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Prevalence of early childhood caries among 5-year-old children: a systematic review

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Prevalence of early childhood caries among 5-year-old children: a systematic review

Abstract:

The aim of this review is to describe the updated prevalence of early childhood caries (ECC) among 5-year-old children globally. Two independent reviewers performed a systematic literature search to identify English publications from January 2013 to Dec 2017 using MEDLINE, ISI Web of Science and Scopus. Search MeSH key words were 'Dental Caries' AND 'Child, Preschool'. The inclusion criteria were epidemiological surveys reporting the caries status of 5-year-old children with the dmft index. The quality of the publications was evaluated with the modified Newcastle-Ottawa Scale. Among 2,410 identified publications, 37 articles with moderate or good quality were included. Twenty included studies were conducted in Asia (China, India, Indonesia, Korea, Nepal and Thailand), seven in Europe (Greece, Germany, Great Britain, and Italy), six in South America (Brazil), two in the Middle East (Saudi Arabia and Turkey), one in Oceania (Australia) and one in Africa (Sudan). The prevalence of ECC ranged from 23% to 90%, and most of them (26/37) were higher than 50%. The mean dmft score varied from 0.9 to 7.5. Based on the included studies published in the recent five years, there is a wide variation of ECC prevalence across countries and ECC remains prevalent in most countries worldwide.

Introduction

According to the American Academy of Pediatric Dentistry (AAPD), early childhood caries (ECC) is defined as the presence of one or more decayed (noncavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child at 71 months of age or younger [1]. ECC is considered as one of the most prevalent diseases in childhood, affecting many children globally. The American Dental Association identifies that ECC is a significant public health problem in deprived communities and is also found throughout the general child population [2]. When comparing with other common childhood diseases, ECC is five times as frequent as asthma and seven times as common as hay fever [3]. Therefore, the American Dental Association urges the public and health professionals to recognize that a child's teeth are susceptible to decay as soon as they begin to erupt.

ECC is an infectious disease. Baby bottle tooth decay is recognized as one of the more severe clinical manifestations of ECC. The term 'ECC' was suggested at the workshop sponsored by the Centers for Disease Control and Prevention in 1994. The aim of this nomenclature was to focus attention on the multiple factors (i.e. socioeconomic, behavioral and psychosocial) contributing to caries at such early ages, rather than ascribing sole causation to inappropriate feeding methods. Four main etiological factors are well documented: susceptible host, cariogenic bacteria, fermentable carbohydrate substrate and time for interaction of these factors [4]. The characteristics of primary teeth, dietary habits and the efficiency of plaque removal make young children one of the susceptible groups [5]. Other environmental risk factors, such as the use of fluoride, access to dental care service, demographic background and socioeconomic status, are also found to be related to ECC. In this context, underprivileged children have a higher prevalence and more severity of ECC [6, 7]. In some developing countries, prevalence of ECC is considered to be at epidemic proportions.

A narrative literature review on the prevalence of nursing caries in the 1990s concluded that high caries prevalence was found in Africa and Southeast Asia [8]. At that time, presence of ECC was uncommon in some developed countries, such as England, Sweden and Finland [9, 10]. In contrast, the prevalence of ECC had increased by as much as 56% in some Eastern European countries [11].

Although no symptoms can be found at the early stage of dental caries, discomfort or pain may occur when the lesion progresses into dentin or involves the dental pulp [12]. Untreated ECC may cause difficulties in sleeping and eating, and possibly affect children's growth and development [13]. Studies reported that children who suffered from cavitated dentin caries were found to have lower body weight and height, compared with those without dental caries [14]. In addition, higher rates of absenteeism were found in children with untreated ECC, leading to a negative impact on their school performance [15]. Moreover, hospitalization or emergency dental visits were reported in some severe cases [16]. Such problems could become serious and even life threatening.

Oral health is an important part of general health and has influences on children's lives and future development. Different preventive strategies have been implemented to reduce the burden of ECC in most countries. It is necessary for health authorities to understand their dental caries situation of primary dentition before setting goals or implementing effective dental services. Since the 5-year-old children are in the latest stage of having a complete primary dentition, the World Health Organization (WHO) has chosen them to be the index age group in basic oral health surveys on the situation of the primary dentition [17]. The rapid changes in dietary and lifestyle patterns have been noted throughout the world, possibly linking to the change of ECC pattern and severity. The aim of this systematic review is to describe the updated information about the prevalence of ECC amongst 5-year-old children globally.

Methods

Search strategy

Three electronic databases (MEDLINE, ISI Web of Science and Scopus) were selected for searching peer-reviewed articles published in English from January 2013 to December 2017. The last search date was 14th January 2018. Using medical subject headings (MeSH), the search key words were ('Dental Caries' [MeSH]) AND 'Child, Preschool' [MeSH]). Duplicate records and papers written in languages other than English were excluded. A manual search was performed to identify additional articles from the bibliography of the retrieved articles.

Study selection

Two reviewers (KJC and SSG) screened the titles and abstracts independently. Eligible publications were identified according to the following three inclusion criteria.

1) Study design: Only epidemiological surveys investigating the prevalence of dental caries were considered in the present review. Any cross-sectional study that was a part of a longitudinal study or clinical trial was excluded. Other types of studies, including laboratory studies, clinical trials, and case-control studies, were not considered. Studies analyzing secondary data were also excluded.
2) Participants: Study participants were 5-year-old (aged 60 to 71 months) children. The selected participants had to be representative of the general 5-year-old population of the studied districts or countries. The sample size needed to be more

than 100 participants to maintain the representativeness.

3) Outcomes: Included studies had to report the caries prevalence and experience using the dmft index.

The two reviewers retrieved and assessed independently the full texts of studies that met the inclusion criteria or those that could not be determined by screening the titles and abstracts. A third reviewer (DD) was consulted to make a decision if there was disagreement between two reviewers.

Data extraction and quality assessment

The following information was extracted and summarized during the full-text assessment: studied site, sampling method, sample size, diagnostic criteria, caries prevalence and caries experience (dmft index). The Human Development Index (HDI) of the survey site was extracted from the United Nations website [18]. The HDI reported by the United Nations was used to study the relationship between the HDI and caries prevalence. A linear regression was performed to analyze the relationship between HDI and caries prevalence, and the statistical significance level was set at 0.05.

The quality of the included studies was assessed with the modified Newcastle-Ottawa Scale adapted for cross-sectional studies (NOS) for risk of bias [19]. Two aspects which were sample selection and the study outcome were scored between 0 and 8. Studies that adopted random sampling method, had favorable sample size (n>100), established comparability between respondents and non-respondents and good response rate (>80%), used well-established diagnosis criteria, had good reliability between examiners (kappa value >0.6) and adopted appropriate statistic methods were rated as a full score or 8 (Appendices). The methodological quality of the studies was categorized as poor (0-2), moderate (3-5) and good (6-8) according to the modified NOS for descriptive purposes. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used as a basis for reporting in this systematic review [20].

Results

A total of 2,410 articles (1,037 from MEDLINE, 552 from ISI Web of Science and 821 from Scopus) were identified and screened based on their titles and abstracts (Figure 1).

An initial screening of the title and abstract revealed that 551 articles were duplicates and 1,707 articles did not meet the inclusion criteria. Full texts of the remaining 152 articles were assessed, and 37 studies [21-57] were included in this study. No additional publication was identified from the bibliography of these 152 articles.

The included publications described the dental caries situations of the 5-year-old children in 16 countries/districts from 6 continents. Most of the studies were conducted in Asia (n=20, China, India, Indonesia, Korea, Nepal, Taiwan and Thailand) [21-40], in Europe (n=7, Greece, Germany, Italy and United Kingdom) [41-47] and in Southern America (n=6, Brazil) [48-53]. Two studies conducted in the Middle East (Saudi Arabia and Turkey) [54, 55], one in Africa (Sudan) [56] and one in Oceania (Australia) [57] were included. Out of 37 publications, 28 were from countries/districts with high or very high HDI scores (HDI>0.70), while only one publication was from a country with a low HDI score (HDI<0.55) (Table 1) [56].

Among the included articles, the prevalence of caries ranged from 22.5% in India to 90.0% in Indonesia, and the median of caries prevalence was 62.7%. Around two-thirds of the studies (26/37) reported a caries prevalence of more than 50% (Table 1). Prevalence of ECC varied in different continents. In Asia, the majority of the studies (17/20) reported that more than half of the study children had dental caries experience. Similarly, two-thirds of the studies conducted in South America and all studies in Africa and Middle East reported that their ECC prevalence was higher than 50%. In contrast, nearly all studies (8/9) conducted in Europe reported lower ECC prevalence, comparing to that of other continents. Twenty-six studies (26/37) reported caries experience in mean dmft scores. There was a wide range of dmft score from 0.9 in Germany, United Kingdom and Italy to 7.5 in Indonesia. The median of the mean dmft score was 2.6. Eleven publications did not report caries experience. Only twelve publications (12/37) reported untreated caries (dt), which constituted the main component of the caries experience (Table 1).

The caries prevalence reported in the included studies varied among countries and continents. In Australia, where the HDI was the highest among the included studies (0.94), the caries prevalence was 44.4%. In Sudan where the lowest HDI (0.49) was, their caries prevalence was 56%. No significant association was found between the

HDI and caries prevalence (p=0.240). Through using the modified NOS to assess the quality of the articles, it was found in this review that all 37 publications had moderate to good methodological quality (Table 2).

Discussion

Various preventive strategies have been implemented to reduce the burden of ECC in different countries. The World Dental Federation (FDI), WHO and the International Association of Dental Research (IADR) have embarked on the activities of preparing the Global Oral Health Goals for the year 2020 [58]. One of the objectives was to minimize the impact of dental caries on individuals and society, and to formulate strategies for the early diagnosis, prevention and effective management of dental caries. Unfortunately, the majority of the included epidemiological studies showed that ECC remained prevalent among preschool children worldwide. In addition, untreated caries in young children is still a significant health burden in many countries, which suggests that greater attempts and different preventive measures are required if this goal is to be reached by 2020.

In addition, the result showed a geographically disproportional distribution of ECC as the situation in Africa and Asia were unsatisfactory compared to other continents. In China which is the most populous country in the world, the present review showed no improvement regarding the status of dental caries in Chinese preschool children, compared to the results of the third national oral health survey in 2005 [59]. In contrast, the situation of ECC among 5-year-old children in Wales and Scotland improved in recent years when comparing to the previous survey in 2002-2003 [60]. As the fourth–most expensive disease to treat, dental caries is one of the major burdens affecting many children and families [61]. Study findings indicate that children at low socioeconomic levels have higher risks of developing dental caries, but their access to dental services is difficult. Therefore, underprivileged children suffering from dental caries is common [62].

The HDI is a composite index of life expectancy, education and per-capita income indicators. Country with a high HDI score has long lifespans, high education levels and high gross domestic products (GDPs) per capita [18]. Studies in European and Oceanian countries that had high HDI scores generally reported a low prevalence of

ECC. In Asia, three studies in India which had a moderate HDI score showed low caries prevalence (<50%) [34, 36, 37]**.** Contradictorily, Korea and Hong Kong had very high HDI scores, but their caries prevalence was high (>50%), compared with their counterparts in Europe. Furthermore, eleven studies in Asia reported mean dmft scores equivalent to or higher than 3 [22, 23, 24, 27, 29, 31-34, 39, 40]. It is noteworthy that the HDI can indicate only the development level of the entire country and that the socioeconomic status of an individual city or district cannot be reflected in this index, which is a limitation of the present review.

The present systematic review has several strengths including using three main databases including MEDLINE, ISI Web of Science and Scopus for searching publications. MEDLINE is a well-established database of the U.S. National Library of Medicine, which is the world's largest biomedical library [63]. MeSH and subheadings make PubMed searches more sensitive and minimize false-negative (missed) hits by compensating for the diversity of medical terminology [64, 65]. By searching 'Dental caries' in MeSH term, 'Dental Decay', 'Carious Dentine' and 'White Spots,' etc., were included; hence, the keyword search was automatically 'expanded' to include more specific terms. ISI Web of Science was another database for the literature search in this review. It encompasses more than 12,000 journals and 160,000 conference proceedings [66]. Scopus is also a big database of peer-reviewed literatures with over 4000 health science titles indexed [67]. By using these three databases in this study, the literature search could cover a large number of citation indexing journals. These journals are generally considered the ones that publish good-quality studies. However, surveys published in local journals and the governmental archives could not be found.

No significant disagreement was found between the independent reviewers in selecting relevant studies in the literature search. The WHO recommends that epidemiological studies should be conducted every 5 years to obtain the most updated ECC situation [17]. Therefore, the present review focused on retrieving articles published from January 2013 to December 2017. Only epidemiological surveys were selected. Cohort and randomized clinical studies were not selected because these studies mostly recruited children from specific community groups. Based on the WHO recommendation, at least 50 subjects in a single survey site should be recruited. [17]. In the current review, only surveys with a sample size of more than 100 were included,

as multiple survey sites would be better representatives of the situation. The dmft index, which was commonly used in dental surveys, was selected as an outcome of the included studies [17]. Four studies adopted deft (decayed, extracted due to caries and filled primary teeth) scores [26, 34, 36, 48] were also included. Following the adopted inclusion criteria, only studies with good quality were included, resulting in limiting number of included studies for this review.

It should be noted that the definition of ECC by AAPD includes both non-cavitated and cavitated carious lesions. In the present review, few studies included both non-cavitated and cavitated lesions as their decay component [46, 49, 52, 55, 57], while most of the included studies adopted the WHO diagnostic criteria by defining caries as the cavitation. To assess the methodological quality, a quality assessment tool was needed. However, no agreed-upon or well-established quality assessment tool for epidemiological surveys existed. In this study, the NOS was modified and adopted. All studies included in this review had moderate to good methodological quality according to the assessment using the modified NOS. They had adequate sample sizes for statistical analysis. Almost all articles stated their statistical analysis methods clearly. Therefore, these observations suggest that the three databases selected in this study contained mostly acceptable studies, and the methodological quality of the included articles was satisfactory.

The present findings urge dental educators and policy makers that prevalence of dental caries is still high among preschool children in many countries, particularly in Asia, South America and Africa. National and international oral health policy should emphasize oral health promotion and prevention for children. It is important to prevent and control ECC as the consequence of untreated ECC negatively affects the chewing ability, speech development and the formation of a positive self-image [5] ECC is a preventable disease, and plenty of preventive methods exist. Two important practical approaches are sugar control and use of fluorides. A systematic review described an association between the amount of sugar intake and dental caries, and suggested that ECC can be reduced by restricting sugar intake [69]. In addition, topical use of fluorides, including mouth rinse and toothpaste, helps to reduce dental caries [70, 71]. Governments and dental authorities should take these two approaches into consideration when proposing oral health promotion programs. Strategies should be

formulated to reduce morbidity from ECC, thereby increase the quality of life of the children. Evidence-based dental public health programs should be prioritized and established to promote oral health in a sustainable way. Furthermore, the common risk factor approach can be used to develop accessible cost-effective oral health systems for the prevention and control of ECC. Oral health promotion and services on the prevention and treatment of ECC can be integrated with other health sectors to improve both oral and general health.

Children are often too young to take care of their teeth and cannot brush their teeth effectively. Therefore, parents and caregivers play an important role in promoting oral health for their children. Evidence suggests that parental engagement is required during the perinatal period for the effective prevention of ECC [71]. The government and health professional organizations should reduce disparities in ECC between different socioeconomic groups within countries, as well as reduce inequalities in ECC across countries. In addition, the government should take responsibility for training health care providers to perform periodically epidemiological surveillance of ECC among young children. In addition to community health workers, social workers and dietitians, can play an effective role in prevention of ECC.

Conclusions

Based on the included studies published in the past five years (2013-2017), prevalence of ECC varies significantly across countries. In addition, ECC remains prevalent in most countries worldwide.

Abbreviations:

ECC: Early Childhood Caries
HDI: Human Development Index
WHO: World Health Organization
MeSH: medical subject headings
NOS: Newcastle-Ottawa Scale

Conflict of Interest and Sources of Funding

The authors declare no conflict of interest and no funding has been available.

References

1. American Academy of Pediatric Dentistry. Policy on early childhood caries (ECC): classifications, consequences, and preventive strategies. *Pediatr Dent* 2016, **38**:52-4.
2. American Dental Association. Statement on early childhood caries. http://www.ada.org/en/about-the-ada/ada-positions-policies-and-statements/statement-on-early-childhood-caries Assessed Feb 10th, 2018.
3. Bagramian RA, Garcia-Godoy F, Volpe AR. The global increase in dental caries: A pending public health crisis. *Am J Dent* 2009; **22**: 3-8.
4. Gupta P, Gupta N, Pawar AP, Birajdar SS, Natt AS, Singh HP. Role of sugar and sugar substitutes in dental caries: A review. *ISRN Dent* 2013; **2013**: 519421.
5. Alazmah A. Early childhood caries: A review. *J Contemp Dent Pract* 2017; **18**: 732-7.
6. Kawashita Y, Kitamura M, Saito T. Early childhood caries. *Int J Dent Oral Health* 2011; **2011**: 725320.
7. Mantonanaki M, Koletsi-Kounari H, Mamai-Homata E, Paaioannou W. Prevalence of dental caries in 5-year-old Greek children and the use of dental services: evaluation of socioeconomic, behavioural factors and living conditions. *Int Dent J* 2013; **63**: 72-9.
8. Milnes AR. Description and epidemiology of nursing caries. *J Public Health Dent* 1996; **56**: 38-50.
9. Douglass JM, Tinanoff N, Tang JMW, Altman DS. Dental caries patterns and oral health behaviors in Arizona infants and toddlers. *Community Dent Oral Epidemiol* 2001; **29**: 14-22.
10. Davies GM, Blinkhorn FA, Duxbury JT. Caries among 3-year-olds in Greater Manchester. *Br Dent J* 2001; **190**: 381-4.
11. Szatko F, Wierzbicka M, Dybizbanska E, Struzycka I, Iwanicka-Frankowska E. Oral health of Polish three-year-olds and mothers' oral health-related knowledge. *Community Dent Health* 2004; **21**: 175–80.
12. Ferraz NKL, Nogueira LC, Pinheiro MLP, Marques LS, Ramos-Jorge ML, Ramos-Jorge J. Clinical consequences of untreated dental caries and toothache in preschool children. *Pediatr Dent* 2014; **36**: 389-92.
13. Ortiz FR, Tomazoni F, Oliveira MDM, Piovesan C, Mendes F, Ardenghi TM. Toothache, associated factors, and its impact on Oral Health-Related Quality of Life (OHRQoL) in preschool children. *Braz Dent J* 2014; **25**: 546-53.
14. Li LW, Wong HM, Peng SM, McGrath CP. Anthropometric measurements and dental caries in children: a systematic review of longitudinal studies. *Adv Nutr* 2015; **6**: 52-63.
15. Neves ÉTB, Firmino RT, de França Perazzo M, Gomes MC, Martins CC, Paiva SM, Granville-Garcia AF. Absenteeism among preschool children due to oral problems. *J Public Health* 2016; **24**: 65-72.
16. Allareddy V, Nalliah RP, Haque M, Johnson H, Rampa SB, Lee MK.

Hospital-based emergency department visits with dental conditions among children in the United States: nationwide epidemiological data. *Pediatr Dent* 2014; **36**: 393-9.

17. World Health Organization. Oral health surveys: basic methods. Geneva: World Health Organization; 2013.
18. Human Development Report Office. Human Development Report 2016. http://hdr.undp.org/en/composite/HDI Accessed Feb 14th, 2018.
19. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol* 2010; **25**: 603-5.
20. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrewm M, Shekelle P, Stewart LA, Group PRISMA-P. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015; **4**:1.
21. Chen KJ, Gao SS, Duangthip D, Li SKY, Lo ECM, Chu CH. Dental caries status and its associated factors among 5-year-old Hong Kong children: a cross-sectional study. *BMC Oral Health* 2017; **17**: 121.
22. Peng SM, Wong HM, King NM, McGrath C. Is dental caries experience associated with adiposity status in preschool children? *Int J Paediatr Dent* 2014; **24**: 122-30.
23. Bridges SM, Parthasarathy DS, Wong HM, Yiu CKY, Au TK, McGrath CPJ. The relationship between caregiver functional oral health literacy and child oral health status. *Patient Educ Coun* 2014; **94**: 411-6.
24. Han DH, Kim DH, Kim MJ, Kim JB, Jung-Choi K, Bae KH. Regular dental checkup and snack-soda drink consumption of preschool children are associated with early childhood caries in Korean caregiver/preschool children dyads. *Community Dent Oral Epidemiol* 2014; **42**: 70-8.
25. Lin YC, Wang WC, Chen JH, Chen PH, Lee CH, Huang HL. Significant caries and the interactive effects of maternal-related oral hygiene factors in urban preschool children. *J Public Health Dent* 2017; **3**: 188-96.
26. Yen CE, Hu SW. Association between dental caries and obesity in preschool children. *Eur J Paediatr Dent* 2013; **14**: 185-9.
27. Li Y, Wulaerhan J, Liu Y, Abudureyimu A, Zhao J. Prevalence of severe early childhood caries and associated socioeconomic and behavioral factors in Xinjiang, China: a cross-sectional study. *BMC Oral Health* 2017; **17**: 144.
28. Jiang YY. Prevalence of Early Childhood Caries Among 2- to 5-year-old Preschoolers in kindergartens of Weifang city, China: A cross-sectional Study. *Oral Health Prev Dent* 2017; **15**: 89-97.
29. Chen X, Zhan JY, Lu HX, Ye H, Ye W, Zhang W, Yang WJ, Feng XP. Factors associated with black tooth stain in Chinese preschool children. *Clin Oral Investig* 2014; **18**: 2059-66.
30. Wulaerhan J, Abudureyimu A, Bao XL, Zhao J. Risk determinants associated with early childhood caries in Uygur children: a preschool-based cross-sectional study.

BMC Oral Health 2014; **14**: 136.

31. Krisdapong S, Somkotra T, Kueakulpipat W. Disparities in early childhood caries and its impact on oral health-related quality of life of preschool children. *Asia Pac J Public Health* 2014; **26**: 285-94.
32. Pattanaporn K, Saraithong P, Khongkhunthian S, Aleksejuniene J, Laohapensang P, Chhun N, Chen Z, Li Y. Mode of delivery, mutans streptococci colonization, and early childhood caries in three- to five-year-old Thai children. *Community Dent Oral Epidemiol* 2013; **41**: 212–23.
33. Adiatman M, Yuvana AL, Nasia AA, Rahardjo A, Maharani DA, Zhang SN. Dental and gingival status of 5 and 12-year-old children in Jakarta and its satellite cities. *J Dent Indones* 2016; **23**: 5-9.
34. Kakanur M, Nayak M, Patil SS, Thakur R, Paul ST, Tewathia N. Exploring the multitude of risk factors associated with early childhood caries. *Indian J Dent Res* 2017; **28**: 27-32.
35. Sujlana A, Pannu PK. Family related factors associated with caries prevalence in the primary dentition of five-year-old children. *J Indian Soc Pedod Prev Dent* 2015; **33**: 83-7.
36. Gupta D, Momin RK, Mathur A, Srinivas KT, Jain A, Dommaraju N, Dalai DR, Gupta RK. Dental caries and their treatment needs in 3-5 Year old preschool children in a rural district of India. *North Am J Med Sci* 2015; **7**: 143-50.
37. Gopal S, Chandrappa V, Kadidal U, Rayala C, Vegesna M. Prevalence and predictors of early childhood caries in 3- to 6-year-old South Indian children--A cross-sectional descriptive study. *Oral Health Prev Dent* 2016; **14**: 267-73.
38. Mittal M, Chaudhary P, Chopra R, Khattar V. Oral health status of 5 years and 12 years old school going children in rural Gurgaon, India: an epidemiological study. *J Indian Soc Pedod Prev Dent* 2014; **32**: 3-8.
39. Sankeshwari RM, Ankola AV, Tangade PS, Hebbal MI. Association of socio-economic status and dietary habits with early childhood caries among 3- to 5-year-old children of Belgaum city. *Eur Arch Paediatr Dent* 2013; **14**: 147–53.
40. Thapa P, Aryal KK, Dhimal M, Mehata S, Pokhrel AU, Pandit A, Pandey AR, Bista B, Dhakal P, Karki KB, Pradhan S. Oral health condition of school children in Nawalparasi district, Nepal. *J Nepal Health Res Counc* 2015; **13**: 7-13.
41. Grund K, Goddon I, Schüler IM, Lehmann T, Heinrich-Weltzien R. Clinical consequences of untreated dental caries in German 5-and 8-year-olds. *BMC Oral Health* 2015; **15**: 140.
42. Bissar A, Schiller P, Wolff A, Niekusch U, Schulte AG. Factors contributing to severe early childhood caries in south-west Germany. *Clin Oral Invest* 2014; **18**: 1411-8.
43. Monaghan, N, Davies GM, Jones CM, Neville JS, Pitts NB. The caries experience of 5-year-old children in Scotland, Wales and England in 2011-2012: reports of cross-sectional surveys using BASCD criteria. *Community Dent Health* 2014; **31**: 105-10.

44. Ferro R, Besostri A, Olivieri A. Survey of Caries Experience in 3- to 5-year-old Children in Northeast Italy in 2011 and Its Trend 1984-2011. *Oral Health Prev Dent* 2017; **15**: 475-81.
45. Nobile CGA, Fortunato L, Bianco A, Pileggi C, Pavia M. Pattern and severity of early childhood caries in Southern Italy: a preschool-based cross-sectional study. *BMC Public Health* 2014; **14**: 206.
46. Ferrazzano GF, Sangianantoni G, Cantile T, Ingenito A. Relationship between social and behavioural factors and caries experience in schoolchildren in Italy. *Oral Health Prev Dent* 2016; **14**: 55-61.
47. Tsanidou E, Nena E, Rossos A, Lendengolts Z, Nikolaidis C, Tselebonis A, Constantinidis TC. Caries prevalence and manganese and iron levels of drinking water in school children living in a rural/semi-urban region of North-Eastern Greece. *Environ Health Prev Med* 2015; **20**: 482.
48. Abanto J, Tsakos G, Martins Paiva S, Carvalho TS, Raggio DP, Bönecker M. Impact of dental caries and trauma on quality of life among 5- to 6-year-old children: perceptions of parents and children. *Community Dent Oral Epidemiol* 2014; **42**: 385-94.
49. Carvalho JC, Silva EF, Vieira EO, Pollaris A, Guillet A, Mestrinho HD. Oral health determinants and caries outcome among non-privileged children. *Caries Res* 2014; **48**: 515-23.
50. Do Amaral RC, Batista MJ, Meirelles MPMR, Cypriano S, de Sousa MLR. Dental caries trends among preschool children in Indaiatuba, SP, Brazil. *Brazilian Journal of Oral Sciences* 2014; **13**: 1-5.
51. Scarpelli AC, Paiva SM, Viegas CM, Carvalho AC, Ferreira FM, Pordeus IA. Oral health-related quality of life among Brazilian preschool children. *Community Dent Oral Epidemiol* 2013; **41**: 336–44.
52. Lourenço CB, de Lima Saintrain MV, Vieira APGF. Child, neglect and oral health. *BMC Pediatrics* 2013; **13**: 188.
53. Corrêa-Faria P, Martins-Júnior PA, Vieira-Andrade RG, Marques LS, Ramos-Jorge ML. Factors associated with the development of early childhood caries among Brazilian preschoolers. *Braz Oral Res* 2013; **27**, 356-62.
54. Al-Meedani LA, Al-Dlaigan YH. Prevalence of dental caries and associated social risk factors among preschool children in Riyadh, Saudi Arabia. *Pak J Med Sci* 2016; **32**: 452-6.
55. Abbasoglu Z, Tanboga I, Kuchler EC, Deeley K, Weber M, Kaspar C, Korachi M, Vieira AR. Early childhood caries is associated with genetic variants in enamel formation and immune response genes. *Caries Res* 2015; **49**: 70-7.
56. Elidrissi SM, Naidoo S. Prevalence of dental caries and toothbrushing habits among preschool children in Khartoum State, Sudan. *Int Dent J* 2016; **66**: 215-20.
57. Blinkhorn AS, Byun R, Johnson G, Metha P, Kay M, Lewis P. The dental health of primary school children living in fluoridated, pre-fluoridated and non-fluoridated communities in New South Wales, Australia. *BMC Oral Health*

2015; **15**: 9.
58. Hobdell M, Petersen PE, Clarkson J, Johnson N. Global goals for oral health 2020. *Int Dent J* 2003; **53**: 285-8.
59. Liu J, Zhang SS, Zheng SG, Xu T, Si Y. Oral Health Status and Oral Health Care Model in China. *Chin J Dent Res* 2016; **19**: 207-15.
60. Pitts NB, Boyles J, Nugent ZJ, Thomas N, Pine CM, British Association for the Study of Community Dentistry. The dental caries experience of 5-year-old children in England and Wales (2003/4) and in Scotland (2002/3). Surveys co-ordinated by the British Association for the Study of Community Dentistry. *Community Dent Health* 2005; **22**: 46-56.
61. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari M, Bhandari B, Murray CJL, Marcenes W. Global burden of untreated caries: a systematic review and metaregression. *J Dent Res* 2015; **94**: 650-8.
62. Pinilla J, Negrín-Hernández MA, Abásolo I. Time trends in socio-economic inequalities in the lack of access to dental services among children in Spain 1987-2011. *Int J Equity Health* 2015; **14**: 9.
63. U.S. National Library of Medicine. MEDLINE Journal Selection. https://www.nlm.nih.gov/pubs/factsheets/jsel.html Accessed on Feb 14, 2018.
64. Georgia State University Library. WHAT IS MESH. http://research.library.gsu.edu/c.php?g=115556&p=753156 Accessed on Feb 14th, 2018.
65. Fatehi F, Gray LC, Wootton R. How to improve your PubMed/MEDLINE searches: 3. advanced searching, MeSH and My NCBI. *J Telemed Telecare* 2014; **20**: 102-12.
66. Clarivate Analytics. Web of Science. http://wokinfo.com Accessed on Feb 14th, 2018.
67. Burnham JF. Scopus database: a review. *Biomedical digital libraries* 2006**; 3**: 1.
68. Bhoopathi PH, Patil, ATIL PU, Kamath BV, Gopal D, Kumar S, Kulkarni G. Caries Detection with ICDAS and the WHO Criteria: A Comparitive Study. *J Clin Diagn Res* 2017; **11**:12.
69. Marinho VCC, Higgins JPT, Logan S, Sheiham A. Fluoride mouthrinses for preventing dental caries in children and adolescents. Cochrane Database Syst Rev 2003; 3.
70. Marinho VCC, Higgins JPT, Logan S, Sheiham A. Fluoride toothpastes for

preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2003; 1.

71. Edelstein BL. Pediatric Dental-Focused Interprofessional Interventions. *Dental Clinics* 2017; **61**: 589-606.

Figure Legends

Figure 1. Flowchart of literature search

Appendices

Appendices: Newcastle-Ottawa Scale adapted for cross-sectional study.

Authorship:

KJC: performing data search, data entry and analysis and writing the manuscript; SSG: performing data search, data entry and analysis; DD: performing data checking and performing critical revision of the manuscript for important intellectual content; ECML: performing critical revision of the manuscript for important intellectual content; CHC: performing critical revision of the manuscript for important intellectual content; All authors read and approved the final manuscript.

Data Sharing and Data Accessibility

The dataset used and/or analyzed during the current study available from the corresponding author on reasonable request.

1 **Table 1.** Summary of the selected studies

Authors Year [Ref]	Study site (Human Development Index)	Sampling method (sample size)	Diagnosis criteria	Caries prevalence	Caries experience (dmft±SD)	Decayed teeth (dt±SD)
Africa						
Elidrissi et al. 2016 [56]	Khartoum State, Sudan (0.49)	Systematic (196)	dmft (WHO)	56.1%	2.8±4.0	N/A
Asia						
Chen et al. 2017 [21]	Hong Kong SAR, China (0.92)	Multistage (501)	dmft (WHO)	55%	2.7±3.7	2.6±3.7
Peng et al. 2013 [22]	Hong Kong Island, China (0.92)	Multistage (390)	dmft (WHO)	75.3%	4.2±4.6	N/A
Bridges et al. 2014 [23]	Hong Kong Island, China (0.92)	Multistage (301)	dmft (WHO)	75.4%	4.2±4.5	3.3±3.9
Han et al. 2014 [24]	Ulsan, Korea (0.90)	Stratified random (530)	dmft (WHO)	60.9%	N/A	N/A
Lin et al. 2017[25]	Kaohsiung, Taiwan (0.88)	Stratified cluster (232)	dmft (WHO)	81.0%	N/A	N/A
Yen et al. 2013 [26]	Taichung, Taiwan (0.88)	Random selection (146)	deft (WHO)	71.0%	4.8±4.2	N/A
Li et al. 2017 [27]	Xinjiang, China (0.74)	Multistage (640)	dmft (WHO)	84.5%	5.2±4.0	N/A
Jiang et al. 2017 [28]	Shandong, China (0.74)	Stratified random (1,080)	dmft (WHO)	63.1%	2.6±2.5	N/A
Chen et al. 2014 [29]	Shanghai, China (0.74)	Multistage (610)	dmft (WHO)	64.8%	3.5±4.1	N/A
Wulaerhan et al. 2014 [30]	Kashgar, China (0.74)	Three-stage stratified (266)	dmft (WHO)	82.0%	N/A	N/A
Krisdapong et al. 2014 [31]	Bangkok, Thailand (0.74)	Stratified random (503)	dmft (WHO)	77.7%	6.2±5.2	5.2
Pattanaporn et al. 2013 [32]	Chiang Mai, Thailand (0.74)	Not report (167)	dmft (WHO)	78.0%	5.3±5.0	N/A
Adiatman et al. 2016 [33]	Jakarta, Indonesia (0.69)	Cluster random (390)	dmft (WHO)	90.0%	7.5±5.5	6.8±4.9
Kakanur, et al. 2016 [34]	Bengaluru city, India (0.62)	Multiphase (298)	deft (WHO)	27.5%	5.1±3.6	N/A
Sujlana et al. 2015 [35]	Haryana, India (0.62)	Multistage (400)	dmft (WHO)	59.0%	2.8±3.2	2.7±3.1
Gupta et al. 2015 [36]	Moradabad, India (0.62)	Simple random (568)	deft (WHO)	47.5%	2.4±1.7	2.2±0.7
Gopal et al. 2016 [37]	Andhra Pradesh, India (0.62)	Simple random (170)	dmft (WHO)	22.9%	N/A	N/A
Mittal et al. 2014 [38]	Gurgaon, India (0.62)	Multistage (619)	dmft (WHO)	68.5%	1.9±0.4	N/A
Sankeshwari et al. 2014 [39]	Belgaum, India (0.62)	Simple random (302)	dmft (WHO)	70.2%	3.0±3.6	3.0±3.6
Thapa et al. 2015 [40]	Nawalparasi, Nepal (0.56)	Systematic random (357)	dmft (Unspecified)	64.4%	4.4±3.1	N/A

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Table 1 (continued). Summary of the selected studies

Authors Year [Ref]	Study site (Human Development Index)	Sampling method (sample size)	Diagnosis criteria	Caries prevalence	Caries experience (dmft±SD)	Decayed teeth (dt±SD)
Europe						
Grund et al. 2015 [41]	Ennepe-Ruhr, Germany (0.93)	Multistage (406)	dmft (WHO)	26.2%	0.9±2.0	0.5±1.4
Bissar et al. 2014 [42]	Heidelberg, Germany (0.93)	Multistage (385)	dmft (WHO)	28.6%	N/A	N/A
Monaghan et al. 2014 [43]	Wales, United Kingdom (0.91)	Multistage (7,734)	dmft (BASCD)	41.0%	1.6	N/A
Monaghan et al.2014 [43]	England, United Kingdom (0.91)	Multistage (133,516)	dmft (BASCD)	27.9%	0.9	N/A
Monaghan et al. 2014 [43]	Scotland, United Kingdom (0.91)	Census (13,232)	dmft (BASCD)	33.0%	1.4	N/A
Ferro et al. 2017[44]	Veneto region, Italy (0.89)	Random selection (728)	dmft (BASCD)	35.2%	1.3±2.6	1.2±2.5
Nobile et al. 2014 [45]	Southern, Italy (0.89)	Two-stage cluster (158)	dmft (WHO)	29.8%	0.9±1.8	0.9±1.7
Ferrazzano et al. 2016 [46]	Campania, Italy (0.89)	Multistage (387)	dmft (Definition)	43.4%	1.4±2.1	1.1±1.7
Tsanidou et al. 2015 [47]	North Eastern, Greece (0.87)	Not reported (317)	dmft (WHO)	64.2%	2.3±2.6	N/A
Middle East						
Al-Meedani et al.2016 [54]	Riyadh, Saudi Arabia (0.85)	Stratified random (252)	dmft (WHO)	75.0%	N/A	N/A
Abbasoglu et al.2015 [55]	Turkey (0.77)	Convenient (145)	dmft (Definition)	66.9%	N/A	N/A
Oceania						
Blinkhorn et al. 2015 [57]	New South Wales, Australia (0.94)	Multistage (820)	dmft (Definition)	44.4%	1.7	1.2±0.1
South America						
Abanto et al. 2014 [48]	Brazil (0.75)	Convenient (335)	deft (WHO)	64.8%	N/A	N/A
Carvalho et al.2014 [49]	Federal District, Brazil (0.75)	Cluster (602)	dmft (Definition)	53.6%	2.1±0.1	N/A
Do Amaral et al. 2014 [50]	Indaiatuba, Brazil (0.75)	Systematic probabilistic (303)	dmft (WHO)	41.6%	1.5	N/A
Scarpelli et al. 2014 [51]	Belo Horizonte, Brazil (0.75)	Multistage (1635)	dmft (WHO)	46.2%	N/A	N/A
Lourenço et al. 2013 [52]	Pacoti, Brazil (0.75)	Census (149)	dmft (Definition)	67.8%	N/A	2.2±2.4
Corrêa-Faria et al. 2013 [53]	Minas Gerais, Brazil (0.75)	Systematic random (134)	dmft (WHO)	62.7%	N/A	N/A

dmft= decayed missing and filled primary teeth, deft=decayed, extracted due to caries, filled primary teeth, WHO=World Heatlh Organization, Definition= Diagnosis criteria set by researchers, BASCD= British Association for the Study of Community Dentistry, N/A= not applicable.

Table 2 Quality assessment of the selected publications with the modified Newcastle-Ottawa Scale

Authors [Ref]	Study site	Item						Total	Quality
		1	2	3	4	5	6		
Africa									
Elidrissi et al. 2016 [56]	Khartoum State, Sudan	1	1	1	2	2	1	8	Good
Asia									
Chen et al. 2017 [21]	Hong Kong SAR, China	1	1	1	2	2	1	8	Good
Peng et al. 2017 [22]	Hong Kong Island, China	1	1	0	2	2	1	7	Good
Bridges et al. 2014 [23]	Hong Kong Island, China	1	1	0	2	0	1	5	Moderate
Han, et al. 2014 [24]	Ulsan, Korea	1	1	0	2	2	1	7	Good
Lin et al. 2017 [25]	Kaohsiung, Taiwan	1	1	0	2	2	1	8	Good
Yen et al. 2013 [26]	Taichung, Taiwan	1	1	0	2	0	1	5	Moderate
Li et al. 2017 [27]	Xinjiang, China	1	1	1	2	2	1	8	Good
Jiang et al. 2017 [28]	Shandong, China	1	1	0	2	2	1	7	Good
Chen et al. 2014 [29]	Shanghai, China	1	1	1	2	2	1	8	Good
Wulaerhan et al. 2014 [30]	Kashgar, China	1	1	0	2	2	1	7	Good
Krisdapong et al. 2014[31]	Bangkok, Thailand	1	1	1	2	2	1	8	Good
Pattanaporn et al. 2013 [32]	Chiang Mai, Thailand	0	1	0	2	0	1	4	Moderate
Adiatman et al. 2016 [33]	Jakarta, Indonesia	1	1	0	2	2	1	7	Good
Kakanur, et al. 2016 [34]	Bengaluru city, India	1	1	0	2	0	1	5	Moderate
Sujlana et al.2015 [35]	Haryana, India	1	1	0	2	0	1	5	Moderate
Gupta et al.2015 [36]	Moradabad, India	1	1	0	2	2	1	7	Good
Gopal et al.2016 [37]	Andhra Pradesh, India	1	1	0	2	2	1	7	Good
Mittal et al.2014 [38]	Gurgaon, India	0	1	0	2	0	1	4	Moderate
Sankeshwari et al. 2014 [39]	Belgaum, India	1	1	0	2	2	1	7	Good
Thapa et al.2015 [40]	Nawalparasi, Nepal	1	1	0	2	0	1	6	Good
Europe									
Grund et al. 2015 [41]	Ennepe-Ruhr, Germany	1	1	0	2	2	1	7	Good
Bissar et al. 2014 [42]	Heidelberg, Germany	1	1	0	2	2	1	7	Good
Monaghan et al.2014 [43]	Great Britain, UK	1	1	0	2	2	0	6	Good
Ferro et al. 2017 [44]	Veneto region, Italy	1	1	1	2	2	1	8	Good
Nobile et al. 2014 [45]	Southern, Italy	1	1	0	2	2	1	7	Good
Ferrazzano et al. 2016 [46]	Campania, Italy	1	1	0	1	2	1	6	Good
Tsanidou et al. 2015 [47]	North Eastern, Greece	0	1	0	2	2	1	6	Good
Middle East									
Al-Meedani et al.2016 [54]	Riyadh, Saudi Arabia	1	1	0	2	2	1	7	Good
Abbasoglu et al. 2015 [55]	Turkey	0	1	0	1	0	1	3	Moderate
Oceania									
Blinkhorn et al. 2015 [57]	NSW, Australia	1	1	0	1	2	1	6	Good
South America									
Abanto et al. 2014 [48]	Brazil	0	1	0	2	2	1	6	Good
Carvalho et al. 2014 [49]	Federal District, Brazil	1	1	0	1	2	1	6	Good
Do Amaral et al. 2014 [50]	Indaiatuba, Brazil	1	1	0	1	2	1	6	Good
Scarpelli et al. 2014 [51]	Belo Horizonte, Brazil	1	1	1	2	2	1	8	Good
Lourenço et al. 2013 [52]	Pacoti, Brazil	1	1	0	1	2	0	5	Moderate
Corrêa-Faria et al. 2013 [53]	Minas Gerais, Brazil	1	1	0	2	2	1	7	Good

Item 1 – Representativeness, Item 2 - Sample size, Item 3 - Non-respondents, Item 4 - Ascertainment of risk factor (diagnosis), Item 5 - Outcome assess, Item 6 –Statistics.

Figure 1. Flowchart of literature search