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Prevalence and Risk Factors of Tooth Erosion in Children

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Tooth erosion is a growing oral health problem among children but data of the prevalence from many countries are inconsistent. The aim of this study was to systematically review the prevalence and risk factor of tooth erosion in children. A PubMed literature search was conducted by filtering the articles published in the last ten years. The studies have reported prevalence rates of tooth erosion ranging from 5-75%. This wide variation is probably related to different diagnostic criteria and study sample characteristics. This review showed that most of the articles suggested dietary habits to be the most common risk factor of tooth erosion, especially lemon and carbonated drink consumption. General health condition such as asthma might increase the risk of tooth erosion. In contrast no studies have reported association between Gastro-Esophageal Reflux Diseases (GERD) and tooth erosion.

Key words: Tooth erosion, risk factor, dietary habits

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INTRODUCTION

Tooth erosion is defined as a progressive lesion which is the loss of hard tissue of tooth that is irreversible, by the chemical process without the involvement of bacteria^{1,2}. Tooth erosion is a multifactor condition caused by the interaction of chemical, biological and behavior factors, where the tooth tissue is having demineralization but not due to the acid of bacterial metabolism^{3,4}. Moreover, tooth erosion might be caused due to intrinsic factors, such as gastric acid. This acid reaches the oral cavity as a result of either vomiting or gastroesophageal reflux. Whereas extrinsic factors include diet, medications, environment and lifestyle⁵.

Symptoms of tooth erosion range from no symptoms through sensitivity to severe pain associated with pulp exposure. In enamel, early signs of erosion include rounding angles, cupping or scooping, thinning of enamel, any restorations present may appear to be above the tooth surface. If the erosion continues, signs become more exaggerated leading to eventual total loss of enamel. Without intervention, erosive wear will progress, leading to deep cupping lesions with exposed dentin and eventual loss of occlusal morphology⁵. The impacts of tooth erosion are compromised aesthetics, dentinal hypersensitivity and reduced chewing ability⁶.

Tooth erosion that happened to primary tooth might increase the risk of tooth erosion in permanent tooth. Early diagnosis and prevention will help prevent damage to permanent tooth³. Globally, several researches have reported

the prevalence of tooth erosion starting from 5-75%. This variation may be related to the different diagnostic criteria and research sample characteristics⁶. Prevalence of tooth erosion to children has been studied by several researchers but inconsistent and differed in describing the risk factors of tooth erosion. This study reported a literature review of the studies on tooth erosion prevalence and related risk factors among children.

SEARCH STRATEGY, STUDY SELECTION and SYNTHESIS OF DATA

This systematic review addressed a question about prevalence and risk factor of tooth erosion in children. The MeSH was used to obtain the correct terms for keywords. The final keywords were tooth erosion, epidemiology, risk factor and children. The systematic review used PubMed database for the articles search, which was published between 2007 until September 2016. The inclusion and exclusion criteria that was used in this review are shown in Table 1. If the publications contained the search thesaurus, they were selected to generate a list of potentially eligible studies to be included in this review. The selected publications were screened by title and abstract. The literature search identified 25 publications. Further, these publications were screened according to the stated inclusion and exclusion criteria. Accordingly, only 20 publications were suitable with the inclusion criteria and were potentially adequate to describe this review's objective. Figure 1 described the flow diagram of the conducted

Table 1: Inclusion and exclusion criteria of the study selection

Criteria	Inclusion	Exclusion
Time period	From 2007-September, 2016	Any study outside the dates
Language	English	Non English
Type of article	Original article, review	Clinical trials
Study focus	Teeth erosion and risk factor	Nil
Geographical area of interest	All international studies	Nil
Subjects	Children with teeth erosion	Adult with teeth erosion

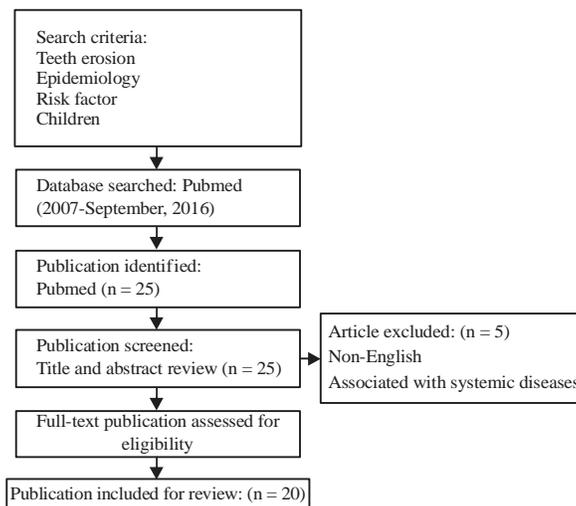


Fig. 1: Flow diagram of systematic review for literature search and selection, based on the PRISMA statement guideline

systematic review for literature search and selection. This method was adapted from guideline of the preferred reporting items for systematic reviews, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

The full papers of the selected publications were obtained. The relevant informations were found in the articles, including the prevalence and tooth erosion risk factor. Table 2 describes the studies related to this review. A summary was made for each publication, according to (a) Investigators and year of publication, (b) Published title and journal, (c) Aim of study, (d) Children's age range, (e) Employed tooth erosion measurement, (f) Sample size and (g) Tooth erosion prevalence and risk factors. Among 20 selected articles, one study was a literature review and 19 of the studies were cross-sectional surveys. Studies were conducted in different countries; they were from Brazil, China, USA, Libya, Hongkong, Jordan, Uruguay, India, Sudan and Isle of Man. The age of the participants varied in each study, with an age range of 3-17 years. Tooth erosion measurement employed in the studies also varied. Tooth erosion indexes used were Basic Erosive Wear Examination (BEWE), dental erosion index proposed by O'Sullivan⁷, Tooth Wear Index (TWI), modified TWI, simplified TWI, Tooth Surface Loss (TSL) and index proposed by O'Brien⁸ and others. Alongside the intraoral measurement, the studies used questionnaires to analyze tooth erosion risk factors, especially in children. The questionnaires included the information about socio-demographic conditions, parent's education level, dietary habits, oral health behavior, knowledge, health behavior and others. All studies reported prevalence and common risk factors for tooth erosion.

PREVALENCE OF TOOTH EROSION

Studies that describe tooth erosion prevalence to children have been developed in several countries, both in developing countries and also in developed countries. Based on studies that have been examined, it showed that the rate of prevalence in every country is diverse and did not show any certain pattern. In developing countries such as Brazil, 15% of children aged 12 years old have tooth erosion in year 2015 and in South India it was recorded that tooth erosion only happened to 8.9% of children^{1,3}. In other developing countries like Uruguay, the prevalence rate is higher, reaching 52.9% and in Libya it reached 40.8%^{4,12}. Compared to other developing countries, Indonesia for example, a study in 2016 revealed that 88% of 12 years old children living in Jakarta have been experiencing tooth erosion²³. Based on those data, it can be seen that the prevalence of tooth erosion differs extensively, although these five countries are categorized as developing countries. This variety might be caused due to different geographical conditions, culture, different diagnosing criteria and sampling method¹¹. The prevalence of tooth erosion in developed countries is lower compared to

developing countries. This can be seen in a study conducted in Texas (USA) in 2009, were only 5.5% 12 years old children had tooth erosion. Further, the prevalence in Kansas City (USA) was 10% in 2013²⁰. A potential explanation of this diversity is due to the higher quality of the dental services provided by the government and there might be established dental health program in developed countries. Tooth erosion can occur since early childhood affecting primary tooth. Based on the studied articles, the highest prevalence of tooth erosion in children under six years old was in Brazil in 2013, which was 51.6%. While in Shanghai (China), the prevalence of tooth erosion was 17.1% and in Kansas (USA) was 13%^{2,11,17}. The study of tooth erosion prevalence and risk factors in preschool children is still very limited. Therefore, studies shall be conducted in young children, considering that the increasing risk in primary tooth might increase the risk of tooth erosion in permanent tooth. Evidence based data might be beneficial for the government to plan effective preventive program for tooth erosion since early childhood.

CLINICAL MEASUREMENT OF TOOTH EROSION

Different clinical examinations were used for diagnosing tooth erosion. These were, the BEWE index and tooth erosion index. BEWE is an assessment system of the condition of tooth erosion that records the most severe tooth surface affected by erosion on each sextant and then summed, resulting a score that is useful to provide management guidance. The BEWE is considered as the convenience index, having adequate sensitivity and specificity but not enough to assess the severity of tooth erosion^{1,4,6,25}. O'Sullivan⁷ proposed an index for the assessment of erosion especially in children. This index records how much tooth surface were exposed to erosion, whether it is less or more than half of the tooth surface. Each tooth was examined and been given three digit score accordance with the part exposed by erosion, severity of tooth erosion (rate of 0-5) and the surface area that are exposed. O'Brien⁸ reported the use of partial recording system to assess tooth erosion in children. The assessments are only applied to the labial and lingual surfaces of maxillary incisors of primary and permanent tooth with erosion. The TWI was developed by Smith and Knight²⁴. The TWI is a comprehensive index that assesses four surfaces (buccal, cervical, lingual and occlusal/incisal) of all existing tooth. This index was first designed to measure and to observe tooth wear. However, there are several issues related to the usage of TWI, such as the length of duration needed to perform the measurement²⁵. Further, the studies also described the tooth regions most affected by tooth erosion is maxilla, particularly incisive on the labial and palatal surfaces and then followed by mandibular molars on the occlusal surfaces^{1-4,7-9,11,15,17,25}. Maxillary incisive tooth locates as the forefront of the oral cavity. Therefore it is often and easily exposed by extrinsic

Table 2: Selected publications related to teeth erosion in children

Authors	Titles	Journals	Aims	Subjects	Tooth erosion measurement	N	Results
Alves <i>et al.</i> ¹	Dental erosion among 12 years old school children: A population-based cross-sectional study in South Brazil	International Dental Journal	To assess the epidemiology and risk indicators for dental erosion among 12 years old school children in South Brazil	12 years old	BEWE and questionnaire	1,528	Prevalence: 15% Risk factors: Socio-demographic conditions, dietary habits
Tao <i>et al.</i> ²	Dental erosion among children aged 3-6 years and its associated indicators	Journal of Public Health Dentistry	To analyze the status quo of dental erosion in 3-6 years old children in Shanghai	3-6 years old	Dental erosion index proposed by O'Sullivan and Questionnaire	1,837	Prevalence of 4 years old: 17.1% Prevalence of 3 years old: 12.0% Risk factors: Socio-demographic conditions, dietary habits
Loureiro <i>et al.</i> ⁴	Erosive Teeth Wear among 12 years old School children: A Population-Based Cross-Sectional Study in Montevideo, Uruguay	Caries Research	To assess the prevalence, extent, severity, intraoral distribution and risk indicators for Erosive Tooth Wear (ETW) among 12 years old schoolchildren from Montevideo, Uruguay	12 years old	BEWE and questionnaire	1,136	Prevalence: 52.9 % Risk factors: No significant results
Zhang <i>et al.</i> ⁶	Dental caries and erosion status of 12 years old Hong Kong children	BMC Public Health	To assess dental caries and erosion status of 12 years old Hong Kong children and study the determinants of dental caries and dental erosion of these children	12 years old	BEWE and questionnaire	600	Prevalence of caries: 21% Prevalence of erosion: 75% Risk factors: Caries experience, dietary habits
Kumar <i>et al.</i> ³	Prevalence and risk factors for dental erosion among 11-14 years old school children in South India	Journal of Oral Science	To assess the prevalence and severity of dental erosion and to determine the potential risk factors for dental erosion among 11-14 years old school children in South India	11-14 years old	Dental erosion index proposed by O'Sullivan and questionnaire	605	Prevalence: 8.9% Risk factors: Dietary habits
Abu-Ghazaleh <i>et al.</i> ⁹	The prevalence and associated risk factors for teeth wear and dental erosion in 15-16 years old schoolchildren in Amman, Jordan	Europe Arch Paediatric Dentistry	To determine the prevalence of teeth wear and associations for a range of dietary and behavioral risk factors	15-16 years old	Modified TWI and questionnaire	1,602	Prevalence: 51 % Risk factors: Dietary habits
Hamasha <i>et al.</i> ¹⁰	Risk indicators associated with dental erosion among Jordanian school children aged 12-14 years of age	International Journal of Pediatric Dentistry	To identify potential risk indicators of Dental Erosion (DE) among 12-14 years old Jordanian school children	12-14 years old	TWI and questionnaire	3,812	Prevalence: 32.2% Risk factors: Socio-demographic conditions, medical condition, dietary habits
Habib <i>et al.</i> ¹¹	Prevalence and Risk Factor of Dental Erosion in American Children	The Journal of Clinical Pediatric Dentistry	To assess the prevalence and characteristic of dental erosion on children aged 2-4 years old and 12 years old	2-4 years old and 12 years old	TSL and questionnaire	243	Prevalence of 2-4 years old: 13% Prevalence of 12 years old: 10 % Risk factors: Low income, dietary habits
Huew <i>et al.</i> ¹²	Dental erosion and its association with diet in Libyan school children	Europe Arch Pediatric Dentistry	To investigate any association between dental erosion and its potential dietary risk factors in a group of schoolchildren in Benghazi, Libya	12 years old	The UK National Diet and Nutrition Survey 2000 criteria for dental erosion examination and questionnaire	791	Prevalence: 40.8% Risk factors: Dietary habits
Huew <i>et al.</i> ¹³	Dental caries and its association with diet and dental erosion in Libyan school children	International Journal of Pediatric Dentistry	To investigate any association between dental caries, dental erosion and potential dietary risk factors in Libyan school children	12 years old	Dental caries and erosion were assessed using the WHO 1997 guidelines and UK National Diet and Nutrition Survey questionnaire	791	Prevalence of caries and erosion: 42% Prevalence of caries without erosion: 39.2%. No statistically significant relationship between dental caries and dental erosion

Table 2: Continue

Authors	Titles	Journals	Aims	Subjects	Tooth erosion measurement	N	Results
Wild <i>et al.</i> ¹⁴	Gastroesophageal Reflux is not Associated With Dental Erosion in Children	Gastroenterology	To determine the pathogenesis of GER-associated dental erosion and the relationship between dental caries to GER and dental erosion	9-17 years old	Simplified TWI and questionnaire	59	Location-specific dental erosion is not associated with GER, salivary flow, or bacterial load
Gatou and Mamai-Homata <i>et al.</i> ¹⁵	Teeth wear in the deciduous dentition of 5-7 years old children: Risk factors	Clinical Oral Investigation	To investigate the distribution and severity of teeth wear in deciduous dentition and its relationship with possible risk factors	5-7 years old	TWI and questionnaire	243	Prevalence: 98.4% Risk factors: Dietary habits
Sanhoury <i>et al.</i> ¹⁶	Teeth surface loss, prevalence and associated risk factors among 12-14 years school children in Khartoum State, Sudan	Community Dental Health	To investigate Teeth Surface Loss TSL, among 12-14 years school children in Khartoum State, Sudan; evaluate pattern, severity and determine relationship between TSL, dietary habits and socio-economical status	12-14 years old	TSL and questionnaire	1,138	Prevalence: 74% Risk factors: Dietary habits
Murakami <i>et al.</i> ¹⁷	Risk Indicators for Erosive Teeth Wear in Brazilian Preschool Children	Caries Research	To assess the prevalence and risk indicators for Erosive Teeth Wear (ETW) in Brazilian preschool children	3-4 years old	O'Brien index and questionnaire	967	Prevalence: 51.6% Risk factors: dietary habits, gastro-oesophageal reflux, age
Taji <i>et al.</i> ⁵	A literature review of dental erosion in children	Australian Dental Journal	To critically review dental erosion in children with regards to its prevalence, etiology, diagnosis and prevention	Children	Dental erosion prevalence, clinical appearance, risk factor, prevention		Dental erosion etiology is multifactorial, in the primary dentition is commonly encountered in children and may continue into the permanent dentition
Wang <i>et al.</i> ¹⁸	The prevalence of dental erosion and associated risk factors in 12-13 years old school children in Southern China	BMC Public Health	To explore the prevalence of dental erosion and associated risk factors in 12-13 years old school children in Guangzhou, Southern China	12-13 years old	Dental erosion index proposed by O'Sullivan and questionnaire	1,499	Prevalence: 27.3% Risk factors: Gender, dietary habits, mother's education level
Bardolia <i>et al.</i> ¹⁹	Prevalence and Risk Indicators of Erosion in Thirteen- to Fourteen-Year-Olds on the Isle of Man	Caries Research	To determine the prevalence of erosion in 13-14 years old children on the Isle of Man and to investigate the strength of association with dietary risk factors	13-14 years old	The clinical examination for dental erosion assessed using criteria from the guidelines of the British Association and questionnaire	629	Prevalence: 51% Risk factors: Age, gender, tooth brushing
Mungia <i>et al.</i> ²⁰	Epidemiologic survey of erosive teeth ware in San Antonio, Texas	Texas Dental Journal	To estimate the prevalence of erosive teeth wear in children aged 12-17 years in the southwest region of San Antonio, Texas, within Bexar Country	12-17 years old	TWI and questionnaire	307	Prevalence: 5.5% Risk factors: Dietary habits
Correr <i>et al.</i> ²¹	Influence of Diet and Salivary Characteristics on the Prevalence of Dental Erosion among 12 years old school children	Journal of Dentistry for Children	To assess the prevalence of dental erosion among 12 years old school children in Piracicaba, Sao Paulo, Brazil	12 years old	Dental erosion index proposed by O'Sullivan and questionnaire	389	Prevalence: 26% Risk factors: Dietary habits, no significant difference among salivary characteristics and erosion prevalence
Mangueira <i>et al.</i> ²² and Olivier, A.F.,	Association Between Socioeconomic Factors and Dental Erosion in Brazilian School Children	American Association of Public Health Dentistry	To evaluate if a higher socioeconomic status is a potential risk factor for dental erosion in 6-12 years old Brazilian schoolchildren	6-12 years old	Dental erosion index proposed by O'Sullivan and questionnaire	983	Prevalence: 19.9% Risk factors: High-educated parents

acid, such as during drinking or eating acidic food^{1,11}. Moreover, the maxillary region is relatively far from major salivary glands, causing its self-cleansing being not as good as the mandibular region^{2,11,15}.

RISK FACTORS OF TOOTH EROSION

As explained by various literatures, tooth erosion is affected by several risk factors and these have been proved by various studies in this systematic review. These risk factors were obtained through questions in the research questionnaire¹. Questions commonly asked were demographic condition, social and economic status, oral health care behavior such as the frequency of tooth brushing and the frequency of visiting a dentist². Other questions were regarding the children's general health condition, in particular asthma, Gastro-Esophageal Reflux Diseases (GERD) and the frequency of vomiting. All studies included questions to analyze tooth erosion related behavior risk factors. These questions were describing the consumption frequency of soft drink, fruit juice, lemon, sports drink, tea, coffee, yogurt, milk, certain medicines and vitamin C. Some studies were also asking the frequency consumption of sweets. Other questions were about the way of consuming those foods or drinks, whether it's directly swallowed, drunk with straw or swishing it in the mouth before swallowing. Tooth erosion risk factors are reported variously among countries⁴. However, acidic diet is the most common risk factor reported. In several studies, it has been proven that boys have higher tooth erosion risk than girls. Some studies assumed that boys prefer acidic foods and have more physical activities that might potentially affect the quantity and quality of saliva¹⁵.

There are two studies that said school type is one of the risk factors of tooth erosion. Children in private school were more likely to have tooth erosion. This might occur due to different lifestyle and diet behavior between private and public school^{1,3}. Other studies reported association between socio-economic statuses and tooth erosion. Tooth erosion was commonly found in families with low income and lower education entitlement¹¹. Socio-economic disparity creates an imbalance in accessing dental care. Potential reasons might be that access to care is dependent on the ability to pay rather than on the need for care, thus reinforcing the issue of dental care inequity²⁶. Moreover, inequality in dental care might be persistent in developing countries²⁷. Access to oral health services might be limited, causing higher proportion of unmet need in the undeserved population²⁸. Further, lack of commitment to preventive community based dental health promotion in developing countries might also be a factor^{29,30}.

General health condition such as asthma, GERD and children who frequently vomit might increase the risk of tooth erosion. A study reported association between asthma and tooth erosion²⁸. It is known that some asthma medicines are acidic, which cause dry mouth and triggers vomiting or gastric

problems¹⁰. In contrast, another study found no association between asthma and tooth erosion¹. The GERD is a chronic digestive tract illness and occurs when stomach acids goes back into the esophagus (reflux), causing nausea and vomiting, which is associated with the likelihood of increasing tooth erosion. Nonetheless no studies proved the association. The low prevalence of samples with GERD in the studies, might be unable to detect this association. Further, no longitudinal study was conducted to analyze the tooth erosion process in relation to GERD^{1,14}. However, some studies concluded frequency of vomiting is associated with tooth erosion^{2,10,16}.

Acidic diet behavior is reported to be the most frequent risk factor for tooth erosion. Soft drinks, sport drink, fruit juice that contains acid, orange, lemon, coffee, tea and vitamin C consumption is widely stated to associate with tooth erosion, respectively^{1,3,5,6,9-14,17-20}. Not only frequency but also how the drinks and food were consumed, are considered as tooth erosion risk factor. Swishing soda drinks before swallowing, increases the risk of tooth erosion¹⁶. On the contrary, other studies found no association between diet and tooth erosion. This might be due to different age of the samples used in these studies. Tooth erosion examination in younger age, might have lower prevalence and severity of tooth erosion, considering shorter period in being exposed by the risk factors². Nonetheless, the association between acidic drink and tooth erosion was confirmed in laboratory research^{31,32}.

The PRISMA statement for reporting systematic review was used in this review to study tooth erosion. This systemic review showed that tooth erosion is often associated with dental caries. Both are caused by tooth's hard tissues demineralization, thus the causal acid type is different. Tooth erosion is caused by extrinsic and intrinsic acid, while dental caries is caused by acid as a metabolism product of bacteria. Children with high caries level have higher tooth erosion level comparing to children who do not have caries⁶. This study's result is contrary to the study in Libya that found no connections among them. However, children with caries are consuming acidic fruit juice with sugar¹³. The factor that connects tooth erosion with dental caries is the acid containing diet, which potentially create acidic environment in the oral cavity and lead to the reduction of tooth hardness. Saliva's quantity and quality are also risk factors of tooth erosion and dental caries⁵. All reviewed studies have analyzed risk factors of tooth erosion, whilst concluding in consistent risk factors. Tooth erosion is a complex multifactorial disease. It requires a longitudinal study to be able to analyze its risk factors comprehensively.

CONCLUSION

Epidemiological data is crucial to study the cause and effect of certain health problems. Although many oral health surveys have been conducted to examine the prevalence, severity and risk factors of tooth erosion, the survey methods

of these studies were not standardized, thus comparison between studies is difficult. Determining the oral health of children is important for planning, implementing services oriented toward meeting their needs and to ensure effective delivery of interventions and optimal allocation of resources, as well as for monitoring community programs to improve the oral health of children. This systematic review showed that tooth erosion is one of commonly encountered oral health problem in children, even in primary dentition. Nonetheless it is rarely diagnosed at its early stages. The most common risk factor is dietary habits, especially lemon and carbonated drink. Awareness and understanding the disease and the risk factors are crucial for establishing an early diagnosis and appropriate preventive methods for preventing erosion that may lead to higher risk of the permanent tooth.

SIGNIFICANT STATEMENT

Prevalence and risk factors of tooth erosion vary considerably in different countries and age groups. Comparison of tooth erosion in epidemiological studies are difficult due to differences in indices, questionnaire and also age group of examination. Lack of consensus regarding internationally accepted tooth erosion index and method to assess diet is complicating the evaluation of the true increase in prevalence reported.

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