International Journal of Research in Engineering, Science and Management
Volume-1, Issue-10, October-2018
www.ijresm.com | ISSN (Online): 2581-5792

Research on Recent Advancements in the Field of Early Childhood Caries - A Multifactorial Disease

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Abstract*—*Aim: **To review and update the current knowledge about early childhood caries (ECC) and its etiology, prevalence, risk factors, management, and preventive strategies.**

Background: **Early childhood caries is a disease affecting significantly both well-developed and industrial nations. The ECC can significantly affect the child's quality of life, as it may lead to infection, swelling, pain, and other symptoms. The ECC affects children after eruption of primary teeth until age of around 5 years.**

Review results: **The ECC affects all parts of the tooth including the smooth surface. Upper anterior teeth and primary molars are usually affected. The lower anterior teeth are less likely affected. The risk factors for ECC are diet, bacteria, and host susceptibility. The additional factors, such as presence of enamel defect and the feeding practices also contribute to the initiation and progress of ECC.**

Conclusion: **Dentists must focus on utilizing existing techniques to distinguish indications of right on time and propelled caries and give guidance on the best way to counteract and control caries in children. Approaches should be directed to preventive caries control strategies among children.**

Clinical significance: **Preventing and controlling the development of ECC among children is important to maintain effective eating, speech development, and formation of a positive self-image.**

***Index Terms*—etiology, risk factors, clinical diagnosis, prevention, future approaches, reference**

I. Introduction

Early childhood caries (ECC) is still one of the most prevalent diseases in children worldwide. ECC does not only affect children's oral health, but also the general health of children. Not only oral pain, orthodontic problems, and enamel defects, but also problems with eating and speaking can occur as well as an increased risk for caries development in the permanent dentition. Premature loss of primary dentition often leads to orthodontic problems in adult life. Not only children are affected, but also parents will be influenced by this disease being the responsible caregivers. For example, dental problems were shown to be the main reasons for hospitalisation of children in Australia in 2015. Thus, ECC leads not only to temporary pain, but more importantly has major effects on the quality of life of the family/caregivers including financial and health implications [1]. The aim of this review article is to present the state of the art of the epidemiology, aetiology, characteristics of primary dentition, risk factors, general recommendations, and strategies for prevention of ECC [2].

The expression "dental caries" is utilized to represent the outcomes, signs, symptoms, and side effects of a localized chemical disintegration of the tooth surface (enamel and dentin) caused by dental plaque and mediated by saliva. Caries is considered as disease with high incidence among childhood chronic conditions, where it is also well-thought-out to cause harm on both population and individual well-being. When comparing it with other common diseases, dental caries is five times as frequent as asthma and seven times as common as hay fever [3].The American Academy of Pediatrics demonstrates that dental and oral infections keep on infecting children and, specifically, very young children. In primary teeth, dental caries is a preventable and reversible disease if treated in early stages, but when left untreated it will lead to pain, bacteremia, alteration in growth and development, premature tooth loss, speech disorder, increase in treatment costs, loss of confidence, and negatively affect successor permanent teeth. Dental caries in young children has a pattern; diverse terms and terminology have been utilized to express them [4].

The definitions used previously to describe this bacterial disease were related to cause and the improper utilization of nursing bottle.

These terms are used interchangeably: "Early childhood tooth decay," "early childhood caries (ECC)," "bottle caries," "nursing caries," "baby bottle tooth decay," or "night bottle mouth." The expression "ECC" was proposed more than 20 years ago during a workshop supported by the Centers for Disease Control and Prevention

(CDC) trying to scope the consideration upon the various issues, such as financial, socio psychological, and behavioral, which contributes to the formation of caries at such initial years, instead of attributing its manifestation solely on feeding bottles[5].

II. Background and Epidemiology

As stated before, ECC is still one of the most abundant

diseases worldwide. The incidence of ECC among children with deciduous teeth is 1.76 billion (95% CI: 1.26 billion; 2.39 billion). Interestingly, ECC is not limited to children with a low socioeconomic status (SES) [6].Recent data, for example, from Australia show a prevalence of more than 50% of 6-year-old children with caries on deciduous teeth. Data from different parts of the world show up to 89.2% of children with ECC in Qatar and 36% in Greece. About the same prevalence (ca. 40%) has been reported in the USA among 2–11 year old children [7]. A recently published study from Germany shows even 10% (up to 26% with initial lesions) of 3-year-old children with ECC and an increase up to about 50% in 6-/7-year-old children [8]. Even though the dmft-index (decayed missing filled teeth) has decreased over time in general, the prevalence has not decreased. However, a study from Germany was also able to show different trajectories and an increase of dmft-values when looking at a smaller scale on a regional level. While most of the districts in a midsized German city showed a decrease of dmft, the dmft increased in other districts over time. Milsom et al. described that children with an already existing caries lesion have a 5–6 times higher incidence of developing new caries lesions compared to previously caries-free children. Sleeping problems and insufficient sleep can also be identified as risk factor for ECC, as sleeping problems lead to a more frequent use of night-time bottle use with sugar-sweetened beverages. As the role of parents is still unclear with respect to their children developing ECC, several studies have focussed on different associations. Sociocultural and socioeconomic backgrounds of the parents can be found as risk factors for ECC, but parental stress does not show a significant increase in ECC with the children[9] Not only children, but also their parents should be motivated to take care of the primary dentition to prevent ECC and consequently further caries development in the secondary dentition.

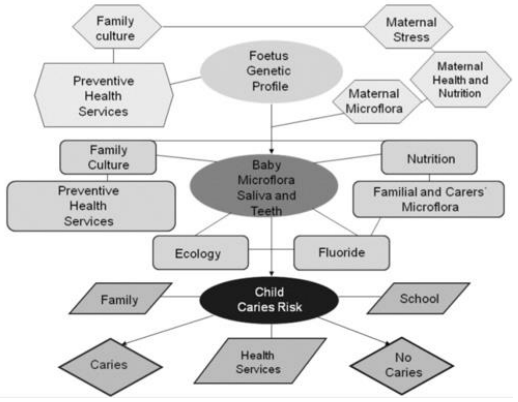

Fig. 1. Explanatory model of early childhood caries: Impacts on the developing child

III. Etiology

Dental caries develops when the dental plaque, a polymicrobial biofilm, is not removed regularly and the diet consists of mainly monosaccharides. Monosaccharides can be metabolized by many of the oral bacteria leading to an increased production of acids which are able to demineralize the enamel. Dental plaque is built on top of the pellicle starting directly after mechanical removal of the biofilm [10]. More than 700 bacterial species/taxa are known in the oral flora. Because the oral habitat consists of many different ecological niches, the relatively high number of different species/taxa can be explained. Oral microorganisms are able to interact with each other and mainly communicate using so-called “quorum sensing” (QS). Nowadays, it is well known that not only bacteria, but also fungi, such as Candida albicans and the interkingdom interactions, can enhance the progression of caries [11]. However, microorganisms grown in polyspecies biofilms are able to produce exopolysaccharides (EPS), also known as extracellular polymeric substances. With the help of the EPS, microorganisms are able to resist antimicrobials that are recently used in toothpastes. Consequently, biofilm formation is not interrupted and together with the absorbed saccharides from the diet leads to a cariogenic dental plaque. The dental plaque on clinically sound enamel of children consists mainly of streptococci and actinomycetes. With a low-sugar diet, these microorganisms are living as commensals in a homeostatic environment controlling each other. As soon as sugars, especially sugary food and beverages, are consumed, the commensal plaque microbiota will absorb these saccharides and metabolize them into acids, mainly lactic acid. This acid production leads to a pH shift from around 7 (neutral) to a pH < 5.5 (acidic) [12]. Acid-tolerant bacteria, mainly mutans streptococci, are able to survive these acidic environments [13]. When oral hygiene habits and nutritional habits do not change, a reduction of highly cariogenic microorganisms (mutans streptococci, Candida spp., and lactobacilli) cannot be achieved. Peterson et al. used next-generation sequencing (NGS) to identify the microbial composition of the dental plaque. They show only slight differences between the biofilms collected from children with and without caries: Streptococcus mitis and Streptococcus sanguinis were found in both groups. Streptococcus was found to be the most abundant genus (>50% of the microorganisms). Veillonella, Granulicatella, Fusobacterium, Neisseria,

Campylobacter, Gemella, Abiotrophia, Selenomonas, and Capnocytophaga were also found in abundance between 1 and 10% of the biofilm. Simon-Soro et. al. [14]. Also detected Lactobacillus-species, known as acid-resistant bacteria, associated with caries. Even though the studies described above used NGS strategies, this technique is rapidly developing and recent studies are able to use even more sophisticated models predicting ECC. Teng et al. used in vivo samples from a 3-year cohort study and showed, with the help of mathematical modelling, that S. mutans were not the main trigger for caries, but identified Veillonella spp. and Prevotella spp. instead. Veillonella atypical, V. dispar, and V. parvula as well as Prevotella spp. were identified as bacteria that are mainly responsible for the development of ECC [15].

In conclusion, ECC develops as soon as the dental plaque is not removed adequately and a sugary diet, especially sweetened food and beverages, is consumed [16].This leads to a changing metabolism with the dental plaque microbiota producing mainly lactic acids that will demineralize the enamel. Prevotellaspp and Veillonella spp. were shown to be microbial risk factors, while together with fungi, bacteria can trigger acid metabolisms and virulence of the microorganisms.

IV. Risk Factors

There are several factors that contribute to the formation of ECC, some of which will be discussed in this review.

A. Microbiological Risk Factors

The ECC is a transmittable disease. Streptococcus mutans (SM) and Streptococcus sobrinus are the most widely recognized causative specialists. Lactobacilli additionally have a distinct role in the caries progression but not in its initiation.Studies have shown that there are two ways for SM transmission: Vertical and horizontal transmission [17]. Vertical transmission is carried between caregiver and child (i.e., mother or father to child). Subsequently, poor maternal oral hygiene and higher sugar intake per day rise the chances of transferring the disease to the child by the mother. Whereas, for horizontal transmission, neonatal factors may increase the chance of acquiring SM. Infant delivery by cesarean section transmits SM earlier than through natural deliveries [18]. The time of 13 to 16 months is roughly needed between SM colonization and caries lesion initiation and advancement.

Fig. 1.

B. Dietary Risk Factors

In addition to infection with SM bacteria, children who have high-sugared drinks also suffer from ECC. Sugar is processed by both SM and lactobacilli that will further more transform it into acid, which will cause demineralization of tooth structure. Evidence recommends that both cow's and human milk are considered to be less cariogenic than sucrose, with cow's milk being the least cariogenic [19]. The cariogenic capability of newborn child equations fluctuated over the reviews, with some being as cariogenic as sucrose. On the contrary, the available evidence in the literature discussing the ariogenicity of breast milk is weak and lacks consistency, 29 whereas the cariogenicity of milk formulas varies across studies. The best accessible data show that low level of caries in nations is associated with sugar utilization between 40 and 55 gm per person in 1 day. The connection among proper diet and dental caries has turned out to be weaker in contemporary society and this has been credited to the broad utilization of fluoride.

C. Environmental Risk Factors

Several studies have confirmed that when SM bacteria have been acquired at an early age, it will mostly lead to ECC, where other factors might contribute to caries progression or prevention, such as socioeconomic status of caregivers, water fluoridation, race, number of years of education, and dental insurance coverage. Relationship among ECC and the financial status has been very much reported [20]. Children with a background marked by dental caries, whose parents and siblings have serious dental caries, are viewed as being at high risk of having dental caries in their future. Additionally, kids involvement of financial burden influences grown-up dental well-being. Absence of access to dental care, deficient accessibility of preventive measures, for example, water fluoridation, fluoride supplementation, and dental sealants, and the absence of information of the significance of oral well-being are contributing elements to an oral well-being decrease in young children [21].

Fig. 2.

V. Diagnosis

The ECC starts with a white spot lesion on the maxillary primary incisors along the cervical third of the crown (on the edge of the gingiva). In general, the decay is first seen on the primary maxillary incisors, and the four maxillary anterior teeth are often involved concurrently [22]. If the lesion is not arrested and disease continues, caries will progress to form a cavitation. The lesion may appear on either facial or lingual surfaces or on both. Young children that have ECC are more susceptible to caries infection in both primary and permanent dentitions [23].The ECC is not only limited to oral health but is also widespread to cause several health problems. Children with ECC have a slower growth rate when compared with caries-free children, where also ECC may be affected with iron deficiency.

Moreover, the implementation of the new expression of ECC is now in use instead of the previous terminology of bottle caries, when at least one of the following criteria is accompanied by.

- Smooth surface caries in children ≤3 years
- In children between 3 and 5 years of age, any smooth surface of an anterior–posterior tooth, i.e., filled, missing (due to caries), or decayed. The decayed, missing, and filled teeth index is equal to 4 or more for children 3 years of age, 5 for children 4 years of age, and 6 for kids 5 years of age.

VI. Prevention

A. Target Cariogenic Feeding and Primary Acquisition of MS

Prevention of cariogenic feeding behavior is one approach for preventing ECC. Sugared beverage consumption with nursing bottles or "sippy cups" enhances the frequency of enamel demineralization. This type of feeding behavior during sleep intensifies the risk of dental caries because oral clearance and salivary flow rates decrease during sleep [24]. Thus, sugared beverage consumption with nursing bottles should be reduced or stopped. Also, the knowledge that the most important risk factor related to dental caries in babies is acquisition of MS should help in determining an optimal preventive approach and interceptive treatment [25]. A promising approach toward primary prevention of ECC is the development of strategies that target the infectious component of this disease, such as preventing or delaying primary acquisition of MS at an early age through suppressing maternal reservoirs of the organism [26].

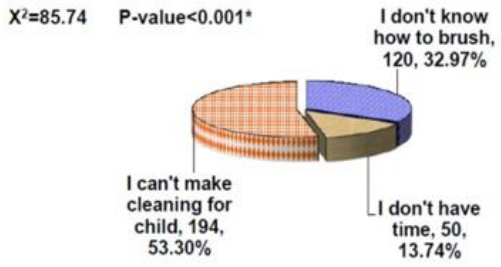

Fig. 3. Illustrates mother's responses towards the inability to maintain oral hygiene to their children

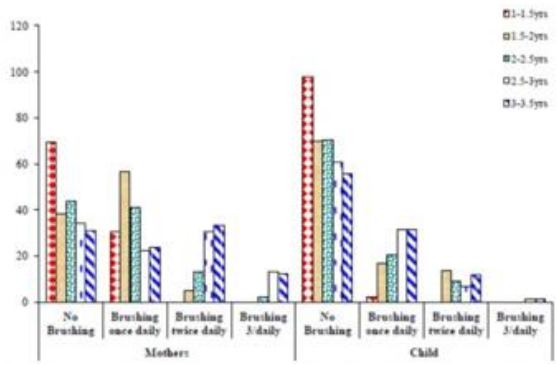

Fig. 4. Illustrates teeth brushing for mothers and their children in different age groups

For this reason, it is better if prevention of ECC begins in the prenatal and perinatal periods (including pregnancy and the first month after birth) and addresses the health of both the mother and the infant. The mother's or caregiver's teeth should be examined. Infants whose mothers have high levels of MS due to untreated dental decay are at greater risk of acquiring the organisms. Dental management of the mother can delay infant inoculation.

B. Topical Antimicrobial Therapy

Topical antimicrobial therapies have been recently described. Topical application of a 10% povidone-iodine solution to the dentition of infants every 2 months in a double-blind, placebo-controlled clinical trial for 1 year increased the number of caries-free infants [27]. These infants were at high risk for ECC as they were all colonized by MS and had decay-promoting feeding behaviors. This study suggested that povidone-iodine had suppressive effects on the oral colonization of MS and prevented dental caries. However, povidone-iodine has strong bactericidal/virucidal effects and demolishes normal flora in the pharynx and the oral cavity, which interfere with pathogenic viral invasion. Therefore, povidone-iodine should not be routinely used. In another study, 6 monthly applications of a 40% chlorhexidine varnish were effective in a 37.3% reduction in caries increment without side effects, and this reduction was also close to that found in a meta-analysis regarding the effectiveness of fluoride varnish on caries prevention in primary teeth, 33% (95% CI = 19–58%). Topical 0.12% chlorhexidine gluconate could significantly reduce MS levels, but chlorhexidine therapy was much less effective at reducing the levels of lactobacilli in the human mouth [28]. Current chlorhexidine products require patient compliance with a rinse that tastes bad and has the potential to stain, and it must be applied numerous times to be effective. Moreover, a systematic review reported that the evidence for a caries-preventive effect of chlorhexidine varnish in children and adolescents was inconclusive.

C. Fluoride

To prevent ECC by home-care approaches, brushing by caregivers using a small quantity of fluoride-containing toothpaste is essential and should start as soon as teeth erupt. Pine et al. showed the benefit of twice daily brushing in newly erupted first molar teeth compared to brushing once daily or less. This study also showed the importance of parental beliefs. If parents feel strongly that there is time to check the condition of their child's teeth, the odds that their child will actually brush twice daily are about three times greater. Thus, it is important to support parents and convince them that their efforts make sense for their child's dental health and that they really can contribute. Moreover, community and professional care approaches have been used to prevent ECC [29].Early screening for signs of dental caries development, starting from about 7-8 months of age, could identify infants who are at risk of developing ECC, assist in providing information for parents

about how to promote oral health, and prevent the development of tooth decay. High-risk infants include those with early signs of ECC, poor oral hygiene (of both infant and mother), limited exposure to fluoride, and frequent exposure to sweet beverages. These infants should be targeted with a professional preventive program that includes oral hygiene instructions for the mother and child, fluoride use, and diet counseling. These professional approaches are important but not sufficient to prevent dental caries in high-risk children. Addressing the social and economic factors that many families face where ECC is endemic is also necessary.

D. Case in Phosphopeptide

Amorphous Calcium Phosphate (CPP-ACP). CPP-ACP nano complexes are casein-derived peptides in which ACP is stabilized by CPP. These nano complexes act as a calcium and phosphate reservoir when incorporated into the dental plaque and on the tooth surface CPP-ACP has been shown to reduce demineralization and promote remineralization of carious lesions both in vitro and in situand to reduce erosive tooth wear in vitro. CPP-ACP cream, which is effective inremineralizing early enamel lesions of primary teeth, wasa little more effective than 500 ppm NaF. Moreover, CPP-stabilized amorphous calcium fluoride phosphate had a greater remineralizing effect on carious lesions compared to fluoride or CPP-ACP individually. Since additive effects were obtained when CPP-ACP was used in conjunction with fluoride, CPP-ACP is better used as a self-applied topical coating after the teeth have been brushed with a fluoridated toothpaste by children who have a high risk of dental caries [30].

E. Pediatricians' Role

Prevention and control of dental caries can be promoted by clinicians other than dentists if such clinicians are appropriately trained. Pediatricians can provide recommendations for the prevention of ECC to mothers and caregivers. Children can be examined by their primary care provider or pediatrician for signs of early carious demineralization, as indicated by white areas around the gingival margin or brown-stained pits and fissures [31]. The detection of dental caries and referral to an appropriate dental care professional for treatment should be thought of as a secondary prevention measure.

F. Dental Fluorosis

Two studies have been published sup-porting the effectiveness of fluoride varnish to prevent dental caries in the primary dentition. However, fluoride varnish can also introduce the risk of the development of enamel fluorosis in the permanent teeth. Evidence of a major benefit from fluoride consumption during infancy is lacking, and thus, it seems reasonable to limit the intake of fluoride to less than 70 µg/kg BW per day, considering the possible risk of enamel fluorosis. To avoid greater intake, water with relatively low fluoride content (e.g., 0–0.3 mg/L) is recommended to be used as a diluent for infant formula, and no fluoride supplement should be given to infants. For children 1–7 years of age, the repeated addition of small amounts of fluoride to oral fluids is important. Consumption of fluoridated water is highly recommended, and the regular use of fluoridated dentifrices is also an effective means of decreasing the prevalence of dental caries. However, with the knowledge that small children swallow much of the applied dentifrice, education regarding appropriate tooth brushing in small children is needed for mothers or caregivers. The recommended limit in the amount of dentifrice should be no more than 0.25 g per brushing. Fluoride supplements have been recommended for preventing caries [32]. A systematic review found that the evidence supporting the effectiveness of supplements in caries prevention in primary teeth was weak. In permanent teeth, the daily use of supplements prevented dental caries. The use of supplements during the first 6 years of life, and especially during the first 3 years, was associated with a significant increase in fluorosis.

VII. Future Approaches to Prevent ECC

Considering the integrated roles of dental, medical, and other health care providers, assessing the effects of public health interventions, and introducing oral health promotion as part of general health promotion are all necessary. The mouth can be both a nidus of infection and the location of the first sign of systemic disease, and pediatricians have frequent access to young children and have opportunities to address issues relating to oral health. Thus, primary care clinicians should be familiar with effective interventions for the youngest children before they require dental services. A study demonstrated that oral health training during residency can increase pediatrician confidence in participating in important oral health-promoting tasks, including anticipatory guidance, oral screenings, and oral health-risk assessments [33].

Additionally, dentists need to establish the best ways to provide preventive and clinically effective care. Scientific advances must blur the demarcation between dental and medical practices; dental caries is a health problem that can be managed by a team of health care providers including dentists and physicians. Physicians must concentrate on using existing methods to detect signs of early and advanced caries and provide advice on how to prevent and control caries in their patients.

Acknowledgement

I would like to thank Dr. Koishik Chakraborty, B.D.S, M.D.S, Professor, Department of Pedodontics and Preventive Dentistry, North Bengal Dental College and Hospital, Siliguri. West Bengal, for his support and providing important information and documents.

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