

# The epidemiology of Early Childhood Caries

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## Abstract

This review explores the epidemiology of Early Childhood Caries (ECC) worldwide and in Asian countries. The literature search was carried out through PubMed and ScienceDirect databases. Due to only limited evidence published in the Asian region, the prevalence of ECC in Asian countries was derived from the WHO website, a conference report and a conference proceedings book. A total of 17 papers were extracted, while the total number of papers read for qualitative information in this review was 66. The results show that, currently, there are too few surveys reporting appropriate data to indicate the true seriousness of ECC problem, especially, in Asian countries. Moreover, variations in case definition and diagnostic criteria often made the data incomparable. Failure to address the seriousness of the problem, including the presence of non-cavitated lesions and pulpally involved teeth resulted in ECC being underestimated. The negative consequences of ECC and untreated ECC, affected the quality of life among children, their families, communities and health care systems. Therefore, harmonization of ECC definition, criteria and index age in conducting epidemiological data may lead to more understanding of ECC in each country and within the Asian region, and more appropriate and effective measures to tackle the ECC problem.

## Keywords

Early childhood caries, Epidemiology of Early Childhood Caries, Review of Early Childhood Caries, Asian countries



## Introduction

Epidemiology is the study of the distribution and determinants of disease or adverse health conditions. Epidemiological data of Early Childhood Caries (ECC) is urgently needed as, currently, appropriate data are not available to indicate the extent and seriousness of the problem. Most of the published data are from surveys of specific groups, e.g. from hospital or dental practice, and these are unlikely to be representative of children in the population. Moreover, variations in case definition and diagnostic criteria have made it difficult to compare studies. Consistent use of standardized case definitions and diagnostic criteria to measure ECC, are needed to indicate the size of the problem of ECC and allow comparisons across different studies.<sup>1-3</sup>

For the last fifty years, dentists and researchers have struggled to define ECC clearly. It has been referred to as 'baby bottle tooth decay', 'nursing bottle syndrome', and 'rampant caries'.<sup>4</sup> Defining ECC has proved challenging and, for this reason, prevalence rates of ECC have varied depending on the definition.<sup>5</sup> The American Academy of Pediatric Dentistry (AAPD) defines Early Childhood Caries (ECC) and severe early childhood caries (S-ECC) as follows:

*Caries is a biofilm (plaque)-induced acid demineralization of enamel or dentin, mediated by saliva. The disease of early childhood caries (ECC) is the 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 months of age or younger. In children younger than 3 years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (S-ECC). From ages 3 through 5 years, 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  $\geq 4$  (age 3),  $\geq 5$  (age 4), or  $\geq 6$  (age 5) surfaces constitutes S-ECC.<sup>6</sup>*

This article will report the epidemiology of ECC worldwide and in Asian countries. Results will be presented, providing information on diagnostic criteria used, the type of survey, as well as the caries prevalence and pattern, caries progression, severity and consequences of ECC.

## Method

Literature to inform this review of aspects of Early Childhood Caries was obtained in several ways.

First, an electronic internet search was made through PubMed and ScienceDirect databases. The primary search term was 'early childhood caries'. Other keywords included tooth decay in young children, dental caries in young children, nursing caries. Other associated terms used in the search included: diagnosis, criteria, epidemiology, prevalence, aetiology, risk factor, prevention, treatment and oral health related quality of life. Eligible studies were included when they met the following criteria: (1) articles in English providing relevant information within the time period 1960 to 2015; (2) presenting evidence relevant to ECC according to the defined themes: epidemiology, aetiology, prevention and treatment; (3) considers dental caries or sequelae in early childhood. Concerning the exclusion criteria, studies were excluded from the review if they focused on either: (1) concerned with other age-groups or other diseases, (2) studies published in languages other than English. A total of 417 articles were identified through database searching; duplicates and references irrelevant to ECC were removed, reducing this list by about one third. Two conference books relevant to the situation in Asian countries were also included.

Second, nine journals were searched by hand: International Journal of Paediatric Dentistry, European Journal of Paediatric Dentistry, Pediatric Dentistry, Journal of Dentistry for Children, Journal Clinical Pediatric Dentistry, Community Dentistry



Oral Epidemiology, Community Dental Health, Caries Research, Journal of Public Health Dentistry. How far back the hand-searches were made, depended on the journal: for most journals it covered 2000 to 2015, while for International Journal of Paediatric Dentistry, the search extended back to 1990.

Third, some back-tracking from the reference lists attached to publications so far discovered was carried out to identify any remaining key articles. This resulted in a database of 380 references on all aspects of ECC, covering the years 1993 to 2016. Out of this database, 66 publications were relevant to this review of the epidemiology and two conference books relevant to the situation in Asian countries were also included.

## Results

### *Caries criteria and outcome measurement*

In this part, a total of 17 papers out of 380 articles were obtained. Seven<sup>10,18,48,50,53,56,59</sup> out of the 17 studies (41%) reported using World Health Organization (WHO) examination methods and diagnostic criteria, one<sup>61</sup> out of the 17 studies (6%) used British Association for the Study of Community Dentistry (BASCD) criteria, one study<sup>3</sup> (6%) used National Institute of Dental and Craniofacial Research (NIDCR) criteria, one study<sup>51</sup> (6%) used the Ontario Ministry of Health guidelines, and 7 studies<sup>49,52,54,55,57,58,60</sup> (41%) reported using other criteria. Ten<sup>10,48,49,50,54,56-59,61</sup> out of 17 reviewed studies (59%) used cavitation as a minimal threshold for caries detection. Seven studies<sup>3,18,51-53,55,60</sup> (41%) reported, used non-cavitated carious lesions (white spot lesion) for the presence of a carious lesion. In 1999, Ismail et al.<sup>7</sup> reported a systematic review of clinical diagnostic criteria of early childhood caries and found a wide variation in the case definitions and diagnostic criteria used to diagnose ECC or define S-ECC. 'Cavitation' was the most common criterion

used to define dental caries. Several studies measured early or non-cavitated carious lesions. Some studies used the presence of 1 dmft maxillary incisor to classify a child with S-ECC.<sup>7</sup> Other studies defined S-ECC by the presence of 2+ or 3+ dmft maxillary incisors, respectively. In the study of migrant Hispanic children in Stockton, California, the prevalence of ECC varied from 12% to 30%, depending upon the clinical criteria used for diagnosis and the case definition.<sup>8</sup> In several publications there were recommendations to standardize diagnostic criteria and case definitions to enhance study comparability. However, these recommendations have yet to be fully realized.<sup>7-10</sup> This review found that seven<sup>3,48,49,50,51,56,61</sup> out of 17 studies (43%) used Klein's dental caries index, by summing the decayed, missing, and filled teeth (dmft) or decayed, missing, and filled tooth surfaces (dmfs).<sup>11</sup> Three studies<sup>53,54,59</sup> use the modified version of 'dmft' proposed by Gruebbel, where the missing component was specified as 'extracted because of dental caries' (deft).<sup>12</sup> The review of the prevalence and measurement of dental caries in young children by Dye et al.<sup>9</sup> revealed that some studies calculate prevalence using only primary maxillary anterior teeth. However, where studies used definitions based on algorithms proposed by the American Academy of Pediatric Dentistry (AAPD), International Caries Detection and Assessment System (ICDAS), or National Institute of Dental and Craniofacial Research (NIDCR), all teeth were included when estimating the prevalence of ECC or dental caries in young children, and not just the six maxillary anterior teeth.<sup>9</sup>

### *Prevalence of ECC*

ECC is very widespread and severe amongst young children worldwide and in Asian countries. The prevalence of ECC has been shown to be highest among low income and minority populations.<sup>13</sup> This review presents an overview of caries prevalence



reported by studies between 1999 and 2014. Most of these studies were limited to small samples in discrete areas within a population. For instance, some studies evaluating children who presented for treatment to a dental facility, so they cannot be taken to represent caries prevalence for general population. The caries diagnostic criteria and case definition varied. Moreover, there was a broad range of age groups used in the studies. Prevalence, from this search of the literature, varied from 3% to 71%.

When looking at the ECC data of 5-year-old children from this review, prevalence varied from 33% to 73%.<sup>33,50,52,53,55,61,62</sup> This can be compared with data reported for ASEAN countries from Oral Health Data Bank website,<sup>14</sup> the International Dental Conference on 'Caries Control throughout life in Asia' 2013,<sup>15</sup> and the 1st ECC forum 2014,<sup>16</sup> which showed that the caries prevalence of 5-year-old children in this region varied from 59% to 94%. (Table I).

Table I: ECC prevalence in 5 -year-old children

Country	Age (y)	% Prevalence	Year of survey
Brunei	3	39	2012
	5	59	2012
Cambodia	3	98	2012
	5-6	93	2011
Indonesia	n/a	n/a	n/a
Lao PDR	3	79	2010
	6	89	2010
Malaysia	5	76	2005
	6	74	2007
Myanmar	5	68	2007
The Philippines	3	85	1999
	5	94	1999
Thailand	3	52	2012
	5	78	2012
Singapore	3-4	25	2005
Vietnam	6	84	2001

#### Sources

International Dental Conference on 'Caries Control throughout life in Asia' 2013 The report of 'The 1st ECC forum' 2014 Oral Health Database - <http://www.mah.se/CAPP/Country-Oral-Health-Profiles/>



### ***Caries pattern***

The clinical appearance of early childhood caries is seen initially on the maxillary incisors as a band of dull white demineralization on the labial surfaces along the gingival margin, which goes undetected by parents. As the condition progresses, the white lesions develop into cavities that girdle the necks of the teeth in a brown or black collar. In advanced cases, the crowns of the four maxillary incisors may be destroyed completely leaving decayed brownish-black root stumps. The four maxillary incisors are affected most, while the four mandibular incisors usually remain sound. The reason for the unique distribution of caries between the maxillary and mandibular incisors and the unequal severity of the lesions between the incisors and the other teeth is related to four factors: the protective role of saliva for the mandibular incisors but which is much less for maxillary incisors, the chronology of primary tooth eruption, the duration of the deleterious habit, and the muscular pattern of infant sucking.<sup>17</sup> The study by Vachirarojpisarn et al.<sup>18</sup> found that, at 9 months of age, the first non-cavitated carious lesion appeared on the maxillary central incisor, and the first cavitated carious lesion appeared in maxillary central incisors at the age of 10 months. Regarding non-cavitated carious lesions, 42% of erupted maxillary central incisors, and 39% of erupted maxillary lateral incisors had these lesions in the 11-14 month-old group. A marked increased proportion of cavitated caries in maxillary anterior teeth was found in 15-19 month-old children.<sup>18</sup>

The typical characteristics of early childhood caries are: (1) rapid development and progress from the enamel into dentine occurs in 6 months or less, (2) maxillary incisors are affected first (these teeth usually erupt around 8 months of age), (3) the next teeth to be affected are the primary maxillary and mandibular molars, which begin to erupt around 12 months of age, and (4) when the disease becomes very severe and remains untreated, the mandibular

incisors are also affected.<sup>19</sup> In the longitudinal study of Grindefjord,<sup>20</sup> 64% of children who exhibited dental caries at baseline progressed to manifest caries during the one-year observation period, and the majority of the new lesions were located on the occlusal surfaces of the second molar.<sup>21</sup>

### ***Caries progression and severity***

Epidemiologic evidence indicates that non-cavitated carious lesions are more prevalent than cavitated lesions during the first 18 months of life.<sup>22</sup> The study of Weinstein<sup>23</sup> found that early pre-cavitation carious lesions could potentially develop into cavities in 6 to 12 months' time. A longitudinal study of early childhood caries in 9- to 18- month old Thai infants by Thitasomakul<sup>24</sup> found that the prevalence of caries was 2%, 22% and 68% among infants 9-, 12- and 18- months old, respectively. The buccal surface of maxillary incisors was the most affected (45%) followed by lingual (24%), mesial (20%) and distal surfaces (9%), respectively. The only posterior teeth present were first molars- their occlusal surfaces were the most affected surfaces (51%), followed by buccal (40%), lingual (8%) and distal surfaces (1%). The transitional probability of caries progression ranged between 1.8% and 15.4% during the follow-up period from 9 to 12 months of age. It was 3.4 to 39.6% from 12 to 18 months old.<sup>24</sup> Results from the multi-country epidemiological survey of children less than 6 years of age in seven Latin American countries showed caries prevalence in these children in each age-year from 1 to 5 years, with and without cavitated lesions, of 29%, 42%, 62%, 81% and 81% among 1-, 2-, 3-, 4- and 5- year-old children, respectively.<sup>25</sup> Severely decayed teeth have a significant impact on children's general health.<sup>26</sup> The use of only the dmft/DMFT index may be misleading in the interpretation of caries epidemiological data. In 2010, Monse et al.<sup>27</sup> introduced a new clinical index characterizing the consequences of untreated dental caries in primary and permanent teeth:



the pufa/PUFA index; lower case letters (pufa) for primary teeth and upper case letters (PUFA) for permanent teeth. It is calculated as the sum of teeth with four diagnoses concerning different kinds of odontogenic infections: [p] pulpal involvement, [u] ulceration, [f] fistula, [a] abscess. Thus, the pufa index complements the dmft index by displaying the severity of dental decay and quantifying odontogenic infections of the pulp and surrounding tissues due to untreated caries.<sup>27</sup> The study of Grund,<sup>28</sup> showed a significant positive correlation between dmft and pufa scores - high dmft scores were associated with high pufa scores. Prevalence and experience of odontogenic infections, and the 'untreated caries-pufa ratio', increased from the younger to the older children. Also, dmft and pufa scores in primary teeth predict a higher caries risk in permanent teeth.<sup>28</sup>

### *Consequences of ECC*

Dental caries has a major impact on children's quality of life, causing many to suffer pain, abscesses, chewing problems, premature tooth-loss, malnutrition, gastrointestinal disorders, low self-esteem, and delayed growth and mental development.<sup>29-33</sup> In addition, children with caries spend more time out of school than in school and do not engage actively in outdoor activities because of restrictions from caries - associated pain.<sup>34</sup> Moreover, children with ECC are shown to have higher risk for new lesions as they get older, both in the primary and permanent dentitions.<sup>35, 36</sup> Dental caries in primary teeth is one of the major reasons for hospitalization of children.<sup>37</sup> For example, Nalliah<sup>38</sup> found that odontogenic infections as a consequence of untreated dental caries are the most frequent reason for the hospitalization of young children in the USA. Moreover, in extreme cases, ECC and its treatment can lead to serious disability and death.<sup>1</sup> ECC is costly to treat<sup>39</sup> and has a negative impact on the oral health-related quality of life - as quantified by the OHRQoL index.<sup>40, 41</sup>

The study of disparities in early childhood

caries and its impact on oral health-related quality of life of preschool children in Thailand<sup>41</sup> found that 28% of children experienced high-level impacts on quality of life, mostly dental pain (58%) and eating difficulties (46%). Children of low socioeconomic status were more likely to have a high level of dental caries and subsequent OHRQoL impact.<sup>41</sup> Studies in Scotland<sup>42</sup> found that the proportion of children with sepsis increased markedly with caries experience. This disadvantage could be mitigated if more of the carious lesions were treated. Around one in 10 children with untreated decay (9% with dt>0) were found to have dental sepsis compared with only around 1 in 100 children who had fillings and no untreated decay. The Scottish data suggest that by not treating primary teeth, particularly where many teeth are affected by caries, the risk of the occurrence of dental sepsis is increased.<sup>42</sup> Moreover, dental treatment makes a very significant impact on the psychological and social aspects of the child's life.<sup>43</sup> These improvements include less pain and improved abilities to eat and sleep. Parents perceived that treatment had positive social impacts on their child: more smiling, improved school performance and increased social interaction.<sup>44</sup> Children with untreated early childhood caries (ECC) have significantly poorer oral health-related quality of life than children without ECC. Treatment in pre-school children makes a very significant difference to the psychological and social aspects of the child's life.<sup>32</sup>

The societal cost of these public health issues were emphasized by Bugis<sup>45</sup> who pointed out that more than 50% of ECC children come from low-income families. Early childhood caries occurs most frequently in disadvantaged families or in those living with economic disadvantages.<sup>46</sup> Oral health promotion and prevention programmes, and early intervention are critical as it may decrease an all-too-common social inequality gap and may improve the oral health, general health, and general well-being of very young children.<sup>47</sup>



## Discussion

Although the term early childhood caries is widely used, the use of various diagnostic criteria, definitions and broad age categories continue to limit comparability across studies.<sup>9</sup> The finding of this review showed that there was a variety of diagnostic criteria used to assess the presence of dental caries. For example, Dye et al.<sup>9</sup> revealed that the definitions used in studies varied and they recommended that epidemiologic research would be facilitated by standardizing diagnostic criteria and case definitions. This was echoed by Ramos-Gomez et al.<sup>8</sup> who also reported that the prevalence of ECC varied, depending upon the clinical criteria used for diagnosis and case definition.<sup>8</sup> Moreover, a systemic review of clinical diagnostic criteria of ECC by Ismail et al.<sup>7</sup> presented evidence showing the inconsistency in the case definition and diagnostic criteria of ECC and S-ECC. Kaste<sup>63</sup> suggested that studies should focus on the development of conceptually more adequate and valid case definitions, as well as more reliable and valid case ascertainment procedures. Moreover, this review found that most of data available were often grouped into broad age categories, a point emphasized by Reisine,<sup>64</sup> making comparisons difficult.

A review of the ECC epidemiology literature from many countries in 1996 by Milnes,<sup>13</sup> reported that prevalence rates varied from 1% to 12% in developed countries, while in developing countries, and within disadvantaged populations of developed countries (e.g. immigrants, ethnic minorities), the prevalence rate was as high as 70%.<sup>13, 49</sup> The study of caries prevalence and distribution in individuals aged 3 to 20 years in Sweden over 30 years (1973–2003), showed improved dental health among most adolescents. However, during the last 10 years, this improvement was not seen in the primary dentition.<sup>55</sup> This aligns with other studies that found no further decrease in caries prevalence in the primary dentition.<sup>48</sup> In some studies, increasing caries prevalence

in the primary dentition has been reported.<sup>49</sup> It is important to continually follow changes in oral health with repeated epidemiological studies to be able to institute necessary preventive measures.<sup>55</sup> Accurate measurement of the prevalence of ECC in a population is, however, very difficult, as toddlers and preschool age children can be difficult to examine. Moreover, they are not readily accessible for examination.<sup>2</sup> The reported prevalence of ECC varies from country to country and from area to area<sup>7, 9</sup> and also varied by case definition. The results from a study in Korea,<sup>3</sup> showed that non-cavitated lesions (d1) were more prevalent than cavitated lesions - ECC excluding d1=40%, including d1= 57%; S-ECC excluding d1=24%, including d1= 47%. In Asian countries, there were a limited number of publications available. Data from the WHO website for the Asian region showed that the age of conducting epidemiological surveys of ECC in very young children varied from ages 3, 3-4, 5, and 5-6 years, making comparisons of data very difficult. Moreover, irregular collection of data may mean that the evidence is not up-to-date. The need for current evidence is very crucial for planning and implementation of effective measures to tackle the ECC problem.

From this study, the majority of studies detected the presence of dental caries diagnosed at the level of cavitation, with only a few studies reporting caries prevalence based on non-cavitated carious lesions. This failure to record non-cavitated lesions may not give a true picture of the extent of the problem of dental caries, as we know from epidemiologic evidence that non-cavitated caries lesions are more prevalent than cavitated lesions during the first 18 months of life<sup>2, 2</sup> and cavities in the early stages can develop into cavities in 6 to 12 months' time.<sup>23</sup> Data from Thailand<sup>18</sup> showed that initial caries detected at the age of 9 months developed into a frank cavity within one month (at the age of 10 months). The transitional probability of caries progression ranged between 1.8% and 15.4% during



the follow-up period from 9 to 12 months old, and it was 3.4% to 39.6% from 12 to 18 months old.<sup>24</sup>

Early detection of carious lesion as soon as possible was recommended for effective prevention in order to prevent the development of ECC<sup>65</sup> and reduce the severity of it.<sup>62</sup> The importance of detecting pulpal involvement was also mentioned in order to provide proper treatment to children to maintain a well-functioning dentition, as this improves the psychological and social aspects of the child's life<sup>43</sup> and quality of life.<sup>32</sup>

Failures to treat caries in very young children have negative effects on the child's health, their well-being and their quality of life. The impact of dental treatment makes a very significant difference to the psychological, social aspects of the child's life, social interaction and oral health related quality of life.<sup>32,42-44,66</sup> Evidence showed that ECC occurs most frequently in disadvantaged families or in conditions of economic disadvantage.<sup>45,46</sup> Regarding treatment, the use of minimal restorative techniques may decrease the trauma to both child and parents.<sup>2</sup> To ensure that oral health gets its rightful share of child health care legislation, there is a need to address access to health care through policy and legislation. Horowitz<sup>2</sup> also mentioned the importance of a public health approach to preventing and controlling ECC but, as ECC is not life threatening, public health has not focused resources on this issue. The emphasis should be on "through organized community effort". Prevention of disease is a prime objective of public health and one where teamwork is essential.<sup>2</sup>

## Conclusions

It is clear that there are inconsistencies in the way that ECC is described. The lack of reliable, current and comparable data has led to poor awareness about the seriousness of the ECC problem, especially in the South East Asia region, where prevalence of ECC is high. The general failure to report oral health data from preschool children and a failure to report data on non-cavitated lesions have meant that the problem of ECC has been underestimated and not given prominence it deserves. ECC should be reported for children below the age of 5 years, including the presence of white spot lesions and pulpally involved teeth. Failure to treat ECC has a negative impact to the child's health and quality of life. There is a general consensus within the existing literature that ECC has a negative impact on the quality of life among children, their parents, especially in vulnerable groups and the health systems. There is a need for each country, especially where ECC is the problem, to develop their oral health data systems, to regularly collect data, and use these data to design effective oral health systems, effective plans, and effective measures to tackle ECC.

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