several different communities including Hutterite, Indigenous, and immigrant or refugee families in southern Manitoba ranged as low as 21% to as high as 42.4%.

Risk Factors

Childhood age is a recognized predictor of ECC and six of the reviewed Canadian studies considered it as a risk factor for ECC (**Table 3**). In 2007, a retrospective chart review to determine the prevalence of preschool dental decay reported that children who did not have their first dental visit before 24 months of age had increased odds of developing decay (40). These findings were further supported in a subsequent prospective study conducted by Schroth et al. (50) where they discovered that infants aged ≥14 months of age at the time of their first dental examination were significantly more likely to have ECC. Similarly, a 2010 study investigating the prevalence of ECC among Hutterite preschool children reported that childhood age was the strongest independent predictor of ECC (OR = 3.49) (47). More recently, Azrak et al. (11) found that older children had a mildly greater risk for developing ECC. Lastly, logistic regression analysis used in a serial cross-sectional study among four Manitoba communities revealed that childhood age was significantly related to S-ECC (**Table 2**) (51).

Another potential risk factor for caries development that was investigated among some of the Canadian studies was the sex of the child. However, out of five studies that employed logistic regression to investigate this relationship, only one 2007 study found males to be at 38% greater risk for developing ECC than females (**Tables 2**, **3**) (40).

Three studies examined the dental history of children as a potential risk factor for caries development (**Tables 2**, **3**). Children with a baseline decayed and filled surface (dfs) score of ≥5 were 4.88 times more likely to have caries over a 2 year interval vs. those whose dfs score was between 0 and 4 (45). In addition, one publication reported that children with a history of missed dental appointments had an 82% greater risk for developing ECC (OR = 1.82) (40). However, a more recent study did not find the location at which dental care was received to be a significant risk indicator for caries (11).

Three studies observed the relationship between debris score and ECC (**Table 3**). Two of these studies did not find the association to be statistically significant. However, one documented that the presence of debris on primary teeth was significantly and independently associated with ECC and S-ECC (11).

Enamel hypoplasia has been identified as additional risk factor in ECC development. Two studies reported that enamel hypoplasia was significantly and independently associated with ECC (**Table 3**). This was first verified in a prospective cohort study where they found that infants with enamel hypoplasia in the form of pits and missing enamel were significantly more likely to have ECC (50). Another study reported that children with enamel hypoplasia were 6.1 and 3.9 times more likely to have ECC and S-ECC, respectively (11).

Specific behavioral factors were categorized and examined for any relationships with ECC. One study investigated difficult child behaviors as a potential risk indicator for caries and found it to be significantly associated to the onset of ECC but not S-ECC (**Table 2**) (41). Three studies also considered how different feeding practices may contribute to ECC development; two of which were reported to be significant (**Table 3**) (10, 41, 44). Certain behaviors such as the bottle propping, the frequency of snack consumption, or having liquids in the mouth for prolonged periods of time were associated with ECC, however the results remain mixed. Lastly, behaviors related to child oral health practices were explored by two studies as possible risk indicators for ECC (**Table 3**). One reported that children who had difficulty brushing were significantly more likely to get ECC but not S-ECC (41). The other reported that independent brushing by the child did not contribute to the onset of ECC (47).

Four studies have considered the influence of caregiver beliefs and attitudes on the incidence of ECC in preschool children (**Table 3**). In 2007, Schroth et al. (38) found that children whose caregivers who believed it is safe to allow an infant to nurse throughout the night in bed were 45% less likely to experience decay in the form of caries(OR = 0.55). In addition, parents who believed that rotten teeth could impact their child's health were more than four times as likely to have children with ECC (OR = 4.33). However, whether parents agreed with the practice of bottle-feeding children after 1 year of age was not associated with ECC (**Table 2**) (38).

Certain socioeconomic factors such as low household income and the level of parental education or employment status can significantly increase the threat of caries development. Among these factors, two studies specifically assessed whether low annual household income is a risk indicator for both ECC and S-ECC

TABLE 2 | Identified risk factors for ECC in Canadian studies.

Study	Risk factors for ECC or S-ECC from multiple logistic regression analyses	Association with nutrition and well-being
Schroth and Moffatt (10)	**Not Significant:** Family size ($p > 0.05$) [family characteristics] Duration of breastfeeding ($p > 0.05$) [feeding behavior] Bottle at bed ($p > 0.05$) [feeding behavior] Gender ($p > 0.05$) [sex] Debris on teeth ($p > 0.05$) [debris]	
Schroth et al. (38)	**Significant:** Disagree that it is okay to let baby nurse in bed with mother all night (OR = 0.55, $p = 0.018$) [beliefs] Rotten teeth could affect child's health (OR = 4.33, $p = 0.006$) [beliefs] **Not Significant:** Bottle feeding after child is 1 year old is bad for his/her teeth (OR = 0.70, $p = 0.162$) [beliefs]	
Tiberia et al. (41)	**Significant:** Leaving bottle with child with ECC (RR = 6.71, $p = 0.002$) and S-ECC (RR = 7.43, $p = 0.002$) [feeding behavior] Having problems brushing with ECC (RR = 3.11, $p = 0.05$) [oral hygiene behavior] Holding liquids in the mouth for prolonged time with ECC (RR = 7.04, $p = 0.04$) [feeding behavior] Using a bottle [protective] with ECC (RR = 0.11, $p = 0.01$) and S-ECC (RR = 0.16, $p = 0.05$) [feeding behavior] Having a difficult child [protective] with ECC (RR = 0.08, $p = 0.04$) [behavior] Caucasian with S-ECC (RR = 7.22, $p = 0.05$) [ethnicity] **Not Significant:** Receive government assistance with ECC (RR = 2.17, $p = 0.34$) and S-ECC (RR = 2.18, $p = 0.34$) [SES] Having problems brushing with S-ECC (RR = 2.36, $p = 0.17$) [oral hygiene behavior] First born child with ECC (RR = 1.98, $p = 0.21$) and S-ECC (RR = 2.06, $p = 0.22$) [family characteristics] Having a difficult child [protective] with ECC (RR = 0.09, $p = 0.12$) [behavior] Holding liquids in the mouth for prolonged time with S-ECC (RR = 5.60, $p = 0.07$) [feeding behavior] Level of parental education with ECC (RR = 1.84, $p = 0.34$) and S-ECC (RR = 2.44, $p = 0.21$) [SES] Caucasian with ECC (RR = 3.11, $p = 0.16$) [ethnicity] Timing of snacks with ECC (RR = 1.65, $p = 0.37$) and S-ECC (RR = 1.80, $p = 0.33$) [feeding behavior] Fluoridated water with ECC (RR = 0.63, $p = 0.22$) and S-ECC (RR=0.53, $p = 0.11$) [fluoride] Daily medications with ECC (RR = 4,385.24, $p = 0.79$) and S-ECC (RR = 3,307.67, $p = 0.80$) [health status]	
Schroth and Cheba (40)	**Significant:** Male child (OR = 1.38, $p = 0.048$) [sex] Age at first visit >23 months of age (OR = 0.19, $p = 0.009$) [age] Low monthly income ($\leq$ \$2000 per month) (OR = 1.79, $p = 0.014$) [SES] Failed dental appointments (OR = 1.82, $p = 0.002$) [dental history] Not being a single parent (OR = 0.61, $p = 0.011$) [family characteristics] **Not Significant:** Community of residence (urban) (OR = 0.55, $p = 0.06$) [community of residence] Low monthly income per family member (<\$325) (OR = 1.28, $p = 0.092$) [SES] Maternal employment status (being employed) (OR = 1.42, $p = 0.054$) [SES]	

(Continued)

TABLE 2 | Continued

Study	Risk factors for ECC or S-ECC from multiple logistic regression analyses	Association with nutrition and well-being
Valencia-Rojas et al. (43)	**Significant:** Having guardianship status [protective] with ECC (OR = 0.14, p = 0.03) [family characteristics] Number of times in care of the Children's Aid Society of Toronto [protective] with S-ECC (OR = 0.16, p = 0.03) [family characteristics] **Not Significant:** Age with ECC (OR = 1.52, p = 0.45) and S-ECC (OR = 1.18, p = 0.79) [age] Sex with ECC (OR = 0.54, p = 0.29) and S-ECC (OR = 0.84, p = 0.77) [Sex] Siblings in care of Children's Aid Society of Toronto with ECC (OR = 0.74, p = 0.65) and S-ECC (OR = 0.81, p = 0.75) [family characteristics] Type of Abuse with ECC (OR = 1.09, p = 0.90) and S-ECC (OR = 0.61, p = 0.48) Number of times in care of the Children's Aid Society of Toronto with ECC (OR = 0.42, p = 0.16) [family characteristics] Having guardianship status with S-ECC (OR = 0.22, p = 0.24) [family characteristics] Period of time under care of Children's Aid Society of Toronto with S-ECC (OR = 1.29, p = 0.73) [family characteristics]	
Lawrence et al. (45)	**Significant:** Control vs. fluoride varnish (FV) (Adjusted OR = 1.96, p = 0.027) [fluoride] Baseline dfs (≥5 vs. 0–4) (Adjusted OR = 4.88, p = <0.001) [dental history] Age (0–2 years vs. 3–5 years) (Adjusted OR = 1.94, p = 0.02) [age] **Not Significant:** Sex (Female vs. Male) (Adjusted OR = 1.14, p = 0.307) [sex] Follow-up timing (18–24 months vs. 12–18 months) (Adjusted OR = 1.33, p = 0.187) [age] Parental Education (<High School vs. ≥High School) (Adjusted OR = 1.27, p = 0.138) [SES] Number of Children (>4 vs. ≤3) (Adjusted OR = 1.28, p = 0.057) [family characteristics]	
Werneck et al. (44)	**Significant:** No insurance (Adjusted OR = 4.87, p = 0.001) [SES] No family dentist (Adjusted OR = 3.96, p = 0.013) [SES] Frequency of snack consumption ≥2 per day (Adjusted OR = 3.79, p = 0.013) [feeding behavior]	
Schroth et al. (47)	Logistic Regression for ECC c/w age: **Significant:** Age of child (OR = 3.49, p = 0.0079) [age] **Not Significant:** Child brushes independently (OR = 0.59, p = 0.54) [oral hygiene behavior] Debris score (OR = 4.03, p = 0.17) [debris] Maternal rating of child's teeth (OR = 4.06, p = 0.11) [beliefs] Number of children in household (OR = 1.54, p = 0.10) [family characteristics] Logistic Regression for ECC w/out age: **Significant:** Maternal rating of child's teeth (OR = 7.49, p = 0.021) [beliefs] Number of children in household (OR = 1.94, p = 0.0057) [family characteristics] **Not Significant:** Child brushes independently (OR = 1.57, p = 0.52) [Oral hygiene behavior] Debris score (OR = 3.80, p = 0.12) [debris]	

(Continued)

TABLE 2 | Continued

Study	Risk factors for ECC or S-ECC from multiple logistic regression analyses	Association with nutrition and well-being
Schroth et al. (49)	2nd Pilot Model: **Significant:** Children whose parents completed ≤Grade 12 were significantly more likely to have S-ECC (CI = 0.69, 3.778, OR = 9.3, p = 0.0046) [SES]	1st Pilot Model: **Significant:** PTH is significantly and independently associated with S-ECC (OR = 0.23, p = 0.004) Children with S-ECC significantly more likely to have higher PTH levels than caries free children **Not Significant:** 25(OH)D with S-ECC (OR = 2.2, p = 0.12). 2nd Pilot Model: **Not Significant:** 25(OH)D with S-ECC (OR = 1.7, p = 0.19).
Schroth et al. (22)		**Significant:** Children with S-ECC were nearly twice the odds of being classified as having low ferritin (OR = 1.48, p = 0.048). Children with S-ECC were over 6 times more likely to have IDA (OR = 6.58, p = <0.0001).
Schroth et al. (23)	**Significant:** S-ECC related to lower household income ($p \leq 0.001$) [SES] S-ECC related to poorer rating of children's general health (p = 0.002) [beliefs]	**Significant:** S-ECC related to lower vitamin D levels ($p = 0.04$)
Schroth et al. (50)	**Significant:** ECC is related to infant age (≥14 months) at the time of dental examination ($p = 0.01$) [age] ECC is related to Enamel Hypoplasia ($p = 0.001$) [enamel hypoplasia] ECC is related to maternal prenatal 25(OH)D levels ($p = 0.05$) [prenatal nutrition]	
Schroth et al. (51)	**Significant:** Prevalence of ECC between the southern First Nation and Thompson ($p = 0.00075$) and the northern First Nation and Thompson ($p = 0.00010$) [community of residence] Prevalence of S-ECC between the southern First Nation and Thompson ($p = 0.00081$) and the northern First Nation and Thompson ($p = 0.044$) [community of residence] Decrease in S-ECC following community development (OR = 0.71, $p = 0.026$) [community of residence] Age ($p < 0.05$) **Not Significant:** Prevalence of ECC and S-ECC between the two urban centers (p = 0.13, $p = 0.97$) [community of residence]	
El Azrak et al. (11)	**Significant:** Age (months) with ECC (OR = 0.98, $p = 0.034$) [age] Debris Score with ECC (OR = 0.17, $p < 0.001$) and S-ECC (OR = 0.04, $p < 0.001$) [debris] Parent thinks child has dental problem with ECC (OR = 5.51, $p <$ 0.001) and S-ECC (OR = 4.44, $p < 0.001$) [beliefs] Presence of enamel hypoplasia with ECC (OR = 6.10, $p = 0.031$) and S-ECC (OR = 3.93, $p = 0.048$) [enamel hypoplasia] **Not Significant:** Child sex with S-ECC (OR = 1.80, $p = 0.14$) [Sex] No dental insurance with S-ECC (OR = 1.12, $p = 0.77$) [SES] Child has visited dentist in Winnipeg with ECC (OR = 1.80, p = 0.14) and S-ECC (OR = 1.32, $p = 0.5$) [Dental History]	

OR, Odds ratios; RR, Relative risk.

TABLE 3 | Canadian studies using Logistic Regression to assess Caries risk factors.

Risk factors	Number of studies assessing risk factor type	Number of studies reported significant associations with risk factor type
Age	6	5 (83.3%)
Sex	5	1 (20%)
Socioeconomic Status (SES)	7	4 (57.1%)
Beliefs	4	4 (100%)
Family Characteristics	6	3 (50%)
Behavior	1	1 (100%)
Feeding Behavior	3	2 (66.7%)
Oral Hygiene Behavior	2	1 (50%)
Debris/Plaque	3	1 (33.3%)
Enamel hypoplasia	2	2 (100%)
Dental History	3	2 (66.7%)
Fluoride Exposure	2	1 (50%)
Community of Residence	2	1 (50%)
Ethnicity	1	1 (100%)
Prenatal Nutrition	1	1 (100%)

(**Table 2**). In each instance, a lower household income increased the strength of an association with both forms of caries (23, 40). These findings were further supported in a cross-sectional study of 349 Inuit children that documented a higher family income as a significant protective factor against caries onset. Four studies also investigated the relationship between paternal education and employment status with presence of decay. Schroth and Cheba (40) did not find any significant differences between maternal employment status and deft scores. Similarly, no associations were observed between ECC and the mother's level of education when logistic regression was performed on participants from a rural Manitoban community (10). This finding was further supported by a RCT conducted with children in Ontario, where they did not find the level of parental education to be related to the child's development of ECC (OR = 1.27, $p = 0.138$) (45). These results were in sharp contrast to a subsequent pilot study investigating the relationship between vitamin D and S-ECC, which reported that children with parents whose educational attainment was $\leq$ grade 12 were 9.3 times more likely to have S-ECC (49).

Specific characteristics of the families children belonged to were also assessed for the presence of any significant associations with ECC (**Table 3**). Three studies considered the impact of family size on a child's likelihood for developing ECC. Neither Schroth and Moffatt (10) nor Lawrence et al. (45) found that children from larger families were at increased risk for developing ECC (**Table 2**). These findings were further supported by a pilot study of Hutterite children in southwest Manitoba (OR = 1.54, $p = 0.10$) (47). However, a subsequent regression model that controlled for childhood age did report statistical significance between family size and ECC (OR = 1.94) (47). One study reported that children coming from single parent households were more likely to be caries-free than those living with two parents (40).

The same pilot study of Hutterite preschool children did not find any significant association between the maternal rating (fair/poor/very poor) of their child's teeth and ECC (OR = 4.06, $p = 0.17$) (47). However, when age was excluded from regression analysis, low maternal ratings of childhood oral health were 7.49 times more likely to develop ECC (47). Since then, other studies have reported similar findings where lower parental ratings of their child's general or oral health was associated with a greater likelihood of experiencing caries (11, 23).

An in depth analysis on the prevalence of caries was conducted in preschool children under the care of the Children's Aid Society of Toronto (CAST), a not-for-profit agency that provides alternate care for young abused or neglected children. The results suggested that the period of time spent under CAST care did not significantly influence the risk of having S-ECC (OR = 1.29, $p = 0.73$) (43). However, they found that having permanent guardianship status of the children in care was protective against ECC development but not S-ECC (OR = 0.14, 0.22) (43). Conversely, an increase in the number of times children were admitted to CAST care was protective against the onset of S-ECC but not ECC (OR = 0.16, 0.42) (43).

One study investigated how differential access to dental care is related to ECC (44) (**Table 2**). This study was conducted on Portuguese-speaking immigrants in Toronto and revealed that children with ECC were more likely to be from families without reliable access to dental care and often lacking dental insurance.

Two studies analyzed the association between ECC and community of residence (urban/rural). One determined the prevalence of ECC among children accessing a community dental clinic and found that the prevalence of ECC among children from Winnipeg did not differ significantly from those residing in rural Manitoba (**Table 2**) (40). Alternatively, the other reported that the prevalence of ECC differed significantly between a southern First Nation and Thompson and a northern First Nation and Thompson, but not between the two urban centers investigated (51). In addition, significant differences in S-ECC were observed between the southern First Nation and Thompson, the northern First Nation and Thompson, but not between Winnipeg and Thompson (51).

Fluoride exposure or the lack thereof was investigated by several studies as a potential risk factor for ECC. A RCT reported that the scheduled application of fluoride varnish (FV) over a 2 year interval led to an 18.3% reduction in ECC among First Nation children and 24.5% reduction in the overall study population (45). Logistic regression further revealed that participants in the FV treatment group were 1.96 times less likely to have caries than comparable controls (45). By contrast, the presence of fluoridated water was not found to be protective against ECC or S-ECC development in another included study (41).

Nutrition and Well-Being

Recently, more robust analysis involving logistic regression performed by our group has validated these initial findings of

associations between ECC and nutritional health and well-being (**Table 2**). In 2013, a case-control study involving nearly 300 preschool children and documented that children with S-ECC were nearly twice the odds of having low ferritin and over six times more likely to have IDA than caries free children (22). The authors further extended their nutritional analysis to investigate the relationship between caries and vitamin D status. They reported that S-ECC was significantly associated with lower levels of vitamin D and elevated levels of parathyroid hormone (PTH) (23, 49). In 2014, a prospective study further supported the relationship between caries and vitamin D status as they found that low maternal prenatal vitamin D levels were associated with an increased risk of caries in infants (50).

Microbiome

Only one study was identified that explored the composition of the oral microbiome of children with S-ECC (**Table 1**). This case control study involved First Nations and Métis children with and without ECC (54). The microbiome analysis of the 16S rRNA gene identified 10 phyla, 95 genera, and 290 species (54). The alpha (Within-sample) diversity analysis did not show any differences in species richness and phylogenetic diversity between groups (54). However, the beta diversity analysis revealed a significant cluster of samples according to caries-status (caries-free vs. S-ECC) (54). Taxonomic classification revealed that the levels of 28 species were significantly different between the groups (54). The caries-free group had 5 and 2-fold higher abundances of Streptococcus gondonii and Streptococcus sanguinis, respectively (54). Conversely, the S-ECC group had 7 and 9-fold higher levels of Haemophilus species (HOT 036) and Porphyromonas species (HOT 284) (54). Further, Veillonella species (HOT 780) was 4.6 times higher in the S-ECC group (54). Streptococcus mutans was detected in both groups, but was three times higher in the S-ECC group (54). These findings indicate that S-ECC is related to the structure of the plaque microbial communities.

DISCUSSION

This review reveals that there have been numerous investigations in Canada on ECC over the last two decades. Many of the studies involved populations often to be considered at high risk for caries, including Indigenous children, those from disadvantaged communities, and newcomer populations to Canada. Unfortunately, there have been no national representative samples to study the true prevalence of ECC in the Canadian population. In the absence of such data, we must rely on regional studies, review national surveys of parental reported ECC in specific populations, or look to pediatric dental surgery under general anesthesia to treat ECC as a proxy measure for the burden of disease in the infant and preschool population in Canada (3, 27, 28).

Despite all the advancements in preventive dentistry, ECC continues to be the most common reason for pediatric day surgery in Canadian hospitals and surgical centers (3). While the average national rate for surgery under general anesthesia to treat caries is 12.1/1,000 children, it is apparent that rates are considerably higher in certain regions of Canada, including rural and remote northern communities, where rates can exceed 100/1,000 children (3, 28). Children living in communities with a high proportion of Indigenous persons are nearly eight times more likely to undergo dental surgery for ECC while those living in rural regions are over three times as likely (3). In addition, children from the least affluent communities are 3.7 times more likely to undergo rehabilitative dental surgery than children from more affluent communities (3).

SES is a well-recognized determinant of oral health and was identified as a risk factor in several of the Canadian studies reviewed. Poverty, inability to pay for or lack of dental insurance can limit access to primary dental care and prevention and increase the risk for ECC and complex dental treatment (3, 4, 57). It can also prevent families from purchasing nutritious foods and oral hygiene supplies, which prevents parents from adopting dental friendly routines at home (8). Parental education and employment status are also some of the social determinants that influence caries development (58). Unfortunately, oral health is not part of Canada's universal healthcare system.

Some of the Canadian studies reviewed provide evidence that past oral health status and the presence of plaque are associated with ECC. Previous caries experience is actually the strongest predictor of future caries (59, 60). Unfortunately, there is considerable variability in what clinical assessments (e.g., plaque/debris levels, developmental defects of enamel) are made during examinations of preschool children in research studies. In fact, only two studies examined enamel hypoplasia as a risk factor, with both finding that these developmental defects of enamel are strongly associated with increased caries risk (11, 50). For many years, enamel hypoplasia has been an underappreciated risk factor for ECC, but there is increasing awareness of its contribution to the caries process as it is easily colonized by cariogenic microorganisms, which allows the caries process to progress more rapidly in these areas as either enamel is thinner or missing (50, 61–64). Future epidemiological studies into ECC should also collect clinical measures of enamel hypoplasia to understand its prevalence, role, and to identify those factors that are associated with its increased prevalence.

Infant feeding practices, such as bottle-feeding and breastfeeding, are complex processes that are difficult to investigate in typical studies on ECC (65). The lack of standardized questioning on these practices and the degree of breastfeeding (e.g., exclusive breastfeeding, partial breastfeeding, mixed feeding with expressed breastmilk), pose challenges as does the fact that such questioning can also be subject to recall bias. Many studies have not properly controlled for other potential modifiers such as the introduction of solids, other dietary behaviors, vitamin D supplementation, and the child's oral hygiene routine (65). While breastfeeding has sometimes been mistaken as a risk factor for ECC in the past, it is actually protective and associated with lower odds for caries (1, 27, 66, 67). However, breastfeeding beyond 24 months of age has been reported to be associated with an increased risk for ECC (68, 69).

Several Canadian publications have reported on the association between ECC and childhood nutritional health

status and well-being and have added to our understanding of the oral-systemic relationship (22, 23, 49, 55, 56). The first Canadian report on the potential association between S-ECC and malnourishment suggested that many children with S-ECC suffered from low ferritin and met the definition for both iron deficiency (ID) and iron deficiency anemia (IDA) (21). Low maternal prenatal vitamin D concentrations was identified as a risk factor in one Canadian study (50). Since then, other investigators have also identified that vitamin D levels and prenatal vitamin D intake are associated with increased risk for ECC (70–72). In the few years it has been revealed that children with S-ECC are more likely to have lower serum levels of vitamin D, lower iron concentrations, and be both ID and have IDA than caries-free children (22, 23, 49). In many of these children these nutritional deficiencies actually co-exist (55). This provides more evidence that ECC is not just about teeth. Canadian children with S-ECC are also known to have higher BMI z-scores than caries-free counterparts. Current research is underway with our team to see whether nutritional status and well-being improve for these children following rehabilitative dental surgery under GA.

The advancement of modern microbiological techniques is undoubtedly enhancing our understanding behind the composition of the microbiome and risk for ECC. While only one Canadian study was identified, the field continues to grow (54, 73, 74). This will inevitably lead to future discussions on incorporating microbiological assessments into caries risk assessment (CRA) and risk prediction at the individual level (74, 75) Current research funded by the Canadian Institutes of health Research is underway to determine the role of taste genes and functional plaque microbiome in caries risk in young children in Manitoba Canada.

CRA is garnering increasing attention and is assisting in shifting our approach to managing caries from a restorative approach one that is non-restorative and minimally invasive. CRA can assists dental providers in tailoring clinical care decisions unique to the individual (76). It is vital that dental professionals familiarize themselves on how to undertake regular CRA of their young patients. CRA tools can also be used by non-dental primary healthcare professionals to screen children, determine their caries-risk, and provide prevention services, including fluoride varnish and anticipatory guidance. Several dental and pediatric organizations have developed CRA tools that can be used to help guide practitioners in determining someone's likelihood of developing caries. As parental belief and values can influence whether caries risk, it might be prudent to consider incorporating questions into CRA tools (38).

Early visits offer tremendous hope to curbing the problem of ECC. While there is growing awareness of the importance for such preventive dental practices, not all Canadian children are benefiting (77–80). Professional dental organizations, including the Canadian Dental Association call for the first dental visit no later than 12 months of age (81). In an attempt to increase dentist and public awareness, the Manitoba Dental Association established its Free First Visit program and the Canadian Dental Association introduced its First Visit First Tooth initiative (77–79).

As previously mentioned, many of the studies assessed in our review focused on Indigenous children, those from newcomer families, and those from disadvantaged communities, all who are known to have a higher burden of ECC than many other Canadian children. Different populations can have different risk factors for ECC as cultural practices and beliefs can play a role. However, one thing that is often common between our diverse at-risk populations is limited access to care and early childhood oral health promotion. Several programs and early childhood oral health initiatives are underway in regions of Canada. The federal Children's Oral Health Initiative is focused on improving the oral health status of young First Nations and Inuit children in Canada by emphasizing prevention and minimally invasive approaches to caries management over traditional restorative methods (82).

The Healthy Smile Happy Child (HSHC) initiative in Manitoba, Canada is a well-established, multidisciplinary partnership that works to address the problem of ECC while also considering the contributing health determinants (16, 51, 83, 84). HSHC is guided by three key pillars; (1) community engagement and development, (2) knowledge exchange, and (3) research, evaluation, and quality improvement (51, 85).

Key objectives of the HSHC initiative are to (1) promote the initiative and gain community awareness and acceptance of the importance of early childhood oral health, (2) use existing early childhood and family focused community-based programs, services and activities to deliver the oral health promotion and ECC prevention activities, and (3) recruit and train natural leaders, including service providers, to assist in program development and to deliver the ECC prevention program on an ongoing basis (51, 84). Further goals are to (4) scale-up capacity within existing programs and communities to assist in the sustainability of the promotional and educational program; and 5) determine the impact this would have on preschool oral health, parental knowledge, and attitudes regarding ECC, and knowledge of existing services and health care providers of the importance of prevention (51, 84). Evidence arising from the HSHC initiative's community development experiences over the past 18 years reveal that their approach is successful in improving parents' and caregivers' knowledge, attitudes, and behaviors toward early childhood oral health and results in significant reductions in caries scores and the prevalence of S-ECC over time (51, 83).

During our review of the Canadian ECC literature, it became apparent that there are some limitations with the Canadian literature. Many studies are cross-sectional in nature, with many being convenience samples of children and parents. A significant challenge with comparing risk factors between studies is the fact that investigators are not using a standardized set of questions or survey instruments. This means that different investigations into the same risk factors may yield differing findings even with the same population. The phrasing of questions into feeding and lifestyle behaviors are extremely variable. Further, not all studies are consistently looking at the risk factors. There is a lack of consistency in how questions about behaviors are being asked, which means that there is no uniformity in how risk factor variables are defined and measured between studies.

While there is finally consensus on how ECC and S-ECC are defined (1), there still is a lack of consensus of what is recorded as caries in epidemiological studies. The World Health Organization recommends that caries be diagnosed if pit and fissure or smooth surface lesions are cavitated and does not record incipient lesions as caries (86). This can result in an underestimation of the actual caries burden in high-risk children. While the recent Bangkok Declaration confirms the clinical definition of ECC, it does not speak to S-ECC (87, 88). However, S-ECC is still an important outcome to track in populations known to be at high risk for caries.

Going forward, researchers would be encouraged to try to use validated survey tools to help standardize data collection and analysis. Clinical researchers should also identify and record non-cavitated caries lesions. Lastly, researchers should continually strive to undertake more robust data analyses, such as multivariate regression (e.g., multiple logistic regression for ECC), to control for confounding variables.

CONCLUSION

Current literature reveals that many Canadian children are affected by ECC. The development of ECC appears to be strongly associated with social determinants of health including low household income and the level of parental education or employment status. Associations were also observed between ECC and the child's age at first dental visit and parental beliefs about child's oral health. Children with enamel hypoplasia are also at significantly greater odds for experiencing caries. Future research should include assessments of developmental defects of enamel to better understand the association between enamel hypoplasia and ECC. Multiple logistic regression should become standard practice to identify true risk factors for ECC as this methodology can help to control for confounders.

AUTHOR CONTRIBUTIONS

AP and SS contributed to design, acquisition, analysis, and interpretation, drafted manuscript, critically revised the manuscript, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. JL contributed to design, drafted manuscript, contributed to interpretation, critically revised the manuscript, gave final approval, and agrees to be accountable for all aspect of work ensuring integrity and accuracy. VC drafted manuscript, critically revised manuscript, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. CG contributed to acquisition, critically revised manuscript for important intellectual content, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. RS contributed to conception and design, contributed to acquisition, contributed to analysis, contributed to interpretation, drafted the manuscript, critically revised the manuscript, gave final approval, and agrees to be accountable for all aspect of work ensuring integrity and accuracy.

ACKNOWLEDGMENTS

RS holds a Canadian Institutes of Health Research Embedded Clinician Researcher salary award in Improving access to oral health care and oral health care delivery for at-risk young children in Manitoba. Operating funds for this research were provided through RS's CIHR Embedded Clinician Researcher program funds.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

REVIEW
published: 24 September 2019
doi: 10.3389/fpubh.2019.00271

Syria Profile of the Epidemiology and Management of Early Childhood Caries Before and During the Time of Crisis

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Syria has witnessed the greatest humanitarian crisis of forcibly displaced population since World War II. The present review aimed to outline Syria's profile of the epidemiology and management of early childhood caries (ECC). Before the crisis, the burden of ECC amongst Syrian pre-schoolers had been growing in prevalence and severity. Comparable data showed an increase in the burden of ECC amongst Syrian children aged five years, rising from 74% in 1991 to 81% in 2011, with a dmft value of 8.6. A similar increase was observed in the burden of ECC amongst Syrian children aged three years, rising from 50% in 1991 to 56% in 2011, with a dmft value of 6.1. Whilst there are no data on the burden of ECC during the current crisis, estimates could be extrapolated from data on the current burden of dental caries amongst Syrian primary school children living inside Syria or in informal settlements outside Syria. Such data suggested that the burden of ECC might have further increased amongst Syrian pre-schoolers during the crisis time. This is due to the crisis exacerbating effect on ECC risk factors, in terms of increasing the existing high sugar intake amongst Syrian pre-schoolers as well as increasing different barriers Syrian families face to fresh foods, sugar-free medicines, oral hygiene and fluoride products and accessing essential preventative dental care. Tackling the growing burden of ECC amongst Syrian pre-schoolers should not be postponed till post-crisis time. The seed work for relevant public health interventions could start and be embedded in different health and social initiatives taking place during the time of crisis. A number of public health interventions informed by relevant international and local (Syrian) studies conducted during the time of crisis have been suggested to tackle the burden of ECC amongst Syrian young children. They include a mix of upstream, midstream, and downstream interventions that aim to reduce sugar intake, improve feeding and oral hygiene practices, increase access to an appropriate source of fluoride and build the capacity of the Syrian dental and wider workforce to tackle the growing burden of ECC in Syrian pre-schoolers.

Keywords: Syria, early childhood caries, oral health, pubic health interventions, humanitarian crisis

OPEN ACCESS

Edited by:
Maha El Tantawi, Alexandria University, Egypt

Reviewed by:
Metin Güngörmüş, University of Gaziantep, Turkey
Hams Hamed Abdelrahman, Alexandria University, Egypt

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *30 April 2019*
Accepted: *09 September 2019*
Published: *24 September 2019*

Citation:
Joury E (2019) Syria Profile of the Epidemiology and Management of Early Childhood Caries Before and During the Time of Crisis. Front. Public Health 7:271. doi: 10.3389/fpubh.2019.00271

BACKGROUND

Syria is a Mediterranean country located in the Middle East, with a population of nearly 24 million people. Before the crisis, Syria was classified as a middle income country, with a health profile characterized by a high burden of non-communicable diseases (NCDs), including obesity, cardiovascular diseases, type 2 diabetes, and dental caries. Syria had a universal health care system with a vaccination coverage of nearly 99% (1).

Recently, Syria has witnessed the greatest humanitarian crisis of forcibly displaced population since World War II. According to the UNHCR, the recent marked increase in the global population of forcibly displaced people was driven mainly by the Syrian crisis (2). The latter has resulted in more than 13 million Syrians displaced within and outside Syria, of which over 5 million refugees are in neighboring countries: Lebanon, Jordan, Iraq, Turkey and Egypt (2). More than half of these refugees are children (2).

The present review aimed to outline Syria's profile in terms of the epidemiology and management of early childhood caries (ECC). More specifically, the objectives of the current work were to:

(i) Give an overview of the prevalence, trend, and impact of ECC before and during the Syrian crisis,
(ii) Outline risk factors of ECC amongst Syrian pre-schoolers with a special focus on the role of the humanitarian crisis as an exacerbating factor, and
(iii) Suggest evidence-based recommendations for the management of ECC in Syria from relevant international and local studies.

This review of literature searched MEDLINE via PubMed through August 2019. The following key words were used for the PubMed search: Syria* and (oral or dent*). Additionally, other resources of gray literature relevant to oral health in Syria were searched. There was no language restriction.

PREVALENCE, TREND, AND IMPACT OF ECC IN SYRIA BEFORE THE TIME OF CRISIS

Before the current crisis, Syria, like other countries in the Middle East, had a high burden of dental caries amongst children aged 5 years and under. Few studies have been conducted to estimate this burden. They varied in their methodological approaches and rigor. Most of them used the World Health Organization criteria for caries diagnosis and were conducted in Damascus (the capital city). Very few studies were carried out in other cities (e.g., Latakia and Aleppo). There are no Syrian national dental health survey data for pre-schoolers.

Taking into consideration the aforementioned limitations in terms of the quantity and quality of available (published and unpublished) studies, and using "comparable" data to make inference on ECC trends, it seems that the burden of ECC amongst Syrian 5-year-olds had been increasing from 74% in 1991 (3) to 81% in 2011 (4), with a dmft value of 8.6. The prevalence of severe ECC among pre-schoolers at the age of five was 77% (4). Amongst 3 year old Syrian children, a similar increase in the prevalence of ECC had been observed, rising from 50% in 1991 (3) to 56% in 2013 (4), with a dmft value of 6.1. The majority of pre-schoolers had untreated ECC (dt) (3, 4).

The impact of ECC on the quality of life of Syrian young children and their families was reported in a cross-sectional study (4). The latter used the Arabic version of Early Childhood Oral Health Impact Scale and included a sample of Syrian pre-schoolers with ECC aged between 3 and 5 years. The most frequently reported impact of ECC (experienced occasionally, often or very often) was pain (75%) followed by family feeling upset (52%) and having difficulty to chew food (48%).

PREVALENCE, TREND, AND IMPACT OF EARLY CHILDHOOD CARIES (ECC) IN SYRIA DURING THE TIME OF CRISIS

During the Syrian crisis, no studies have to date been conducted to estimate the burden of ECC amongst pre-schoolers (including those who have or have not been internally or externally displaced). Emerging evidence from protracted Syrian refugee informal settlements in Lebanon suggests that the burden of ECC might have increased amongst refugee pre-schoolers. Such estimation is based on the findings related to the burden of dental caries amongst older Syrian children attending refugee primary schools in Bekkaa, Lebanon (5). The prevalence of dental caries has hit a record high of over 90% amongst these children. Oral pain was reported by 57%, of which 55% had moderate to severe oral pain and 38% had oral pain for more than a month (5). Furthermore, 9% had dental abscess. The difference in the number of teeth with untreated dental caries between children in a protracted displacement situation and those who have been displaced for <5 years was highly statistically significant (5). This suggested that protracted displacement might lead to an increase in the burden of dental caries amongst children and the deterioration of their oral health. Similar findings were reported by another study conducted on a small convenience sample of Syrian refugee children aged 6–12 years at al-Zaatari camp in Jordan (6).

Indeed, when comparing oral health between Syrian refugee children and their counterparts who had not been displaced or had been internally displaced within Syria it appears that the former had a much higher burden of dental caries compared with the latter. For example, a recent cross-sectional survey (7), conducted on Syrian children aged 8–12 years living in Damascus, reported 79.1% caries prevalence. The latter is more than 10% lower than the caries prevalence found amongst Syrian refugee children of the same age group (5). It is worth mentioning that Damascus is one of the Syrian cities that have had the highest prevalence of dental caries and now is hosting a mix of children that had not been displaced as well as children who had been internally displaced in Syria. This implies that the prevalence of oral diseases amongst Syrian refugee children in low and middle-income countries is much higher than the highest prevalence of oral diseases found in the country of origin (Syria). In other

words, the Syrian crisis affected negatively the whole Syrian child population on a scale of intensity that is proportionate to the extent of displacement. Syrian children who have not been displaced are less affected compared with their internally displaced counterparts, who in turn are less affected than their refugee or externally displaced peers.

Syrian refugee caregivers had voiced strong concerns about their children's oral health in humanitarian settings and its considerable impact on families (8). Child's dental pain had been repeatedly reported to cause considerable distress for Syrian refugee parents (and children) and served as a trigger for deeper feelings of anger, frustration and helplessness (8). This might explain why international humanitarian organizations such as the UNICEF and UNHCR have become highly interested in addressing the burden of dental caries amongst displaced and refugee children (9, 10).

RISK FACTORS FOR ECC AMONGST SYRIAN CHILDREN

A number of studies explored the proximal (behavioral) and distal (social) risk factors of ECC amongst Syrian pre-schoolers. Behavioral risk factors focused on poor feeding practices, high sugar intake, poor oral hygiene, limited exposure to an appropriate source of fluoride and low dental care utilization. The role of the current Syrian humanitarian crisis as an exacerbator for ECC risk factors was noted in the literature.

Poor Feeding Habits Amongst Syrian Pre-schoolers

Although breastfeeding is the most common type of infant feeding in Syria some poor feeding practices were identified. A recent cross-sectional study that targeted 1 year old Syrian infants attending vaccination clinics in Damascus found that 47% of infants were breastfed, 42% were breast and bottle fed and 11% were exclusively bottle fed (11). The use of exclusive bottle feeding was more common amongst working mothers (11). Nearly 50% of Syrian infants who used the bottle were put to sleep with the bottle (11, 12), increasing therefore the risk of having ECC. Additionally, other poor infant's feeding practices such as the prolonged use of bottle-feeding (beyond the child's first birthday) were identified among Syrian pre-schoolers with ECC (12).

High Sugar Intake Amongst Syrian Pre-schoolers

A number of studies have highlighted the high intake of sugar (i.e., free sugars) among Syrian pre-schoolers, which tends to start early during their first year of life. Nearly 43% of Syrian infants had high frequency of sugar intake (>4 times a day) (11). Furthermore, 75% had sugar added to their beverages (11). Amongst Syrian pre-schoolers aged 3 to 5 years, 86% had 3–4 meals and/or snacks with high sugar content daily (12).

In regard to child's liquid medicines available on the Syrian market, the vast majority has sugar. The number of sugar-free medicines has dropped during the current Syrian crisis (13). Additionally, a cross-sectional study found that only 18% of Syrian pediatricians were aware of sugar-free liquid medications available on the Syrian market and only 10% prescribed such medications (13).

Poor Oral Hygiene and Limited Access to an Appropriate Source of Fluoride Amongst Syrian Pre-schoolers

Less than six percent of 1 year old infants had their teeth cleaned regularly with a toothbrush or piece of clean gauze (11). The percentage of pre-schoolers aged 3–5 years who had their teeth cleaned at least twice a day had increased from 1.4% in 2007 (12) to 12.3% in 2011 (4). Fluoride toothpaste was rarely used amongst Syrian infants (11).

Community-based water or salt fluoridation schemes have to date not been possible in Syria (3). Very few Syrian areas contain naturally fluoridated water at either sufficient levels to protect tooth decay (nearly 1 ppm) or excessive levels that might cause fluorosis (e.g., Palmyra and Alhasak) (3).

A recent study highlighted that preventive oral care products, including fluoride toothpastes, gels, and varnishes, that adhered to evidence-based recommendations were either few in number or not available on the Syrian market (14). Several fluoride toothpastes had fluoride concentrations that were low (i.e., below the effective concentration for caries prevention), or high with potential long-term toxic effects in children. Thirteen toothpastes with fluoride concentration <1,000 ppm claimed to have anticaries effects. Another three fluoride toothpastes did not declare their fluoride concentration. Additionally, 17 toothpastes with high fluoride concentration were available for purchase without prescription and had instructions for use in children younger than the safe evidence-based recommended age. In terms of fluoride gels and varnishes, only three fluoride gels were available (14). No fluoride varnish was found (14), which is known to be more effective than the gels for prevention of dental caries (15). During the current Syrian crisis, the number of preventive oral care products available on the market has decreased and some of the currently available products are still non-adherent to evidence-based recommendations (14).

Low Dental Care Utilization Amongst Syrian Pre-schoolers

Low dental care utilization is another risk factor of ECC amongst Syrian pre-schoolers. Less than two percent of young Syrian children had visited the dentist by their first birthday (11).

Social Risk Factors of ECC Amongst Syrian Pre-schoolers

A few studies documented social inequalities in ECC amongst Syrian pre-schoolers (4). Socioeconomic inequalities were also identified in the frequency of sugar intake among Syrian infants (11). Infants whose fathers were not working were more likely to have high frequency of sugar intake compared to their counterparts whose fathers were working. Furthermore, Syrian infants whose mothers had low knowledge about infant's oral health behavior or high frequency of sugar intake were more

likely to have high frequency of sugar intake (11). Mother's knowledge of infant's oral health behavior and her frequency of sugar intake explained the socioeconomic inequality in infant's frequency of sugar intake. This suggested the importance of addressing such factors (i.e., mother's knowledge of infant's oral health behavior and her frequency of sugar intake) to reduce inequalities in pre-schoolers' oral health. The vast majority of Syrian mothers reported the importance of primary teeth (94%) and voiced their desire to receive information about infant's oral health (99%) (11). Only 6% of Syrian mothers reported receiving information about child's oral health (11).

The Syrian Humanitarian Crisis as an Exacerbator for ECC Risk Factors Amongst Syrian Pre-schoolers

The Syrian humanitarian crisis has created many political, economic and social negative circumstances that had a profound impact on different living aspects of the Syrian population. The levels of mal- and under-nutrition had increased as a result of the disturbance in food channels during crisis time. For example, many Syrian refugee families mentioned barriers related to the availability and affordability of fresh foods (e.g., fresh fruits and vegetables) (8). The latter is expected in view of complex emergences and disaster context (16). Foods and drinks with high sugar content are usually more available at the camps' tuck shops at affordable prices. Additionally, due to forced displacement the family's daily routine is likely to be negatively affected and parents and carers are more likely to experience loss of control over their children's behaviors. The latter might be one of the reasons behind the increase in children's sugar consumption.

Similar to fresh food, refugee parents and carers face multiple barriers to oral hygiene products and accessing dental care, leading to the deterioration of their children's oral health.

RECOMMENDATIONS FOR THE MANAGEMENT OF ECC IN SYRIA

Tackling the growing burden of ECC amongst Syrian pre-schoolers should not be postponed till post-crisis period. It is acknowledged that there are many barriers to implement public health interventions to tackle the ECC burden in Syria during crisis time as opposed to post-crisis period. Nonetheless, the seed work for such interventions could start and be embedded in different health and social initiatives taking place at the time of crisis.

The following suggestions for public health interventions are not only guided by evidence emerging from international studies, but also and more importantly they are informed by evidence emerging from local studies showing the feasibility, acceptability and preliminary effectiveness and cost-effectiveness of such interventions within the Syrian context during crisis time. Yet, it should be acknowledged that institutionalizing such recommendations and rolling them out across the country during the time of crisis would need further larger national studies dedicated for investigating barriers and enablers to implementing these recommendations on a national scale. The dependency on external aids should be minimized, as such aids are unlikely to create sustainable changes (17).

Syrian oral health strategies should aim to decrease sugar intake, promote good feeding, and oral hygiene practices, increase exposure to an appropriate source of fluoride and build the capacity of the Syrian dental and wider workforce to promote oral health and tackle the growing burden of ECC across multi-sectoral settings.

A mix of sustainable and affordable upstream, midstream, and downstream interventions are recommended. The principles of propionate universalism (18) should guide the roll out of suggested interventions to ensure that the scale of their delivery is proportionate to the intensity and levels of needs.

Reducing Sugar Intake Amongst Syrian Pre-schoolers

Reducing sugar intake would not only improve the oral health of Syrian pre-schoolers, but also it would improve their general health. High sugar intake is a common risk factor for child's mal-/under-nutrition and dental caries.

The main effective and cost-effective means to reduce sugar intake amongst Syrian pre-schoolers is to develop and implement public health policies with related regulations and legislations. The following is evidence-based recommendations to inform governmental leaders and policymakers regarding potential public health policies and strategies to reduce sugar consumption particularly amongst young Syrian children.

The Syrian government should formulate country-specific goals to decrease the high levels of sugar consumption and reach the latest recommended maximum of 5% of total energy (19). This equates to ∼22 g/day for 4–6 year olds and 16 g/day for 1–3-year-old children (20).

Furthermore, the Syrian government should adopt the Health in All Policies (HiAP) framework. The latter would aid in developing intersectoral partnership among the Syrian ministries and yield large returns on investment as a result of targeting a common risk factor (i.e., high sugar intake), and preventing thereby a spectrum of childhood diseases (e.g., dental caries, malnutrition and obesity) (21, 22) as well as other sugar-related NCDs that young children are likely to develop over the life course (e.g., adulthood obesity, type 2 diabetes and dental caries) (23, 24). The HiAP approach should include:

- Introducing taxes on imported or locally manufactured sugary foods and drinks in Syria: sugar is easy to tax because it goes through a long chain. Introducing a tax on sugar as a mass commodity is the simplest form of sugar taxation (25). It is recommended to have an increase by at least 20% in the retail price of sugary items to achieve a desirable effect on consumers' demand and hence consumption (25). No taxes should be imposed on sugar-free foods, drinks or medicine products. Sugar-tax returns could be used to subsidize the prices of fresh vegetables, fruits, and sugar-free medicines available on the Syrian market.
- Introducing regulations and legislations pertaining to the Syrian food industry: the Syrian government should put pressure on the food and pharmaceutical industry to reduce

the sugar content in their products and offer a wide range of sugar-free alternatives (25). Appropriate legislations are needed to support such efforts. Additionally, clear and unbiased labeling is key. Products containing more than 2.5% free sugars should be labeled as "high."

- Policies on food provided particularly in nurseries, kindergartens, maternal, and child community centers in Syria: packed lunches and food provided in nurseries and other young children's settings should be sugar free or at least sugar reduced (25). Fruit juices and sugar-containing treats and confectionaries should be limited to a maximum of 2.5% energy intake.
- Restrictions on the advertisement of sugary foods and drinks in Syria: the Syrian government should set more stringent codes of practice and restrictions on the advertisement of sugary foods and drinks, particularly to children (26).
- Calling the Regional Office of the World Health Organization for the Eastern Mediterranean to review its recommendation on adding little quantities of sugary items to baby's food (27). The latter is still communicated to Syrian mothers in early childhood programmes.
- All the aforementioned policies should be supported with initiatives to increase the public awareness of the need to reduce the intake of sugary food and drinks from infancy throughout the life course, using integrated pre/post-natal interventions within the Syrian national nutrition and maternal and child programmes (e.g., the Syrian breastfeeding and vaccination programmes). These whole population interventions should be supported by other tailored oral health education and dietary interventions to target vulnerable or disadvantaged Syrian families to reduce social inequalities (11).

Promoting Good Feeding and Oral Hygiene Practices and Increasing Exposure to an Appropriate Source of Fluoride Amongst Syrian Pre-schoolers

Public health interventions should aim to promote good feeding and oral hygiene practices as well as increase exposure to an appropriate source of fluoride amongst Syrian pre-schoolers. Fluoride toothpaste might be the only vehicle that could provide Syrian infants and pre-schoolers with access to fluoride (28). However, this should not cease efforts to explore the feasibility of salt or water fluoridation schemes in Syria. Water fluoridation mapping and feasibility studies were conducted in Syria during the 1980s and thus they are quite dated now. The following is evidence-informed recommendations based on a number of recent local studies (14, 28–30):

- Running community-based programmes to establish tooth-brushing with fluoride toothpaste and bottle feeding termination practices amongst Syrian infants: a randomized controlled trail demonstrated the feasibility, acceptability and preliminary effectiveness and cost-effectiveness of such interventions in the Syrian context (28). This trail integrated the intervention within the Syrian national vaccination programme and delivered an oral health promotion package free of charge, without health workers' counseling. The package included an infant oral health pamphlet, a baby toothbrush, fluoride toothpaste (1,000 ppm) and a trainer cup. Infants who received this package were less likely to have old plaque (as a measure of tooth brushing behavior) and more likely to stop bottle-feeding than their counterparts who did not receive the package.
- Carrying out national water and salt fluoridation mapping and situation analyses: this would assess the feasibility and acceptability of rolling out water or salt fluoridation schemes. Such schemes have shown in other countries effectiveness not only in decreasing ECC but also in reducing oral health inequalities amongst pre-schoolers.
- Running targeted fluoride varnish or silver diamine fluoride school-based programmes for vulnerable/disadvantaged groups of pre-schoolers, such as those with special needs (29, 30).
- The Syrian Ministry of Health should review its regulations and carry out necessary reforms for fluoride products so that they become subject to drug monitoring systems to ensure effective and safe fluoride concentrations in such products (14).
- Effective communication should be established with Syrian manufacturers to reformulate their preventive oral care products to have evidence-based effective and safe fluoride concentrations, labeling and instructions for use (14). The return on investment of producing silver diamine fluoride and fluoride varnish locally should be investigated. Additionally, strict regulations should be imposed on imported preventive oral care products. All available self-care products should have instructions for use written in Arabic, so they can be read and understood by Syrian consumers (14).
- The Syrian Arab Committee for Measurements and Standards needs to update its standards related to preventive oral care products (14). The latest update took place in 1995 and it is quite dated now. Several preventive care products that are available on the Syrian market include instructions for use that contradict current evidence-based international recommendations (14).

Building the Capacity of the Syrian Dental and Wider Workforce to Tackle the Burden of ECC Amongst Syrian Pre-schoolers

As there is "No health without health workforce" (31), it is important to ensure that the Syrian dental workforce has the right capacity and capability to tackle the growing burden of ECC. Before the crisis, there were nearly 20,000 registered Syrian dentists with nearly 2,000 new dental graduates annually. Although there are no data on the current capacity and capability of the Syrian dental workforce it is expected that these two aspects have been negatively affected during the current Syrian crisis. A brain drain of the Syrian dental workforce had taken place during the crisis time. Thus, it is important to develop capacity building strategies and interventions to ensure that the Syrian dental and wider workforce is able to address the burden of ECC in Syria.

The following is recommendations based on a number of recent regional and local studies (14, 17, 29, 30):

- Reforming and modernizing healthcare curricula to ensure the competencies around oral health promotion and ECC evidence-based prevention are embedded across dental, medical, and pharmacy curricula taught in Syrian universities. The modernization of the dental public health discipline in Damascus University, with its outreach programme and activities "Syrian Smiles" (28, 29) is a successful example of building the competency of dental under- and post-graduates in oral health promotion and prevention for children during the time of the Syrian crisis.
- Promoting skill mix in dentistry in Syria through introducing appropriate governance and educational reforms: such reforms would ensure the presence of (i) a clear scope of practice for Syrian dental nurses and hygienists; (ii) regulations and legislations governing the work of dental care professionals (DCP) within the Syrian healthcare system and dental services; and (iii) modernized DCPs curricula that include training on up-to-date evidence-based preventive care for children. The possibility of training community health care workers (CHCWs) on delivering outreach basic preventative care to families with young children could be considered. Yet, supportive evidence is needed regarding its feasibility, acceptability and cost-effectiveness.
- Running continuing professional development (CPD) courses for the Syrian dental and wider workforce (e.g., doctors, pediatricians, midwives, and pharmacists etc.) dedicated to promoting the oral health of pre-schoolers.
- The Syrian General Dental Association should distribute a user-friendly booklet for preventive care to assist dental practitioners in implementing evidence-informed preventive care (14).
- Establishing a national team responsible of conducting regular national oral health surveys for Syrian children aged 5 years: this is highly important to monitor the trends in ECC among Syrian children and evaluate the national and local oral health interventions aiming to tackle the ECC burden in Syria.

CONCLUSION

Syria has witnessed the greatest humanitarian crisis of forcibly displaced population since World War II. The burden of ECC amongst Syrian pre-schoolers had continued to grow in prevalence and severity. The humanitarian crisis had exacerbated ECC risk factors, in terms of increasing the existing high sugar intake amongst Syrian pre-schoolers as well as increasing different barriers Syrian families face to fresh foods, sugar-free medicines, oral hygiene and fluoride products and accessing essential preventative dental care. The seed work to tackle the burden of ECC could start and be embedded in different health and social initiatives taking place during the time of crisis. A number of public health interventions informed by international and local (Syrian) studies have been suggested to tackle the ECC burden amongst Syrian young children. They include a mix of upstream, midstream, and downstream interventions that aim to reduce sugar intake, improve feeding and oral hygiene practices, increase access to an appropriate source of fluoride and build the capacity of the Syrian dental and wider workforce to tackle the growing burden of ECC in Syrian pre-schoolers.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

REVIEW
published: 15 November 2019
doi: 10.3389/fpubh.2019.00337

Early Childhood Caries in Peru

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Early Childhood Caries (ECC) is a global oral health problem, and Peru may be one of the countries with high prevalence of untreated ECC in South America. In this study, we constructed an epidemiologic profile of ECC in Peru through a comprehensive review of published data. The prevalence of ECC, risk factors for it, its impact on child development, and public oral health interventions on ECC have been included. The study revealed extremely high rates of ECC in Peru and significant oral-health disparities. Risk factors for ECC were poverty, high sugar consumption, and low oral health literacy. However, the number of studies is limited and their quality questionable. Oral health has not received high public-health priority in Peru. However, in recent years, new regulations and evidence-based documents (the first Clinical Practice Guideline for the Prevention, Diagnosis, and Management of Caries in Children; the Guideline for Children's healthy Growth and Development; the Law on Healthy Diet; and the Manual on Food Advertising) give hope for the future of infants' oral health in the nation.

Keywords: early childhood caries, dental caries, Peru, oral health education, oral health children, oral health related quality of life

OPEN ACCESS

Edited by:
Maha El Tantawi,
Alexandria University, Egypt

Reviewed by:
Nneka Kate Onyejaka,
University of Nigeria, Nigeria
Nourhan Mostafa Aly,
Alexandria University, Egypt

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *30 April 2019*
Accepted: *28 October 2019*
Published: *15 November 2019*

Citation:
Castillo JL, Palma C and Cabrera-Matta A (2019) Early Childhood Caries in Peru. Front. Public Health 7:337. doi: 10.3389/fpubh.2019.00337

OVERVIEW OF PERU

Peru is the third largest country in South America, located in the western side of the continent, facing the Pacific Ocean. Peru is divided into three regions: the Andean region; the Amazon jungle; and the coast, facing the Pacific Ocean. The three regions have unique geography, culture, ethnicity, and economic development.

The estimated population of Peru was 31,237,385 inhabitants according to the most recent census (1). Children under 14 years of age constituted 26.4% of the population, and the total population of children 0–5 years old was 3,405,500. Peru is considered a developing country, with upper-middle income economy, according to the World Bank (2).

This article presents an overview of the status of early childhood caries (ECC) in Peru, a country with limited public health resources.

EPIDEMIOLOGIC PROFILE OF ECC (PREVALENCE)

Only two national epidemiologic studies on caries in primary teeth have been carried out in Peru. Both studies were designed by the National Center of Epidemiology, Prevention, and Disease Control of the Ministry of Health. The first study, conducted during 2001–2002, found that the prevalence of caries at age 6 years was 87.3% ($n = 1,280$), with an average dmft (decayed, missing, and filled teeth) of 6.7; the contribution of the decayed component was 6 of 6.7, revealing a high proportion of untreated caries (3). Although this study did not include younger children, results revealed that ECC has been a public health problem in Peru for more than 15 years (4).

The second national study found a caries prevalence of 76.2% in 3–5-year-old children ($n = 2,195$). The data were collected in all 25 Peruvian cities, across the three regions, between 2012 and

2014. The average dmft at this age range was five, with the decayed component contributing 4.5 to this score (4). Even though this study is the biggest ever conducted in the country and played an important role in better understanding of the extent and magnitude of ECC, the prevalence might be underestimated because WHO criteria were used and initial non-cavitated lesions were not considered. This methodologic problem was evident in three recent studies in Lima, which reported prevalence in two populations: those with and those without non-cavitated lesions (5–7). From those investigators' results, the prevalence of ECC is underestimated by about 11.9–24.8%, depending on the type of population. Severity measures, such as number of affected teeth, are also greatly underrated when cavities are the caries diagnostic threshold.

A selection of studies on ECC prevalence in Peru published in the last 10 years is shown in **Table 1**. More than 50% of the studies were conducted in children 3–5 years old with complete primary dentition. Although sample sizes were small, there were some important findings: Reported prevalence according to WHO criteria is above 70% in all studies, and average dmft is between 3.6 and 5 (6, 9, 11, 13, 14, 16, 17, 20). Data on younger children are sparse; only two studies have reported prevalence on children younger than 3 years (12, 15). Both studies included initial non-cavitated lesions in their criteria for assessment of caries, and they found a prevalence of 65.8 and 46.3% in 1–3 year-old and 6–36 month-old children, respectively. It is noteworthy also that, overall, higher prevalence was found in underserved groups, a finding that is supported by a recent systematic review of parental factors influencing ECC in developing nations, in which socioeconomic status was found significantly associated with ECC in 13 studies (21).

The studies on ECC in Peru, shown in **Table 1**, have limitations. Few of these reports have undergone a peer-review publication process; most are undergraduate theses published in online national repositories. Moreover, many of the reports did not describe the calibration process, and most did not report intra- and inter-Kappa coefficients. Another limitation is that the variation in levels of caries detection limits our ability to compare prevalence rates in cities in Peru and worldwide. Among the criteria used in national studies, we found these: WHO, WHO plus initial non-cavitated lesions, and International Caries Detection and Assessment System (ICDAS) (**Table 1**).

According to the article published by Kassebaum et al. (22), the age-standardized prevalence and incidence rates of untreated dental caries in deciduous teeth in 2010 for both sexes combined in the Andean region, which Peru is part of, was 8.3 and 14,470, respectively. Also, El Tantawi et al. reported that Peru is in the group of countries with highest prevalence of caries in children aged 36–71 months, between 75–100% (23).

Summarizing, dental caries in Peru is the most prevalent disease in school and preschool children and the main reason for external visits in primary healthcare centers. The prevalence and severity of this disease are dramatic, and they increase with age. Since Peru is among countries with the highest prevalence of caries in children in South America, urgent action is needed to reverse this situation.

RISK FACTORS OF ECC IN PERU

According to the most recent definition of ECC, made during the ECC consensus meeting in Thailand, in 2018, dental caries is a dynamic and multifactorial disease, mediated by the biofilm and driven by sugar, that results in phasic demineralization and remineralization of the dental hard tissues. Dental caries also is determined by biological, behavioral, and psychological factors.

In this section, we will review the risk factors for ECC that have been studied in our country, considering that the number of studies is limited to specific groups, and extrapolation of the data to the whole population is difficult. We must remember that Peru is a diverse country with high disparities in oral health among the population.

Sugars as a Risk Factor for ECC

Latin America has the highest sugar consumption per capita (41.8 kg/years in the 2015–2017 period) among developed and developing regions in the world (24). In Peru, the per capita consumption is about 38.2 kg/years (25). WHO guidelines recommend that intake of free sugars provide $\leq$10% of energy intake, with further reductions to <5% of energy intake throughout life to protect dental health (26). Peruvian children consume sugars from a very early age (27). According to a study by the National Institute of Health (INS), in 2015, children aged 6–36 months old have a high carbohydrate consumption, averaging 126.7 grams per day. Children consume diverse products that may produce a high risk for dental caries, such as sugar cane, which may be chewed habitually (28), and panatela, a combination of rice and sugars and other components. Parents sometimes add sugars or honey to liquids their babies consume to produce a better flavor, but the parents have little knowledge about the harm these practices do to the dental tissues. Villena and Bernal (29), found that 73% of children started eating sugars in liquid form before 6 months of age; 30% of children under 5 months of age consumed sugars an average of 2.5 times a day, and the rate increased to 4.6 times a day in children 1 year of age. In a study by Castillo et al. (30), most Peruvian children were found to like milk sweetened with some type of sugar, and, whereas only 44% of children liked plain milk, 96% liked sugared milk.

Many studies about the relationship of sugar consumption and ECC in children under 6 years old have been published in Peru. Unfortunately, many of these studies have methodologic problems and uncertainty about representation of the sample. Some studies have found a correlation between ECC and sugar consumption in various forms (27, 27, 31, 32). A study by Flores and Montenegro (33), however, found no relationship between the daily consumption of sugars and ECC, but all the patients were at high risk, which may have biased the results.

Oral Hygiene

Peltroche et al. (34) found that among 3- to 6-year-old children with high caries risk, the most common factor was inadequate oral hygiene and visits to the dentist. Diaz et al. (35) found a relationship between poor oral hygiene and ECC in children under 3 years old. According to Rios (36) and Vega (37), the main

TABLE 1 | Caries prevalence in children under 6 years old in Peru, 2010–2019.

References	Type of Population (age)	Sample size	Caries criteria	Prevalence	Average dmft**
Gonzales and Villena (5)	Preschoolers in a poor urban community in Lima (1–5 years)	230	ICDAS	87.2% 99.1%*	NR
Del Aguila and Isuiza (6)	Preschoolers in an underserved community in Loreto (3–5 years)	230	WHO	78.3%	NR
Olivera and Villena (8)	Preschoolers in an urban community in Lima (1–5 years)	230	ICDAS	59.1% 77%*	3.5 5.2*
Jiménez-Guillén and Cárdenas-Flores (9)	Preschoolers in a poor urban community in Lima (3–5 years)	92	WHO	72.8%	NR
Quiroga and Villena (7)	Preschoolers and babies during routine pediatric check-up in a poor urban community in Lima (1–5 years)	250	ICDAS	68.8% 93.6%*	5.4 10.6*
Huarachi and Barreda (10)	Schoolchildren in urban community in Arequipa (2–6 years)	192	NR	81.2%	4
Saravia and Macedo (11)	Preschoolers in an underserved community in Puno (3–5 years)	130	ICDAS	98.5%	NR
Clemente and Ortiz (12)	Routine pediatric check-up in mayor Hospital in Lima (6 months−3 years)	130	ICDAS II	46.3%	NR
Tobler et al. (13)	Preschoolers in an underserved community in Iquitos (3–5 years)	246	WHO	95.9%	5
MINSA (4)	Preschoolers from the three regions—National study (3–5 years)	2,195	WHO	76.2%	5
Muñoz-Luna (14)	Preschoolers in a poor urban community in Lima (3–5 years)	212	WHO	81.5%	NR
Cardenas-Flores and Perona-Miguel de Priego (15)	Schoolchildren in urban community in Ica (1–3 years)	231	WHO plus initial lesions	65.8%	NR
López-Ramos (16)	Preschoolers in a poor urban community in Huaura-Lima (3–5 years)	153	WHO	76.5%	3.6
Tamayo (17)	Preschoolers in a poor urban community in Lima (3–5 years)	90	WHO	85% (3 years) 90% (4 years) 92% (5 years)	3.6 (3 years) 4.3 (4 years) 5.9 (5 years)
Sanchez-Huamán and Sence-Campos (18)	Preschoolers in an underserved community in Lima (3 – 4 years)	623	WHO	70.6%	3.4
Villena et al. (19)	Routine pediatric check-up in poor urban communities in Lima (6 months−5 years)	332	WHO plus initial lesions	62.3%	3
Torres (20)	Schoolchildren in an underserved community in Lima (3–5 years)	246	NR (cavities)	83.7%	4.6

**Initial non-cavitated lesions (white spot) included.*
***dmft- decayed, missing, filling per tooth.*
NR, Not reported.

tools used for oral hygiene in children under 6 years old was a piece of gauze or a toothbrush.

Oral Health Literacy

According to Cupé-Araujo and García-Rupaya (38), 29.2% of Peruvian mothers of infants have deficient or irregular knowledge or oral health. Chambi (39) found that the level of oral health knowledge was poor in young mothers of children under 5 years old; those mothers did not receive any information about oral health when they were pregnant. Benavente et al. (40) found that even with a higher knowledge of oral health in mothers of children under 5 years old (77.6% of mothers had regular and good knowledge of oral health), ECC levels were high. Clemente and Ortiz (12) found that 55.4% of mothers of children under 3 years old did not receive any information about oral health.

Nutrition and Dental Caries

Several studies on nutrition and dental caries have been conducted in Peru (41–43). The authors have found that one mild-to- moderate malnutrition episode during the first year of life is associated with increased caries in both the deciduous and permanent teeth. In another study, Delgado-Angulo et al. (44) found that stunting was a significant risk indicator for caries in permanent teeth over a 3.5-years period, independent of other well-known risk factors for caries development. Another study found no correlation between nutrition status and dental caries (45), although others (46) have reported a possible connection between malnutrition, enamel defects, and dental caries.

Socioeconomic Factors

Several studies worldwide have found a relationship between dental caries and socioeconomic and education status. The only

study that addressed this issue in Peru was that of Delgado-Angulo et al. (47), who found that poverty and social exclusion were associated with dental caries in primary and permanent dentition, and that children living in poor households had 2.25 times more risk for dental caries than did children living in non-poor households; although this study is the only one published regarding socioeconomic factors and ECC in Peru, the relation between poverty and ECC seems evident.

Despite the small sample size in many of the studies described above, which limits the generalizability of the results in the overall Peruvian population, many risk factors that influence the presence of ECC in Peruvian children have been established.

IMPACT OF ECC ON IMMEDIATE AND LONG-TERM GROWTH, DEVELOPMENT, SOCIAL, AND MENTAL HEALTH, AND WELL-BEING

During the ECC Summit in Thailand (2018), dental caries was described as common, usually untreated, and having a deep impact on children's lives. According to Martins et al. (48), dental caries is the main oral condition with the greatest impact on children's quality of life. Several studies have reported the impact of untreated dental caries on the quality of life of preschool children (49, 50). Lopez-Ramos and Garcia-Rupaya (16), using the Early Childhood Oral Health Impact Scale, validated in Spanish, found that ECC had a negative impact on oral health-related children's quality of life. However, there is little information published on the impact of ECC on the quality of life of Peruvian children.

A study by Diaz-Pizan (51) evaluated the quality of life related to oral health before and after dental treatment in children from Lima younger than 6 years of age. The average total score before treatment of children with ECC was 17.89, which decreased to 2.57 after treatment.

PUBLIC ORAL HEALTH INTERVENTIONS AND DOCUMENTS

Untreated dental caries is a huge burden for Peru's health economy (52). However, public health policies haven't given priority to oral health, probably because of the greater demands of life-threatening, prevalent diseases. Most community programmes have had no impact on reducing ECC prevalence in Peru, especially in the younger and underprivileged populations.

Fortunately, during the last few years, the Peruvian Ministry of Health has issued official documents on the importance for children's oral health (described below) (53). It remains to be seen if those documents will standardize oral health messages among health professionals and increase the use of protective factors during the first year of life.

Community Programs

- In 1985, the Peruvian Ministry of Health approved a resolution to add fluoride to all commercially available salt (200 ppm of sodium fluoride per kg) (54). To date, there is no epidemiological data available on the effectiveness and/or employment of this resolution.
- In the year 2001, the Ministry of Health issued a guideline to regulate the use of glass ionomer cements for atraumatic restorative treatment. This guideline tried to offer a population approach to caries management with hand instruments (55).
- Other health strategies have been implemented in the past. They include the program "*Salud Escolar*" (Healthy Schools), started in 2013 and administered by the Health Promotion Department, which offers integral health evaluation and counseling to preschool and primary students in public schools. Oral examinations were performed on children, and basic oral health education was given to parents and teachers. The program intended to promote healthy habits in public schools (including toothbrushing) and provide a healthy environment (including healthy snacks in school kiosks) (56). Although the use of a common risk-factor approach is valid, no surveillance was performed. Thus, the positive outcomes of these programs have not been quantified and published.
- The main barriers to implementing preventive programs in Peru are the meager financial resources designated to children's health in general, but especially to oral health.

New Documents

- In 2017, the Peruvian Ministry of Health issued the first Clinical Practice Guideline for the prevention, diagnosis, and management of caries in children below 11 years of age (57). (Eleven years is the age of the end of primary school education in Peru.) The recommendations of the Ministry are based on the best available evidence to assist practitioners and patients in making oral health decisions. The preventive recommendations (classified as grade A) include the regular use of standard fluoridated toothpaste from the time of eruption of the first tooth, the use of fissure sealants, and regular applications of fluoride varnish.
- In the same year, the Ministry of Health published the update of the Guidelines for the Healthy Growth and Development of Children below 5 years of age (58). The norm by which all nurse and health professionals abide states that oral health is a "priority issue" and that all children must be referred to a dentist or pediatric dentist before age one. The oral health appendix includes tables and pictures in concert with the national Clinical Practice Guidelines on dental caries; it comprises topics such as toothbrushing technique (lifting the lip); diagnosis of early caries lesions (white spots); control of sugar intake; correct use of fluoridated toothpaste (concentration and amount depending on age); and oral health recommendations based on the age of pre-schoolers. Educating and including other health professionals in oral health promotion may yield improved results in the oral health-related quality of life of Peruvian children.
- Other recent and important regulations developed by an alliance between the Peruvian Ministry of Health and the Ministry of Education will probably have a positive impact on oral health. The "Law on Healthy Diet" (59) and the "Implementation Manual on Food Advertising" (60) promote

a healthier diet for all children and regulate commercial food labeling (black and white octagons). All food and beverages that contain high amounts of sugar, sodium or saturated fats, must indicate that in the corresponding octagons on the front of its package. The law was planned in two stages so that industries have time to adapt. The first stage is mandatory from June 2019. It states that all food products containing sugar $\geq$22.5 g/100 g and beverages containing sugar $\geq$6 g/100 ml should have a "High in Sugar" Octagon. The second stage, due September 2021, will require all food products containing sugar $\geq$10 g/100 g and beverages containing sugar $\geq$5 g/100 mL to have the "High in Sugar" Octagon. Moreover, an ordinance for "Healthy Kiosks" was passed, so that all public schools offer healthy food options for all students inside and outside their premises (61).

CONCLUSIONS

Early childhood caries has recently been designated a global health problem (48, 62, 63). Despite limitations and variability across studies that have been conducted in Peru, we believe that Peru is amongst the countries with the highest prevalence of untreated ECC in the region, with negative consequences on the quality of life of preschoolers. High sugar consumption and oral health disparities (poverty, social exclusion, and low oral health literacy) may contribute to the high prevalence of ECC. From a research point of view, greater effort should be made to standardize methods in studies on ECC prevalence and related risk factors. It is also crucial to include children younger than 3 years old in national epidemiological studies, as was concluded in the recent WHO Global Consultation on ECC (63). Historically, public health policies have not given oral health high priority, but in the past 3 years, new regulations and evidence-based documents project a more favorable view on infant oral health in Peru.

AUTHOR CONTRIBUTIONS

JC has worked on the abstract, risk factors, quality of life, and conclusions sections. CP has worked on the abstract, prevention, quality of life, and conclusions sections. AC-M has worked on the epidemiology and conclusions section.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

POLICY BRIEF
published: 06 August 2019
doi: 10.3389/fpubh.2019.00210

Indonesia: Epidemiological Profiles of Early Childhood Caries

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The Indonesia government has succeeded in achieving national health development targets and has invested heavily in public health. Many positive results have been achieved, which indicate an increasing number of school-aged children free of caries and a decrease in caries experience scores. However, result of previous studies on early childhood caries (ECC) in pre-school children showed high prevalence and severity. Understanding the link between the epidemiology of the ECC and components of health development is critical for formulating appropriate actions. The purpose of this study is to provide a comprehensive review of the epidemiology of ECC in Indonesia based on the results of the national basic health surveys. The complementary data describes access, utilization and profile of oral health personnel in Indonesia.

Keywords: early childhood caries, Indonesia, caries, policy, children

OPEN ACCESS

Edited by:
Morenike Oluwatoyin Folayan, Obafemi Awolowo University, Nigeria

Reviewed by:
Selda Rizalar, Istanbul Medipol University, Turkey
Katalin Dr. Papp, University of Debrecen, Hungary

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *30 April 2019*
Accepted: *15 July 2019*
Published: *06 August 2019*

Citation:
Amalia R, Chairunisa F, Alfian MF and Supartinah A (2019) Indonesia: Epidemiological Profiles of Early Childhood Caries. Front. Public Health 7:210. doi: 10.3389/fpubh.2019.00210

INTRODUCTION

Dental caries affects people of all ages and remains the major problem of dental health among children worldwide (1). For preschool children, early childhood caries (ECC) defined as the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries) or filled tooth surfaces in any primary tooth in children <71 months of age (2). ECC is highly prevalent (3), associated with multiple risk factor (4), and reduces the quality of life (5). If ECC treatment is delayed, the condition of the child worsens and becomes harder to treat, increasing the treatment cost.

ECC is also highly prevalence in preschool children living in developing countries like Indonesia (6). Every 5 years, the Indonesian government conducts basic health surveillance. There are surveillance reports on oral health and caries in children for the years 2007, 2013 and 2018 (7–9). Unfortunately, direct comparison of data is difficult because the reporting format is not in a same manner for each year. This study will therefore be limited to a comprehensive review of the available data on ECC accessible from the basic health surveillance reports, and data from the scientific publications on ECC in Indonesia. Situational analysis of oral health services in Indonesia will also be explored. This description is intended to be a highlight of the factors associated with ECC in Indonesia that may facilitate the review of a national oral health policy for Indonesia.

ANALYSIS ON POLICY OPTIONS AND IMPLICATIONS

Epidemiological Data Analysis on ECC in Indonesia

Table 1 presents an overview of the prevalence of ECC and possible risk factors in Indonesia extracted from the basic health surveys conducted in 2007, 2013, and 2018 (7–9). This table is quite revealing in several ways. It is apparent from the table that more than half of children aged

TABLE 1 | Oral health data pertaining to preschoolers from 2007 to 2018.

Variables	2007	2013	2018
PERCENTAGE OF CHILDREN EXPERIENCING ORAL HEALTH PROBLEMS (PARENTS' PERCEPTION)			
Age <1 years	1,1	1,1	NA
Age 1–4 years	6.9	10.4	NA
Age 3–4 years	NA	NA	41.1
Age 5	NA	NA	57.9
PERCENTAGE OF CHILDREN WHO CLAIMED TO HAVE RECEIVED DENTAL CARE (PARENTS' PERCEPTION)			
Age <1 years	28,1	36.9	NA
Age 1–4 years	27.4	25.8	NA
Age 3–4 years	NA	NA	4.3
Age 5	NA	NA	9.5
PERCENTAGE OF CHILDREN WHO CLAIMED TO HAVE RECEIVED MEDICATION FOR DENTAL PROBLEMS (PARENTS' PERCEPTION)			
Age <1 years	83,0	NA	NA
Age 1–4 years	93.0	NA	NA
Age 3–4 years	NA	NA	39.8
Age 5	NA	NA	48.9
PERCENTAGE OF CHILDREN WHO TO HAVE RECEIVED FILLINGS OR AN EXTRACTION (PARENTS' PERCEPTION)			
Age <1 years	10.9	NA	NA
Age 1–4 years	9.7	NA	NA
Age 3–4 years	NA	NA	0.8
Age 5	NA	NA	2.0
PERCENTAGE OF RESIDENTS WHO CLAIMED TO HAVE BRUSHED THEIR TEETH PROPERLY (PARENTS' PERCEPTION)			
Age 3–4 years	NA	NA	1.1
AVERAGE SCORE OF DMFT			
Age 3–4 years	NA	NA	6.2
Age 5 years	NA	NA	8.1
PERCENTAGE OF CHILDREN WITH CARIES FREE			
Age 3–4 years	NA	NA	19.0
Age 5 years	NA	NA	9,9

NA, Not available.
Source: Ministry of Health Republic Indonesia (7–9).

5 years were experiencing oral health problem. Unfortunately, those who got treatment were only 9.5%. The data also looks unsatisfactory since only 2% of the children received treatment of fillings or extraction. The most disappointing results to emerge from the national survey is that a high prevalence of ECC and poor behavior on brushing teeth properly.

However, a comparison of the data could not be conducted because of inconsistencies in the measures of the oral variables used for the surveillances. ECC severity using the dmft index, was only conducted in 2018. Also, the data on the dmft was not disaggregated. Data on the proportion of preschoolers who brush their teeth properly was only available in 2018. Despite this limitation, the table highlights a few important issues. First, it suggests that prevalence of ECC is increasing over the study period, and second, it suggests that children age 3–4 years contribute significantly to the high prevalence of ECC in the country. Caries severity also appears to increase by almost a third between the ages 3–4 and 5 years.

Publications on ECC in Indonesia has been limited in scope. Most of them were conducted in cities with few participants. In 1992, a study on preschool-aged children in the Jakarta area showed an ECC prevalence of 85.17% (10). Other research on ECC conducted in Jakarta in 2001 and 2008 reported prevalence of 81.2% (11) and 80.95% (12), respectively. The study in 200l was conducted in children 3–5 year old while that in 2008 was conducted in 3 year olds. The studies suggest that the prevalence of caries increased with age. Lower prevalence were reported in studies conducted in West and East Java; in West Java ECC prevalence was 70% (13) while it was 42.9% or children aged 3 years in East Java. The prevalence of severe ECC was 57.1% in East Java (14). Caries prevalence of 94.3% was reported in 4–6 year old children in Yogyakarta (15), and a prevalence of 100 and 88.5% reported in 5-year-olds resident in South Kalimantan and North Sulawesi, respectively (16, 17). Identified risk factors for ECC studies in Indonesia include low maternal education (12, 15), poor maternal knowledge of oral health (13, 16), and consumption of cariogenic foods, which had a significant relationship with the severity of ECC (12). Children who do not brush their teeth regularly from an early age also had high risk of ECC (15).

Socio-Demographic Context

Indonesia is an archipelago state which is located between two continents (Asia and Australia) and two oceans (Indian and Pacific). The width of land area in Indonesia is around 1,916,862.2 km^2, while the width of its sea is about 3,257,483 km^2. Indonesia is a country with the fourth largest population worldwide (18). Indonesian people are comprised of many ethnics and cultures. There are more than 700 local languages and dialects in the daily life of its people (19).

It is evident that variations in caries prevalence among children are associated with multiple factors, including ethnicity and culture. Results of national basic health surveys in Indonesia also show that prevalence and severity of oral disease varies across ethnic groups. Yearly, the highest average caries index is found on the island of Borneo, followed by Java and Sulawesi. Factors like socioeconomic status, natural fluoride content in the water, and the culture of sweet food consumption have been suggested as causes of the high caries prevalence. unfortunately the data is presented in general for all ages, while specific data about ECC in children is not available. Interestingly, since the causes of caries are the same at all ages, it can be hypothesized that the variation in the prevalence of ECC across ethnic groups will not be much different.

Health Policy Implications on ECC

Indonesia is classified as a country with lower-middle income population with increasing rate of national income per capita (20, 21). Despite this, 6.8% of Indonesians are living below the poverty line (22). To secure sufficient and sustainable health financing, The National Health Insurance (NHI) scheme was initiated to improve the access of all citizens to health. The scheme was started in January 2014 with the aim of covering

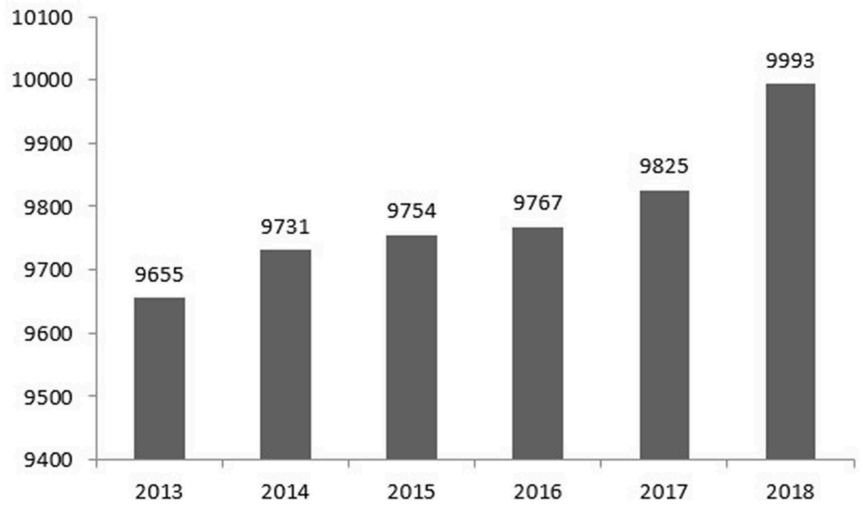

FIGURE 1 | Number of community health centers in Indonesia (2013–2018). Source: Ministry of Health Republic Indonesia (18, 27–31).

about 250 million by 2019, thereby making it the world's largest social health insurance (23). In the Indonesia NHI scheme, oral health service is included as one of the benefit packages received by people. Benefit package for oral care in primary care including counseling, curative treatment (teeth restoration and minor surgery) and dental emergency care (24). This NHI package is valid for all ages, including children. The package also includes treatments for caries in children, including preventive restoration of fissure sealants. Unfortunately, to date, there is no detailed data available regarding utilization by groups of children under 5 years of age and what types of care are received by children related to ECC.

Recently, Ministry of Health developed the oral health provision grand design for 2015–2030 with the goal of having a healthy Indonesia free of caries by 2030. The Healthy Indonesia Free Caries campaign roadmap is revised every 5 years. The Road map started with the issuance of the National Act Plan of Oral Health Service which focused on strengthening policy, resources, and oral health service delivery. Targets were set for caries control in 12 years old children, oral health program at Community Health Centers (CHCs) were standardized, and the role of school-based dental programs and community-based health efforts were strengthened (25). The grand design of oral health provision accompanied the emergence of national policy on oral health laid out in the Ministry of Health Decree No. 89/2015 which identified oral health as an integral part of general health (26). Oral health services for infants focus on maintaining the health of the oral cavity before the teething stage, up to the age of 12 months. Information on oral health is provided to the parents and other family members by (a) counseling them about the growth phase of primary teeth, the conditions that accompany the process of teething and related abnormalities or diseases that often occur in infants as well as (b) educating them on how to maintain the health of their infant's oral cavity before teething until the incisors grow fully. It is stated that oral health services for children under the age of 5 years (between 12 and 72 months) is not very different from that for infants (26). The synergy of oral health policy for pre school and school children is expected to be a good foundation for reaching the target because, in the first 6 years, parents are expected to get good education about caries prevention for children, and the next 6 years of oral health education are applied directly to the children.

It is worthy to note that recently, the government of Indonesia has implemented the decentralization policy in the health sector, under Law No. 23/2014 on Local Government, stated that local government has a responsibility to focus on the delivery of defined essential services (which include health) while the central government has the responsibility to determine the expected standard for the provision of services. Decentralization plays a part, with each authority having an important role in setting policy in its region; every region has a unique approach depending on its individual needs. Unfortunately, reports about the success of ECC prevention program that take advantage of the opportunity for decentralization have not been published.

The number of community health centers and health workers in Indonesia has increased rapidly in the last few decades. **Figure 1** shows the number of community health centers in Indonesia between 2013 and 2018. In 2013, this number stood at more than 9,600 units and then rose moderately to more than 9,700 units in 2014 and peaking at almost 10,000 units in 2018 (18, 25–31). **Figure 2** compares the number of health workers working at CHCs between 2013 and 2018. Nurses and midwives account for the largest share of health workers, followed by medical doctors and community health officers (at ∼20,000, respectively). Dentists accounted for the smallest share of health workers, with <10,000. Unfortunately, data on the national health profiles of dental therapists is only available for the years 2013 (10,150 persons) and 2014 (10,219 persons). The low number of oral health personnel and the unequal geographical distributions of existing oral health resources are constraints for the provision of oral healthcare. In 2018, 46.97% of CHCs did not have a dentist (18, 31).

Oral health personnel and CHCs have important role in the implementation of oral health policy regulations. Dental care

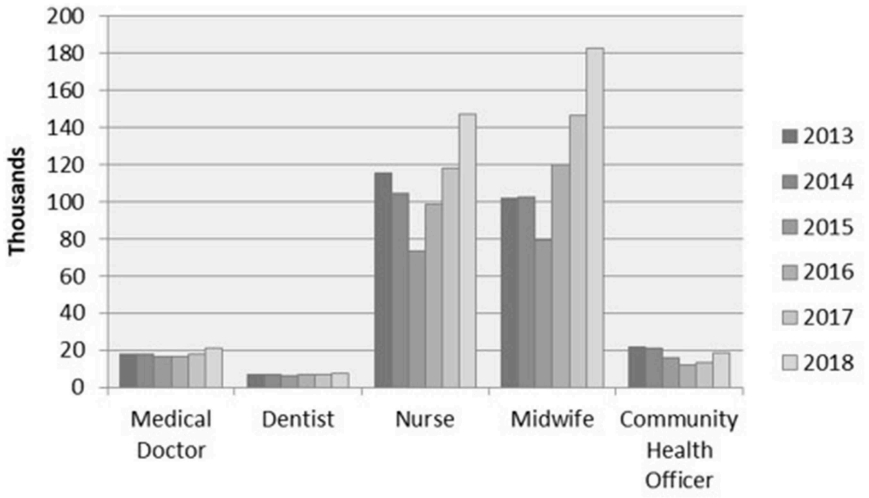

FIGURE 2 | Number of health personnel in community health centers (2013–2018). Source: Ministry of Health Republic Indonesia (18, 27–31).

has been offered to school children via the national school-based dental program (SBDP) for years. As part of the national school health strategy, SBDP are organized by community health centers located throughout Indonesia, and these aim to promote health by preventing oral disease and developing healthy behaviors. Community Health Centers also have responsibility to manage community-based dental programme where mothers and toddlers are the target of health programs including oral health. The issue of unsufficient number and unequal distribution of oral health personnel in Indonesia are quite worrying because the driving force for the dental public health program in CHC is expected to be the oral health personnel. It is evident that areas that have sufficient numbers of oral health personnel have been shown to have a school-based dental program that runs well and has a high rate of dental treatment to treat children's caries, and vice versa (32).

DISCUSSION

It is evident that the number of ECC studies carried out in Indonesia over the last 20 years is limited, yet in general the data generated consistently shows high prevalence. Methodological differences and confounding factors, especially socio-demographic influences, limit national comparisons of data on caries prevalence.

The increasing number of oral health personnel, along with the increase in the per-capita expenditure toward health services, does not seem to have had a significant impact. However, the decision maker (e.g., district health office) need to realize that the chosen strategic model to tackle ECC cannot be separated from the socio-economic context. For instance, since economic growth is a rapid process in Indonesia, consequently the consumption of sugar will be augmented. Therefore, dental caries in preschoolers can be expected to increase in coming years. In this case, successful cases of sugar restrictions policy in other countries could serve as examples of the importance of continuous oral health promotion (33).

Nevertheless, this approach is not without challenges. Sociodemographic variations can be a significant barrier, especially in low-income and low-education populations, and can have an impact on low awareness of the importance of oral health for children. This lack of awareness can be seen in the low rate of tooth brushing. This condition must be an alarm for policy makers because the current best practices for reducing the risk of ECC include twice-daily brushing with fluoridated tooth paste. Fortunately, due to policies in Indonesia, toothpaste is relatively affordable and must contain fluoride, so this should be an advantage in caries-prevention strategies. Following this, the role of parents is very important. This should be a concern because children's health development is very dependent on the health and well-being of their parents. The study concluded that some important health behaviors in parents, such as tooth brushing habits are important determinants of these behaviors in their young children. So promoting parent knowledge and attitude could affect their children oral health behavior and status (34).

Indonesia has had a series of policies regarding caries prevention strategies for children. The strength of this program is the direct involvement of parents for children under 6 years old, with parents at the center of counseling on how to maintain children's dental health. This program is community-based, with mothers as the targets. For children 6 years and older, the programs are directly applied and school-based. However, it is worth considering whether school-based dental programs that only focus on elementary education actually have a weakness, because children, at an early age (preschool, in kindergarten, or early childhood education), receive only limited information about good oral hygiene practices directly from oral health personnel. It is also important for oral health personnel to manage the ECC strategy for early childhood/kindergarten children conducted in schools, including conducting ECC risk assessments, teaching daily tooth brushing, and introducing the importance of regular dental visits.

Related to policy development at the regional level (decentralization), the role of the District Health Office is very important. Detailed directions or guidelines can be given to program implementers in the field regarding what should be conveyed to parents to prevent ECC, including the importance of avoiding sticky and sugary foods, not prolonging the use of bottles, and proper practice of oral hygiene. Decision-makers in each region will better understand the various approaches that can be attempted, depending on the specific conditions in each region. A policy of implementing a homogeneous strategy would not bring optimal results due to, for example, the presence of language and literacy barriers in remote and underdeveloped areas. Providing information using local languages or adapting modifiable procedures to cultures can help to overcome obstacles to understanding how to implement healthy behavior.

Despite limitations, there is a strength in the national policy implemented in Indonesia. NHI can be a guarantee of access to health services, reaching even families with low socio-economic status and children with special needs. It is important to note that dental health services at NHI also include preventive services, such as early detection, and preventive restoration, such as fissure sealants. However, parents often do not know that such services exist; they only know about services like restoration and tooth extraction (24). This understanding results in parents taking their children to the dentist only after the child has experienced pain (a toothache), which usually means the hole in the tooth is already deep.

It is important for oral health personnel to consistently and continuously conduct policy-maker advocacy regarding the consequences and preventive strategies for ECC. The national road map of the caries prevention strategy cannot only be targeted at school children, but must also be aimed at preschool children. The national target that considers only school children has even resulted in a lack of attention to ECC among oral health personnel themselves. This is such a concern because, nationally, there is no ECC program, and oral health personnel are not spread evenly. The high numbers of other health workers should be a resource that can be used to deal with dental diseases that occur in children.

ACTIONABLE RECOMMENDATIONS

Taken together, the results of analysis on epidemiological data and oral health policy suggest following recommendations:

- National preventive program toward ECC should be prioritized including activity of prevention program in kindergarten or early childhood education. However, oral health programs for young children cannot rely solely on school-based and the decision maker must consider a reasonable range of alternatives to expand the provision of the program.
- Expanding the program via maternal care should be considered as a potential alternative. Integrating immunization programs with dental check-ups also could be another option, since this program is widely spread and accepted among citizen.
- Oral health training can be provided for other health workers, like midwives, to help them identify, and refer high-risk patients for subsequent care management in a dental clinic. Such programs should be actively delivered via early childhood education programs by involving teachers and health cadres via integrated healthcare posts.
- Under the NHI system, there is a potential scheme in implementing early screening for ECC for pre-schoolers. Children referred upon screening will be treated free of charge in CHCs.
- National data on caries should illustrate the prevalence for each of the provinces to indicate regional differences. If the decision maker seeks to develop an efficient and sustainable oral health system, the successes, and failures of the existing service model must be identified. The decision maker needs to realize that the chosen strategic model to tackle ECC cannot be separated from the socio-economic context.

CONCLUSION

There is a necessity to review dental public health policies and develop effective strategies to prevent the epidemic of ECC in Indonesia. The key to success in the prevention and curative management of ECC lies not only in the availability of oral health personnel but also in a joint commitment with other parties. Further, advocacy to prevent healthcare problems among children is critical because this will have consequences for general health. In particular, policies that promote children's oral health as part of public health initiatives can help attract people's attention.

AUTHOR CONTRIBUTIONS

RA initiated the idea for the manuscript, wrote the initial framework, and edited the manuscript. FC, MA, and AS added materials according to their expertise. Each author critically reviewed the manuscript for its intellectual content.

ACKNOWLEDGMENTS

Authors thank to Dr. Iwan Dewanto, Vice Secretary General of Indonesia Dental Association for providing the latest data of Basic Health Survey on Oral Health.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 11 October 2019
doi: 10.3389/fpubh.2019.00285

How Much Country Economy Influences ECC Profile in Serbian Children—A Macro-Level Factor Analysis

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Introduction: Serbia has universal health coverage (UHC) for pediatric dental care and similar country distribution for dentists and physicians per 1,000 inhabitants. However, a high prevalence of early childhood caries (ECC) with wide variation across the country was observed in previous studies. This paper aimed to analyze the association between economic and healthcare country macro-level factors with ECC prevalence and treatment.

Method: The outcome variables were ECC prevalence and frequency of untreated ECC in 36- to 71-month-olds. Cross-sectional pathfinder survey on a nationally representative sample of children was conducted in order to obtain data. Independent variables included the following: gross domestic product (GDP), social and health care budget beneficiaries' expenditures, local self-government budget, unemployment rate, population density and density of physicians and dentists. Guided by the WHO's Basic Methods for Oral Health Surveys stratified cluster sample, 17 sites were randomly chosen to obtain adequate distribution of data regarding urban, peri-urban and rural areas in each analyzed statistical territorial unit. The variables were analyzed using the independent *t*-test or Mann–Whitney *U* test. A probability value of <0.05 was considered significant.

Results: The final sample included 864 children aged 36 to 71 months. Observed prevalence of ECC was 41.1%. Although no statistically significant difference was found, children with ECC compared to healthy children were living in parts of the country with averages of ≈122€ lower GDP per capita, ≈4€ lower social and health care expenditures per capita, 9 inhabitants per km^2 lower population density, almost 7€ per capita lower local self-government budget and a 0.6% higher unemployment rate. Furthermore, although without a statistically significant difference, untreated ECC was associated with ≈302€ lower GDP per capita, ≈12€ lower social and health care expenditures per capita, 34 inhabitants per km^2 lower population density, almost 20€ per capita lower local self-government budget and a 1.7% higher unemployment rate.

OPEN ACCESS

Edited by:
Morenike Oluwatoyin Folayan, Obafemi Awolowo University, Nigeria

Reviewed by:
Monika Sharma, Christian Medical College & Hospital, India
Chun Hung Chu, The University of Hong Kong, Hong Kong

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *25 April 2019*
Accepted: *19 September 2019*
Published: *11 October 2019*

Citation:
Markovic D, Soldatovic I, Vukovic R, Peric T, Campus GG and Vukovic A (2019) How Much Country Economy Influences ECC Profile in Serbian Children—A Macro-Level Factor Analysis. Front. Public Health 7:285. doi: 10.3389/fpubh.2019.00285

Conclusions: This study, performed in a nationally representative sample of preschool children, revealed the association of economic macro-level factors with ECC prevalence and its (non-) treatment. Further research on a larger sample is necessary to confirm the results. These findings suggest that most of the public-health efforts regarding prevention and early treatment of ECC should be directed at regions with lower economic performance.

Keywords: caries, child preschool, epidemiology, prevalence, universal coverage, economy

INTRODUCTION

In the era of worldwide epidemic of non-communicable diseases (NCDs) (1), and considering oral disease as being part of this group and sharing the same etiology (2), poor oral health in preschool children has arisen as a public health issue that needs attention (3). In order to reduce disease burden, public health experts recognized the necessity of introducing a feasible prevention program that would be in accordance with population needs—therefore, understanding the etiological concept of oral disease as NCD might represent the crucial part of this process.

The current concept of the etiology of childhood caries suggests a strong impact of micro-level factors described in two groups: *risk factors* (social/behavioral, clinical) and *protective factors* (exposure to fluoridated water, utilization of fluoridated toothpaste and regular dental services) (4). However, if considering oral disease as NCD, the process of prevention planning needs to involve introduction and understanding of other factors that strongly correlate with health inequalities and originate from macro- or country-level factors such as social, economic, environmental and political determinants (5). Poor health is strongly connected to low productivity, country market value and economy performance, and it also affects the welfare of inhabitants (6). However, little is known regarding the social determinants of oral health in children and youth (7). Development and implementation of appropriate preventive strategies and adequate policies requires thorough oral health knowledge from a social and economic point of view (8).

Although Serbia has universal health coverage (UHC) for pediatric dental care and a similar distribution of physicians and dentists per 1,000 inhabitants, results from previous studies showed high prevalence and wide variation of ECC within the country (8). Having this in mind, the main goal of this study was to elucidate the possibility of an association between economic and healthcare macro-level factors and ECC profile in Serbian children.

METHOD

Study Design

This was an ecological study using data published in the statistical yearbook of municipalities, cities and regions in the Republic of Serbia (9) and data derived from a pathfinder cross-sectional survey with a nationally representative sample of preschoolers in Serbia.

Informed and written consent was obtained from parents before the children's examinations. Furthermore, the appropriate approvals from the following authorities were obtained: Ethical Committee of University of Belgrade School of Dental Medicine (approval number 36/10), Ministry of Health Republic of Serbia, management of primary health care centers (Head of the Staff) and management of kindergartens.

Setting

By the Law of the Regional Development and the Law of the Official Statistics, Republic of Serbia is divided into 4 statistical territorial units: (1) Sumadija (central) and Western Serbia, (2) Southern and Eastern Serbia, (3) the northern region called Vojvodina, and (4) the City of Belgrade (the capital) (10). Each statistical territorial unit is a geographic entity and corresponds to the administrative division of the country. This subdivision of the country was made in accordance with European Union (EU) principles and methodology—the Serbian national nomenclature of statistical territorial units has been harmonized with the European nomenclature of territorial units for statistics (NUTS), and they correspond NUTS level 2 (regions of the country) (11). These statistical territorial units are used for purposes of measuring regional economic performance, gathering data, statistical analysis, social and health care planning, etc.

Participants and Sampling Method

The study sample consisted of children aged 36 to 71 months of age attending public kindergartens in Serbia. As suggested by the World Health Organization's (WHO) Basic Methods for Oral Health Surveys, stratified cluster sampling was used in order to obtain a nationally representative sample: additionally, it was stratified according to three types of residency (urban, peri-urban and rural) involving most important population subgroups with possible differences in the disease level (12). Therefore, overall prevalence might be considered nationally representative. The WHO suggests at least 12 randomly chosen locations (600 participants) to obtain a representative sample (12). Out of 158 primary health care center locations in the whole country (6), 17 locations were randomly chosen to obtain an adequate distribution of data regarding urban, peri-urban and rural areas in each analyzed statistical territorial unit—we aimed to involve at least 850 participants (**Table 1**). Additionally, in each location—adequate urban/peri-urban/rural sites—public kindergartens were randomly chosen with the approval of local authorities. The study participants from each

TABLE 1 | Schematic equation of sampling method.

4 sites in the capital (2 urban and 2 peri-urban) (4 × 50 = 200)
2 sites in 3 large towns (1 urban and 1 peri-urban in each town) (6 × 50 = 300)
1 urban site in 3 large towns (urban) (3 × 50 = 150)
1 site in 4 rural areas (4 × 50 = 200)
Total = 17 sites × 50 = 850

site (kindergarten) involved children attending randomly chosen kindergarten groups.

Variables

The oral health outcome variables for this study were:

- **ECC prevalence in the 36- to 71-month age group** calculated as total number of decayed, filled or missing teeth due to caries.
- **Frequency of untreated ECC in 36 to 71 months age group** calculated as total number of teeth with caries lesions, fillings with secondary caries and caries sequels.

Independent variables included data on macro-level factors used or calculated from the documents available at the official web page of the Statistical Office of the Republic of Serbia and involved country information on economic performance, population characteristics and healthcare system factors (10):

- **Regional gross domestic product (GDP) [per capita, 1,000 Serbian dinars (RSD)]**—represents the sum of value added of all local units that are active in the territory of the subject region (plus taxes on products less subsidies on products). Regional GDP "is the main indicator used for measuring the regional economic performances and the effectiveness of the regional policies and programs aimed at reducing the gaps between the regions in socio-economic development and distribution of the national wealth" (10);
- **Social and health care budget beneficiaries' expenditures (per capita, 1,000 RSD)**—involved data regarding budget beneficiaries' expenditures on human health and social work activities. These data were collected via the national regular statistical annual survey on budget beneficiaries and balance of payment received from the treasury administration, and published in the statistical yearbook of municipalities, cities and regions (9);
- **Local self-government budget (per capita, RSD)**—involved data on total budgetary revenues in each statistical territorial unit of the country covering all budgetary beneficiaries that are financed from the local government funds, consisting of current (tax and non-tax) revenues, receipts from selling non-financial assets and receipts from borrowing and selling financial assets. These data are collected and processed by the Ministry of Finance and published in the statistical yearbook of municipalities, cities and regions (9);
- **Unemployment rate (%)**—was calculated by subtracting the registered number of employed persons (persons who have contract of employment for a limited or unlimited time period, persons who are self-employed and run their own business and those who take agricultural activities) from the working age population (15–64 years) and presented as a percentage (10);
- **Population density (n)**—number of inhabitants in each statistical territorial unit of the country per 1 km^2 of area; the data that were used involved population estimates for the post-census 2017 according to the population estimate as of the end of the previous year (December 31st, 2016) in addition to data on the results of processed statistics on natural and mechanical migrations of the population in 2017, published in the statistical yearbook of municipalities, cities and regions (9);
- **Density of physicians/dentists (n)**—number of inhabitants per one physician/dentist in each statistical territorial unit of the country: these data are in accordance with the Institute of Public Health of Serbia "Dr. Milan Jovanovic Batut" and are gathered from health care institutions in the Republic of Serbia, which are included in the Plan of Health Institutions Network, published in the statistical yearbook of municipalities, cities and regions (9).

Data Sources

The Oral Health Assessment Form for Children according to teeth surfaces (12) was used for collecting data. All oral examinations were done from March to December 2018, in the field (in kindergartens) by calibrated primary health care pediatric dentists, using the plain dental mirror to detect caries lesions, gauze for drying the tooth surface and natural light with positioning the subject to get the best possible illumination (12).

Bias

The calibration workshop was performed prior to data collection, involved all the examiners and included analyzing patients' photos with different stages of caries lesions on primary teeth. The examiners were instructed to detect any cavitated or non-cavitated lesions on the surface of primary teeth (13).

Study Size

The sample size calculation used for this study included proposed at least 50 participants per location or at least 600 participants in a sample (**Table 1**). A sample size of at least 50 participants per location was chosen since the results from previous epidemiological studies in Serbia determined caries prevalence in more than 80% of children in the referent age group (12-year-olds) (12, 14–19).

Statistical Methods

Results were presented as frequencies (percentages) or mean ± standard deviation (SD) depending on data type. The differences in the means of variables were analyzed using the independent *t*-test in case of normally distributed continuous variables or Mann–Whitney *U* test for non-normally distributed continuous variables. A probability value of <0.05 was considered significant. SPSS version 20 (SPSS Inc, Chicago, IL) was used for the statistical analysis.

TABLE 2 | Regional social economic indicators regarding ECC in primary teeth.

	Participants with healthy teeth (mean ± SD)	Participants with ECC (mean ± SD)	Total (mean ± SD)	*p*
GDP per capita (1,000 RSD)	601.6 ± 245.6	587.2 ± 241.3	595.7 ± 243.8	0.4
Physician density (# inhabitants per 1 physician)	361.3 ± 46.9	363.3 ± 45.8	362.1 ± 46.5	0.9
Dentist density (# inhabitants per 1 dentist)	4442.2 ± 298.8	4444.2 ± 288.1	4442.9 ± 294.3	0.9
Social and health care expenditures per capita (1,000 RSD)	27.3 ± 6.4	26.8 ± 6.3	27.1 ± 6.4	0.2
Population density (# inhabitants per km^2)	188.6 ± 195.6	179.9 ± 190.9	185.0 ± 193.6	0.4
Unemployment rate (%)	57.8 ± 10.5	58.4 ± 10.3	58.1 ± 10.4	0.4
Local self-government budget per capita (RSD)	39857.2 ± 12892.2	39064.6 ± 12969.4	39531.6 ± 12810.7	0.2

TABLE 3 | Regional social economic indicators regarding untreated ECC.

	Participants with treated ECC (mean ± SD)	Participants with untreated ECC (mean ± SD)	Total (mean ± SD)	*p*
GDP per capita (1,000 RSD)	619.9 ± 269.8	584.3 ± 238.8	587.2 ± 241.3	0.9
Physician density (# inhabitants per 1 physician)	350.6 ± 48.4	364.4 ± 45.4	363.3 ± 45.8	0.1
Dentist density (# inhabitants per 1 dentist)	4417.2 ± 372.2	4446.6 ± 279.9	4444.2 ± 288.1	0.9
Social and health care expenditures per capita (1,000 RSD)	28.1 ± 6.8	26.7 ± 6.3	26.8 ± 6.3	0.3
Population density (# inhabitants per km^2)	211.2 ± 212.3	177.1 ± 188.9	179.9 ± 190.9	0.9
Unemployment rate (%)	56.8 ± 11.4	58.5 ± 10.1	58.4 ± 10.3	0.9
Local self-government budget per capita (RSD)	41258.1 ± 13887.1	388869.8 ± 12589.7	39064.7 ± 12696.5	0.3

RESULTS

The final sample included a total of 864 children aged 36–71 months. ECC was present in 355 (41.1%) examined children. Of these, untreated ECC was present in 326 (91.8%) children. Caries prevalence was statistically significantly ($p < 0.01$) higher in rural and peri-urban locations (44.9 and 46.5%, respectively) compared to urban areas (36.3%).

Physician and dentist density were similar across all country territorial units. Although no statistically significant associations were observed between oral health outcome variables and healthcare professionals' density, the results showed that children with untreated ECC compared to children with treated caries lived in the parts of the country with almost 14 inhabitants more per physician and almost 29 inhabitants more per dentist (**Tables 2**, **3**).

Although no statistical significance was found, the analysis showed that ECC-affected children, compared to caries-free children, were living in parts of the country with an average of 14400RSD (≈122€) lower GDP per capita, 500RSD (≈4€) lower social and health care expenditures per capita, 9 inhabitants per km^2 lower population density, almost 793RSD (≈7€) lower local self-government budget per capita and a 0.6% higher unemployment rate (**Table 2**).

Further analysis showed children with untreated ECC compared to children with treated ECC were more likely to live in parts of the country with an average of 35600RSD (≈302€) lower GDP per capita, 1400RSD (≈12€) lower social and health care expenditures per capita, 34 inhabitants per km^2 lower population density, almost 2390 RSD (≈20€) lower local self-government budget per capita and a 1.7% higher unemployment rate (**Table 3**).

DISCUSSION

This is the first study to determine the prevalence of ECC in preschoolers aged 36–71 months in the Republic of Serbia using a nationally representative sample of children, in accordance with the methodology proposed by the World Health Organization (12). The established ECC experience in a nationally representative sample of Serbian children aged 36–71 months was 41.1%, which is alarmingly high, considering that Serbia has pediatric UHC for dental and general healthcare and a similar density of physicians and dentists in each national territorial unit.

According to our knowledge, this is the first study to analyze the connection between macro-level social economic indicators and prevalence of ECC on a country level. Furthermore, macro-economic analysis showed that, although no statistically significant difference was found, oral health outcomes were associated with country economic performance: higher ECC

prevalence and untreated ECC were more frequently observed in parts of the country with lower GDP per capita, lower social and health care expenditures per capita, lower population density, lower local self-government budget per capita and higher unemployment rate.

Although our study provided novel information on the association of ECC and country economic performance, the caution is necessary when interpreting the results due to some limitations.

Firstly, the obvious limitation could be the calibration procedure—the training of all examiners on patients was not feasible since the ethical committee and parental associations in the kindergartens would not approve participation of young children in the exhausting calibration process. In order to avoid possible non-consistency, the project team leader and peers reviewed all the answers so consensus during examination could be ensured.

Secondly, another possible limitation of our study could be the fact that all examinations were performed in the field (in kindergartens). However, although this method might potentially result in overlooking some of the non-cavitated caries lesions, this method is endorsed as the most practical and suitable for epidemiological studies in nationally representative samples (12).

Thirdly, the possible limitation, especially considering risk assessment, would be using the dmft (DMFT) index instead of ICDAS; therefore, the authors acknowledge possibly underreporting ECC prevalence since some non-cavitated lesions might be overlooked. Although ICDAS allows more detailed recording on non-cavitated lesions, dmft records both past and present ECC experience as well as (non-) treatment (20). Furthermore, it has been known and used for years by the primary health care dentists who were calibrated examiners for our survey. Although the WHO's Basic Methods for Oral Health Surveys (12) suggested excluding early stages of caries (white spots) because of the difficulty in distinguishing them in epidemiological field examinations without dental units, in order to have the most extensive possible coverage and the results representative of the population, the examiners were instructed to note if any non-cavitated lesions were observed during the survey.

Furthermore, since the data on the frequency of sugar consumption in different statistical territorial units of the country were not available, they were not used as a confounder for this study. This could be considered as a study limitation.

Finally, the possibilities of ecological fallacies should be highlighted as a possible limitation of the study. Furthermore, considering that this is a cross-sectional study, cause-effect relationships could not be assessed.

El Tantawi et al. (7) published in 2018 the first study that highlighted the connection between ECC prevalence and different health care and economic determinants of the United Nation's 193 countries—better ECC data availability and lower ECC prevalence was observed in countries with UHC. A high prevalence of ECC in preschoolers suggests an obvious presence of a gap in oral health care utilization.

However, despite pediatric general and dental UHC (21) and similar distribution of physicians and dentists across the country (10), the present survey showed a high prevalence of poor oral health in Serbian children −41.1% of children aged 36 to 71 months had ECC. Even more alarming is the fact that despite two National Oral Health Prevention Programs (1996–2000, 2009–2015) which raised concerns about oral health of Serbian children (22), we are observing the worsening of children's oral health during last 10 years when compared with the results of the oral health survey from 2009 conducted according to the same method (30.3%) (8).

Number of dentists and physicians in a region represent strong indicators of availability and accessibility of primary oral health care in preschool children (7, 23). Having in mind the high prevalence of oral disease in the population and the obvious lack of professionals (14), we could assume that most commonly provided treatments could be urgent, also leading to the UHC utilization gap. However, this should be confirmed in future studies.

In having a clear understanding of ECC as an NCD as well as identifying the national prevalence and differences in the disease level and risk subgroups, we fulfilled the essential requirements for designing effective preventive intervention according to population needs (24–26). Our results suggested influence of social determinants on ECC, therefore emphasizing the need for properly understanding and treating preschoolers' oral health (as NCD) using preventive strategies based on carefully planned policies. Identifying high-risk children is a task that requires special attention (27). Knowing that people from lower social economic levels rarely use dental health care (28), and having in mind that our data indicated higher proportion of children with ECC in regions with worse economic performance, it is necessary to confirm this hypothesis with a larger sample of children. Then, it would be possible to design a proper and cost effective preventive strategy that targets most vulnerable risk groups—the youngest possible and children with lower socio-economic profile.

The results of the present study suggested that health is much more than *"medical/dental knowledge and technologies"*—it involves social, economic indicators and polices (5). Social injustice and economic inequalities lead to worsening of health in people with lower socioeconomic position—these health inequities are unjustifiable and are avoidable (29). Every child—no matter of place of birth, living conditions, social or economic position, deserves to develop his or her full potential for good oral health. Our results suggest that country economic performance might be considered as a strong indicator of oral health.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

AUTHOR CONTRIBUTIONS

AV 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. DM designed the study, interpreted the data, and critically reviewed and revised the manuscript. RV, TP, and IS contributed to the collection of macro-level and disease prevalence data, were involved with the data analyses and reviewed and revised the manuscript for important intellectual content. GC contributed to study methods, data collection and data analysis, and critically reviewed and revised the manuscript. All authors approved the final version of the manuscript.

FUNDING

Publication of the paper was supported by The Borrow Foundation, a UK-based charity. The data were collected within Program for Oral Health Improvement in Children and Youth in Serbia, approved by the Government of Serbia, Ministry of Health, Program number 1802, Project activity number 4015.

ACKNOWLEDGMENTS

The authors would like to express sincere appreciation to the Ministry of Health, Sector for Public Health and Project Implementation, Borrow Foundation, WHO Country Office for Serbia, WHO Collaborating Center for Epidemiology and Public Health at University of Milan, and the team from the Prevention of Non-communicable Diseases (NCDs) department, WHO Headquarters, Geneva (Dr. Benoit Varenne). We gratefully acknowledge the kind help of pediatric dentists, oral hygienists and assistants from site locations in collecting all the necessary data for the nationwide database: Dr. Aleksić Tanja, Dr. Bogdanovic Natasa, Dr. Bozic Zorica, Dr. Drazic Jovanka, Dr. Dukić Vanja, Dr. Durković Marija, Gočanin Jasmina, Dr. Ikodinovic Natasa, Dr. Ivana Maksimovic, Dr. Javor Milica, Dr. Jeremic Marko, Kreculj Ksenija, Kruškonja Lidija, Dr. Labović Nebojša, Dr. Ljajić Jasera, Dr. Ljiljana BoŽović, Dr. Madic Katarina, Dr. Marjanovic Eleonora, Dr. Mijatović Sanja, Dr. Milenkovic Sonja, Dr. Milić Marija, Prof. Dr. Milojkovic Zoraida, Dr. Naida Hamzagić, Dr. Paunović Mirjana, Dr. Perović Marina, Petković Tijana, Dr. Petrovic Dusan, Dr. Sekula Lovrov Violeta, Dr. Škrijelj Maida, Dr. Stevanovic Marko, Dr. Stević Dušan, and Dr. Svetlana Milić. The authors sincerely acknowledge hard work of Lana Milenkovic and Jovana Tajevic, 5th-year students of the School of Dental Medicine, University of Belgrade, who helped with the collection of all data and database entries.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 03 July 2019
doi: 10.3389/fpubh.2019.00175

Developing an Effective Community Oral Health Workers—"Promotoras" Model for Early Head Start

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Purpose: To determine the effectiveness of a train-the-trainer program for Community Oral Health Workers (COHWs) with the goal of reducing Early Childhood Caries (ECC).

Methods: Thirteen Latina caregivers from a local Early Head Start program participated in an 8 h bilingual oral health training program that provided information and hands-on experiences pertaining to prenatal and children's oral health. Once trained, the 13 COHWs conducted a series of bilingual interactive oral health promotion workshops at local community sites. Pre/post-tests were conducted after each workshop with a total of 157 caregivers of young children. Bivariate analyses were used to assess changes in knowledge, attitudes, and practices of the COHWs and caregivers regarding children's oral health.

Results: Significant positive changes ($p < 0.05$) in COHWs' knowledge were observed for age a child can brush his/her teeth alone and what a pregnant woman with morning sickness can do to protect her teeth. Positive trends were observed for knowing that tap water with fluoride prevents cavities and that poor oral health of parents affects their children's dental health. While community caregivers in the workshops reported a high consumption of sweet snacks and beverages, there was a significant positive increase ($p < 0.05$) in knowledge and attitudes regarding oral health care. Significant increases in knowledge were obtained regarding: when a child can brush his/her teeth well alone, the age when fluoridated toothpaste can be used, ways tooth decay can be prevented, when a child's first dental visit should be, and what a pregnant woman with morning sickness can do to protect her teeth. Significant positive improvements were found regarding caregiver's favorable attitude that fluoridated water can help prevent cavities, disagreeing that tap water is dangerous, and agreeing that a parent's dental health affects their children's dental health.

Conclusions: The study showed a targeted and culturally competent oral health program can significantly improve knowledge, attitudes, and self-reported practices of COHWs and the caregivers they trained. Although longitudinal studies are needed to determine if a COHW model can help reduce ECC in underserved communities, preliminary results support the utilization of this model as a viable option that should be expanded.

Keywords: Early Childhood Caries (ECC), prevention, Community Health Workers (CHWs), promotoras de salud, workforce development

OPEN ACCESS

Edited by:
Frederick Robert Carrick, CMHR in association with University of Cambridge, United Kingdom

Reviewed by:
Anne Wilson, University of Colorado Denver, United States
Kimon Divaris, University of North Carolina at Chapel Hill, United States

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *10 April 2019*
Accepted: *11 June 2019*
Published: *03 July 2019*

Citation:
Villalta J, Askaryar H, Verzemnieks I, Kinsler J, Kropenske V and Ramos-Gomez F (2019) Developing an Effective Community Oral Health Workers—"Promotoras" Model for Early Head Start. Front. Public Health 7:175. doi: 10.3389/fpubh.2019.00175

INTRODUCTION

Dental caries is the most common chronic childhood infectious disease and continues to be a serious public health problem affecting both developing and industrialized countries, yet it is preventable (1–6). In the U. S., Early Childhood Caries (ECC) affects 53.8% of children ages 2–19 years and ∼12% of children ages 2–5 years (7, 8). Children from disadvantaged populations and low socioeconomic status are at increased risk for developing ECC. For example, among youth 2–19 years of age, total dental caries affects Hispanics (57.1%) disproportionally as compared to their non-Hispanic Black (48.1%) and non-Hispanic White (40.4%) counterparts (7).

Additionally, the proportion of children with *untreated* dental caries in their primary teeth increases with age: 10.9% among children aged 2–5 years and 17.4% among children aged 6–8 years; a larger proportion of Hispanic (19.4%) and non-Hispanic black children (19.3%) had *untreated* dental caries in primary teeth compared with non-Hispanic white (9.5%) children (8). Left untreated, dental caries can lead to infections, pain and loss of teeth, affecting the child's quality of life by interfering with the ability to perform daily activities like eating, sleeping, learning, and playing (9–11). From 2011 to 2016, a decrease was seen in the prevalence of total dental caries (from 50.0 to 45.8%) in youth, however, this decline was not statistically significant (7).

While numerous factors contribute to ECC (diet, oral hygiene habits, oral bacteria, access to care, etc.), it can be preventable with appropriate behavior modifications (6, 12, 13). Although oral health education is not the only step in dental caries prevention, it is a critical and important factor, especially among vulnerable populations who experience less access to oral health care services (9, 14).

The Hispanic/Latino population is projected to be the third fastest growing minority group in the U.S., which is estimated to increase by 115% by 2060 (15). Thus, dentistry's success in meeting the challenges of an increasingly ethnically diverse population is dependent upon considering the larger social and cultural context in order to have an impact on personal behavior change (9, 16–18). Community Health Workers (CHW) play a vital role in connecting marginalized and medically underserved populations to the health and social service systems intended to serve them (19–22). CHWs (i.e., promotoras, lay-person health educators, peer health advocates) work in community settings and serve as connectors between health care consumers and providers to promote health among groups that lack access to adequate care (16, 23, 24). CHW's understand the cultural perspectives of the communities they serve and can help reduce barriers to health care and increase access to preventive oral health services (16, 19).

The "promotora" CHW model is a culturally appropriate approach to delivering preventive health interventions for Latino populations, and has been shown to be effective in creating behavior change in reducing chronic disease risk factors and health conditions through education, dietary interventions, and increasing screening rates (9, 19, 25–29). Promotoras have been used extensively to reach diverse populations such as mothers and infants, migrant farm workers, and Latino populations. Adams et al. showed significant improvements in plaque index, bleeding on probing, and pocket depths 4 mm or greater after promotora-provided brief oral health education and skill-building activities during prenatal care (30). In the Contra Caries Oral Health Education Program (CCOHEP), promotoras led 2 h interactive sessions for Spanish-speaking parents. Immediately after attending CCOHEP, caregiver-reported behavior performance improved to 44% (from baseline of 13%); 3 months after attendance, it increased to 66%. Four of the five reported tooth brushing behaviors improved between pretest and post-test, especially brushing at night (12). Thus, the CHW promotora model is a promising method for improving oral health-related knowledge and behavior among underserved and underinsured minority communities (9, 31–33).

The purpose of this study was to train Latina Community Oral Health Workers (COHWs) using a promotora CHW model to educate underserved and minority populations in Los Angeles County on best practices in oral health care, with the ultimate goal of reducing ECC. The trained COHWs then conducted oral health workshops in the community for other caregivers of young children. We hypothesize there will be significant increases in knowledge and positive changes in oral health beliefs and practices of the COHWs and caregivers after the oral health training/workshops using pre-/post-tests.

METHODS

The UCLA School of Dentistry through the Center for Children's Oral Health (34) conducted a pilot project in 2016-2017 (COHWs I) with two community partner sites in Los Angeles County. In the COHW I pilot study, 10 Latina caregivers were trained as COHWs. The pre/post-tests of the 10 COHWs showed a significant increase in total knowledge and practices (35). Building on these findings, a Professor of pediatric dentistry and a bilingual Latina pediatric dental resident developed this COHW II project in which caregivers were trained as COHWs. After completion of the oral health training, the COHWs conducted oral health workshops in the community for other caregivers of young children. Changes in the COHWs and caregiver's knowledge, beliefs, and practices regarding children's oral health were assessed before and after the COHW training and the COHW-led workshops.

Participants and Community Partners

Hope Street Margolis Family Center (HSMFC) is a well-established community center located in downtown Los Angeles (36) which is a health, education, and recreational resource for children and families and also provides the federally funded Early Head Start (EHS) program. EHS supports low-income pregnant women and families with infants and toddlers with in-home and on-site educational, health/wellness, developmental, and social services. Upon consultation with the HSMFC management team, it was decided to make the COHW training open to members of the EHS Policy Council. The Policy Council is a group of EHS parents who are selected by their peers to help advise the Head Start director and governing board on important matters related to the center. These caregivers have already shown leadership

potential that could be further developed by their participation in this project. Thirteen EHS parents volunteered to participate in the COHW II training and received $550 for their time and participation, which was given in the form of small gift cards and cash to offset their cost of transportation and childcare.

Procedures

The project lasted 14 months and was completed in the following three phases:

Phase I: Formative research and oral health curriculum development,
Phase II: COHW training, and
Phase III: COHW-led oral health promotion workshops.

Figure 1 presents the project timeline and overview. All participants gave written informed consent prior to participation and UCLA IRB approval was obtained (**IRB # 18-000014**).

Phase I: Formative Research (Focus Group) and Oral Health Curriculum Development

A focus group was conducted with Latina caregivers of young children from HSMFC in the third month of the project development with the aim of revising the existing oral health curriculum from COHW I to meet the needs of the target population for the current COHW II study. All caregivers with children between the ages of 0–5 were eligible to participate in the focus group. Bi-lingual recruitment flyers were posted at the HSMFC. The HSMFC family services coordinator assisted with recruitment and coordination of the focus group. The majority of volunteer participants were bilingual (English/Spanish) Latina mothers, between the ages of 20–42 years, had a high school education and were married. The focus group was conducted at HSMFC and was led by a bilingual pediatric dental resident. The focus group lasted 90 min and was guided by open-ended questions on tooth brushing habits, toothpaste usage, fluoridated water usage, dental visits, dental insurance, and barriers to dental care. Notes were taken during the focus group and specific quotes were documented and highlighted. After the focus group, the notes were fully transcribed. Notes and open-ended questions were examined for themes using content analysis. The focus group was not audio-recorded.

Based on focus group findings and consultations with the UCLA interprofessional team of dentists and nurses, the existing COHW I curriculum was revised. The COHW II curriculum for this study included the following five main topic areas:

1. Review of basic oral anatomy and characteristics of healthy vs. unhealthy teeth (using many pictures, tooth models, and videos),
2. Teaching COHWs how to identify differences between normal and abnormal findings in the mouth (e.g., how to look for cavities),
3. Creating awareness of pregnancy and child preventive oral health practices known to reduce ECC (morning sickness, tooth brushing, flossing, snacking, fluoride, etc.),
4. Creating awareness of particular challenges involved in dealing with special needs children such as autistic children (e.g., how to brush the teeth of an uncooperative child and where to seek dental help for special needs children) and
5. How to perform a regular and thorough basic oral screening of infants and children.

The curriculum was kept at a 6th grade literacy level and all written materials were translated (and back translated) into Spanish. The curriculum is available at the following link: http://www.uccoh.org/research.html (34).

Phase II: COHW Training

The COHW training consisted of 4 consecutive weekly 2 h sessions which included a combination of classroom lectures, hands-on training, and discussions. Total in-person training time was 8 h; an additional 4–5 h for reading assigned homework materials and listening to webinars was required. The training introduced COHWs to evidence-based health knowledge about the nature, prevalence, and consequences of oral manifestations of chronic oral diseases across the lifespan with an emphasis on children as well as the oral-systemic connection. The COHWs learned how to assess a child's oral health, identify basic healthy vs. abnormal oral conditions and to apply basic concepts of a caries risk assessment (37). They performed basic oral health screenings on their own children and children of their peers. They learned their role as promotoras in preventing oral disease in the community, addressing frequently encountered oral health problems, and promoting oral health in their community. Reflection sessions allowed the COHWs and the project team to exchange ideas and thoughts. The COHWs were required to review a list of course materials prior to the start of some of the trainings. These included selected online sections of the "Smiles for Life" curriculum (38), a Colgate Webinar on: "The Art of Perinatal and Infant Oral Health" by Dr. Ramos-Gomez (available in Spanish), and links to the UCLA Infant Oral Care Clinic documents (39). Training sessions were presented simultaneously in English and Spanish by the pediatric dental resident and two nurse practitioner students. The pediatric dental resident conducted sessions 1, 3, and 4 and the two nursing practitioner students conducted session 2. Childcare and light refreshments were available at all training meetings. **Table 1** provides a brief description of the topics covered during the 4 training sessions:

Phase III: COHW-Led Oral Health Promotion Workshops

The 13 COHWs who completed the training conducted 15 1 h bilingual oral health promotion workshops in teams of two to a convenience sample of 157 caregivers of young children in the local community. These 1 h bilingual oral health workshops were conducted at local elementary schools, parks, homes, and WIC sites. A UCLA team member was present to assist and help collect data. The bilingual pediatric dentist attended most workshops, offering support. Workshop locations, dates, and times were selected by the COHWs who made all the necessary arrangements (flyers, number of anticipated attendees, etc.) with the host site. UCLA provided free oral hygiene supplies, small raffle gifts, and light refreshments at all workshops. The

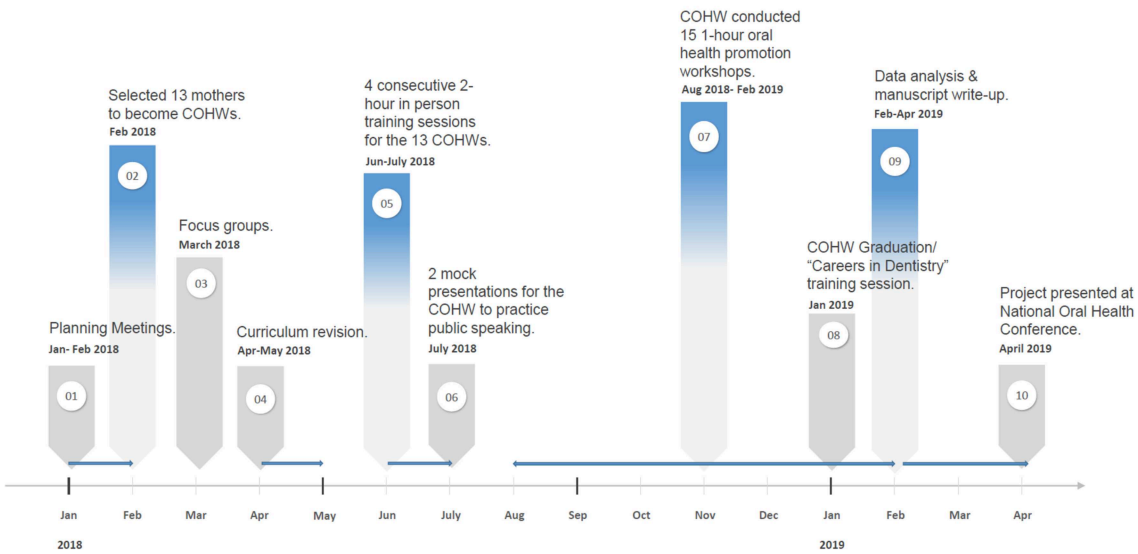

FIGURE 1 | Timeline.

TABLE 1 | 4 in-person bilingual training sessions (each 2 h) for the 13 COHWs.

Training session 1	Training session 2	Training session 3	Training session 4
• Introduction to basic oral health • Early Childhood Caries (ECC) development • Caries risk & protective factors • Prevention tips for all ages	• Oral health care during pregnancy • Pregnancy gingivitis • Morning sickness treatment • Tap water • Nutrition	• Nutrition and snacking • Brushing and flossing • White Spot Lesions (WSL) • Caries progression • Fluoride • Teething	• Radiographs • Types of child dental treatments • Emergency dental care • Nitrous oxide vs. oral sedation vs. general anesthesia • Insurance • Self-management goals • Motivational Interviewing

curriculum used for these workshops was a condensed version of the curriculum used for the COHW training. All written material was kept at a 6th grade literacy level and was translated (and back translated) into Spanish. The learning objectives for the 1 h oral health workshops conducted by the COHWs are listed below:

1. To understand the importance of perinatal oral health care, including vertical transmission.
2. To be able to list the main causes of Early Childhood Caries (ECC).
3. To be able to list the negative impacts of ECC.
4. To identify the early signs of caries.
5. To understand how to prevent ECC through the use of fluoride, dental home by age 1, proper oral hygiene, and appropriate nutrition.
6. To identify the benefits of fluoridated tap water.
7. To demonstrate the proper brushing and flossing techniques.

Data Collection

The 13 COHWs who participated in the training completed a 34-item written paper and pencil pre- and post-test questionnaire (available in English and Spanish) to assess changes in knowledge, beliefs, and practices regarding children's oral health (see **Supplementary Datasheet 1** for the COHW questionnaire). Fourteen items were related to oral health knowledge, 10 addressed the COHWs beliefs toward children's oral health, and 10 related to oral health practices. Answer choices ranged from multiple choice, true/false, Likert scales (strongly agree/agree/disagree/strongly disagree), and some write-in answers. The pre-test was completed by the COHWs at the beginning of the first training session. The post-test was completed 6 weeks after the training ended.

Caregivers participating in the workshops completed a written paper and pencil pre- and post-test questionnaire (it took between 8 and 10 min to fill it out) to assess changes in knowledge and beliefs regarding children's oral health. Pre-test questionnaires were filled out at the beginning of each workshop and the post-tests were completed immediately following. The questionnaire contained 16 items on the pre-test and 11 items on the post-test (see **Supplementary Datasheet 2, 3** for the caregiver questionnaire). Pre- and post-test responses were matched. Eight items related to oral health knowledge, three addressed beliefs

about children's oral health, and five were related to oral health practices. Oral health practices were only addressed on the pretest as changes in practice would not be measureable following a 1 h workshop. Answer choices included multiple choice, true/false, Likert scales (strongly agree/agree/disagree/ strongly disagree), and some write-in answers.

Statistical Analysis

Data for the COHW training and caregiver workshops were entered into RedCap and analyzed with R software (www.r-project.com). Summary statistics were generated to characterize the COHWs ($N = 13$) and the workshop attendees ($N = 157$). Paired t-tests and McNemar tests were used to assess changes in knowledge, beliefs, and practices between pre- and post-test results for the COHW and changes in knowledge and beliefs for workshop attendees.

RESULTS

Phase I: Formative Research (Focus Group)

Four major topic areas regarding oral health care were identified among focus group participants: (1) tooth brushing habits, (2) knowledge regarding cavities and baby teeth, (3) drinking water/fluoridation, and (4) barriers to dental care. Below is a summary of the findings along with representative quotes for each topic area.

Tooth Brushing Habits

Common tooth brushing habits among children included brushing in the morning and evening and brushing after their child eats candy. The two biggest factors affecting tooth brushing were bad taste of toothpaste and children being scared of the toothbrush. Singing and playing music were reported as strategies for calming children down so parents could brush their teeth.

"Every time my child wakes up, she brushes. She also brushes at night time."
"My child brushes first and then I check or brush for her."

Knowledge Regarding Cavities and Baby Teeth

Focus group participants described cavities as being black stains, spots, or holes. The most common responses regarding causes of cavities were drinking milk (especially during night if a child sleeps with a bottle), mother giving cavities to their child, and not brushing your child's teeth consistently. Most participants knew that cavities in baby teeth could affect adult teeth. If cavities were not treated early enough, participants were aware that children could become toothless or get sick. When asked what to do if a young child's tooth hurts or is knocked out, responses included: take them to the emergency room if it happens at night, place something cold on the area, and place the tooth in a glass of milk and take it to the emergency room.

"*Cavities can form most likely during the night, especially if child sleeps with a bottle. The germs in mouth at night can form cavities.*"
"A cavity in baby teeth can influence infection in the gums, and this can affect the adult teeth that come out."
"Cavities can lead to infections in the heart and other places in the body."
"*Every 6 months we should take our children to the dentist. They will check with radiographs to start treating cavities early. It is important to not miss these appointments because if we miss them because we get lazy, we can be harming our child."*

Drinking Water/Fluoridation Knowledge

Most participants reported drinking filtered or bottled water. Some were concerned that bottled water was not good because it did not have fluoride while others were concerned about drinking water that had too much fluoride. Most did not know whether their drinking water had fluoride.

"Don't know if our water has fluoride, and I do not know where to check."
"I heard that fluoride is not good for children when they are young."

Barriers to Dental Care

Most participants wanted dentists to provide them with more information about what was going to happen to their child during the dental visit. They also wanted the dentist to speak with the child to explain what would be happening to them during the visit. A few participants thought receptionists at dental clinics should be nicer to patients and more knowledgeable about insurance coverage.

"I did not like that the dentist showed up covered in a gown with big glasses because my child got so scared. I had prepared her beforehand asking her to be ready to open her mouth big for the dentist, but when the dentist entered the room fully gowned with mask, it wasted all the preparation I did with my child. I was very frustrated about that."
"I did not like that the dentists did not let me in the room when they were treating her. I did not like that they did not explain my options for treatment. I would rather that my child be put to sleep for the treatment, and even though they put her to sleep, they didn't tell me they were going to do that."
"Some clinics have more experience with younger children. Some dental office will try to over diagnose or treat you. When I took my child to the dentist that didn't have a lot of experience with children, they said she needed nerve treatment and a crown. I asked why because she was only 3 years old, they said that we should go see a specialist. When we went for a second opinion with the pediatric dentist they said that all the patient needed was a small filling."
"When I went to the dentists, the clinic receptionist was very mean to me. They referred me to another clinic and the number they gave me was not even to a dental clinic."

Focus group participants had several unanswered questions about oral health. Most questions pertained to the following topics: (1) how to properly brush and floss children's teeth and when to start using floss; (2) whether or not children should use mouthwash; (3) when should children start using toothpaste with fluoride; (4) whether teeth of children who suck their thumb can move forwards/backwards; and (5) when should a child stop

breastfeeding. Results from the focus group were used to revise the COHW training curriculum.

Phase II: COHW Training

All 13 COHWs were Latina and mostly bilingual English-Spanish. Over half (54%) were between 30 and 39 years of age (mean age was 36 years), 61% had a high school education or greater, and all had kids between the ages of 0–5 years. Most were married (69%) and homemakers (62%; see **Table 2**).

There were significant increases in 2 of the 14 knowledge questions from pre- to post-test among COHWs in the training. The number of COHWs who knew a pregnant woman with morning sickness could protect her teeth by rinsing her mouth with water or a mixture of water and baking soda immediately after vomiting increased from $N = 2$ at pre-test to $N = 8$ at post-test ($p = 0.05$). Additionally, the number of COHWs who identified the correct age (7–9 years) at which children could generally brush their teeth well by themselves increased from $N = 3$ at pre-test to $N = 12$ at post-test ($P = 0.05$). As a composite score for all 14 knowledge questions combined for all 13 COHWs responses, the mean number of correct responses increased from 7.46 (SD 2.11) at pre-test to 10.67 (SD = 1.89) at post-test ($P < 0.001$). There were no significant increases from pre-test to post-test on the belief questions, although two showed a positive trend. The number of COHWs who believed tap water with fluoride prevents dental cavities increased from $N = 7$ at pre-test to $N = 13$ at post-test. Additionally, the number of COHWs who believed a parent's dental health affects their child's dental health increased from $N = 7$ at pre-test to $N = 13$ at post-test. Please refer to **Supplementary Datasheet 1** (survey instrument) to view all knowledge and belief questions and their respective response categories.

Regarding the oral health practice questions, all 13 COHWs stated that their children had a dental home and 11 out of 13 (85%) stated the reason for their children's last visit to the dentist was routine care (dental check-up). Additionally, the COHWs reported that the mean age they took their children to the dentist for the first time was at 13 months of age (the general recommendation is to take your child to the dentist by the time the child is 12 months of age or earlier). Eight of the 13 (62%) COHWs reported they have a dental home for themselves. The COHWs who did not have a dental home for themselves stated they did not qualify for public dental insurance ($N = 4$) and one stated she had no money to pay for dental care.

TABLE 2 | Demographic characteristics of the 13 COHWs.

Demographics	*N* (%)
Gender	
Female	13 (100%)
Age	
18–29	3 (23%)
30–39	7 (54%)
40–49	3 (23%)
Race	
White	13 (100%)
Ethnicity	
Latina/Hispanic	13 (100%)
Education	
Less than high school	5 (39%)
High school/GED	2 (15%)
Some college/college degree	5 (39%)
Post graduate/professional degree	1 (7%)
Employment	
Homemaker	8 (61%)
Full time worker	1 (8%)
Part time worker	4 (31%)
Marital status	
Married/partner	9 (69%)
Single/separated	4 (31%)
Previous oral health worker training	
No	12 (92%)
Yes	1 (8%)

Phase III: COHW-Led Oral Health Promotion Workshops

The majority of caregivers who attended the workshops were female Latinas (88%). Just over half (51%) were between the ages of 30–39 years (mean age 36 years). Most were married (63%) and over half (56%) reported being homemakers. Approximately one-third (31%) reported a high school education or greater. The mean number of children reported by caregivers was 2.6 with a mean age of 8 years (see **Table 3**).

Table 4 presents the pre-test and post-test comparisons for changes in five of the eight knowledge questions and all three belief questions that were statistically significant. As a composite score for all eight knowledge questions combined for all 157 caregiver responses, the mean number of correct responses increased from 2.11 (SD = 1.41) at pre-test to 3.43 (SD = 1.74) at post-test ($P < 0.001$). To see the complete list of the knowledge and belief questions with their respective response categories, please refer to the questionnaire in **Supplementary Datasheet 2, 3**.

When caregivers were asked, "*How often does your child eat sugary snacks like fruit snack gummies, chocolate, crackers, cookies, etc.*?," 58% of respondents said their child eats them once a week or less than once a week. When asked, *"How many times per day does your child drink soda, fruit juice, fruit drinks, or sports drinks* ***not*** *with a meal?,"* 27% of the caregivers responded that their child **never** drinks soda, fruit juice, fruit drinks, or sports drinks **not** with a meal. Over three quarters of caregivers (78.4%) reported the reason for their child's last visit to the dentist was a routine check-up and only 5% reported the reason for their child's last visit to the dentist was pain. Over three quarters of caregivers (78%) said they have a dental home for themselves and 65% of them indicated it has been between 6 months and 2 years since their last dental visit. The reasons most frequently stated for not having a dental home included no dental insurance coverage (58%) and it is too expensive (21%). Still, 13% of the caregivers reported it had been 2–5 years since their own last dental visit and 2% stated they have never seen a dentist.

TABLE 3 | Demographic characteristics of the oral health workshop attendees ($N = 157$)*.

Demographics	*N* (%)
Gender	
Female	130 (88%)
Male	18 (12%)
Age	
18–29	26 (18%)
30–39	80 (55%)
40–49	30 (21%)
50+	9 (6%)
Race	
White	99 (88%)
Black/African-American	2 (2%)
Asian/Pacific islander	4 (3%)
Multi-racial	8 (7%)
Ethnicity	
Latino/Hispanic	150 (100%)
Education	
Less than high school	73 (52%)
High school/GED	35 (25%)
Some college/college degree	28 (20%)
Post graduate/professional degree	4 (3%)
Employment	
Homemaker	88 (58%)
Full time worker	26 (17%)
Part time worker	33 (22%)
Other	4 (3%)
Marital status	
Married/partner	98 (64%)
Single/separated	37 (24%)
Other	19 (12%)
Previous oral health worker training	
No	116 (87%)
Yes	18 (13%)

Frequencies do not add up N = 157 as some attendees did **not answer all questions.*

DISCUSSION

Oral health education interventions framed in a culturally appropriate and sensitive manner have a much higher likelihood of modifying participants' oral health risk behaviors than those developed generically and translated for other target populations (9, 27, 40, 41). Our study demonstrated that the use of COHWs to deliver oral health workshops to members of their community resulted in positive changes in oral health-related knowledge and beliefs following a 1 h workshop. Working with native-speakers from the community drew on the value of the community and created a comfortable and safe environment for participants to learn about oral health care.

In order to best tailor and refine the oral health curriculum content and activities for our COHW and community participants, qualitative information was gathered from a focus group which included participants with the same demographics as the target population. While the focus group participants appeared to have a fair amount of oral health knowledge, including being aware of key health promoting oral health concepts, they still had several unanswered questions about oral health care practices such as flossing, use of mouthwash, and at what age to start using toothpaste with fluoride for children. Focus group participants also reported several barriers to dental care, including lack of communication between dentist/dental office staff and the patient regarding dental procedures at the time of visit, and over diagnosing and aggressive dental treatment for young children. Dental providers who treat children should be better trained to work with children and their families. Communication strategies used by dental providers must be culturally and linguistically appropriate, and increasing the standards for dental training and practice with regards to treating young children is crucial.

The 13 COHW participating in the training showed significant increases from pre-test to post-test on the knowledge questions regarding the age when children can brush their teeth well alone and what a pregnant women with morning sickness can do to protect her teeth. Although only a few items showed statistical significance after the four training sessions, it should be noted that these 13 COHWs had a high oral health IQ before the training started. This is likely attributed to their participation in the EHS program where parents are provided with oral health information and almost half (46%) of the 13 COHWs reported a college education or greater. Thus, the lack of more statistically significant findings might be due to a ceiling effect where the COHWs had already high scores on questions at pre-test so there was little room to increase scores on the post-test.

Among the caregivers who participated in the 1 h COHW-led oral health workshops, there was a significant increase from pre- to posttest in knowledge and beliefs regarding oral health care. Significant increases in knowledge were obtained regarding when a child can brush their teeth well alone, the age when fluoridated toothpaste can be used, ways tooth decay can be prevented, when a child's first dental visit should be, and what a pregnant woman with morning sickness can do to protect her teeth. Significant positive improvements were found regarding caregiver's beliefs toward agreeing that fluoridated water can help prevent cavities, disagreeing that tap water is dangerous, and agreeing that a parent's dental health affects their children's dental health. Findings from our study are in agreement with previous findings from the Contra Caries Oral Health Education Program which found their program was effective at improving low-income Spanish-speaking parents' oral hygiene knowledge and self-reported behaviors for their young children (12).

LIMITATIONS

This study had limitations. First and foremost, this study was not a cause and effect study. All responses to the questionnaires were self-reported and therefore subject to social desirability. This study was based on a convenience sample, thus the results may not be generalizable. Three of the COHWs training sessions were conducted by a pediatric dental resident and two nurse

TABLE 4 | Changes in knowledge and beliefs from pre-test to post-tests among caregivers who attended the workshops ($N = 157$).

Questions (with correct response category)	Answered correctly		*P*-value
	Pre-test *N* (%)	Post-test *N* (%)	
KNOWLEDGE			
At what age in years can children generally brush their teeth well by themselves? (7–9 years)	38 (24%)	69 (44%)	<0.05
At what age do you start using toothpaste with fluoride for your child? (6 months and/or when the first tooth comes in)	64 (41%)	121 (77%)	<0.05
Tooth decay can be prevented with (fluoride, brushing, flossing)	53 (34%)	77 (49%)	<0.05
A child's first dental visit should be (after the first baby tooth erupts or by their first birthday)	122 (78%)	143 (91%)	<0.05
When a pregnant woman has morning sickness (vomiting), what can she do to protect her teeth? (rinse mouth with water or a mixture of water and baking soda)	39 (25%)	115 (73%)	<0.05
BELIEFS			
Tap water is dangerous (strongly disagree/disagree)	102 (65%)	135 (86%)	<0.05
Tap water with fluoride prevents dental cavities (strongly agree/agree)	78 (50%)	143 (91%)	<0.05
A parent's dental hygiene affects their child's dental health (strongly agree/agree)	105 (67%)	143 (91%)	<0.05

practitioner students. We did not calibrate the trainers, so we were not able to account for inter-trainer reliability. While the 13 COHWs who conducted the workshops with caregivers were instructed to present the same educational material, it is possible not all COHWs were 100% adherent to the program protocols since process evaluation and program monitoring activities were not incorporated into the project, thus potentially impacting the fidelity of the program. Administering the post-test immediately following the 1 h workshop limits our ability to assess the reliability of the study findings and effectiveness of the program. Additionally, the short time frame between pre-test and post-test did not allow us to assess behavior change. While increasing knowledge and changing beliefs regarding oral health care is an important step in changing behavior, it does not always translate into behavior change (42). Future studies with a longer follow up time-period (6 months−1 year) are needed to more reliably examine retention of knowledge and changes in beliefs and behaviors. Although this study did not have a control group, within-person comparisons for the pre- and post-test statistical analysis helped minimize the risk of confounding from individual characteristics and threats to validity.

CONCLUSION

Few culturally and linguistically appropriate oral health promotion programs have been developed for low-income Spanish-speaking caregivers of young children (12, 37, 43–45). Our study showed that a COHW-led oral health promotion workshop resulted in significant improvements in caregivers oral health-related knowledge and beliefs. Future work using COHWs might entail implementing a formalized system of incorporating COHWs into the dental health care system. The COHWs could be responsible for connecting families with the right type of care. They could also provide referrals to patients in person and offer to assist them in setting up appointments to help ensure children actually see a provider and obtain needed follow up care, as opposed to just receiving a piece of paper with a referral written on it. Navigating the health care system is not as straightforward as many assume. Thus, viewing COHWs as an important link between the community and utilization of oral health care services, especially for high-risk and vulnerable populations, should be a priority.

Investing in COHWs to provide oral health promotion in the future will require long-term studies to validate best practice approaches that promote oral health within the context of the overall social determinants of health (access to a dental home, transportation, insurance coverage, access to healthy food options, etc.). A nationwide, streamlined, consistent training curriculum such as the American Dental Association's Community Dental Health Coordinator Curriculum (with core competencies that are evidence-based and tested) (46) as well as scope of practice and oversight will be needed. Paying COHWs through state or Los Angeles County oral health funds, Dental Transformation Initiative (DTI) pilots, and health insurance model payments should also be strongly considered.

It is crucial to design long-term *clinical* studies to examine the oral health status of the children of trained COHWs and the workshop attendees to determine if short-term improvements actually translate into positive *clinical* health outcomes in children. Previous studies have shown that caregivers have a fair amount of knowledge regarding oral health care, yet this knowledge is not necessarily translated into improvements in oral health care practices (12, 42). There continues to be a disconnect between oral health care knowledge and actual oral health care practices and clinical outcomes (similar to other chronic diseases), especially among minority and underserved populations. In light of the current high prevalence of ECC in Latino children, future studies are needed to further examine the relationship between the high prevalence of ECC among young children in underserved populations and oral health care knowledge and practices. In summary, our study results support the utilization of COHWs for ECC prevention as a viable option that must be expanded.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

The study was reviewed and approved by the UCLA Office of the Human Research Protection Program for Institutional Review Board (IRB) (IRB Approval # 18-00014).

AUTHOR CONTRIBUTIONS

FR-G was the principal investigator and senior advisor of the study. JV was the co-principal investigator and contributed to the study design and study implementation. HA contributed to the study design, study implementation, data evaluation, and manuscript preparation. IV contributed to the study design and manuscript preparation. VK contributed to the study design and was the site cohort director. JK contributed to the manuscript preparation.

ACKNOWLEDGMENTS

This project was supported by a grant from Colgate's Alliance for a Cavity Free Future (ACFF: http://www.allianceforacavityfreefuture.org/en/us/about-us/). The proposal was written on behalf of the UCLA Center for Children's Oral Health (UCCOH: http://www.uccoh.org/). UCCOH is a multidisciplinary initiative utilizing evidence-based research translated into training in clinical care and to aid in policy development and oral health advocacy. The main goal of UCCOH is to improve children's oral health at the local level as well as nationally and internationally. The Center aims to build, strengthen, develop, and integrate activities in children's oral health through interprofessional education in a pediatric oral health training program in coordination with the UCLA Schools of Medicine, Nursing, Public Policy, and Public Health. Special thanks to our two project coordinators, Vanessa Sanchez Medina and Paula Echeverry and to the Hope Street Family Center management team.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2019.00175/full#supplementary-material

Supplementary Datasheet 1 | Pre- and post-test for the COHWs (34 items, available in English and Spanish).

Supplementary Datasheet 2, 3 | Appendix B Pre and posttest for the workshop attendees (pre:16 items and posttest: 11 items, available in English and Spanish).

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 07 November 2019
doi: 10.3389/fpubh.2019.00322

Parental Knowledge and Acceptance of Different Treatment Options for Primary Teeth Provided by Dental Practitioners

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Background: Parents have an influence on dental treatment options for young children regarding type of care provided. The aim of this study was to assess parents' knowledge and acceptance of different treatment options for primary teeth provided by dental practitioners for their children.

Materials and Methods: In this descriptive, cross-sectional study, caregiver/child dyads ($n = 476$) were recruited from patients at Pediatric Dental Clinics, Jordan University of Science and Technology. The data collection questionnaire to parents included: 1-demographic data 2-parental knowledge and practices regarding child's oral hygiene, caries and caries prevention 3-parental knowledge and acceptance of different treatment options for primary teeth including two given clinical scenarios (ICDAS-5 molar requiring intra-coronal restoration, ICDAS-6 molar requiring pulp therapy and stainless steel crown) with pictures before and after treatment. Afterwards, the child underwent a dental examination to record dmft/DMFT, gingival and plaque indices. Data was analyzed using SPSS, significance was set at $P \leq 0.05$.

Results: Children's ages were 2–12 years (mean/SD 6.97 ± 2.5); with 255/53.6% males, 221/46.4% females. There were (166) children 2–5 years in primary dentition; (108/166) 65% had ECC, and ($n = 62/166$) 37.4% had S-ECC, and (310) 6–12 years in mixed dentition; (278/310) 89.7% had caries. Scaling and extraction were the highest known and accepted treatments for primary teeth by parents (35.5 and 30.1%, respectively), while nitrous oxide/oxygen sedation was the least (3.6%). Parental educational level was significant for composite restorations, fluoride gel application and pulp therapy ($P = 0.03$, 0.02, and 0.03, respectively) and age above 40 for amalgam restorations ($P = 0.04$). In both scenarios, most parents preferred to leave any care decision in hands of the dentists with no effect of educational level ($P > 0.05$). There were 81.5% parents who reported that their children's dental status was good, however, 78.4%/42.8% children had an average dmft/DMFT score 5.34/2.32 and mean PI/GI scores 0.88 ± 0.20/0.17 ± 0.23.

Conclusion: Parental knowledge and acceptance about dental treatment options for primary dentition was generally low. Parental education and age had an impact

OPEN ACCESS

Edited by:
Francisco Ramos-Gomez, UCLA School of Dentistry, United States

Reviewed by:
Sadeq Al-Maweri, Al-Farabi College, Saudi Arabia
Cihad Dundar, Ondokuz Mayis University, Turkey

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *08 April 2019*
Accepted: *18 October 2019*
Published: *07 November 2019*

Citation:
Al-Batayneh OB, Al-Khateeb HO, Ibrahim WM and Khader YS (2019) Parental Knowledge and Acceptance of Different Treatment Options for Primary Teeth Provided by Dental Practitioners. Front. Public Health 7:322. doi: 10.3389/fpubh.2019.00322

on parental knowledge and practices regarding child's oral hygiene, caries and caries prevention, and some treatment options. There was an overrated parental opinion of their child's teeth status despite the high dmft/DMFT and PI.

Keywords: parental knowledge and acceptance, treatment options, primary teeth, caries prevention, DMFT/dmft, children

INTRODUCTION

Oral health has an important role in the general well-being of individuals. The adoption of good oral health habits in childhood often takes place with parents, especially mothers (1, 2) and is affected by parental dental knowledge, attitudes, cultural beliefs and awareness about infant diet and feeding practices, oral hygiene habits, preventive regular dental visits, care of primary teeth and concern for oral health. It has been found that the more positive the parent's attitude is toward dentistry, then the better will be the dental health status of their children (3). Therefore, interventions targeting parental oral health beliefs and practices may be beneficial in the prevention of oral health problems.

Dental treatment of young children is usually provided only after explanation and consent with parents (4). There are a few studies on parental acceptance of dental treatment at the dental office for their children; some were limited to parental acceptance of dental treatment under general anesthesia or nitrous oxide, which was reported to be less than 10% for both (5); and acceptable in one third of parents in another study that evaluated acceptance of dental treatment under general anesthesia (6). In other studies, two scenarios were given to the parents to assess the acceptance of pulp therapy and restorative treatment, they found that most of the parents relied on the dentist to choose the treatment (4, 6, 7), one-third refused to do any treatment for asymptomatic teeth (4, 6), and 9–37% preferred tooth extraction for symptomatic teeth (6, 8).

Unfortunately, there is little information in the literature to show if parental age and education affects their preferences for the dental care of their children (6). The relationship between parental treatment preferences and factors such as their knowledge about oral hygiene, caries and caries prevention hasn't been fully investigated. Therefore, the aims of this study were:

(1) To assess parents' knowledge and acceptance of different treatment options for primary teeth provided by dental practitioners for their children.
(2) To assess parental knowledge and practices regarding the child's oral hygiene, caries and caries prevention.

MATERIALS AND METHODS

Ethical Approval

Ethical approval was gained from the IRB, JUST (Institutional Review Board, Jordan University of Science and Technology), grant # 175/2014. In addition, written informed consent was obtained from all parents/caregivers after explanation of study objectives.

Study Design, Setting, and Subjects

This was a descriptive, cross-sectional study with a convenient sample of families that lived in North Jordan. The sample consisted of 476 subjects who were recruited from a group of parents accompanying their children to Pediatric Dental Clinics for free dental treatment at the Faculty of Dentistry, Jordan University of Science and Technology Irbid, Jordan between April, and December, 2014, respectively. Inclusion criteria for participation were: families of a healthy child, aged 2–12 years, with primary or mixed dentition, selected randomly among the family's children where the oldest or the youngest child was chosen sequentially in the consenting family.

Data Collection

The data were gathered by means of a self-reported questionnaire given for the primary caregiver (father or mother). A self-designed questionnaire in the local language (Arabic) was used. An investigator was responsible to choose a child randomly from each family after explaining the purpose of the study to the parent and giving instructions to completely fill the questionnaire specifically about the chosen child. Random choice of the child per family was based on choosing the only child, or choosing the eldest and youngest consecutively among each family with more than one child. Before data collection, the questionnaire was piloted twice, over a week interval, on 20 patients to ensure reproducibility, consistency and clarity; there was 95% agreement between the two times.

Two trained investigators (dentists), whose examination technique was calibrated, with (97.6%) agreement, were responsible for the child examination. Inter-examiner and intra-examiner reproducibility was measured by re-examination of 20 children participating in the study with a 1-week interval between both examinations. The *k*-value of intra-examiner reliability was calculated to be (0.97). After that, the parent was met to explain the oral health of the examined child and to clarify findings of the examination.

The Questionnaire and Clinical Scenarios

A questionnaire was used to collect the data in the form of 30 close-ended multiple-choice questions. The questions were split into three sections.

Section 1: demographic data
Section 2: parental knowledge and practices regarding the child's oral hygiene, caries and caries prevention
Section 3: parental knowledge and acceptance of different treatment options for primary teeth and parental opinion toward two given clinical scenarios (**Figures 1, 2**).

FIGURE 1 | Restorative treatment ICDAS 5- "If your child has a carious asymptomatic primary tooth that needed to be restored, will you accept dental treatment or not? And if you accept the treatment, will you leave the decision of the material to be used to the dentist or will you choose between amalgam and composite?" Results: 60.3% of participants preferred to leave any care decision in the hands of the dentists, and there was no difference between university educated and secondary school level educated parents ($P = 0.09$). A few parents (8.4%) did not want any treatment to be provided since the tooth was primary and symptom-free.

FIGURE 2 | Restorative treatment ICDAS 6- Pulp therapy and Stainless steel crown-"If your child has a carious primary tooth which is causing toothache and needs pulp therapy and a stainless steel crown, will you accept dental treatment or will you choose to extract the tooth or leave it as it is? Results: 72.9% of the parents accepted the treatment option given by the dentist but 16.8% did not want any treatment. Around 11.3% of parents preferred the tooth to be extracted. Parental educational level did not play a significant role in their preferences for treatment ($P = 0.58$). Comparisons in parental choices for both clinical scenarios were not significant between children age groups (<6, 6–12) or gender.

Examination of the Child

From each family, the randomly selected child was fully examined intra-orally using a sterile dental front mirror and a periodontal probe (Michigan O probe with William's coding) to record dental caries, modified O'leary gingival and plaque indices (0 = absence, 1 = presence on sextant primary teeth). Dental caries was recorded at baseline using WHO Oral Health Survey Basic Methods 1997 criteria; dmft/DMFT index revealed decayed (d/D), missing/extracted (m/M) and filled (f/F) teeth (t/T) in deciduous/permanent teeth (9). The modified index was used in previous studies (10) and was based on the O'Leary index (11) and The Plaque Assessment Scoring System (12) was used in obtaining the plaque index (PI) score. Measurements were obtained by recording plaque deposits on all surfaces (buccal, lingual, mesial and distal) of the following teeth: 16/55, 21/61, 24/either 64 or 63, 46/85, 41/81, 44/84. If plaque was visible on the probe, the surface was counted as positive for plaque accumulation and given a score of 1 for plaque presence at that surface otherwise a score of 0 for no plaque. There were 24 possible plaque surfaces per patient. Gingival index (GI) scores were obtained for the teeth using the same method in scoring PI. Gingivitis was considered present if there was bleeding on probing clinically. The plaque/ gingival index for the child is the percentage of surfaces positive for plaque/gingivitis. For both indices, the score of the patient would range between 0 and 1. Based on a previous study, patients were considered not to have plaque or gingivitis if the score was between 0 and 0.13; if the score of patients was from 0.17 to 1.0 they were considered to have plaque, calculus or gingivitis (10). Subjects were rewarded for cooperative behavior by gifts.

Sample Size Calculation

The sample size was calculated assuming that 50% of parents had proper knowledge and practices regarding child's oral hygiene, caries and caries prevention. The assumption of 50% was used to yield the largest sample size. At a power of 80% and level of significance of 0.05, the sample needed was estimated at 385 for estimating the expected proportion with 5% absolute precision.

Statistical Analysis

Data entry and statistical analysis were done using Statistical Package for the Social Sciences (SPSS version 25.0) for windows (SPSS Inc., Chicago, USA). Means and standard deviations for the variables were calculated. The Chi-square test was used to compare percentages. Multivariate analysis using binary logistic and multinomial regression was conducted to test the differences in parental knowledge and practices according to parental age and education. A $P \leq 0.05$ was considered statistically significant.

RESULTS

The response rate was 91.5% ($n = 526/575$). Of the 526 parents/children who participated in this study, 50 forms were excluded due to incomplete data or examination. The remaining 476 forms were analyzed. Parental demographic data are shown in **Table 1**. The children's ages ranged between 2 and 12 years with a mean (SD) age of 6.97 (2.5) years. Of the total examined children, 255 were males (53.6%) and 221 were females (46.4%). For the sake of analysis, the children were divided into two groups; ages <6, years ($n = 166$ children, with primary dentition), and ages 6–12 years ($n = 310$, in the mixed dentition).

Parental knowledge and practices toward their children's oral hygiene at home is shown in **Table 2**. Comparing between children age groups (<6, 6–12 years), differences existed in choosing the age appropriate toothpaste ($x^2 = 11.1$; $p < 0.001$), correct tooth brushing technique ($x^2 = 78.5$, $p \leq 0.001$), caregiver supervision during tooth brushing ($x^2 = 8.1$, $p = 0.004$), and additional teeth cleaning methods ($x^2 = 9.3$, $p = 0.002$). In the multivariate analysis, parents aged 20–40 years and those with university education had significantly better knowledge and practices toward children's oral hygiene at home with regards to

having a toothbrush, brushing frequency and supervision during brushing.

Parental knowledge of caries and caries prevention is shown in **Table 3**. Parental opinion about their child's teeth was rated as good by 81.5%. Parents of the two age groups differed significantly in their knowledge about missing school days due to toothache ($x^2 = 21.6$, $p < 0.001$), reason for visiting the dentist ($x^2 = 59.5$, $p < 0.001$), and fluoride sources ($x^2 = 6.0$, $p = 0.048$). Parental knowledge about caries and caries prevention regarding effect of dental caries and periodontal problems on general health and fluoride effect on teeth was significantly better in university educated parents compared to secondary school educated parents in the univariate and multivariate analysis. Age was not a significant factor with regards to any of the variables in **Table 3**.

TABLE 1 | Parental demographic data according to children's age (years), total sample $n = 476$ (<6 years old = 166, 6–12 years old = 310), % are based on the total sample size.

Variable	Father N (%)		Mother N (%)	
	Children <6	Children 6–12	Children <6	Children 6–12
Age (years)				
20–40	54 (11.3)	82 (17.2)	93 (19.5)	123 (25.8)
Total	136 (28.6)		216 (45.4)	
More than 40	14 (2.9)	74 (15.5)	5 (1.1)	31 (6.5)
Total	88 (18.5)		36 (7.6)	
Education				
Secondary school	22 (4.6)	41(8.6)	31 (6.5)	68 (14.3)
Total	63 (13.2)		99 (20.8)	
University	46 (0.97)	115 (24.2)	67 (14.1)	86 (18.1)
Total	161 (33.8)		153 (32.1)	
Total = 476	**224**		**252**	

Parental knowledge and acceptance of different treatment options of the primary teeth by parents is shown in **Table 4**. From the provided treatment option list, scaling and extraction were the highest known and accepted treatment by the parents (35.5 and 30.1%, respectively), while treatment under nitrous oxide/ oxygen sedation was the least (3.6%). Comparisons between parental knowledge and acceptance of treatment options were not significant for both children age groups (<6, 6–12) and gender. There was no significant difference in knowledge and acceptance of all the treatment options among the participants according to parental educational level except for composite restorations, fluoride gel application and pulp therapy, where university educated parents knew and accepted those two treatment options more ($P = 0.03$, 0.02, and 0.03, respectively). With regards to age, those who were above 40 years had significantly more knowledge and acceptance of amalgam restorations than those between 20 and 40 years ($P = 0.04$). The findings of the multivariate analysis were consistent with the findings of the univariate analysis.

Responses of parents to the clinical scenarios are indicated in the figure legends of **Figures 1**, **2**. Regarding the importance of dental treatment for the primary dentition as compared to permanent teeth, 55% of the parents stated that primary teeth will be replaced and no need to do any dental treatment. As to whether parents had enough information about oral health of their children, 91.6% of parents were interested in receiving more information about the primary dentition.

The number of decayed, filled and missing teeth were summed together to give the DMFT score for the permanent dentition and the dmft score for the primary dentition (**Table 5**). The mean dmft and DMFT for the children was 4.64 (SD 3.95) and 1.08 (SD 1.47), respectively. Only 58 (12.2%) of children had dmft = 0, and 32 (6.7%) children had DMFT = 0. The modified O'leary plaque index mean was 0.88 (SD 0.20) with a maximum score of 1 in 66.2% children and a minimum score of 0 in

TABLE 2 | Parental knowledge and practices toward their children's oral hygiene at home.

Variable	<6 years old (*N* = 166)		6–12 years old (*N* = 310)		Total (*N* = 476)		Chi-square value	*P*-value
	n	%	n	%	N	%		
Child has a tooth brush	149	89.8	294	94.8	443	93.1	3.46	0.063
Tooth brush bristles							0.06	0.812
Soft	112	67.5	224	72.3	336	70.6		
Hard	37	22.3	70	22.6	107	22.5		
Type of fluoridated tooth paste (TP) used per age group								
Adult's TP	57	34.3	174	56.1	231	48.5	11.10	<0.001
Children's TP	109	65.7	174	56.1	283	59.5		
Brushing frequency (daily)							2.66	0.102
Once- Twice	119	71.7	243	78.4	362	76.1		
Never	47	28.3	67	21.6	114	23.9		
Parent knowledge of correct tooth brushing technique	126	75.9	310	100.0	436	91.6	78.50	<0.001
Caregiver supervision during tooth brushing	124	74.7	190	61.3	314	66.0	8.07	0.004
Additional teeth cleaning methods	22	13.3	80	25.8	102	21.4	9.30	0.002

TABLE 3 | Parental knowledge of caries and caries prevention.

Variable	<6 years old (*N* = 166)		6–12 years old (*N* = 310)		Total (*N* = 476)		Chi-square value	*P*-value
	n	%	n	%	N	%		
Opinion about children's teeth status							4.6	0.031
Good	144	86.7	244	78.7	388	81.5		
Poor	22	13.3	66	21.3	88	18.5		
Opinion about the reason for dental decay							2.5	0.417
Sugar consumption	42	25.3	83	26.8	125	26.3		
Poor oral hygiene	12	7.2	36	11.6	48	10.1		
Both	101	60.8	170	54.8	271	56.9		
Don't know	11	6.6	21	6.8	32	6.7		
General health is affected by dental caries and periodontal disease	127	76.5	238	76.8	365	76.7	0.001	0.968
Missing school days due to toothache	26	15.7	113	36.5	139	29.2	21.6	<0.001
Fluoride sources							6.0	0.048
Tooth paste	77	46.4	180	58.1	257	54.0		
Drinking water	42	25.3	58	18.7	100	21.0		
Don't know	47	28.3	72	23.2	119	25.0		
Fluoride effect on teeth							0.5	0.758
Whitening teeth	28	16.9	57	18.4	85	17.9		
Strength and caries resistance	108	65.1	191	61.6	299	62.8		
Don't know	30	18.1	62	20.0	92	19.3		
Reason for visiting the dentist							59.5	<0.001
Dental pain	73	44.0	220	71.0	293	61.6		
Check up	15	9.0	45	14.5	60	12.6		
Never been there	78	47.0	45	14.5	123	25.8		
Knowledge about pediatric dentistry specialty							2.29	0.318
Yes, and treat there	71	42.8	147	47.4	218	45.8		
Yes, but treat with general practitioner	58	34.9	111	35.8	169	35.5		
Don't know	37	22.3	52	16.8	89	18.7		

TABLE 4 | Parental knowledge and acceptance of different treatment options in primary teeth.

Treatment option	Knowledge	Acceptance	Knowledge and acceptance
Scaling	53.6%	48.8%	35.5%**
Fissure Sealant	9%	13.9%	5.4%*
Fluoride Gel Application	27.1%	30.7%	18.7%
Composite Restoration	36.1%	42.2%	23.5%
Amalgam Restoration	28.3%	27.7%	17.5%
Pulp therapy	13.9%	12%	7.2%*
Stainless steel Crown	11.4%	14.5%	6%*
Extraction	48.8%	41.6%	30.1%**
Space Maintainer	26.5%	31.3%	18.7%
Nitrous oxide Sedation	6%	10.2%	3.6%*
General Anesthesia	15.7%	24.7%	8.4%
Dental Radiographs	34.9%	43.4%	27.1%

**Treatments less known and accepted by the parents.*
***Treatments most known and accepted by the parents.*

0.2% which was in one child. Moreover, the modified O'leary gingival index mean was 0.16 (SD 0.23) with a maximum score of 1 in 2.3% and a minimum score of 0 in 50.8% of children. Of the 81.5% parents who reported that their children's dental status was good, only 21.6 and 57.2% had dmft and DMFT = 0, while 78.4 and 42.8% had an average dmft/DMFT score of 5.34/2.32. However, the PI and GI = 0 was present in 11.9 and 74.2%.

DISCUSSION

The preservation of healthy teeth is one of the key health issues in childhood and parents play an important role in their children's oral health. Parental education played a significant role in knowledge and practices toward children's oral hygiene at home with regards to having a toothbrush, brushing frequency and supervision during brushing. A high percentage of children in the sample were reported to brush their teeth at least once to twice daily, similar results were found in other studies (14–16), and the brushing frequency was more when the parents were university educated, similar to that reported by Rajab (17). More than half of the total sample of parents guided and supervised their children while brushing their teeth (**Table 2**) and this was similar to other's findings (18). The use of additional measures was low in our sample, similar to other studies (16, 19), and this could be attributed to the lack of knowledge of benefits of

TABLE 5 | Average DMFT/dmft table for children in the sample by age (years), total sample $n = 476$ (<6 years old = 166, 6–12 years old = 310), % are based on the total sample size.

Age of child		Average DMFT/dmft	N (%)	Diagnosis
<6 years old ($n = 166$)	2–3 years 40 (8.4%)	Average dmft = 0	18 (3.8)	Caries free
		Average dmft = 1.6	11 (2.3)	Dental caries (ECC)*
		Average dmft ≥ age +1	11 (2.3)	S-ECC**
	4–5 years 126 (26.5)	Average dmft = 0	40 (8.4)	Caries free
		Average dmft = 2.9	35 (7.4)	Dental caries (ECC)*
		Average dmft ≥ age +1	51 (10.7)	S-ECC**
6–12 years old	6–12 years 310 (65.1)	Average DMFT/dmft = 0	32 (6.7)	Caries free
		Average DMFT/dmft = 5.5	278 (58.4)	Dental caries
Total		**476**		

**ECC: Early Childhood Caries defined as presence of 1 or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 month of age or younger (13).*

***S-ECC: Any sign of smooth-surface caries in children younger than 3 years of age. From age 3 through 5, 1 or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth or a decayed, missing, or filled score of ≥4 (age 3), ≥5 (age 4), ≥6 (age 5) surfaces (13).*

these auxiliary methods (15, 16, 19, 20). Studies in Jordan on early childhood caries revealed several risk factors associated with caries in children. Some of these factors included; infant feeding habits, oral hygiene practices and socioeconomic status (17, 21, 22). Regarding socioeconomic status there were conflicting results about its actual impact on ECC in Jordan (22–25). Yet, no indices were used to measure oral hygiene and plaque scores and their association with ECC in these studies (26).

In relation to parental knowledge about caries and caries prevention, most of the parents in both age groups recognized the sources of fluoride and its effect on teeth and many of the parents reported that poor oral hygiene and high sugar consumption were the causes for dental decay and this is consistent with other studies (16, 17, 20), and indicates good knowledge about causes of teeth decay. Again, parental education was significantly related to knowledge about effect of dental caries and periodontal problems on general health and fluoride effect on teeth. A high proportion of the subjects reported that children's bad oral health could affect the general health which implies that their children's oral health should be in a good status, however, this wasn't the case since dmft/DMFT was 4.64/1.08. Similar to previous studies (16, 18–20) parents reported that pain was the main reason for visiting the dental office instead of regular check-up.

The lack of knowledge of parents about different treatment options for primary teeth, especially treatment under general anesthesia or nitrous oxide/oxygen sedation that are used in special situations for pediatric patients could be attributed to fear and low dental awareness (5, 6). Additionally, knowledge regarding pulp therapy and stainless steel crowns for primary teeth was found to be very low, and this explains the low parental acceptance of the treatment with these two options and the impact of parental education which was significant compared to those who have less education. Preventive treatment options that can be provided for children such as fissure sealants were neither known by parents nor accepted opposite to what was found in other countries such as in Australia (27), and this could partially explain the high dmft/DMFT and plaque index in the children and the highest knowledge and acceptance for scaling and extraction. Parental education was significantly important in those who recognized fluoride gel application and accepted it as a treatment. Regarding dental filling materials, composite restorations were significantly more known and accepted by university educated parents and those in the 20–40 age group more than amalgam restorations, which indicated that aesthetic was more of a concern than other factors that influence the restoration material selection in this group of participants (28). The need for more knowledge about primary dentition preservation and treatment was in agreement with other studies (29, 30), indicating that more attention should be given for dental educational programs for parents and children.

In the two given scenarios, the majority of parents were happy to leave the decision about the treatment to the dentist and parental educational level or age did not play a significant role in their preferences for treatment. The reliance of parents on dentist for decision on the choice of their children's dental treatment suggested the need for dental health education to both parents and children on dental treatment (4, 6, 7). Notably, 91.6% of parents were interested in receiving more information about the primary dentition. In the asymptomatic carious primary tooth scenario, studies showed that some parents refused any treatment to be provided for a primary tooth as it will be replaced by a permanent successor (4, 6, 20, 29). In the second scenario were the child had a carious primary tooth with toothache requiring pulp therapy and stainless steel crown, some parents decided that the best treatment to be provided for this primary tooth was the extraction to relieve the pain as found by other studies (6, 8). Some parents in other studies reported that primary teeth were important and should be preserved (18, 31).

The poor status of the children's teeth in terms of mean dmft/DMFT scores and plaque index didn't correlate with parental assessment of their child's oral health. Of parents who reported that their children's dental status was good, 78.4 and 42.8% had an average dmft/DMFT score 5.34/ 2.32. Studies in Jordan showed that the overall prevalence of early childhood caries ranges between 48 and 72% (22–24, 32). The plaque index in most children (66.2%) was 1 which indicates presence of dental plaque when the children were examined; this reflects poor oral hygiene practices and predicts more caries and more gingival problems at a young age (6, 15, 33, 34).

There were some limitations for this study as it relied on a self-constructed questionnaire that lacked content and construct validity and was a single center study that didn't assess different regions in Jordan and other socio-economic factors that could have affected the choices by the parents. In addition, Berkson error could have been caused as the study was carried out on patients admitted to a clinic, and results could be subject to bias report given the nature of the study (questionnaire-based) and selection bias, and factors such as differences in maternal and paternal perception of choices of treatment since any of the parents answered the questionnaire based on who attended with the child. On the other hand, a relatively high number of subjects, compliance between observers, clear evaluation criteria

and extensive sociodemographic data were the strengths of the study. In conclusion, parental knowledge and acceptance about dental treatment options for primary dentition was generally low. Parental education and age had an impact on parental knowledge and practices regarding the child's oral hygiene, caries and caries prevention, and some treatment options. There was an overrated parental opinion of their child's teeth status despite the high dmft/DMFT, PI and GI in the children. This reflects the need of more effective communication between dental professionals and parents in addition to public preventive and educational programs in order to educate them how to take care of their child's oral health, the importance of regular dental visits and including parents in the decision of treatment instead of the total reliance on dental professionals which could be a recommendation for future studies.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/supplementary material.

ETHICS STATEMENT

Ethical approval was gained from the IRB, JUST (Institutional Review Board, Jordan University of Science and Technology), grant # 175/2014. In addition, written informed consent was obtained from all parents/caregivers after explanation of study objectives.

AUTHOR CONTRIBUTIONS

OA-B conceived the research idea, designed the study, and wrote up the manuscript. HA-K performed data collection and data entry. WI assisted in data collection and YK performed data analysis. All authors agreed on the final manuscript.

ACKNOWLEDGMENTS

This project was funded by the Deanship of Scientific Research, at Jordan University of Science and Technology, Irbid 22110, Jordan (grant # 20140175).

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 18 September 2019
doi: 10.3389/fpubh.2019.00259

Prevalence and Treatment Needs for Early Childhood Caries Among 3–5-Year-Old Children From a Rural Community in Uganda

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Introduction: Early Childhood caries (ECC) is the term used to describe dental caries in children aged 71 months and below. ECC causes a lot of pain and discomfort in the affected children and is expensive to treat. There is limited data on the prevalence of ECC in preschool children resident in the rural Uganda.

Aim: To determine the prevalence and treatment needs for ECC among 3–5-year-old nursery school children in a rural community in Rukungiri District, Uganda.

Study Design: This was a descriptive cross-sectional study in which 432 nursery school children aged 3–5 years from rural Nyakagyeme sub-county in Ugandan, participated. Informed consent for participation in the study by the children was obtained from their parents/guardians prior to the commencement of the study. The examination of the participants was done under field conditions, with the child lying his or her back of the neck on the PI's lap, with both of them seated on a bench and using natural light augmented with a headlamp to examine the oral cavity. The findings of the examination were recorded on individualized modified WHO Oral Health Assessment Forms for children.

Data Analysis: The data gathered were analyzed using Windows SPSS Version 23.0 computer programme, and descriptive results for the variables obtained and Mann Whitney and Kruskal–Wallis tests used to compare and relate the variables. The $P<0.05$ was considered statistically significant with the Confidence interval set at 95%. The findings were presented in Tables and Figures.

Results: A total of 230 (53.2%) male and 202 (46.6%) female participants, with 118 (27.3%), 145 (33.6%), 169 (39.1%) aged 3, 4, and 5 years old respectively, participated in the study. The overall prevalence of dental caries among the participants was 48.6%, with 11.6%, 18.5% and 18.5% recorded for the 3-, 4-, and 5-year old children, respectively. The male participants had a higher prevalence (26.1%) than the female counterparts (22.5%). The mean "**dmft**" for the participants was 2.04 ($SD = 3.01$) with the decay component (dt) having the highest value ($M = 1.97$, $SD = 2.89$), and contributing to 88.6% of the dental caries experience. The mean "**dmft**" was 1.79, 2.37 and 1.91 for the 3-, 4-, and 5-year old children, respectively, and the difference in the mean "**dmft**" among the age groups was not statistically significant.

OPEN ACCESS

Edited by:
Francisco Ramos-Gomez, UCLA School of Dentistry, United States

Reviewed by:
Cihad Dundar, Ondokuz Mayis University, Turkey
Figen Cavusoglu, Mayis University, Turkey

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *07 April 2019*
Accepted: *27 August 2019*
Published: *18 September 2019*

Citation:
Musinguzi N, Kemoli A and Okullo I (2019) Prevalence and Treatment Needs for Early Childhood Caries Among 3–5-Year-Old Children From a Rural Community in Uganda. Front. Public Health 7:259. doi: 10.3389/fpubh.2019.00259

Conclusion: The prevalence of ECC of 48.6% was moderate in this study population. The high level of unmet treatment need as exemplified by the high dental caries experience, was a cause for concern as this forms a risk factor for caries in the permanent dentition.

Keywords: early childhood caries, treatment needs, primary school children, Rukungiri District, Uganda

INTRODUCTION

Dental caries remains a major public health burden for babies, pre-school, primary school going children and adolescents in both the developed and less developed countries (1, 2), with the greatest burden being borne by children from the disadvantaged communities (2). Early Childhood caries (ECC) is the term used to describe dental caries in children aged 71 months and below (3). The disease has a multifactorial etiology involving interaction of factors that include, a susceptible host tooth, micro-organisms with cariogenic potential S. mutans, S. sobrinus, and Lactobacili), a substrate (dental plaque and/or biofilm) that is suitable for the survival of the pathogenic flora and time for changes to take place (3–8). Diet is a critical factor in the etiology of dental caries and children who consume cariogenic carbohydrates frequently for longer periods have increased risk of developing ECC (2, 3, 9). Additionally, environmental factors like low socio-economic status, lower level of education and non-exposure to fluoride from the water supply and the other fluoride sources play a part in the process (3, 4, 6, 8, 9).

ECC affects the children's teeth with a distinctive pattern, with the smooth surfaces of the primary upper incisors being affected first, followed by the occlusal surfaces of the primary molars in succession as they erupt. The lower primary incisors are usually spared because of the protection provided by the tongue and the copious saliva from adjacent submandibular and sublingual glands (2, 5, 7, 8). Initially, the disease presents as a white chalk lesion of demineralised enamel, and if not arrested at this stage it will progress to enamel surface cavitation (5, 8). The rough cavities formed on the enamel surfaces become retentive areas for further accumulation of the dental plaque that potentiates the possible replication of the process leading to eventual total destruction of the tooth (8).

ECC causes a lot of discomfort besides pain and loss of the affected tooth. ECC can also affect feeding, speech development, and psycho-social well-being of the child (6), not to mention expensive treatment in the form of restorations, pulpotomies/pulpectomies, extractions, and space management than is often needed. In cases where the child is uncooperative and basic behavior modification techniques have failed, conscious sedation or general anesthesia may have to be used, and these are expensive management modes (2).

The reported prevalence of ECC from the few studies conducted in Uganda has ranged from 17.6 to 65%. However, these studies have been conducted mostly in the urban and peri-urban communities (10–12). Although these reported prevalence rates appear to be high, they are still few studies and Uganda still has limited information on ECC and its burden on children particularly from the rural communities within Uganda. Furthermore, the Ugandan health sector is still faced with challenges like shortage of human resource in the public hospitals, irregular/ineffective supervisions of health services offered at these public hospitals, limited financial resource within the national budget and a high attrition rate of the oral health care professionals in the public health sector (13). All these factors are likely to affect the provision of the requisite oral health care to most of the children with ECC residing in the rural communities.

The purpose of the current study was, therefore, to determine the prevalence and treatment needs for ECC in a rural child population in Uganda.

METHODOLOGY

Study Design and Study Population

This was a descriptive cross-sectional oral health survey conducted in 2016 and involved 3–5-year-old nursery school children in government and private primary schools in Nyakagyeme sub-county, Rukungiri District in South-western Uganda.

Sampling

The study population was drawn from the 25 primary schools in Nyakagyeme Sub-county each with pre-primary/nursery section. Using the Uganda national population census results of 2014, the sub-county was estimated to have $\sim$ <6,000 children aged 5 years and below. Stratified random sampling procedure was used to select the schools with the aim of selecting at least one school in each parish. The sub-county has 8 parishes and thus 8 strata were formed and each parish was given a code (P1–P8). The list of the schools in each parish also was generated and from the lists formed, each school in the parish was assigned a unique letter code. The schools in the parishes that had at least 50 pupils or more (18 schools), whose ages were 3–5 years age, were eligible for selection. Ballots with the number assigned to each of the selected schools in each parish were made, folded and mixed in a box. If a parish had no school with at least 50 pupils in nursery, the school with the highest number of pupils was then selected for inclusion in the study. Thereafter, the principal investigator (PI) then randomly selected one school from each parish by picking a ballot from the box. A total of 8 schools were thus selected from the sub-county and these schools has a total number of 619 children eligible for participation in the study. The participating schools' register was then used as the sampling frame to select the study population, provided they met the inclusion criteria, which included being in good general health and whose parents provided written informed consent for their participation in the

study. The children were then examined for dental caries and the dental treatment needed as prescribed in the study.

The study population had been calculated with the assumption that, the population of children below 6 years in the sub-county was below 10,000 and the prevalence of caries among them to average 50%, a 95% confidence level being considered and 5% degree of accuracy. This gave the number of the participants as 384. However, a total of 432 children in the sub-county aged 3 to 5 years (230 males and 202 females; mean age 4.1, $SD = 0.8$) met the inclusion criteria and were examined during the survey.

Data Collection

Prior to collection of data, Ethical clearance was obtained from Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (Ref: P460/06/2016) and the School of Health Sciences Institution Review Board and Ethics Committee, Makerere University, Kampala, Uganda (SHSREC REF: 2016-036). Permission was also obtained from the Rukungiri District Education Officer (DEO) and individual participating schools, for children to participate in the study. Before the commencement of the study, the recording clerk was trained and pretested in the data collection exercise. The principle investigator (PI) was also calibrated by one of the supervisors under field conditions on detection of dental caries and dental treatment needs using 3–5-year-old children and who were not part of the study population. The process was repeated again in the field. The mean Cohen kappa score for the inter-examiner consistency were 0.90 and 0.95 ($N = 15$) for dental caries and dental treatment needs, respectively. The PI also regularly carried out intra-examiner consistency during the collection of data stage, and the mean Cohen Kappa scores were 1.00 and 0.98 ($N = 43$) for dental caries and dental treatment needs, respectively.

During the examination phase, the PI used visual and tactile methods to examine participants for dental caries. A sterile mouth mirror and WHO dental probe were used to carry out the procedure under natural light. An assessment Form (modified World Health Organization (WHO) Oral Health Assessment Form for children, 2013) (14), was used to record the findings of the clinical examination. The children's age and gender were also recorded. In carrying out the examination, individual teeth were first isolated, wiped clean and dried with sterile gauze before the detection for dental caries was undertaken. The data obtained was also used to calculate the "**dmft**" in order to get a record of the dental caries experience of the participants (14). Incipient lesions were diagnosed when a tooth had a whitish chalky area/spot on the cervical areas and occlusal surfaces with no signs of structural breakdown. A tooth was recorded as having caries whenever enamel and/or dentin breakdown was observed or detected by the WHO probe. A tooth was recorded to be missing due to caries if a history of early extraction due to caries could be confirmed by the teacher, parent and/or guardian on further inquiry or explained by the decay pattern in the contra-lateral quadrant(s) in the child. Radiographs were not used to detect caries.

The normative dental treatment needs for each participant were also assessed and recorded using the intervention urgency criteria (modified) as recommended by the WHO (14). This was made through an assessment of what treatment was needed for each child using a modified Intervention Urgency criterion from that described by the WHO. For this study, the study participants were assessed on variables that they could not ascribe a treatment need to, given their age and lack of knowledge regarding severity of ECC. Therefore, only a normative needs assessment was possible as such data would be readily available and easy to collate (15). The assistant also recorded the treatment needs for each child depending on the findings made by the PI. The PI would then cross-check with the recorded findings at the end of each session before the children were dismissed to make sure they had been coded correctly.

Data Analysis

The Data gathered in the study were analyzed using SPSS version 23.0 to determine the descriptive and inferential statistical characteristics. Mann Whitney and Kruskal-Wallis tests were used to compare and relate the variables, with the confidence interval was set at 95%.

RESULTS

Socio-Demographic Characteristics

A total of 432 children composed of, 118 (27%), 145 (33.6%), and 169 (39.1%) aged 3, 4, and 5 years, respectively, participated in the study, with 230 (53.2%) being male and 202 (46.8%) female participants. The participants had a mean age of 4.1 ($SD = 0.8$) years and a mode of 5 years. The mean age of the male participants (4.10, $SD = 0.78$) was slightly higher than that of the female participants (4.00, $SD = 0.82$) but this difference was not statistically significant [$t_{(430)} = 0.0810$, $p = 0.418$].

Prevalence of ECC/Dental Caries Experience

Out of the 432 participants, 209 of them had frank caries, 93 had teeth with incipient lesions and 13 had missing teeth due to dental caries and only 3 participants had at least one filled tooth. Only 35 (8.1%) participants were found to have missing teeth that were not due to caries, but rather as a result of a traditional practice called "*Ebiino*," a form of Infant Oral Mutilation (IOM) involving the primary canines in both arches. The presence of decay was found to vary in decreasing order as follows; primary second molars in both arches and primary first upper incisors (85, 75, 51, 61, 55, 65) as the most affected teeth (0.8–1.1%), and the lower incisors being the least affected by decay.

The overall prevalence of ECC in the children who participated in this study was 48.6%, with the male participants having higher prevalence of dental caries (26.1%) against the female participants' figure of 22.5%. In accordance to the age of the participants, the prevalence ranged from 11.6% (50), 18.5% (80), and 18.5% (80) for the 3-, 4-, and 5-year olds, respectively.

The mean "**dmft**" for the participants was 2.04 ($SD = 3.01$), with the mean decayed component (dt) of 1.97 ($SD = 2.89$), and the mean "**dmft**" of 2.19 ($SD = 3.00$) and 1.87 ($SD = 3.02$) for male and female participants, respectively. The difference

TABLE 1 | The distribution of the dental caries experience among the study participants according to their gender and age.

	dt	mt	ft	dmft
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Overall	1.97 ± 2.89	0.06 ± 0.38	0.002 ± 0.04	2.04 ± 3.01
Gender				
Male	2.10 ± 2.87	0.073 ± 0.40	0.004 ± 0.065	2.19 ± 3.00
Female	1.81 ± 2.92	0.04 ± 0.35	0 ± 0	1.87 ± 3.02
Mann-Whitney test $z = 1.331$, $p = 0.183$				
Age				
3 years	1.79 ± 2.87	0 ± 0	0 ± 0	1.79 ± 2.87
4 years	2.26 ± 3.05	0.09 ± 0.49	0.006 ± 0.08	2.37 ± 3.19
5 years	1.82 ± 2.76	0.08 ± 0.40	0 ± 0	1.91 ± 2.93
chi-squared = 3.250, $p = 0.1969$				
chi-squared with ties = 3.771, $p = 0.1518$				

TABLE 2 | Distribution of the "**dmft**" components among the study participants.

Characteristics	*n*	dt	mt	ft
dmft	1,006	881 (87.57%)	124 (12.33%)	1 (0.09%)
Overall	8,640	881 (10.20%)	124 (1.44%)	1 (0.01%)

dt, decayed teeth; mt, missing teeth; ft, filled teeth. n = 8,640 (total number of teeth examined).

between these means was not statistically significant (Mann–Whitney test $z = 1.331$, $p = 0.183$). The mean "**dmft**" for the 3-, 4-, and 5-year old children was, 1.79 ($SD = 2.87$), 2.37 ($SD = 3.19$), and 1.91 ($SD = 2.93$), respectively, but the difference in the mean "**dmft**" among the age groups was also not statistically significant (chi-squared =3.250, $p = 0.1969$). "Decay" contributed the most to the dental caries experience (88.6%) and "filled" was the least (0.09%) depicting a very high unmet-treatment need among the participants (**Tables 1**, **2**).

Dental Treatment Needs

The PI evaluated the dental treatment needs for the participants through the assessment of the status of individual teeth and the treatment needs. Decayed teeth contributed to the largest need for treatment, with 181 of the participants having at least a tooth that needed a one surface filling, 106 having at least one tooth in need of a 2 or more surface filling and only 2 children needed a stainless-steel crown as the primary treatment because they had some primary molars that were hypoplastic, in addition to the 54 participants who had teeth that would require pulp therapy prior to placement of stainless-steel crown (**Figure 1**). A total of 93 children had incipient lesions that would benefit from fluoride varnish application. However, given the high prevalence of decay seen, all children would benefit from this form of treatment. Space management was required in 40 children as a result of missing teeth majorly contributed by teeth missing due to "*Ebiino*."

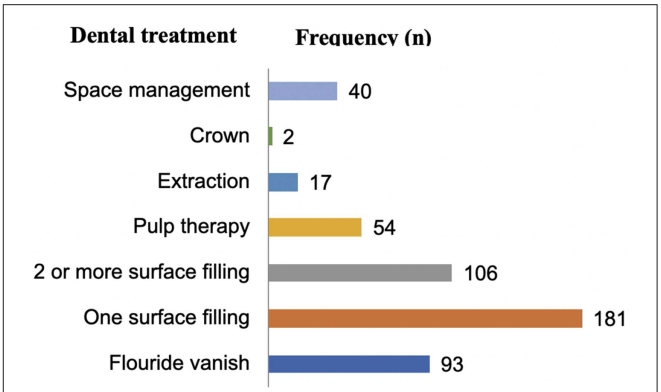

FIGURE 1 | The dental treatment needs among the study participants.

DISCUSSION

Prevalence of ECC

The current study on the prevalence and treatment needs of ECC was the first of its kind to be undertaken in Nyakagyeme sub-county, Rukungiri District and the greater south western part of Uganda. Previous studies in Uganda on ECC (11, 12) were conducted in the urban and peri-urban areas of Uganda, and focused mainly on determining the prevalence of ECC and the dental caries experience among children aged 3-, 4-, and 5-years old children. Only one study (16) reported on the dental treatment needs for children aged 5–7 years from a rural sub-county in central Uganda.

The prevalence of ECC of 48.6% in this study was lower than that reported by Kiwanuka et al. (11) for central Kampala and Nakawa division in Uganda of 56 and 64%, respectively in the same age group. Comparatively, the prevalence rate of ECC reported in a Sudanese study by Awooda et al. (17) in 2013 was also lower at 17.0%, and was thought to have been probably due to the criteria used to define and diagnose the ECC in that study. However, the current prevalence rate of ECC was higher than that reported by Birungi et al. (10) of 38–41% among 5-year-old children in Mbale District, Uganda. In the current study, the male participants had a higher prevalence than their female counterparts, with the dental caries experience increasing with the increase in age of the study participants. This difference in the dental caries experience between the male and female, and among the 3-, 4- and 5-year age groups, however, was not statistically significant ($p = 0.183$) and ($p = 0.1969$), respectively. The prevalence rates observed in this study were almost similar to those reported by studies conducted in Kenya (59 and 46.3%) (18, 19), Tanzania (42.5 and 59.1%) (20), India (45%) (21), Hong Kong (49%) (22), and Beijing (20–65%) (23). A look at the outcome of similar studies on the prevalence of ECC in East Africa in the recent past and how they compare to the current study is illustrated in **Table 3**.

The probable causative and/or risk factors of ECC in the children who participated in the current study need to be explored in order to understand better the unique oral health challenges faced by this population. Furthermore, caution needs

TABLE 3 | Comparison of the dental caries experience in the present study to similar studies done previously within the East African Region.

Region	Sample		Dental caries		References
			Rate %	dmft	
Nyakagyeme sub-county, Rukungiri District, Uganda	*n* = 432		48.6	2.04	Present study
	Gender	Female	22.5	2.19	
		Male	26.1	1.87	
	Age	3	11.6	1.79	
		4	18.5	2.37	
		5	18.5	1.91	
Kampala Central and Nakawa Division, Uganda	*n* = 586		56 and 64	–	(11)
	Age	3	45	1.7	
		4	59	2.4	
		5	65	3.1	
Mbale District, Uganda	*n* = 417				(10)
	Age	5	38 – 41	1.5–1.7	
Kiambaa Division, Kiambu County, Kenya	*n* = 336		59.9	2.46	(10)
	Gender	Female	54.9	2.29	
		Male	64.5	2.63	
	Age	3	47	1.35	
		4	55	2.31	
		5	63	2.61	
Moshi Municipality, Tanzania	*n* = 372		30.1	0.96	(24)
	Age	3	–	0.43	
		4	–	1.01	
		5	–	1.23	

to be exercised when interpreting the results of this study and making comparisons with results from previous studies within Uganda and other regions. This is because, at times, various age ranges for children aged below 6 years may be considered like how the Kenya National Oral health Survey and Birungi et al. studied only 5-year olds (10, 19). The diagnostic criterion for ECC can also vary among researchers, for example Awooda et al. (17), in their study only considered a child to have ECC when their maxillary primary incisors had dental caries and this contributed to the lower prevalence rate of ECC reported in that study. This in a way makes it arduous to comprehensively make comparisons of the prevalence rates of ECC within the different regions of the world with the changing times. In this study, the most affected teeth were the primary molars in both the mandibular and maxillary arches as well as the maxillary incisors, closely followed by the canines with the lower incisors being the least affected by ECC. This pattern of ECC has been observed in many other studies (2, 3, 5, 8, 9) and is thought to be pattern followed in children affected with ECC.

The decay component contributed the most to the "**dmft**" index while filled had the least contribution. Studies by Njoroge et al. (18) and Rwakatema and Nganga (24) also reported a very high percentage contributed by the decay component to the caries experience. Factors that may be contributory to this finding include; limited oral health service provision, shortage of dental health professionals, lack of awareness, and insufficient funding for oral health related treatment within the region and country at large.

Dental Treatment Needs

The present survey also documented the normative dental treatment needs during each child's dental assessment. It was noted that, a treatment needs assessment that evaluates all the four categories of needs as described by Bradshaw (15, 25) could provide a comprehensive evaluation based on what a researcher seeks to investigate. Given that the prevalence of ECC was high and the decay component contributed to most of the dental caries experience (mean **dt** = 1.97), it was indicative that the participants had an unmet dental treatment need. This was reflected in the high number (66.4%) of children who needed at least one surface or 2-surface filling as a form of treatment. At least 12.5% of the children needed pulp therapy; probably this figure could have increased if the assessment involved radiographic examination which would have influenced the decision made regarding the proposed treatment of certain lesions.

The dental treatment needs reported in this study were relatively similar to the dental treatment needs reported for pre-school children from Narmada district, in Gujurat, India that were reported in 2015 by Dixit et al. (26). A previous Ugandan study on dental treatment needs among 5–7-year-old children had noted that 52.7% of the children needed fillings or a dental extraction. Among those that needed fillings, 36.4% needed one or more surface fillings (16).

The reasons for the high number of untreated dental decay in the current study could be related to, lack of knowledge regarding oral health, shortage of oral health professionals and

related services at the respective health centers and the district hospital as earlier noted. Dental treatment is reported to be very expensive (2, 27) and given that the people in Nyakagyeme sub-county are rural peasant farmers (28) and oral health care in the Ugandan health system faces lots of challenges (13), it is highly unlikely that this population would afford the cost of treatment from private facilities. Thus, for such a population, preventive measures could play a key role in ensuring that the suffering these children experience when affected by dental caries and other oral health related problems is minimized, but again the shortage and/or lack of human resource would pose a significant challenge to successfully implement these measures.

One of the local oral health issue noted in the study population was that of "*Ebiino*," which is a traumatic and heinous traditional practice that should not be done to any child in the world. It is possible that through the formulation and effective implementation of appropriate national oral health policies and programmes on dental health education and prevention, control of most these common oral condition in these children can be achieved country-wide. These include, provision of adequate and skilled oral health professionals to provide advice and oral health care, adherence to proper oral hygiene instructions, appropriate and effective tooth brushing using fluoridated toothpaste and brushing as soon as the primary teeth erupt (6, 29).

CONCLUSION

The overall prevalence of ECC in the study population of 48.6% is high with the "decay" component (**dt**) contributing the most (88.6%) to the dental caries experience. This has represented a high level of unmet dental treatment need in the study population besides the practice of "*Ebiino*" that could result in possible future orthodontic treatment needs.

There is therefore, a need for intervention programmes like oral health education and outreach programmes to support this community in dealing with dental caries and the traditional practice of "*Ebiino*."

DATA AVAILABILITY

The datasets for this manuscript are not publicly available because the data set was handed over to the University of Nairobi Library for Storage and archiving. Requests to access the datasets should be directed to musakulu@gmail.com.

ETHICS STATEMENT

The study was carried out in accordance with the recommendation of the International Ethical Guidelines for Epidemiological Studies of the World Health organization and approved by Kenyatta National Hospital-University of Nairobi Ethics and Research committee (Ref: P460/06/2016) and the School of Health Sciences Institutional Review Board and Ethics committee, Makerere University Kampala, Uganda (SHSREC REF: 2016-036) with written informed consent obtained from the parents and/or guardians of all the subjects. All parents of the participants gave written informed consent in accordance with the declaration of Helsinki and the protocol approved by the School of Health Sciences Institutional Review Board and Ethics committee, Makerere, University, Kampala, Uganda. All the participants accents to be examined and only health children without any underlying medical illness or condition were included in this study.

AUTHOR CONTRIBUTIONS

NM designed the current study as part of his Master's Dissertation and, in collaboration with AK and IO, wrote the research protocol. NM with the assistance of AK designed the aims of the study and NM clinically examined the study participants and collected data under the supervision of IO while collaborating with AK. NM and AK analyzed the Data and NM wrote the initial draft of the manuscript. All authors participated in the interpretation of the data, made corrections to the manuscript, and approved the submitted version of the manuscript.

ACKNOWLEDGMENTS

We acknowledge the invaluable assistance of the school authorities, the children who participated and Dr. Nuru Nalumansi for her assistance with data collection. We are also grateful to Pediatric Dentistry Working Group (PDWG) and Intra-ACP mobility Project for their financial support.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 26 February 2020
doi: 10.3389/fpubh.2020.00006

Impact of Health Promotion Interventions on Early Childhood Caries Prevention in Children Aged 2–5 Years Receiving Dental Treatment Under General Anesthesia

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OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

Received: *26 March 2019*
Accepted: *09 January 2020*
Published: *26 February 2020*

Citation:
Razeghi S, Amiri P, Mohebbi SZ and Kharazifard MJ (2020) Impact of Health Promotion Interventions on Early Childhood Caries Prevention in Children Aged 2–5 Years Receiving Dental Treatment Under General Anesthesia. Front. Public Health 8:6. doi: 10.3389/fpubh.2020.00006

Aim: This study was conducted to evaluate the impact of health promotion interventions on early childhood caries prevention in 2–5 year-olds receiving dental treatment under general anesthesia.

Materials and Methods: Thirty-seven mother-child couples presenting to the clinic of the Dental School of Tehran University of Medical Sciences for treatment under general anesthesia were randomly divided to two groups: 19 couples in the pamphlet and fluoride varnish four times a year, and 18 couples in the pamphlet plus six phone call reminders and fluoride varnish four times a year. A standard questionnaire on demographics and children oral health-related practice of parents was completed by respondents. On children's oral examination, the Simplified Oral Hygiene Index (OHI-S), dmft, and the presence of new white spot lesions (WS) were recorded in both phases. At the final stage, Early Childhood Oral Health Impact Scale (ECOHIS) was completed by parents. The length of follow-up was 24 months.

Results: In both groups, there was an increase in the number of mothers who knew how to brush their children's teeth as well as the number of mothers who brushed their children's teeth ($P < 0.05$). In the reminder group, an improvement occurred in the mothers' perception of their perceived ability to make their children brush their teeth twice a day ($P = 0.03$). Clinical examination revealed a significant decrease in the OHI-S (from 1.9 ± 0.8 to 1.15 ± 0.5) and the number of WS (from 8.5 ± 5.5 to 0.08 ± 0.5) in both groups on the follow-up visit. The mean dmft was 11.0 ± 4.0 with a mean d component of 10.56 ± 4 at the baseline, which decreased significantly to 1.44 ± 1.96 after dental treatment. No significant increase was seen in new caries in the intervention groups. There was no significant difference in the ECOHIS score between the two groups.

Conclusion: The similar impact of both interventions suggests the possibility of applying the simpler one, i.e., the educational pamphlet, fluoride varnish and frequent follow-ups. However, in the reminder group, the mothers' perception of their perceived ability to make children brush their teeth twice a day was improved.

Keywords: early childhood caries, general anesthesia, educational intervention, quality of life, oral health promotion

INTRODUCTION

The overall prevalence of caries has been decreasing in recent decades although it remains the most common chronic disease in childhood (1, 2). The most recent report on the Iranian oral health showed a high prevalence of dental caries in preschool children (more than 87% of 5–6 year-olds) with a mean dmft of 5.16 and the d component comprising more than 70% of the total mean (3).

Dental caries in preschoolers poses a clear risk to the general health as a common disease in childhood. Additionally, this disease is associated with a marked functional, aesthetic, and psychological impact on the quality of life in children and their families, and imposes high costs on them (2, 4). Moreover, primary teeth caries is the strongest predictor of caries in the permanent dentition (1, 5). Despite development of alternative treatment modalities, many children still require dental treatment under general anesthesia (GA), which is costly and risky (6, 7). Unfortunately, a marked proportion of these children may need further dental treatment under GA due to the disease or problems not present at the time of the first GA (1, 6, 8). Therefore, despite the extreme stress of dental treatment under GA for parents, it does not seem to raise any alarms regarding modification of their children's oral health-related behaviors in the long term (9).

Dental caries is mostly preventable through controlling several factors affecting its onset and progression, such as dietary practices, preventive care, certain drugs (7, 10), and improved oral health literacy (11). Oral health preventive strategies for the whole family, such as educational intervention beside child-focused preventive strategies, have shown to be important for pediatric oral health preservation (4, 12, 13). Oral health education in various aspects such as tooth brushing, dietary and feeding habits, and regular dental visits, together with using fluoride supplementation have been well-documented as useful methods for ECC prevention (12–14).

To our knowledge, however, the effectiveness of various forms of health promotion interventions on ECC prevention, especially for children receiving dental treatment under general anesthesia, has not been investigated. The objective of the present study was to evaluate the long-term effectiveness of two health promotion interventions on early childhood caries prevention in children aged 2–5 years receiving dental treatment under GA and to investigate the oral health-related quality of life (OHRQoL) in parents.

MATERIALS AND METHODS

Sampling

The Minitab software (Minitab Inc., Pennsylvania, USA) was used with a minimum significant difference = 15%, mean standard deviation = 19% for OHI-S, alpha = 0.05, and beta = 0.2 for sample size determination (15). The sample size calculation showed that 18 mother-child pairs were required for the baseline study.

Thirty-seven pairs of mothers and their 2–5 year-old children who needed dental treatment under general anesthesia were selected and randomly divided to two intervention groups: 19 couples in the pamphlet and fluoride varnish four times a year (PV) and 18 couples in the pamphlet plus six phone call reminders and fluoride varnish four times a year (PVR).

Study Methodology and Interventions

Before dental treatment under GA, the mothers completed an anonymous self-administrated valid and reliable questionnaire (16). Moreover, all children underwent a clinical dental examination. After dental treatment under GA, all mothers received a pamphlet containing recommendations (14) on proper tooth brushing, using appropriate amount of fluoridated tooth paste, proper dietary and feeding habits, and the necessity for regular dental visits and using fluoride varnish. This material was written in Farsi and had colorful pictures and a proper instructional design.

Two years after the interventions, all couples were recalled and the same questionnaire was completed by mothers. Another clinical oral examination was done for all children. During this period, all children had regular dental check-ups with fluoride varnish application every 3 months; moreover, the reminder group received six reminder phone calls once a month during the first 6 months after dental treatment under GA. In these 20 min phone calls, one of the researchers provided oral health recommendations for the child, which matched the educational pamphlet content completely.

Questionnaire

The mothers were requested to complete a questionnaire before and 2 years after the interventions. They were asked to write a unique code at the top of the first and second questionnaires. This code was used to assess individual changes throughout the study. In addition to demographic characteristics (child's age and gender, birth order, primary caregiver, family income,

TABLE 1 | Demographics of study participants ($n = 37$).

Demographic variables	Groups	
	PV	PVR
Child gender		
Boy	13 (68.4%)	11 (61.1%)
Girl	6 (31.6%)	7 (38.9%)
Birth order		
First	11 (57.9%)	7 (38.9%)
Second/third	8 (42.1%)	8 (44.4%)
Other	0 (0.0%)	3 (16.7%)
Primary caregiver		
Mother	17 (89.4%)	18 (100.0%)
Kindergarten	2 (10.6%)	0 (0.0%)
Family income*		
High	4 (25.0%)	3 (23.1%)
Moderate	10 (62.5%)	2 (15.4%)
Low	2 (12.5%)	8 (61.5%)
Mother's level of education		
High	9 (47.4%)	3 (16.7%)
Moderate	9 (47.4%)	12 (66.7%)
Low	1 (5.3%)	3 (16.7%)
Father's level of education		
High	10 (52.6%)	8 (44.4%)
Moderate	5 (26.3%)	5 (27.8%)
Low	4 (21.1%)	5 (27.8%)

**There were few participants who did not respond to this question.*

and parents' level of education), the questionnaire included the following items:

Feeding Habits (Multiple-Choice Questions).

Total duration of prior breastfeeding, total duration of prior bottle-feeding, nighttime feeding practices, most common contents of daytime bottle, frequency of giving sugary snacks.

Mother's and Child's Oral Cleaning Habits (Multiple-Choice Questions).

Cleaning frequency (for both mother and child), cleaning device (for child), and adult's role in oral cleaning for the child.

Mother's Perceptions of Her Ability to Maintain the Child's Oral Hygiene (a 5-Point Likert Scale Ranging From Strongly Agree to Strongly Disagree).

Three statements regarding knowing how to brush the child's teeth properly, devoting sufficient time to brushing child's teeth, and having the ability to make the child brush his/her teeth twice a day.

Besides, in the 2 year recall, all mothers completed the Persian version of the Early Childhood Oral Health Impact Scale (ECOHIS) containing 13 questions on OHRQoL based on the perceptions of parents and their understanding of health and illness of their children (17, 18). This questionnaire has two components: nine questions about the impacts of oral health on the child's daily activities and 4 questions about these impacts on the family. Each question assesses the frequency of an oral health-related problem and is scored from 1 (never) to 5 (very often) with a choice of "I don't know." The possible range of ECOHIS score is 13–65 with higher scores indicating greater impacts and/or more problems.

Oral Examination

An experienced pediatric dentist conducted the oral examination of children in both stages. Using a dental mirror and explorer, the children's oral and dental condition was recorded before the beginning of the dental treatment. The Simplified Oral Hygiene Index (OHI-S), the dmft index (the number of decayed, missing, and filled primary teeth), and tooth surfaces with white spot lesions (WS) were recorded. Two years after treatment under GA, all children were re-examined using the above indices. All parents received verbal oral health recommendations in the same sessions.

Statistical Analysis

Descriptive statistics and the SPSS package were used. Wilcoxon Signed Ranks and Mann–Whitney test were applied to compare the outcome variables between the two groups before and after the interventions. The level of significance was set at 0.05.

RESULTS

Thirty-seven (19 pairs in PV and 18 pairs in PVR group) and 34 mother-child pairs (18 pairs in PV and 16 pairs in PVR group) attended the baseline and 2 year follow-up data collection for questionnaire completion and oral examination, respectively. The total response rate was 91.9%.

At baseline data collection, the mean age of the children was 46.5 ± 10.7 months (44.6 ± 10.3 months in PV and 48.5 ± 11.1 months in PVR) of whom 24 (64.9%) were boys and 18 (48.6%) were first children regarding the birth order. In most of the children (94.6%), the mothers were the main caregivers and the others went to kindergarten. **Table 1** shows the demographic characteristics of the participants in both groups.

Feeding Habits

The mean total duration of prior breastfeeding was 20.0 ± 9.8 months. Moreover, the mean of total duration of prior bottle-feeding was 15.5 ± 15.3 months. Nighttime breastfeeding in the past was reported by 41.2% of the mothers, and 32.4% of mothers stated that they used to give a bottle containing milk or sweet liquids to their children during the night. Only eight mothers reported that they did not practice night nursing. The most common content of the daytime bottle was cow's milk (23.5%) and daytime sugary snacking was more than twice daily in 64.7% of the children.

On the 2 year follow-up, no significant difference was seen in feeding habits between the two groups ($P > 0.05$). At the same time, in both groups, the total duration of bottle-feeding decreased significantly compared to the baseline ($P = 0.04$). There was no significant change in other feeding habits in each group.

TABLE 2 | Results of Wilcoxon signed rank test of changes in responses of mothers ($n = 34$) regarding perceptions of their ability to maintain the child's oral hygiene during 2-year follow-up.

		PV N (%)			PVR N (%)		
Mother's perceptions of her ability to maintain the child's oral hygiene	**Choices**	**Baseline 19 (100.0%)**	**2-year follow-up 18 (100.0%)**	***P*-value**	**Baseline 18 (100.0%)**	**Baseline 19 (100.0%)**	**2-year follow-up 18 (100.0%)**
I don't know how to brush or clean my child's teeth properly	Completely agree	1 (5.3%)	3 (16.7%)	0.03*	1 (5.6%)	0 (0.0%)	0.007*
	Agree	6 (31.3%)	2 (11.1%)		6 (33.3%)	3 (20.0%)	
	Disagree	5 (26.3%)	10 (55.6%)		7 (38.9%)	8 (53.3%)	
	Completely disagree	4 (21.1%)	3 (16.7%)		1 (5.6%)	3 (20.0%)	
	Do not know	3 (15.8%)	0 (0.0%)		3 (16.7%)	1 (6.7%)	
We don't have time to brush or clean our child's teeth twice daily	Completely agree	1 (5.3%)	2 (11.1%)	0.49	1 (5.6%)	1 (6.3%)	0.42
	Agree	2 (10.5%)	5 (27.8%)		5 (27.8%)	4 (25.0%)	
	Disagree	12 (66.7%)	8 (44.4%)		9 (50.0%)	8 (50.0%)	
	Completely disagree	3 (15.8%)	3 (16.7%)		1 (5.6%)	3 (18.8%)	
	Do not know	1 (5.3%)	0 (0.0%)		2 (11.1%)	0 (0.0%)	
We cannot make our child brush or clean his/her teeth twice daily	Completely agree	3 (15.8%)	5 (29.4%)	0.59	2 (11.1%)	1 (6.3%)	0.03*
	Agree	11 (57.9%)	4 (23.5%)		8 (44.4%)	1 (6.3%)	
	Disagree	5 (26.3%)	8 (47.1%)		5 (27.8%)	11 (68.8%)	
	Completely disagree	0 (0.0%)	0 (0.0%)		1 (5.6%)	3 (18.8%)	
	Do not know	0 (0.0%)	0 (0.0%)		2 (11.1%)	0 (0.0%)	

*$P < 0.05$.

Mother's and Child's Oral Cleaning Habits

On the 2 year follow-up, 58.8% of the mothers reported brushing their own teeth at least once a day, and 32.4% reported brushing more than once a day. Oral cleaning once a day was reported in 67.4% of all children. The mothers reported oral cleaning twice daily in 26.5% of the children, and only two mothers reported a lower frequency of tooth brushing for their children. In most of the children (91.2%) the most common cleaning device was a toothbrush. In 50% of the children, tooth brushing was done by or with the help of one of the parents.

On the 2 year follow-up, an increase was observed in the number of mothers who brushed their children's teeth in both groups ($P < 0.05$).

Mother's Perceptions of Her Ability to Maintain the Child's Oral Hygiene

On the 2 year follow-up, 70.6% of the mothers stated that they knew how to brush their children's teeth, and 64.7% stated that they devoted sufficient time to brushing their children's teeth. Moreover, 64.7% of the mothers believed that they could make their children brush their teeth twice a day (**Table 2**).

Compared to the baseline, no significant difference was seen in the mothers' perceptions of their ability to maintain the child's oral hygiene between two groups ($P > 0.05$). Moreover, in both groups, an improvement occurred in the number of mothers who knew how to brush their children's teeth. In the reminder group, the mothers' perception of their perceived ability to make the children brush their teeth twice a day improved significantly ($P = 0.03$).

OHRQoL

The mean ECOHIS score was 29.2 in PV, and 28.5 in PVR (from up to 60). The mean ECOHIS score was 18.5 and 16.8 (from up to 45) in the child impact section in PV and PVR, respectively. Moreover, the mean ECOHIS score was 10.7 and 11.7 (from up to 20) in PV and PVR in family impact section, respectively. No significant difference was seen in the mean scores of ECOHIS, child impact section, and family impact section between the two groups.

Oral Health Status

dmft

At baseline, the mean dmft was 11.0 ± 4.0 in all subjects, 11.3 ± 3.6 in PV, and 10.7 ± 4.5 in PVR. In the 2 year follow-up, the mean dmft was 10.1 ± 3.4 in all subjects,10.3 ± 3.7 in PV, and 9.8 ± 3.1 in PVR, indicating no significant difference compared to baseline ($P = 1.8$). Totally, the d component decreased significantly from 10.6 ± 4.3 at baseline to 1.4 ± 1.96 in the follow-up visit after dental treatments.

OHI-S

At baseline, the mean OHI-S was 1.9 ± 0.8 in all subjects, 2.0 ± 0.6 in PV, and 1.8 ± 0.9 in PVR. In the 2 year follow-up, the mean OHI-S was 1.2 ± 0.5 in all subjects, 1.1 ± 0.5 in PV, and 1.2 ± 0.4 in PVR. A significant decrease was observed in OHI-S in the 2 year follow-up in both groups.

WS

At baseline, the mean WS was 8.5 ± 5.5 in all subjects, 3.8 ± 2.6 in PV, and 4.7 ± 2.9 in PVR. In the 2 year follow-up, the

mean WS significantly decreased to 0.1 ± 0.5 in all subjects, 0.2 ± 0.5 in PV, and 0.0 in PVR ($P < 0.001$). No significant difference was observed in the number of WS between the two groups ($P = 0.17$).

DISCUSSION

The aim of this study was to investigate the long-term impacts of two health promotion interventions on ECC prevention in children aged 2–5 years who underwent dental treatment under general anesthesia. Furthermore, the oral health quality of life was evaluated in the sample population. The results of the study showed an increase in the number of mothers who knew how to brush their children's teeth and the number of mothers who brushed the children's teeth in both interventional groups. The reminder group experienced an improvement in the mothers' perception of their perceived ability to make the children brush their teeth twice a day. Moreover, clinical examination showed a significant decrease in OHI-S and the number of WS in both groups in the follow-up visit. Furthermore, no significant increase was observed in new caries in both groups. The mean ECOHIS score was almost good in both groups. There was no significant difference in the ECOHIS score and its components between the two groups.

General anesthesia is an essential and reliable approach for safe and successful dental treatment in some challenging children in whom behavior guidance techniques are inadequate for their management, e.g., very young children and those who are not cooperative (19). In spite of comprehensive dental treatment under GA, the arte of caries experience is reported to be high in children leading to a second round of treatment under GA in many cases. (9, 19–23). To avoid the development of new caries and repetition of GA, the present study focused on pairs of mothers and their children who received comprehensive dental treatment under GA. On the other hand, parental beliefs and behaviors affect childhood oral health. Many studies investigating health promotion interventions in preschool children have engaged parents because of their critical role and influence in development of proper oral health related behaviors (4, 7, 9, 16, 24–26).

In the final stage of the present study, the mean value of the d component of dmft was 1.4, which was a promising outcome. Furthermore, the mean WS was about 0.1, which confirmed the positive effects of interventions on the prevention of dental caries recurrence. It should be mentioned that nearly all participants were recalled every 3 months for oral examination, fluoride varnish therapy, and oral health consultation. All mothers received verbal oral health recommendations on tooth brushing, daily sugar intake, and feeding habits. These findings are similar to other studies that showed positive impacts of health promotion interventions on ECC prevention (4, 26, 27). This is an encouraging outcome when we notice that many previous studies reported high relapse rates of dental caries after dental treatment under GA in children (9, 19–23). The dmft index decreased in the 2 year follow-up, which was because the age of the children matched early mixed dentition. This might be because of natural exfoliation of some primary teeth.

The OHI-S index decreased significantly in both groups in the 2 year follow-up. Thus, the interventions seem to be successful in promoting oral hygiene status in children. Considering the increased number of mothers who brushed their children's teeth themselves and the number of mothers who knew how to brush their children's teeth, the OHI-S drop was expectable. These findings are consistent with the oral health education goals defined as acquiring knowledge and positive attitude toward oral health, and ultimately adoption of healthy behaviors leading to improved oral health-related indicators (27).

The results of our study showed no significant differences in the study outcomes except for mothers' perception of their ability to make the children brush their teeth twice a day between the two interventional groups, which was better in reminder group. However, in both groups, interventions led to a significant improvement in the number of mothers who brushed their children's teeth and the number of mothers who knew how to brush their children's teeth. The reason for these findings can be the point that the educational content designed for the telephone reminder completely matched the educational content of the pamphlet. Moreover, in regular follow-ups, oral health recommendations were verbally delivered to all mothers in addition to fluoride varnish therapy for all children. It seems that communication with mothers at regular follow-ups and through phone calls promoted oral health behaviors at least in the children's oral cleaning habits as well as the mothers' perception of their ability to maintain the children's oral hygiene. Regular contact with mothers of preschool children for dental health education was supported in a previous study as it showed more preventive effects on dental caries in children when compared to less frequent contacts (28). Besides, the intense emotional effect of GA on parents should be considered as it could motivate them to take immediate action and implement changes in oral health behaviors. However, Amin et al. stated that such an effect would fade over time, leading to poor oral health behaviors in long term (9).

Feeding practices have been target points for interventions for ECC prevention, especially in early stages of life. Early-life feeding habits such as food-intake frequency, breastfeeding, bottle-feeding, and the introduction of complementary foods would affect health over the course of the life (28). Frequent intake of sugars, repeated bottle-feeding at night, *ad libitum* breast-feeding, and breastfeeding more than 12 months are particular risk factors for caries development in children (14, 28, 29). In our study, the mean total duration of prior breastfeeding was about 20 months. This finding was in a line with the results of previous studies in Iran (25) and Canada (9). However, Lee et al. reported that three quarters of children received breastfeeding up to 11 months of age in the US (29). Cultural characteristics and religious beliefs, which recommend breastfeeding up to 24 months of age, may indicate the differences between studies. In the present study, other risky behaviors were nighttime breastfeeding and bottle feeding containing milk or sweet liquids reported by about 41 and 32% of mothers, respectively.

Furthermore, about 60% of mothers reported their children consumed sugary snack more than twice a day. These are in contrast to the American Academy of Pediatric Dentistry recommendations for preventing ECC, which advises against frequent consumption of sugary liquids and/or solid foods in a baby bottle, *ad libitum* breast-feeding after the first primary tooth begins to erupt, and baby bottle use after 12–18 months (14).

Moreover, the present study found no significant change in dietary habits in both groups 2 years after GA and interventions. This finding is similar to the results of a study by Lee et al. (29) in the US in which less than half of parents stated they made improvements in their children's diet after GA. The reason may be the child growing up and her/his easier access to more cariogenic foods. It should also be considered that the child's diet is affected by the family's dietary habits, which is very difficult to change. Moreover, it seems that the dietary practices are established and maintained in the first 12 months of life (14).

In our study, in the 2 year follow-up, the mean ECOHIS score was relatively favorable in both groups. Regarding OHRQoL in children after dental treatment under GA, a systematic review by Jankauskiene and Narbutaite revealed that oral rehabilitation using GA could lead to immediate improvement in the quality of life in children and their families (30). Furthermore, another study by Gaynor and Thomson suggested that dental treatment of small children using GA was associated with a marked improvement in the OHRQoL (31). Thus, the results of the present study seem to be consistent with the findings of other studies.

The data collection tool was a questionnaire used in a previous study in Iran (16). In the 2 year follow up, a 13-item questionnaire, the ECOHIS, was added to evaluate the OHRQoL in children. The validity and reliability of the Persian version of the ECOHIS was tested by Jabarifar et al. (17). The self-administered nature of the questionnaires encourages the participants to answer more in line with social norms compared to the actual situation, which is referred to as "social desirability" (32). For instance, a study found evidence of social desirability bias in caregiver-reported oral health behaviors (33). Moreover, recall bias should also be considered since more important events to respondents are more likely to be recalled accurately (15). Another limitation of present study was encouraging participants to attend the final follow-up session. Some parents did not attend follow-ups and had irregular presence for recalls. We tried to overcome this problem by providing adequate explanation for parents as well as free oral examination and fluoride varnish therapy. Furthermore, if a child required new, a treatment session was scheduled. However, three pairs of participants dropped out of the study due to living in far locations and difficult access. Moreover, we could have more significant results if we had a larger sample size; on the other hand, the 2 year follow-up, except for three pairs, was the strength of the study.

CONCLUSION

Both interventions improved the self-reported performance of mothers and reduced plaques and white spots. Very few new caries developed in the intervention groups that were not significant. Similar impacts of both interventions suggest the possibility of using the simpler one, i.e., the educational pamphlet, fluoride varnish and frequent follow-ups. However, a marked improvement was seen in the mothers' perception of their perceived ability to make the children brush their teeth twice a day as an attitudinal change in the reminder group.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of The Research Ethics Committee of Tehran University of Medical Sciences (code IR.TUMS.DENTISTRY.REC.1397.097) with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the The Research Ethics Committee of Tehran University of Medical Sciences.

AUTHOR CONTRIBUTIONS

SR and SM led the overall study and contributed to study design. SR and PA contributed to the data collection and wrote the manuscript. MK contributed to the research design and the data analysis and interpretation. All authors read, contributed to, and approved the final manuscript.

FUNDING

This research has been supported by Tehran University of Medical Sciences & Health Services grant no 970219436481.

ACKNOWLEDGMENTS

The authors gratefully thank Dr. Mohammad R. Khami for his constructive contribution in the editing of this manuscript.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 09 July 2019
doi: 10.3389/fpubh.2019.00186

Assessing the Impact of Early Childhood Caries on the Development of First Permanent Molar Decays

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Aim: The aim of this study was to evaluate whether the treated and untreated severe early childhood caries (ECC) in children would make any impact on the Permanent First Molar (PFM) decays.

Materials and Methods: Our descriptive epidemiological study was conducted in Ataturk University, Faculty of Dentistry, Department of Pediatric Dentistry/Erzurum-Turkey, between 2011 and 2017. We included a total of 90 children (44 girls, 46 boys), and divided them into 3 equal groups. They were 6–9 years old with a mean age of 7.38 ± 0.89. Group 1 consisted of the patients who had previously been treated under GA, Group 2 included the patients with untreated ECC and with no previous dental treatment, and Group 3 consisted of the patients who had been periodically treated in normal clinical settings. Each patient was processed through; dmft scoring and PFM caries evaluation process in accordance with International Caries Detection and Assessment System (ICDAS), respectively. The obtained data was analyzed with SPSS v20.0. And also, we used *One-way ANOVA*, *Kruskal-Wallis and Mann Whitney U* tests.

Results: In accordance with ICDAS, we found that Group 3 had the highest mean number of PFMs (2 ± 1.43) and Group 2 had the lowest (1.43 ± 1.45). In Group 2, the number of ICDAS-determined carious PFMs were significantly lower than the other groups ($p < 0.05$). However, ICDAS score 6 was 0 in Group 1, while it was determined higher as 4.2% in Group 2.

Conclusion: In respect to our research outcomes, which revealed that regardless of treated or not severe ECC had a significant impact on the PFMs, we strongly recommend that the parent of the children experiencing ECC should be informed about the risk of future caries in PFMs.

Keywords: early childhood caries, first permanent molar teeth caries, window of infectivity, general anesthesia, ICDAS

OPEN ACCESS

Edited by:
Maha El Tantawi, Imam Abdulrahman Bin Faisal University, Saudi Arabia

Reviewed by:
Saba Kassim, Taibah University, Saudi Arabia
Balgis Gaffar, Imam Abdulrahman Bin Faisal University, Saudi Arabia

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *14 January 2019*
Accepted: *20 June 2019*
Published: *09 July 2019*

Citation:
Songur F, Simsek Derelioglu S, Yilmaz S and Koşan Z (2019) Assessing the Impact of Early Childhood Caries on the Development of First Permanent Molar Decays. Front. Public Health 7:186. doi: 10.3389/fpubh.2019.00186

INTRODUCTION

Permanent First Molars (PFMs), which usually erupt between ages of 6–7 years are the most critical teeth in the dental arc. Nonetheless, this renders them to be at the highest risk for carious lesions. Hi-carb diets, poor oral hygiene, parental lack of knowledge on the PFM eruption time and previous caries experience are among the predisposing factors for the dental caries in these teeth (1, 2).

It is well-established that caries status of the young permanent teeth is correlated with ECC in the primary dentition (3). However, in predicting the permanent teeth caries, determination of ECC experience is not sufficient alone. Caries presence in the permanent teeth is correlated with the cariogenic factors as well as the caries presence in the primary teeth (4, 5).

Although some researches have already been conducted to determine the impact of ECC that was experienced in the primary dentition, on the permanent teeth caries (6–11), the longitudinal studies should be augmented. Since the studies conducted on this issue were mostly retrospective and data have been collected from the old records, credibility of these researches was limited. In contrast to the retrospective studies, prospective researches are more credible since they utilize the identical and standardized diagnosing methods. However, their biggest disadvantage is the prolonged follow-up time, which may lead to participating patient attrition and loss to follow-ups (12). Thus, the impact of primary tooth caries on dental decays in the permanent dentition is evaluated rather retrospectively (8, 11).

The correlation between the previous caries history and caries development in the permanent teeth has been reported by several researches (3, 7, 13). Gray et al. (14), remarked that history of three or more primary molar caries might be the best predictors for PFM caries development at the age of 7. Similarly, in another research conducted among the Chinese children, authors found a strong correlation between the primary and permanent teeth caries and they emphasized the importance of assessing the caries status in predicting the future risks of caries and also they highlighted the importance of implementing the preventive programs (15).

In their study examining the Mexican children, Vallejos-Sanchez et al. (10) revealed that presence of caries in the primary and permanent teeth was a good predictor for determining the increment of subsequent caries and they also remarked that the previous caries experiences were important in implementing the preventive dental programs. In parallel with all these data given, previous deciduous tooth caries experience was regarded as the main risk factor for future caries development and this indicator was accepted as a "caries predictor" in longitudinal studies (11).

In their study, Tagliaferro et al. (16) re-examined the 13–16 years old children whose primary tooth caries had been evaluated 7 years ago and they concluded that caries in the primary teeth well indicate the caries development in the permanent teeth. They also reported that the risk of new caries development in the children with primary tooth decays during a 7 years period was 2.3 times higher, and they remarked that caries-free status was a protective factor against the future caries development.

In another study, Skeie et al. (17) reported that caries presence on more than two surfaces of the primary second molars was a convenient predicting tool for the future caries risks.

Opposing to all these studies, in a research examining 185 Brazilian children, authors stated that there was no positive relationship between ECC and caries development in the permanent teeth and ECC alone was not a good PFM caries indicator (8).

Early caries development in PFMs of the children in Turkey made us consider reviewing the ECC-PFM caries correlation. A review on caries prediction (5) reporting "*the presence of multiple cavities that will significantly increase the bacterial level in the oral cavity during the second window of infectivity, which also covers especially the PFM eruption period, may affect the development of PFM caries*" was another factor motivated us to conduct this research.

In our study, we aim to assess the future caries development in PFMs of the child patients whose oral health status had been improved through the previous dental treatments in normal clinical settings or under GA and compare their PFM caries to those of previously untreated patients with multiple dental cavities.

The null hypotheses tested were as follows: (1) There was no significant difference between the caries prevalence of PFMs in the children with previously improved oral health but still experiencing ECC and the PFM caries prevalence of the untreated patients also suffering from ECC. (2) Whether treated or not, the children with past ECC experience had higher risks of developing future PFM caries.

MATERIALS AND METHODS

Ethics Committee's Approval and Other Consents

This study was conducted by the Department of Pediatric Dentistry, Faculty of Dentistry, Ataturk University in regard to the provisions of Turkish Ministry of Health Clinical Researches Regulation No.28030 dated as August 19, 2011 and also in accordance with the Faculty of Dentistry Research Ethics Committee's written approval (session No.08/2017 resolution # 53). All participating parents were briefed and informed consent forms were obtained in accordance with Declaration of Helsinki.

Study Type, Study Time and Place

Our study is a descriptive epidemiological research. The study was conducted in Ataturk University, Faculty of Dentistry, Pediatric Dentistry Department/Erzurum-Turkey between 2011 and 2017. After obtaining all the necessary consents, we retrospectively recruited the children in to the study based on 2011–2015 data. We used convenience sampling method in our study, by choosing the patients from General Anesthesia (GA) medical records. In order for comparing PFM caries, we established a control group by randomly selecting among the child-patients with similar age periods, similar dmft scores and with previous ECC experience, who presented to our clinic in 2017.

Patient Selection Bias, Study Groups and Their Contents

For participating in the research, the children were required to be between 6 and 9 years old and with no systemic disease. Additionally, they should have previous ECC experiences, their PFMs should be retained in mouth and they should have a minimum dmft index score of 5. We determined the dmft score as 5, since the patients who had previously received dental treatment under GA had a dmft score of minimum 5. And the control group was consisted of the patients with a dmft score of 5, similarly.

Our study evaluating the PFMs in a total of 90 children was divided into 3 groups, each included; 30 patients between the ages of 6 and 9 (at the beginning of the research) with severe ECC experience and who were previously treated under GA in our clinic between 2011 and 2015, 30 patients at the same age range who were normally treated in our clinic in 2017 and another 30 child -patients who were previously untreated.

In order to establish the study groups, we scanned the dental records of 152 patients who had been treated under GA between 2011 and 2015. Seventy six of those patients were excluded from the study since they didn't meet the research criteria. Remaining 76 patients were called by phone but 30 of them didn't participate since they couldn't be reached because they switched their numbers or didn't answer the calls.

Sixteen of 46 patients whom we could reach didn't participate in the study, because they moved to another city and they had some difficulties in intercity traveling or they just avoided involving in the research. Remaining 30 patients were included to establish one of the study groups. The other two groups of patients were chosen among the children who admitted to our clinic in 2017 and also matched the research criteria. We formed the groups of thirty children in order to meet the parametric test conditions. Statistical power of the study was calculated as 78% in the *post-hoc* power analysis. The study groups were as follows;

Group 1: This group included children from 6 to 9 years old with severe ECC history and who were previously treated under GA before the PFM eruption in our clinic between 2011 and 2015. They had Stainless Steel Crowns (SSCs) placed in their primary first molars and had a minimum dmft score of 5.
Group 2: 6–9 years old patients who presented to our clinic in 2017 with ECC experience and prevalent multiple carious primary teeth but with no previous dental treatment constituted this control group. They had a minimum dmft score of 5 and multi-surface dentinal caries in their primary teeth.
Group 3: This study group consisted of 6–9 years old patients with ECC history whose primary teeth had previously been treated in clinical settings and had too many filled or missing primary teeth back then. They also had a minimum dmft score of 5 and multi-surface fillings usually in a single tooth.

Tools and Techniques for Data Collection

Study data were collected with anamnesis and examination forms improvised by the authors. Anamnesis form was developed for obtaining the patient's individual social information and medical history while the examination form was prepared for evaluating the caries and oral hygiene status. Examination form consisted of sections for dmft/dmfs and Simplified Oral Hygiene Index (OHI-S), and ICDAS scoring for PFMs as well. A single dentist (FS) who received a calibration training in accordance with ICDAS Coordinating Committee Manual (lit http://www.icdas.org) evaluated the caries. Evaluation steps were as follows;

- Filling the anamnesis form.
- Oral hygiene scoring in accordance with OHI-S.
- Determining dmft score after polishing.
- ICDAS scoring consequent to the clinical examination of PFMs.

Study Indices and Scoring

Caries status of the primary teeth was assessed with dmft/dmfs indices. Teeth extracted due to the caries related reasons were categorized in the (M) dental status code. Exfoliated primary teeth were not included in the (M) category. Anterior teeth were considered having 4 surfaces and posterior teeth were accepted to have 5 surfaces in the dmft calculations. Mean dmft and dmfs values were calculated for all groups.

OHI-S was used to assess oral hygiene status of the patients (18).

Caries status of PFMs were scored with ICDAS and we removed plaque layers from the PFMs for detecting the ICDAS scorings. Four PFMs were evaluated and scored in each patient (PFMs were unrestored and unsealed). Thus, we scored 120 PFMs in each group and 360 PFMs in total. Since ICDAS score frequency for one or more cell was <5, Chi-square analysis would not have a Chi-square distribution and so, our test (p-value) would not be valid. Thus, we categorized the ICDAS scores, which were equal or lower than 3 as "non-carious" and the scores higher than 3 as "carious."

ICDAS scoring was performed by employing the definitions for caries scoring shown in **Table 1**. Sound tooth surfaces showed no evidence of visible caries (no or questionable change in enamel translucency) when cleaned and after air-dried for 5 s (19).

Statistical Analysis

We used *Statistical Package for Social Sciences* (SPSS v20.0) for analyzing the data collected. Numerical data were presented by standard deviations, arithmetic means, minimum and maximum values, and medians while the categorical data were described by numbers and percentages. With histograms and *Kolmogorov-Smirnov* tests, we checked if the data were normally distributed. We used *one-way ANOVA* test for the multiple comparisons of normally distributed numerical data and *Kruskal-Wallis* test for the non-normal distributions. When the results of *Kruskal-Wallis* test were found to be significant, we used *Mann Whitney U with Bonferroni Correction* test for pairwise comparisons. *Mann Whitney U* test was used again for the comparisons of the paired numerical variables, which were not normally distributed and χ^2-test was used for analyzing the multiple categorical variables. Correlations between the numerical and ordinal variables were measured with *Spearman Correlation* test. Statistically significant results were obtained when $p < 0.05$.

TABLE 1 | Classification of the carious status based upon the International Caries Detection and Assessment System (ICDAS).

Sound tooth surface: Code 0
There should be no evidence of caries (either no or questionable change in enamel translucency after prolonged air drying (suggested drying time 5 s). Surfaces with developmental defects such as enamel hypoplasias; fluorosis; tooth wear (attrition, abrasion, and erosion), and extrinsic or intrinsic stains will be recorded as sound. The examiner should also score as sound a surface with multiple stained fissures if such a condition is seen in other pits and fissures, a condition which is consistent with non-carious habits (e.g., frequent tea drinking). This table provides a useful guide for differential diagnosis for carious opacities vs. other opacities
First visual change in enamel: Code 1
Code 1: Pits and fissures When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying (approximately 5 s is suggested to adequately dehydrate a carious lesion in enamel) a carious opacity or discoloration (white or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel OR When there is a change of color because of caries which is not consistent with the clinical appearance of sound enamel and is limited to the confines of the pit and fissure area (whether seen wet or dry). The appearance of these carious areas is not consistent with that of stained pits and fissures as defined in code 0 Code 1: Smooth tooth surfaces When seen wet there is no evidence of any change in color attributable to carious activity, but after prolonged air drying a carious opacity (white or brown lesion) is visible that is not consistent with the clinical appearance of sound enamel. This will be seen from the buccal or lingual surface
Distinct visual change in enamel: Code 2
The tooth must be viewed wet. When wet there is a (i) carious opacity (white spot lesion) and/or (ii) Brown carious discoloration which is wider than the natural fissure/fossa that is not consistent with the clinical appearance of sound enamel (Note: the lesion must still be visible when dry)
Localized enamel breakdown because of caries with no visible dentin or underlying shadow: Code 3
The tooth viewed wet may have a clear carious opacity (white spot lesion) and/or brown carious discoloration which is wider than the natural fissure/fossa that is not consistent with the clinical appearance of sound enamel. Once dried for approximately 5 s there is carious loss of tooth structure at the entrance to, or within, the pit or fissure/fossa. This will be seen visually as evidence of demineralization [opaque (white), brown, or dark Brown walls] at the entrance to or within the fissure or pit, and although the pit or fissure may appear substantially and unnaturally wider than normal, the dentin is NOT visible in the walls or base of the cavity/discontinuity If in doubt, or to confirm the visual assessment, the WHO/CPI/PSR probe can be used *gently across a tooth surface* to confirm the presence of a cavity apparently confined to the enamel. This is achieved by sliding the ball end along the suspect pit or fissure and a limited discontinuity is detected if the ball drops into the surface of the enamel cavity/discontinuity
Underlying dark shadow from dentin with or without localized enamel breakdown: Code 4
This lesion appears as a shadow of discolored dentin visible through an apparently intact enamel surface which may or may not show signs of localized breakdown (loss of continuity of the surface that is not showing the dentin). The shadow appearance is often seen more easily when the tooth is wet. The darkened area is an intrinsic shadow which may appear as gray, blue or brown in color. The shadow must clearly represent caries that started on the tooth surface being evaluated. If in the opinion of the examiner, the carious lesion started on an adjacent surface and there no evidence of any caries on the surface being scored then the surface should be coded "0"
Distinct cavity with visible dentin: Code 5
Cavitation in opaque or discolored enamel exposing the dentin beneath The tooth viewed wet may have darkening of the dentin visible through the enamel. Once dried for 5 s there is visual evidence of loss of tooth structure at the entrance to or within the pit or fissure—frank cavitation. There is visual evidence of demineralization [opaque (white), brown, or dark brown walls] at the entrance to or within the pit or fissure and in the examiner judgment dentin is exposed The WHO/CPI/PSR probe can be used to confirm the presence of a cavity apparently in dentin. This is achieved by sliding the ball end along the suspect pit or fissure and a dentin cavity is detected if the ball enters the opening of the cavity and in the opinion of the examiner the base is in dentin. (In pits or fissures the thickness of the enamel is between 0.5 and 1.0 mm. Note the deep pulpal dentin should not be probed)
Extensive distinct cavity with visible dentin: Code 6
Obvious loss of tooth structure, the cavity is both deep and wide and dentin is clearly visible on the walls and at the base. An extensive cavity involves at least half of a tooth surface or possibly reaching the pulp

RESULTS

The distribution age and gender of the patients by the groups are given in **Table 2**.

Assessments of the mean dmft, dmfs, and OHI-S indices are shown in **Table 3**. We determined a mean dmft index score of 8.35 ± 1.88 between the participants; and among all groups, Group 1 had the highest mean dmft score while Group 2 had the lowest. According to the results of ANOVA test that was performed for comparing dmft ratios, no statistically significant difference was found between the groups, regarding the mean dmft index score ($p = 0.32$). We found a mean dmfs index score of 20.35 ± 7.53 for all participants. The result of Kruskal Wallis test made for comparing the dmfs index variables of the groups was statistically significant. *Mann Whitney U* test with Bonferroni correction was used for performing pairwise comparisons. Test results revealed that, in terms of the mean dmft index scores, there was a statistically significant difference between Group 1 and 2 and also between Group 2 and 3 ($p < 0.01$ for both pairs). In the test results, mean dmfs index scores of Group 1 and 3 were significantly higher than those of Group 2. We determined a mean OHI-S index score of 0.91 ± 0.44 for all participants. With respect to the results of ANOVA test, which was made for comparing OHI-S index ratios, no statistically significant difference was found between the mean OHI-S indices of the groups ($p = 0.68$).

The distributions of ICDAS scores for evaluating the presence of caries in PFMs were expressed in numbers/percentages (**Table 4**).

We recognized the PFMs with ICDAS Code 3 and above as "carious" and compared the caries status of the groups, respectively (**Table 5**). Generally, considering the teeth with ICDAS Code 3 and higher as "carious," decays were detected in 160 teeth out of a total of 360 PFMs (44.4%) and no caries was found in 200 PFMs (55.6%) in our analysis. Among the groups, Group 3 had the highest caries rate (50%) and Group 2 had the lowest (34.2%). Caries rate in Group 1 was 49.2%. According to the statistical analysis results, there was a significant difference between the groups in terms of caries prevalence distribution (χ^2 $p = 0.02$) and Group 2 showed the lowest caries prevalence. Group 1 and Group 3 had close caries rates.

For each group, distribution of the patients by the number of carious PFMs and their group averages are given in **Table 6**. The mean numbers of caries in PFMs of the patients in the groups have been compared. In accordance with ICDAS, we found that Group 3 had the highest mean number of carious PFMs (2 ± 1.43) and Group 2 had the lowest (1.43 ± 1.45). Numerical values in Group 1 and Group 2 were close and lower in Group 2. We found no statistically significant difference between the groups. The number of patients with all four PFMs decayed were the highest in Group 1. Mean number of carious PFMs was determined as 1.80 ± 1.52 in all children.

DISCUSSION

Only few longitudinal follow-up studies reporting "how past caries experiences may affect the future oral health" have been conducted so far. In our study, we aimed to search the impact of ECC on PFM decays by comparing PFM caries in the patients whose oral health conditions were improved with the dental treatments under GA or with the treatments in normal clinical settings to the caries in the patients with multiple cavities who were not previously treated.

Several researches reported that the caries history in primary dentition was a predisposing factor for the caries in permanent teeth, although their study designs were different from ours (15, 20–24). All of these studies in the literature included only the follow-ups of the patients experienced ECC in the past, they did not include monitoring of the patients with treated ECC. Thus, since our research is the first study in which the caries status of PFMs in patients with previously treated ECC has been

TABLE 2 | Distribution of gender and age by the groups.

	Number	Gender		Age
		Girl	Boy	Mean ± SD(*)
Group 1	30	12	18	7.70 ± 0.98
Group 2	30	17	13	7.10 ± 0.88
Group 3	30	15	15	7.33 ± 0.71
Total	90	44 (%48.9)	46 (%51.1)	7.38 ± 0.89

Standard deviation.

TABLE 3 | Mean dmf-t, dmf-s, and OHI-S indices of the groups.

		Group 1	Group 2	Group 3	*p*
Number		30	30	30	
dmf-t	Min–max	5–12	5–12	5–14	0.32
	Mean ± SD	8.73 ± 1.87	8.00 ±1.89	8.33 ±1.88	
dmf-s	Min–max	12–40	7–33	7–35	<0.01
	Mean± SD	24.37 ± 6.09	15.33±6.19	21.17 ± 7.56	
	Median	(24)	(15)	(20.5)	
OHI-S	Min–max	0–2	0–2	0–2	0.68
	Mean ± SD	0.97 ± 0.44	0.88 ± 0.46	0.90 ± 0.41	

TABLE 5 | Number of ICDAS-determined caries in all PFMs and their distribution by the groups.

		Caries status of PFMs in accordance with ICDAS			
Groups		No caries	Caries	Total	*P*
Group 1	Number	61	59	120	0.02
	(%)	(50.8%)	(49.2%)	(100%)	
Group 2	Number	79	41	120	
	(%)	(65.8%)	(34.2%)	(100%)	
Group 3	Number	60	60	120	
	(%)	(50%)	(50%)	(100%)	
Total	Number	200	160	360	
	(%)	(55.6%)	(44.4%)	(100%)	

TABLE 4 | Distribution of ICDAS-scored PFMs by the groups.

		ICDAS scores							
Groups		Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6	Sum
Group 1	Number	28	16	17	24	21	14	0	120
	(%)	(23.3%)	(13.3%)	(14.2%)	(20%)	(17.5%)	(11.7%)	(0%)	(100%)
Group 2	Number	11	41	27	20	7	9	5	120
	(%)	(9.2%)	(34.2%)	(22.5%)	(16.7%)	(5.8%)	(7.5%)	(4.2%)	(100%)
Group 3	Number	26	20	14	31	16	8	5	120
	(%)	(21.7%)	(16.7%)	(11.7%)	(25.8%)	(13.3%)	(6.7%)	(4.2%)	(100%)
Total	Number	65	77	58	75	44	31	10	360
	(%)	(18.1%)	(21.4%)	(16.1%)	(20.8%)	(12.2%)	(8.6%)	(2.8%)	(100%)

TABLE 6 | Distribution of the patients by the number of carious PFMs and their group averages.

Groups	Number	DMFT index for PMSs					Mean DMFT indices for PFMs Mean ± SD(*)
		No caries number (%)	1 caries number (%)	2 caries number (%)	3 caries number (%)	4 caries number (%)	
Group 1	30	9 (30%)	4 (13.3%)	5 (16.6%)	3 (10%)	9 (30%)	1.97 ± 1.65
Group 2	30	10 (33.3%)	9 (30%)	4 (13.3%)	2 (6.6%)	5 (16.6%)	1.43 ± 1.45
Group 3	30	6 (20%)	6 (20%)	6 (20%)	6 (20%)	6 (20%)	2 ± 1.43
Total	90	25 (27.7%)	19 (21.1%)	15 (16.6%)	11 (12.2%)	20 (22.2%)	1.80 ± 1.52
							Kruskal Wallis $p = 0.28$

*Standard deviation.

evaluated; currently there is no sufficient literature data to be compared with.

In our study, we determined that the caries rate in PFMs of the 6–9 years old children with past ECC experience was 44.4%. Even though no secondary caries presented because some of these children with severe ECC had previously been treated under GA and thus, dental caries in their primary teeth had been managed and then the teeth were restored with SSCs, permanent tooth caries had not been prevented yet. When the number of carious PFMs, which had been determined in accordance with the ICDAS scores of the groups was assessed; Group 2 showed the lowest caries prevalence and there was a significant difference between the groups regarding the prevalence of caries distribution. With this fact, the first null hypothesis stating "*There was no significant difference between the caries prevalence of PFMs in the children with previously improved oral health but still experiencing ECC and the PFM caries prevalence of the untreated patients also suffering from ECC*" was rejected.

Although all groups had similar dmft scores, the reason for obtaining lower PFM caries rates in Group 2, which included the patients with untreated primary teeth carious lesions can be explained by its lower dmfs rates. In Group 2, parents might have not made their children treated, since they had less severe and asymptomatic caries.

Early childhood dental visits provided by most families may indicate the children's early dental problems rather than the parental responsibilities (25–27). In this situation, we may consider that however the dental cavities of the children who experienced primary tooth caries at very young ages had already been removed prior to the eruption of PFMs, problems related with teeth structures, genetic factors, ineffective tooth brushing techniques and insufficient self-training levels of the families might also have increased the caries rate in the permanent teeth (28–30). Moreover, even if the dental cavities had been eliminated, some bacterial causes; such as a certain size of bacterial population remained constant in oral cavity due to the previous bacterial exposure in high levels might also have affected this condition (31). Further studies are needed to assess the bacterial levels. Factors associated with early caries in the primary teeth can also cause the same patient to develop permanent tooth caries.

Our study showed that the removal of the cavities in the primary teeth before the eruption of the permanent teeth had no positive impact in declining the development of the permanent teeth caries. However, we should also keep in mind that the patients treated under GA developed high rates of dmft scores at much earlier ages.

In our study, mean number of carious PFMs was determined as 1.80 ± 1.52 in the children at the maximum age of 9 and with past ECC experience, regardless of they had been previously treated or not. Thus, the second null hypothesis that "*whether treated or not, the children with past ECC experience had higher risks of developing future PFM caries,*" was accepted.

In our study, the rate of carious PFMs was lower in the patient group with untreated permanent tooth decays, who visited our clinic for the first time (Group 2). In contrast to our expectations, number of the carious PFMs were higher in the Group 1, in which ECC were comprehensively treated under GA. According to these results, in this patient population with previous ECC history, presence of untreated primary teeth caries in the permanent teeth eruption period alone is not a strong predictor for caries development in the permanent dentition. Nevertheless, further studies determining the bacterial levels are needed for extensive evaluations.

The primary purpose of our study was to search the impact of treated and untreated ECC in children, on PFM decays. Besides, the reason for including Group 3 in the study was the consideration of establishing a third group involving multi-session treatments so that the caries would be managed over a long period of time, in order for comparing it with Group 1, in which better restorations were placed and caries were removed under GA.

We used SSCs in the posterior restorations placed under GA but compomers were used in the posterior restorations placed in Group 3, because the child-patients were very young. Researches reported that SSC restorations had superior durability and longevity than the class II amalgam and resin-based composite restorations (32).

In the light of above information, we aimed to search how an age-associated long-term ECC treatment that was carried-out in normal clinic environment would affect the PFM development by comparing it to a single-visit treatment, which was performed

under GA and with better restorative materials (e.g., SSCs especially in the teeth adjacent to PFMs).

In accordance with the data obtained, we found that removal of dental caries in the children with previous ECC experience alone had not decreased the risk of developing PFM decays. Thus, although the dental treatments have been provided for the patients who experienced carious lesions especially at very young ages, frequent follow-up visits and supervising the dental preventive programs are also important in order for maintaining the dental health during the permanent tooth eruption period. In this issue, the dentists' role includes; informing the parents of the ECC-experiencing children about PFM caries risks, ensuring regular, and effective caries-preventive applications, explaining the importance of oral care and periodic dental check-ups to the parents and encouraging them.

CONCLUSION

The data obtained in this study revealed that regardless of having been treated or not, ECC posed a risk for developing PFM caries. However, since we could follow-up only a limited number of child-patients, further clinical studies with extensive patient groups are needed.

ETHICS STATEMENT

This study has been conducted in Department of Pediatric Dentistry-Ataturk University Faculty of Dentistry, Erzurum in accordance with the provisions of Ministry of Health regulation 28030, dated as 19 August 2011 (court # 08/2017, Resolution # 53) and was based on the signed parental informed consents.

AUTHOR CONTRIBUTIONS

FS: scanning archive data, control of patients, examination of patients, and article writing. SS: study design, sharing the archive data for this study, article writing, and English translation of the article. SY and ZK: statistically analyses and article writing.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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