

Early Childhood Caries: A Multi-Factorial Disease

Annerosa Borutta¹, Maik Wagner², Susanne Kneist³

¹ Ph.D., D.D.M., D.H.C. Professor, WHO Collaborating Centre on Prevention of Oral Diseases at the Centre for Dental, Oral and Maxillofacial Surgery, University Hospital, Jena, Germany. ² Dipl. Math. Faculty of Economic Science, Friedrich Schiller University of Jena, Germany. ³ Prof. Dr. rer. nat. habil. WHO Collaborating Centre on Prevention of Oral Diseases at the Centre for Dental, Oral and Maxillofacial Surgery, University Hospital, Jena, Germany.

Abstract

In this paper, the authors review the literature on early childhood caries (ECC) and suggest that it has become a public health problem because of its relatively high and apparently growing prevalence and its rapid progression, which may lead to the destruction of the deciduous dentition. The paper reviews and discusses the definition of early childhood caries and its diagnostic criteria. It then reviews the literature on the causes and determinants of social and economic factors as risk factors for early childhood caries. It concludes that:

early childhood caries may be a growing problem in many countries; risk factors for early childhood caries include a number of social and behavioural determinants; there is still insufficient scientific evidence to weight their contribution to the problem; the complicated mixture of many determinants and risk factors for early childhood caries needs further research to obtain reliable information for explanatory models that will identify at-risk infants.

Key Words: Review, Early Childhood Caries, Aetiological Factors, Risk Factors

Introduction

Oral health is one component of general health and is an important factor in the normal development of a child. Oral health problems or illnesses can influence the general development of a child and its general health and can adversely affect quality of life [1].

In Germany, for more than a decade, there have been initiatives to improve oral health in childhood and adolescence. These initiatives have applied to both the primary (deciduous) and the secondary (permanent) dentition, and improvement has been achieved [2]. However, over this period, the overall reduction in the prevalence of dental caries in primary teeth has been much smaller than in permanent teeth and caries has become polarised to children from poorer socio-economic backgrounds. Currently, 6- to 7-year-olds have almost twice as many carious teeth as 12-year-olds [3]. Furthermore, at least two studies suggest that there may be an increasing caries prevalence (a rebound of caries) in pre-school children [4,5]. One reason for this deterioration in the oral health of pre-school children is the increased occurrence of early childhood caries. This can be observed in the second year of life and, if left untreated, quickly leads to rapid destruction of the primary dentition.

Like any other form of dental caries, early childhood caries is multi-factorial, and is the result of a time-specific interaction of microorganisms with sugars on a tooth surface [6]. In addition to the causal factors, the influence of social and behavioural risk factors, which often result from a generally unhealthy lifestyle [7,8], have been implicated. Poor nutrition, lack of exercise, tobacco, alcohol and drug use, coupled with irregular use of medical or dental services are all risk factors that exert a negative influence on the development and progress of both general and oral diseases [1]. Such factors have led to the design and implementation of modern public health strategies and the so-called common risk factor approach [9-12].

Although early childhood caries occurs in small children in all social classes, those families with patterns of risk behaviour are particularly vulnerable to diseases.

Aim

Against this background, the aim of this paper is to describe early childhood caries and its multi-factorial nature with respect to different explanatory models of social determinants.

Corresponding author: Professor Dr. Dr. h.c. Annerose Borutta, WHO Collaborating Centre on Prevention of Oral Diseases at the Centre for Dental, Oral and Maxillofacial Surgery, University Hospital Jena, Bachstrasse 18, 07743 Jena, Germany; e-mail: Annerose.Borutta@med.uni-jena.de

Definitions of Early Childhood Caries and Diagnostic Criteria

There have been many definitions of early childhood caries. This has led to some confusion over the diagnostic criteria and the multi-factorial origins of this complex disease. In 1862, an American physician, Abraham Jacobi [13], was the first to describe the clinical appearance of early childhood caries, which he observed in one of his own children. Beltrami (1932) [14] described “Les dents noires des tout-petits” (black teeth in small children). Fass (1962) [15] coined the term *nursing bottle mouth*. The literature contains a variety of other terms used to describe early childhood caries and its diagnostic criteria. Most of them relate to the use of a feeding bottle or prolonged breastfeeding (feeding bottle tooth decay, feeding bottle syndrome, nursing caries, nursing bottle mouth, and so on). The authors wish to highlight the danger of excessive drinking from a baby bottle, if it contains sweetened liquids, or prolonged on-demand breastfeeding [16].

However, all the above definitions or descriptions failed to consider the actual relationship between dental caries and its a full range of aetiological factors. Furthermore, parents were confused regarding the benefits and risks of bottle-feeding or breastfeeding. To inform the scientific community with internationally comparable data on the incidence of early childhood caries, delegates to a conference at the Centers for Disease Control and Prevention [1994] coined the term *early childhood caries* “in order to better the multi-factorial pathogenesis of the disease” [17]. Unfortunately, this term was seen to have its limitations. Three years later, a further conference on early childhood caries, organised by the National Health Institute (USA), added two further definitions/descriptions,

which were *rampant infant caries* and *early childhood dental decay* (RIECDD) [18]. These differences in definition were due above all to diversity in diagnostic criteria.

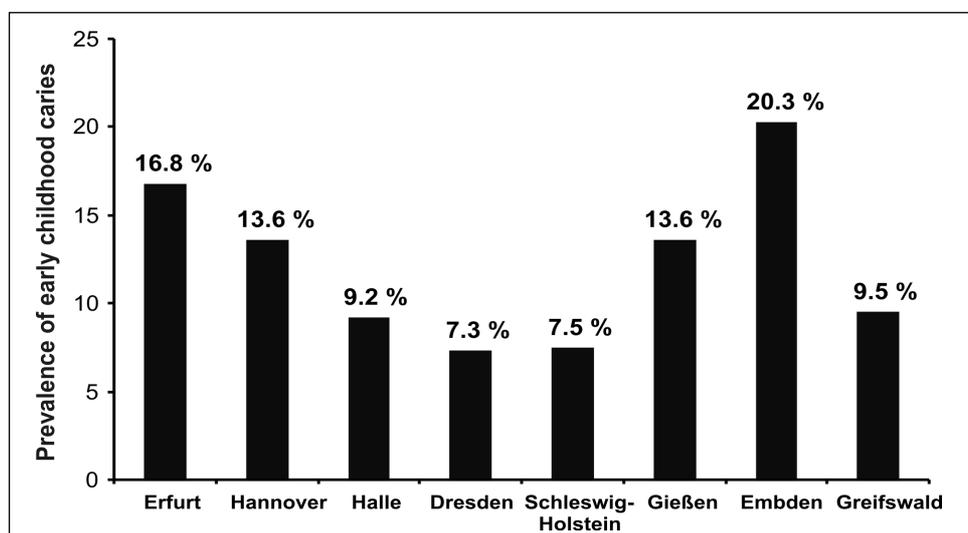
Subsequently, Wyne (1999) [19] distinguished three types of early childhood caries (ECC):

- ECC type I (mild to moderate form): isolated carious lesions in molars and/or incisors (often between two and five years of age).
- ECC type II (moderate to severe form): labial and palatal carious lesions in the maxillary incisors and primary molars.
- ECC type III (severe form): almost all teeth affected, including the lower incisors; in general, this form occurs between the three and five years of age.

Notwithstanding all these definitions, today the definition that has prevailed is that of early childhood caries is any carious lesion on any tooth surface that occurs within the first three years of life [20-22].

In spite of its worldwide prevalence, very few representative data on early childhood caries are available; most are estimates. In the 1980s, clinical observations in Germany led to an acceptance of an increased occurrence in very young children [23,24], which led to the implementation of a prevalence study in Giessen. The results indicated that 5% of the one-year-olds already had carious teeth. This percentage increased with age and in the three-to four-year-olds was 23% [25]. The results of recent epidemiological studies from Germany into early childhood caries are shown in *Figure 1*. It shows a prevalence between 7.3% and 20.3%. In other countries, the prevalence is between 3% and 45%, and it increases in socio-economically deprived communities, to as high as 70-90% [26,27]. Thus, early childhood caries

Figure 1. Results of regional studies of the prevalence of early childhood caries in Germany between 1997 and 2008 (from Splieth et al., 2009 [3]).



has developed into a public health problem, whose solution requires further research into the disease and the design and development of complex prevention strategies.

Causes and Determinants of Social and Economic Factors as Risk Factors for Early Childhood Caries

According to the guideline of European Academy of Paediatric Dentistry (EAPD) on the prevention of early childhood caries, early childhood caries represents a public health problem with biological, social, and behavioural determinants [28]. It was suggested that of the biological determinants, the three key causal factors for dental caries were microorganisms, substrate, and host [29]. However, subsequently a fourth—time—was added by König in 1971 [30]. These four factors can be graphically represented by four overlapping circles (*Figure 2*).

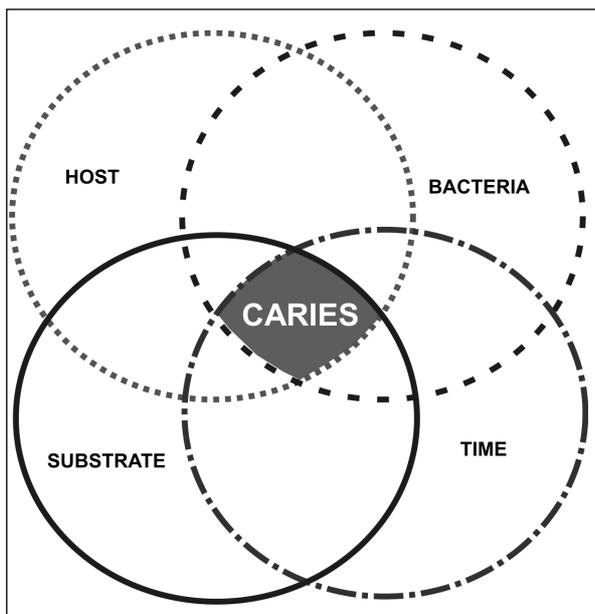


Figure 2. Aetiological factors for caries (after Keyes, 1962 [29]; modified by König, 1971 [30]).

Although the caries is often described as an infectious disease, it is not a “real” infectious disease in the classical pathological understanding, because it does not follow Koch’s postulates. Bacteria necessary for caries development belong to the normal physiologic flora in the mouth and initially have a low cariogenic potential (low virulence) unless the subject is caries-free. The extended ecological plaque hypothesis states that a change in oral environment leading to a shift in the balance between the cariogenic bacteria, natural or acquired

factors, that determine the acid susceptibility or resistance of the tooth surfaces (host defences to control), and local tooth surface modifying factors such as plaque and saliva is necessary to increase the cariogenic potential of the microflora (increase its virulence) and initiate caries [31,32]. Mutans streptococci and in particular *S. mutans* and *S. sobrinus* have been implicated as the most important bacteria for caries initiation and its progression [33]. They have a number of virulent characteristics that determine the cariogenicity of plaque or biofilm. Besides the ability to produce acids from sugars, especially lactic acid, which demineralise tooth enamel, they also produce extracellular polysaccharides that allow for further plaque growth. *S. mutans* can also form intracellular polysaccharides, which allow them to maintain the acid production during periods of low substrate supply. In addition to the mutans streptococci, lactobacilli and the yeasts are recognised as being important in the pathogenesis of early childhood caries. Their increased presence is associated with frequent sugar intake [34].

Typically, the highest risk sites for caries are fissures, pits or interproximal areas, where plaque is less likely to be disturbed, enabling a progression from initiation to cavitation. However, in early childhood caries, the smooth surfaces of the maxillary incisors are involved at an early stage, whereas in any other form of dental caries involvement of these sites is at a later stage in the carious process. Initial changes can often be observed at the end of the first year of life, and will then result in caries in the molars and canines soon after they have erupted. Such early childhood caries is an extremely aggressive form of the disease. The most important requirement is an early infection, usually with the mother’s cariogenic bacteria, for example, between the age of 19-31 months. However, earlier and later infection is a possibility [35,36]. After transmission of cariogenic bacteria and a frequent supply of substrate (sucrose) to the plaque, usually given as a sugary drink (juices and so on from a feeding bottle) or in older children, in snacks in the form of solid-cariogenic foods such as sweets, chocolates, cakes, biscuits, the development of early childhood caries occurs. If this loading of the plaque with sugars occurs at bedtime (night) and there is no tooth-brushing, caries can progress rapidly. In addition, during bottle-feeding with sugar-containing drinks, the upper incisors bathe in these sugar-containing drinks but the saliva from minor salivary glands in

the area of these teeth has only limited remineralising properties, whereas the lower incisors remain largely protected by the tongue during bottle-feeding. In addition to the other severe types of early childhood caries, feeding on demand with cariogenic food and liquids is regarded as a co-factor for early childhood caries [37].

As mentioned earlier, many social and behavioural determinants are risk factors for early childhood caries. As with many other chronic non-communicable diseases, low socio-economic status, immigrant families, inadequate health literacy and low educational attainment in parents, in particular in mothers, are all risk factors for a number of diseases including early childhood caries. Social and behavioural factors have been described in association with early childhood caries in numerous publications [38-41]. A recent systematic literature review [42] of the international literature from 1966 to 2002 identified 260 publications on this topic and then analysed the importance of individual risk factors for caries in primary teeth. A total of 106 risk factors for the prevalence or incidence

of caries were identified; the most significant combination was an early infection with *S. mutans*, an unfavourable dietary pattern, and frequent intake of sugar with inadequate oral hygiene. However, it was clear that, if an unfavourable diet was accompanied by good oral hygiene it would no longer be a risk factor, because the oral hygiene practices negated the dietary factor. Overall, the authors recommended the integration of only a few validated factors into explanatory models, thus facilitating a comparison of the results.

A recent collaboration of specialists from different scientific disciplines used a structured standardised questionnaire to develop different models to explain early childhood caries in the light of social and cultural issues from an international perspective [43]. They considered the process from the development of the fetus to the dentate pre-school child and included the influence of family, culture, maternal stress, the use of health services, education, nutrition and environmental factors on the disease risk (Figure 3). They concluded that poverty influenced the development of caries as strongly as

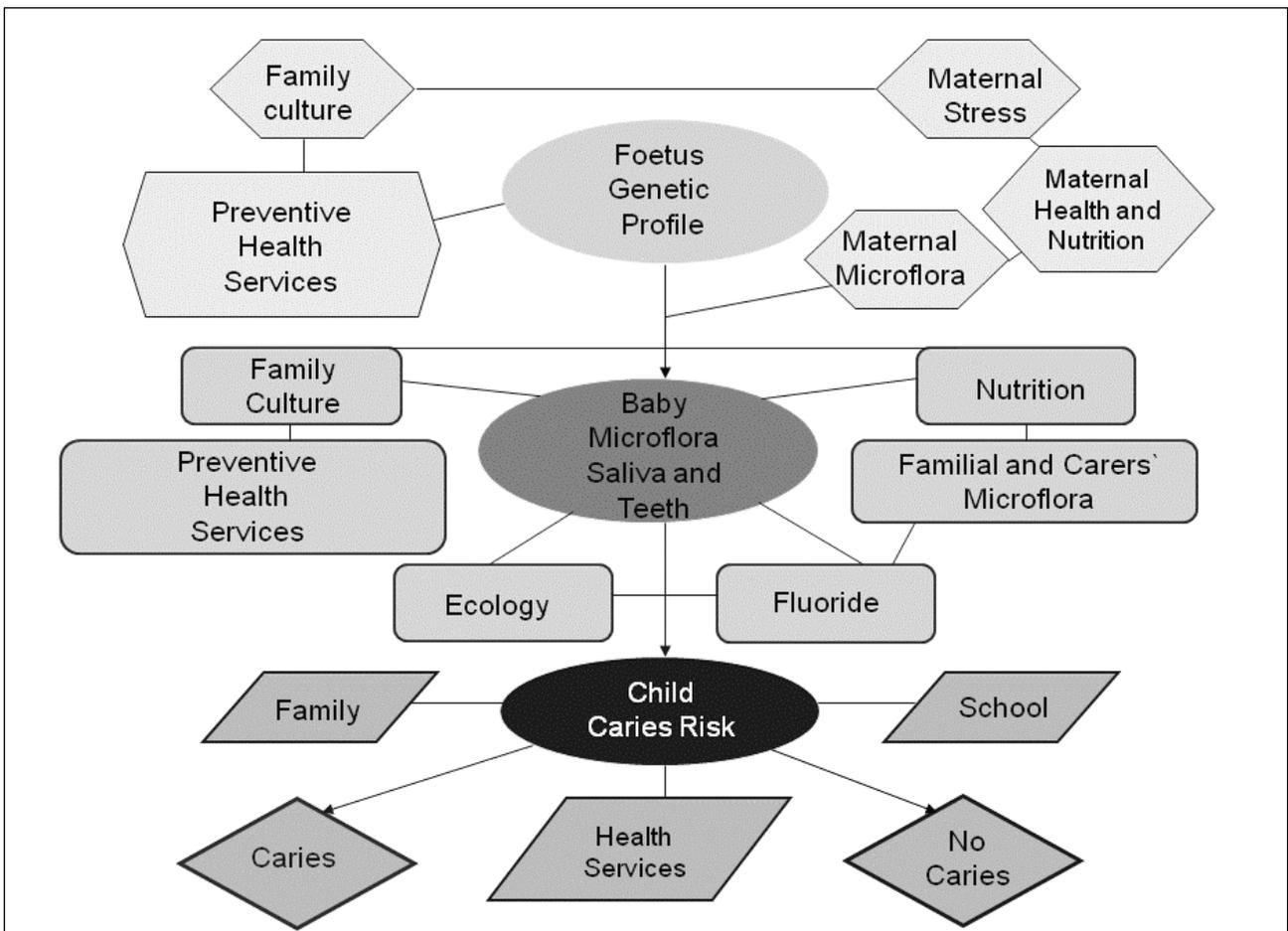


Figure 3. Explanatory model of early childhood caries: impacts on the developing child (Pine et al., 2004 [43]).

various ethnic factors [43]. The collaboration [43] further concluded that the impact of health-related behaviours on disease can depend on the setting and a consideration of the setting may enable some behavioural patterns to be predicted (*Figure 4*).

Between 2002 and 2008, the WHO Collaborating Centre on Prevention of Oral Diseases at Jena University Hospital initiated a multi-centre study of early childhood caries that was carried out in five countries. Data were gathered from regional studies in Ouro Preto (Brazil), Erfurt (Germany), Riga (Latvia), Volgograd (Russia) and Minsk (Belarus). Infants aged between 26 and 34 months were included and a uniform methodology (study design) [44] was used in all countries. It involved health surveys of mothers and oral examinations of the infants. *Figure 5* shows an explanatory model for early childhood caries based on the data from the five countries. There were various correlations, especially between the country, the use of feeding bottles and the plaque on early childhood caries. The extent to which, the influence of the country was a factor in isolation can only be speculated on at present. The influence of these factors is extremely complex and requires further research, especially from the point of

view of the circumstances pertaining to barriers for certain behaviours. Considerations should also include the determinants of people’s social networks and relationships and who these may influence their health behaviour [10].

In summary, this paper has presented data and information that confirm the seriousness of early childhood caries, the urgent need for it to be considered as a public health problem, and for efforts to find a satisfactory solution for all concerned. Measures implemented to date, either through group dental prophylaxis or individual dental or medical interventions, have shown no significant and lasting success. This is because the disease often occurs before children visit a dentist for the first time and thus measures such as individual prophylaxis and education of the mother are too late to prevent the disease. Initial lesions are not recognised by the mothers and they often only become apparent when the child complains of pain.

Conclusions

It can be concluded that:

- Early childhood caries may be a growing problem in many countries.

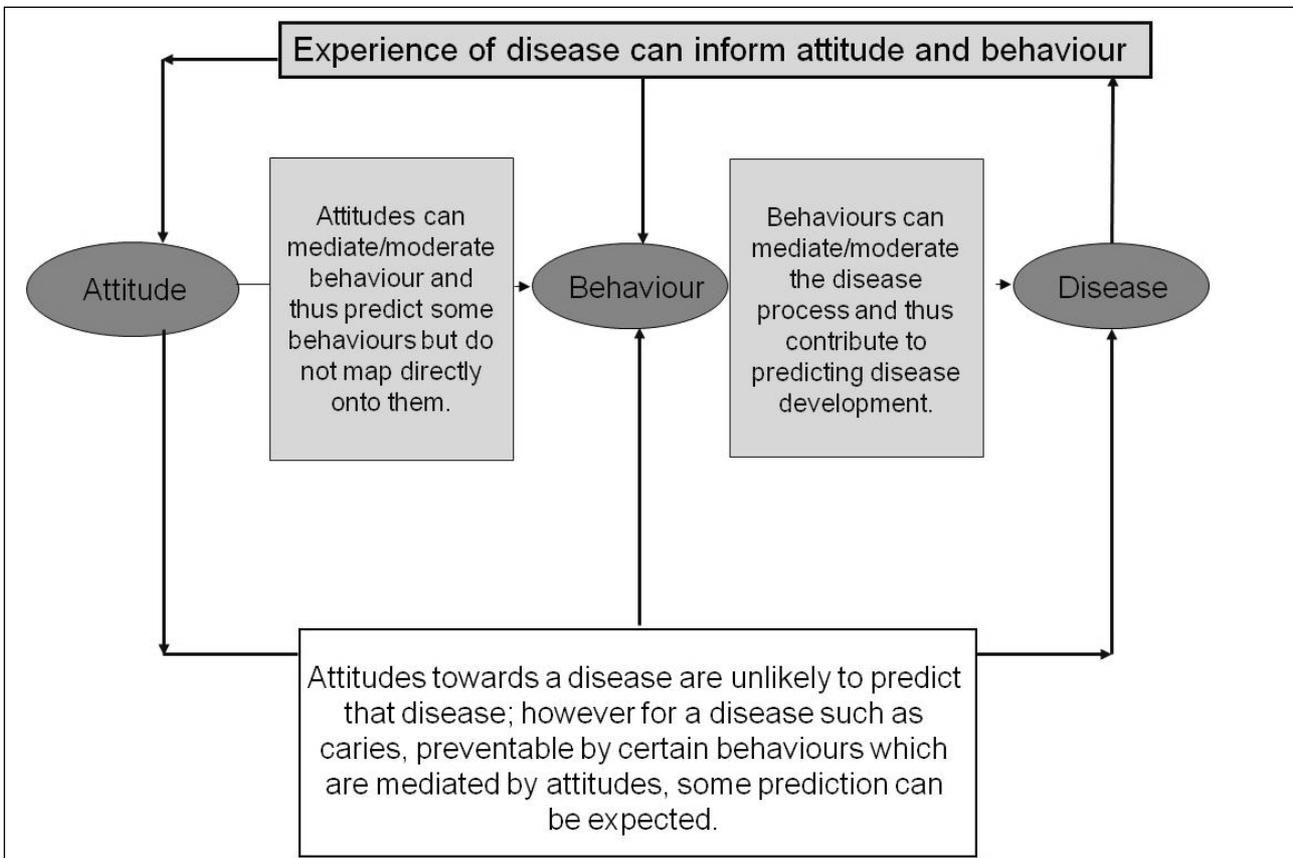


Figure 4. Relationships between attitudes, behaviour and disease (Pine et al., 2004 [43]).

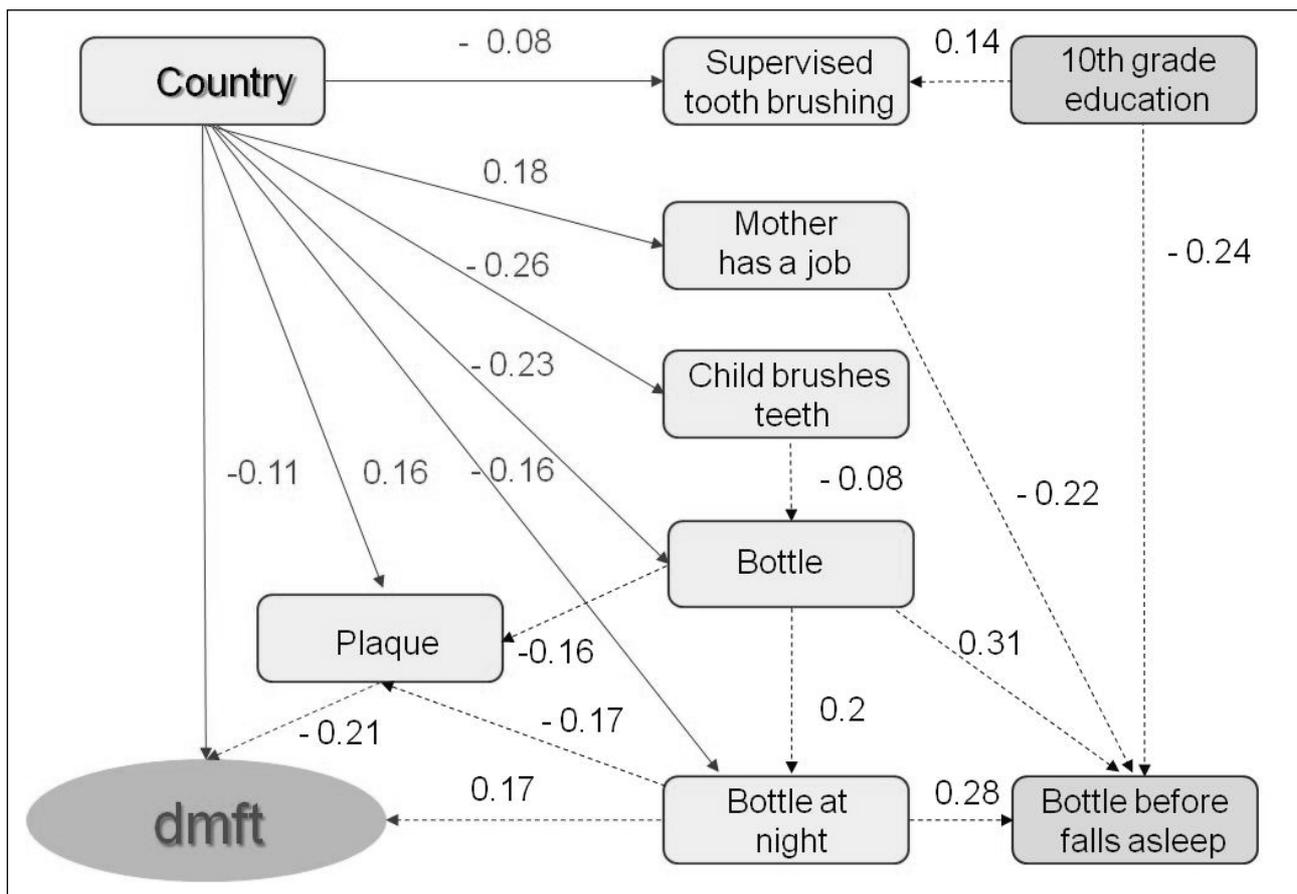


Figure 5. Explanatory model of early childhood caries, as developed by the multicentre study of five countries

- The risk factors for early childhood caries include a number of social and behavioural determinants.
- There is still insufficient scientific evidence to weight their contribution to the problem.
- The complicated mixture of many determinants and risk factors needs further research to obtain reliable information for explanatory models that will identify at risk infants.

Acknowledgements

The authors would like to thank their partners for performing the multicentre study on the multi-factorial model of early childhood caries in their countries: Prof. Care, Riga, Latvia; Dr. de Moura Sieber, Ouro Preto, Brazil; Prof. Maslak, Volgograd, Russia; Prof. Tserekhava, Minsk, Belarus.

References

- Petersen PE, Kwan S. World Health Organization global oral health strategies for oral health promotion and disease prevention in the twenty-first century. *Prävention und Gesundheitsförderung* 2009; **4**(2): 100-104.
- Pieper K. [Epidemiological Surveys for Group Prevention Programmes 2004.] Bonn, Germany: German Working Committee for Oral Health Promotion of Children; 2005. [Article in German]
- Splieth CH, Treuner A, Berndt C. Oral health in toddlers. *Prävention und Gesundheitsförderung* 2009; **4**: 119-123.
- Poulsen S. Dental caries in Danish children and adolescents 1988-94. *Community Dentistry and Oral Epidemiology* 1996; **24**: 282-285.
- Speechley M, Johnston DW. Some evidence from Ontario, Canada of a reversal in the dental caries decline. *Caries Research* 1996; **30**: 423-427.
- Tanzer JM, Livingston J, Thompson AM. The microbiology of primary dental caries in humans. *Journal of Dental Education* 2001; **65**(10): 1028-1037.
- Petersen PE. Sociobehavioural risk factors in dental caries: international perspectives. *Community Dentistry and Oral Epidemiology* 2005; **33**: 274-279.
- Sabbah W, Tsakos G, Chandola T, Sheiham A, Watt RG. Social gradients in oral and general health. *Journal of Dental Research* 2007; **86**: 992-996.
- Deutsche Arbeitsgemeinschaft für Jugendzahnpflege e.V. [German consortium for oral health promotion in children; registered association. Recommendations/Guidelines for Oral Health Promotion/Assessment of High Caries Risk in Children.] Bonn, Germany: DAJ; 1994. Available [in German] via:

10. Frühbuß J, Schäfer M. Inequality of oral health: Challenge for public health service. *Prävention und Gesundheitsförderung* 2009; **4**: 105-112.
11. Sheiham A, Watt RG. The common risk factor approach: a rational basis for promoting oral health. *Community Dentistry and Oral Epidemiology* 2000; **28**: 399-406.
12. Zimmer ST. [Caries prevention as multifactorial preventive strategy. Dissertation.] Berlin: Humboldt University, Charité/Virchow University Hospital; 2000. [Article in German]
13. Jacobi A. *Dentition: Its Derangements. A Course of Lectures Delivered in the New York Medical College*. New York: Ballière Brothers; 1862.
14. Beltrami G. [Black teeth in toddlers.] *Siècle Medical* 1932 Apr 4. Cited in Beltrami, G. *La mélanodontie infantile* [Infantile Melanodontia]. Marscilles, France: Leconte Editeur; 1952. [Book in French]
15. Fass E. Is bottle feeding of milk a factor in dental caries? *Journal of Dentistry for Children* 1962; **29**: 245-251.
16. Schroth RJ, Brothwell DJ, Moffatt MEK. Caregiver knowledge and attitudes of preschool oral health and early childhood caries (ECC). *International Journal of Circumpolar Health* 2007; **66**: 153-167.
17. Kaste LM, Gift, HC. Inappropriate infant bottle feeding: Status of the Healthy People 2000 Objective. *Archives of Pediatrics & Adolescent Medicine* 1995; **149**: 786-791.
18. Quartey JB, Williamson DD. Prevalence of early childhood caries at Harris County clinics. *Journal of Dentistry for Children* 1998; **7**: 127-131.
19. Wyne AH. Early childhood caries: nomenclature and case definition. *Community Dentistry and Oral Epidemiology* 1999; **27**: 313-315.
20. Drury TF, Horowitz AM, Ismail AI, Maertens MP, Rozier RG, Selwitz RH. Diagnosing and reporting early childhood caries for research purposes. A report of a workshop sponsored by the National Institute of Dental and Craniofacial Research, the Health Resources and Services Administration, and the Health Care Financing Administration. *Journal of Public Health Dentistry* 1999; **59**(3): 192-197.
21. Ismail AI. Prevention of early childhood caries. *Community Dentistry and Oral Epidemiology* 1998; **26**(Suppl 1): 49-61.
22. Twetman S, García-Godoy F, Goepferd SJ. Infant oral health. *Dental Clinics of North America* 2000; **44**(3): 487-505.
23. Wetzel WE. ["Sweet tea caries": a new form of deciduous tooth caries in small children.] *Deutsche Zahnärztliche Zeitschrift* 1981; **36**: 330-332. [Article in German]
24. Wetzel WE, Schlömer R. [Effect of apical tooth diseases on mineralisation and eruption of permanent teeth.] *Deutsche Zahnärztliche Zeitschrift* 1986; **41**: 179-181. [Article in German]
25. Buhl S, Wetzel WE, Bödecker RH. [Studies on the incidence of caries prevalence in 6- to 48-month old infants.] *Deutsche Zahnärztliche Zeitschrift* 1989; **44**: 673-677. [Article in German]
26. Milnes AR. Description and epidemiology of nursing caries. *Journal of Public Dental Health* 1996; **56**: 38-50.
27. Slavkin HC. *Streptococcus mutans*, early childhood caries and new opportunities. *Journal of the American Dental Association* 1999; **130**: 1787-1792.
28. European Academy of Paediatric Dentistry. *Guidelines on Prevention of Early Childhood Caries: An EAPD Policy Document*. Dublin, Ireland: EAPD; 2008.
29. Keyes PH. Recent advances in dental caries research. *International Dental Journal* 1962; **12**: 443-464.
30. König K. [Caries and Caries Prevention.] Munich, Germany: Goldmann; 1971. [Book in German]
31. Davies GN. Early childhood caries: a synopsis. *Community Dentistry and Oral Epidemiology* 1998; **26**(Suppl 1): 106-116.
32. Takahashi N, Nyvad B. Caries ecology revisited: Microbial dynamics and the caries process. *Caries Research* 2008; **42**: 409-418.
33. Loesche WJ. Role of *Streptococcus mutans* in human dental decay. *Microbiological Reviews* 1986; **50**(4): 353-380.
34. Beighton D, Brailsford S, Samaranyake LP, Brown JP, Ping FX, Grant-Mills D, et al. A multi-country comparison of caries-associated microflora in demographically diverse children. *Community Dental Health* 2004; **21**(Suppl 1): 96-101.
35. Caufield PW, Cutter GR, Dasanayake AP. Initial acquisition of mutans streptococci by infants: evidence for a discrete window of infectivity. *Journal of Dental Research* 1993; **72**: 37-45.
36. Wan AKL. Oral colonization of *Streptococcus mutans* in six-month-old preterm infants. *Journal of Dental Research* 2001; **12**: 2060-2065
37. Wendt LK, Birkhed D. Dietary habits related to caries development and immigrant status in infants and toddlers living in Sweden. *Acta Odontologica Scandinavica* 1995; **53**: 339-344.
38. Fédération Dentaire Internationale. Technical report No. 31. Review of methods of identification of high caries groups and individuals. *International Dental Journal* 1988; **38**: 177-189.
39. Horowitz HS. Research issues in early childhood caries. *Community Dentistry and Oral Epidemiology* 1998; **17**: 292-295.
40. Reisine S, Douglass JM. Psychosocial and behavioural issues in early childhood caries. *Community Dentistry and Oral Epidemiology* 1998; **26**: 32-44.
41. Seow WK. Biological mechanisms of early childhood caries. *Community Dentistry and Oral Epidemiology* 1998; **26**: 8-27.
42. Harris R, Nicoll AD, Adair PM, Pine CM. Risk factors for dental caries in young children: a systematic review of the literature. *Community Dental Health* 2004; **21**: 71-85.
43. Pine CM, Adair PM, Petersen PE, Douglass Ch, Burnside G, Nicoll A, et al. Developing explanatory models of health inequalities in childhood dental caries. *Community Dental Health* 2004; **21**: 86-95.
44. Borutta A, Kneist S, Kischka P, Eherler D, Chemnitz P, Stösser L. Oral health in toddlers in relation to relevant influence factors. *Deutsche Zahnärztliche Zeitschrift* 2002; **57**: 682-687.