



REVIEW ARTICLE

A systematic review and meta-analysis of primary teeth caries studies in Gulf Cooperation Council States



W. Al Ayyan^a, M. Al Halabi^a, I. Hussein^a, AH. Khamis^b, M. Kowash^{a,*}

^a Department of Pediatric Dentistry, Hamdan Bin Mohammed College of Dental Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences, Dubai, United Arab Emirates

^b Department of Biostatistics and Genetic Epidemiology, Hamdan Bin Mohammed College of Dental Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences, Dubai, United Arab Emirates

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KEYWORDS

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Abstract *Objectives:* The aim of the study was to evaluate the prevalence and severity of dental caries in pre-school children in the Gulf Cooperation Council (GCC) area.

Methods: A search of literature was conducted to identify articles of dental caries in primary dentitions published during the period from January 1st, 1992 to June 30th, 2016. PubMed, Google Scholar search, and hand searching of journals was conducted to identify relevant articles. The search strategy employed both dental subject headings and free-text terms.

Results: Out of a total of 193 studies that fit the initial inclusion criteria, 159 studies were further excluded. Only 34 studies were included in the systematic review and meta-analyses. The overall mean *dmft* in the primary teeth was 5.14 with prevalence of 80.9% in the GCC area. A high level of heterogeneity in the selected studies was found as demonstrated by Q-value of 2538.501 ($df = 21$) and I^2 value of 99.17%. However, the funnel plots showed symmetrical shape at the bottom in both *dmft* and prevalence studies indicating absence of publication bias, which was also confirmed by insignificant result of Egger's regression statistical test (Egger's test $P = 0.179-0.358$).

Conclusion: Caries in the primary dentition in the GCC States was high both in terms of mean *dmft* (5.14) and prevalence (80.95%).

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* Corresponding author.

E-mail address: mawlood.kowash@mbru.ac.ae (M. Kowash).

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1. Introduction

Dental Caries is a progressive irreversible microbial disease affecting the hard tissues of the tooth. It is the most prevalent chronic disease affecting the human race and is painful, expensive to treat and can cause harm to nutrition and overall health (Al Agili, 2013). Dental caries in infants and young children is known as Early Childhood Caries (ECC). It is defined as the presence of one 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” (American Academy of Pediatric Dentistry, 2007-2018). Once it has occurred, its manifestations persist throughout life even after the lesion has been treated. It affects both genders, all races, all ages and all socio-economic groups (Moses et al., 2011). Caries can cause pain, which varies in severity, but has the potential to compromise the quality of life of affected children. Caries may not only result in disfigurement but also have deleterious effects on future dentition (Kowash, 2014). It is a widely established fact that dental caries is an infectious disease induced by diet. The main etiological factors causing this disease are; cariogenic bacteria, fermentable carbohydrates, a susceptible tooth (host) and time (Harris et al., 2004). In children, dental caries is particularly critical because even following repair, the affected tooth structure exhibits increased vulnerability to damage (Al Agili, 2013).

The mechanism of the caries process leads eventually to cavitation of the tooth structure. As a result of the fermentation of carbohydrates, organic acids are produced by oral bacteria, including lactic, formic, acetic and propionic acids. These acids are able to penetrate dental tissues and dissolve the enamel forming the outer layer of the tooth, together with the underlying dentin and the cementum which forms the root of the tooth. The erosion of substance can lead, in time, to cavitation (Featherstone, 2004). Usually the examination for dental caries is performed after teeth have been air-dried, under artificial light and with the aid of a dental mirror and an explorer which is used for the removal of plaque. The number of teeth with caries is recorded for each patient. All erupted teeth are evaluated according to the criteria recommended by the World Health Organization (WHO) using the **d**ecayed, **m**issing, **f**illed **t**ee**t**h (**dmfi**) index for primary teeth (Pezzementi and Fisher, 2005).

There are a limited numbers of studies done in the Gulf Cooperation Council (GCC) States regarding the prevalence of dental caries, therefore more studies are needed to more clearly understand the status of caries in this region. The

format of a systematic review is very effective in collecting a large amount of data and analyzing it simultaneously. Examples of GCC States caries status can be seen in studies that have assessed the national prevalence of dental caries and its severity in children in the Kingdom of Saudi Arabia (KSA) and the United Arab Emirates (UAE). In the KSA, caries prevalence was estimated to be approximately 80% for primary dentition (Al Agili, 2013). While in the UAE, the prevalence of dental caries was very high in preschool children, 36% to 47% at two years of age, 71% to 86% at age 4 years and 82% to 94% at five years of age according to Al-Hosani and Rugg-Gunn (1998). According to a UAE survey done in 2006, the proportion of five-year olds who had caries experience in the primary dentition was 83% overall; this varied from 71% in Ajman to 93% in the Western Region (El Nadeef et al., 2010). Therefore, the main objective of this systematic review was to identify the overall prevalence and severity of dental caries in pre-school children in the GCC area.

2. Methods

A literature search on the prevalence of dental caries in GCC countries was conducted at the Hamdan Bin Mohammad College of Dental Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU). Studies identified by database searches including PubMed, Google Scholar search, and hand searching of journals and an attempt to gather unpublished reports. Conference proceedings were outside the scope of the review. The PubMed database and Google search were conducted using the search by key words as follows: *dental caries, child, prevalence, DMFT, dmft, and GCC countries (Bahrain, Oman, Kuwait, KSA, Qatar, and UAE)*. The search included all literature published in English and Arabic from January 1st, 1992 to June 30th, 2016. The titles, authors, and abstracts from all studies identified were printed and reviewed independently on the basis of keywords, title, and abstract by two reviewers to determine whether these meet the inclusion criteria. The principle investigator (WA) and main supervisor (MK) assessed the retrieved records for inclusion independently. They were not blinded to the identity of the authors, their institution or the results of the research. The principal investigator obtained and assessed the full report of the records considered to meet the inclusion criteria. Disagreements if any were resolved by discussion. The protocol was approved by the Research and Ethics Committee of MBRU.

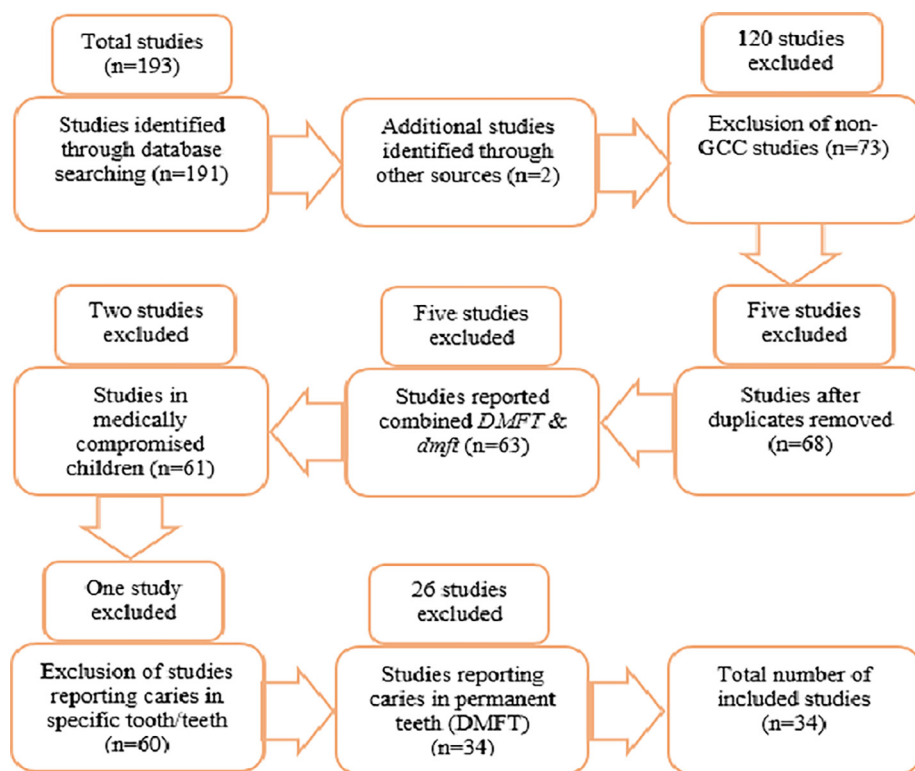


Fig. 1 Flow diagram of literature search.

2.1. Data collection

The inclusion criteria were: (1) studies conducted in one of the six GCC countries; (2) studies including prevalence and/or *dmft* data; (3) healthy participants without systemic diseases. Whereas the exclusion criteria were: (1) studies in children with systemic diseases; (2) studies with participants below two years or older than 16 years; (3) studies on prevalence and/or severity of caries in specific teeth; (4) any study published before January 1992; (5) studies with duplicated data. Search results showed 193 articles, which had one or more of search key word/text in the title or abstract. Almost all (191) identified through database search and two through other sources. The aforementioned inclusion and exclusion criteria were applied to the 193 searched articles and subsequently 120 were excluded due to them being non-GCC studies. From the 73 studies that remained and were assessed in full-text 39 were excluded for various reasons (five studies duplicates, five studies reported combined *dmft*/DMFT in mixed dentition, two studies investigated caries in medically compromised children, one study investigated specific teeth and 26 studies reported caries in permanent dentition Fig. 1). Data extracted from the 34 studies included information for primary teeth caries (prevalence and *dmft* data) Table 1).

2.2. Statistical analysis

The overall prevalence and severity in different studies were expressed as standardized values (i.e., the standardized mean difference) together with the relevant 95% confidence interval (CI), to enable quantitative synthesis and analysis (Deeks et al., 2008). The random effects methods for meta-analysis was used combining data from studies that reported similar

measurements in appropriate statistical forms (Der Simonian, 1986; Borenstein et al., 2009), since they were expected to differ across studies due to differences in study populations, sample size, and study design. All analyses were carried out with comprehensive meta-analysis software version 2.2046 (2007 Biostat Inc., Englewood, New Jersey, USA). Significance was set at $P < 0.05$, except for 0.10 used for the heterogeneity (Jp, 2008). Visual inspection of forest plot and Chi-square test was used to test the presence of heterogeneity. Funnel plot was used to check the possibility of publication bias. A plot of sample size according to effect size must show funnel shape (Richard and Pillemer, 1984).

3. Results

The results' data of all studies included in the systematic review were compiled into one table. The following data were presented for each study: author or authors' name, year of publication, country, sample size, age in years, mean *dmft* and standard deviation and prevalence Table 1.

Following implementation of all of the inclusion criteria, 34 studies were included in the systematic review. In seven studies the mean *dmft* data were not recorded, while only in one study the prevalence was not reported. The overall sample size of those studies in primary teeth prevalence (Fig. 2) was 98,497 children. While, sample size for the mean *dmft* was 15,421 children. A large proportion of studies were carried out in KSA (19 of total studies included). Bahrain however did not have any publication Table 1.

A forest plot (Fig. 2) represents studies that had mean *dmft* values. Visual inspection of the forest plot indicates the presence of heterogeneity; a Q statistic (chi-square test) was used to

Table 1 Final list of the studies included in the systematic review.

Author	Year	Country	Sample	Age	dmft(SD)	Prevalence (%)
Nasseb et al. ^a	–	Bahrain	–	5	–	85
Murtomaa et al. (1995)	1995	Kuwait	450	3–7	4.1(3.6)	61
Al-Dashti et al. (1995)	1995	Kuwait	227	1.5–4	–	53
Al-Mutawa et al. (2010)	2010	Kuwait	639	4	–	32
Al-Mutawa et al. (2010)	2010	Kuwait	638	5	–	24
Al-Malik and Holt (2000)	2000	KSA	80	4–5	0.95(2.03)	30
Al-Banyan et al. (2000)	2000	KSA	272	5–12	3.8(3.2)	–
Gandeh and Milaat (2000)	2000	KSA	82,250	6–11	–	83
Khan et al. (2001)	2001	KSA	457	6–7	4.45(3.76)	82.9
Wyne et al. (2000)	2001	KSA	77	4	0.91(2.42)	20.8
Wyne et al. (2001)	2001	KSA	1016	4.51	8.6(3.4)	27.3
Wylie (2002)	2002	KSA	449	7–11	6.3(3.5)	94.4
Wyne et al. (2002)	2002	KSA	322	4–5	2.92(3.51)	62.7
Al-Malik et al. (2003)	2003	KSA	987	2–5	4.8(4.87)	73
Paul (2003)	2003	KSA	103	5	7.1(5.7)	83.5
Aldosari et al. (2004)	2004	KSA	249	6–7	6.53(4.3)	91.2
Aldosari et al. (2004)	2004	KSA	182	6–7	6.35(3.83)	91.2
Al-Malik and Rehbini (2006)	2006	KSA	300	6–7	8.06(4.04)	96
Wyne (2007)	2007	KSA	789	3–5	6.1(3.9)	74.8
Farsi (2010)	2010	KSA	510	4–5	3.9(3.185)	45.4
Al-Majed and Pedo (2011)	2011	KSA	522	8–10	4.96(3.03)	86.2
Alkarimi et al. (2014)	2014	KSA	436	6–8	5.7(4.2)	87.1
Farooqi et al. (2015)	2015	KSA	397	6–9	3.66(3.13)	78
Al-Meedani and Al-Dlaigan (2016)	2016	KSA	388	3–5	3.4(3.6)	69
Al-Ismaily et al. (1997)	1997	Oman	3114	6	4.61	84.5
Alkhtib et al. (2016)	2016	Qatar	250	4–5	7.6(5.1)	89.2
Al-Hosani and Rugg-Gunn (1998)	1998	UAE	217	2	–	41.5
Al-Hosani and Rugg-Gunn (1998)	1998	UAE	204	4	–	78.5
Al-Hosani and Rugg-Gunn (1998)	1998	UAE	219	5	8.4	88
El Nadeef et al. (2010)	2010	UAE	1340	5	5.1	83
Hashim et al. (2010)	2010	UAE	518	5	4.0(4.1)	72.9
Hashim et al. (2010)	2010	UAE	518	6	4.9(4.3)	80
Kowash (2015)	2015	UAE	176	2–5	10.9	99.4
Kowash et al. (2017) ^b	2017	UAE	540	3–6	3.07 (0.14)	74.1

^a Unpublished study.

^b Unpublished study during data collection.

authenticate the presence of heterogeneity. The test provided a significant P-value (< 0.001), which confirms the heterogeneity between studies. A high level of heterogeneity was found as demonstrated by Q-value of 2538.501 ($df = 21$) and I^2 value of 99.17%. A random effect model was used to find the overall mean *dmft*. The average of *dmft* was estimated as 5.136 ($SD = 0.038$) with 95% confidence interval (5.016–5.211).

A forest plot (Fig. 3) shows that the overall estimation of the prevalence of caries in primary teeth was 80.9% and with 95% confident interval (80.6–81.1%). It was very clear that the width of the CI was very small due the large number of participants in the analysis. As in the *dmft* forest plot, high heterogeneity was found as demonstrated by Q-value of 4139.441 ($df = 30$) and I^2 of 99.27% (p -value < 0.00). The funnel plot shows symmetrical shape at the bottom of both *dmft* and prevalence studies (Figs. 4 and 5). Egger's regression statistical test was used for confirmation of the absence of publication bias, as shown by an insignificant result (Egger's test $P = 0.179$ – 0.358).

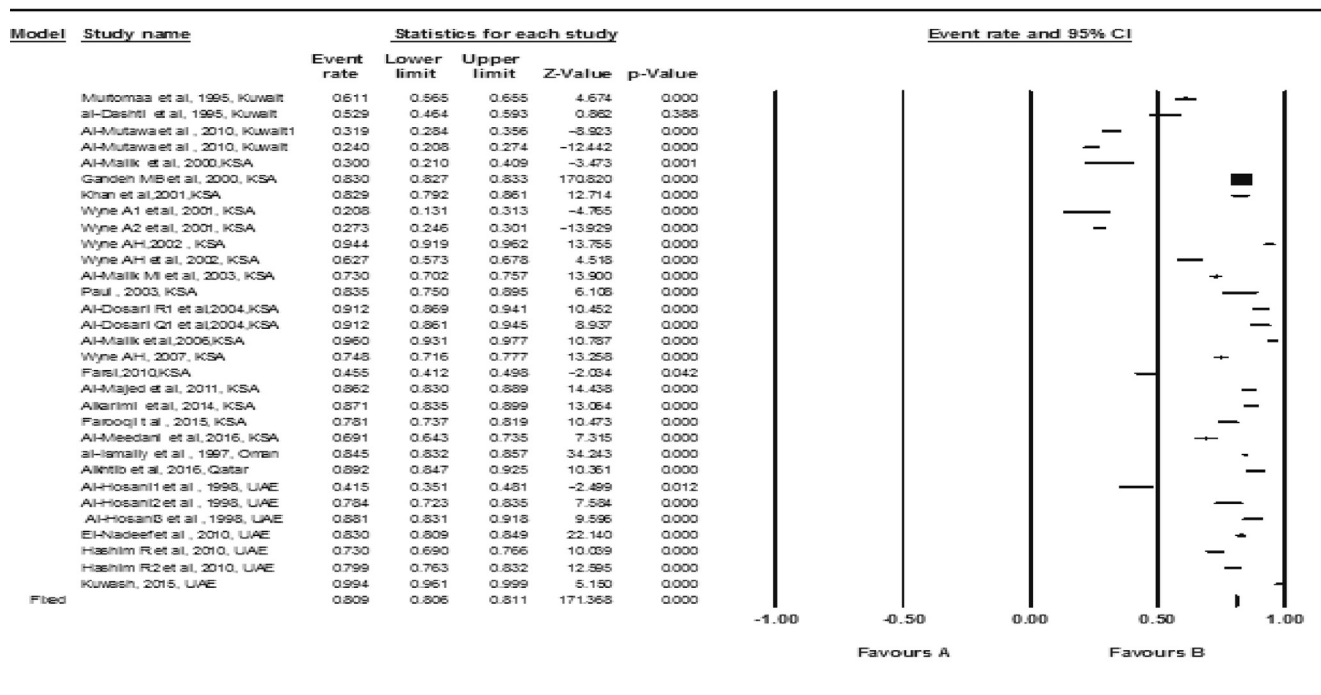
4. Discussion

The study focused on all the articles reporting caries in terms of *dmft* and prevalence among preschool children in GCC countries. Out of the 34 studies which were selected from an

initial sample of 193 research papers published and unpublished during the period from 1992 to 2016 met the inclusion criteria and included in the systematic review. Khan (2014) in a meta-analysis study in 23 countries of Arab league during the period from 1999 to 2012 reported that 35 research papers met the inclusion criteria and were included their study.

Although this systematic review and meta-analysis study provided valuable information about the prevalence and severity of dental caries in pre-school children of GCC countries, it is clear that the majority of the studies were carried out in KSA and the UAE with few studies in Kuwait, Oman, Qatar and no published studies in Bahrain. Furthermore, even in KSA most of the studies were conducted in major cities like Riyadh and Jeddah. Therefore, the current meta-analysis may not be representative of the whole populations in the GCC countries or even within individual countries. However, it could be argued that the participants are all GCC nationals who have similar socioeconomic and cultural backgrounds.

Another possible weakness, which is common in most dental caries studies, was the use of different methodologies including: sample size, methods of diagnosis and recordings, randomization and type of study. Other inevitable limitations in most meta-analysis studies are heterogeneity and publication bias, the latter was not evident in this meta-analysis study.



Model	Effect size and 95% interval				Test of null (2-Tail)		Heterogeneity			Tau-squar	
	Number Studies	Point estimate	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared
Fixed	31	0.809	0.806	0.811	171.368	0.000	4139.441	30	0.000	99.275	0.899
Random	31	0.742	0.671	0.802	6.062	0.000					

Fig. 3 Study-specific and summary effect estimates [mean and 95% confidence interval (CI)] for prevalence of caries in primary dentition.

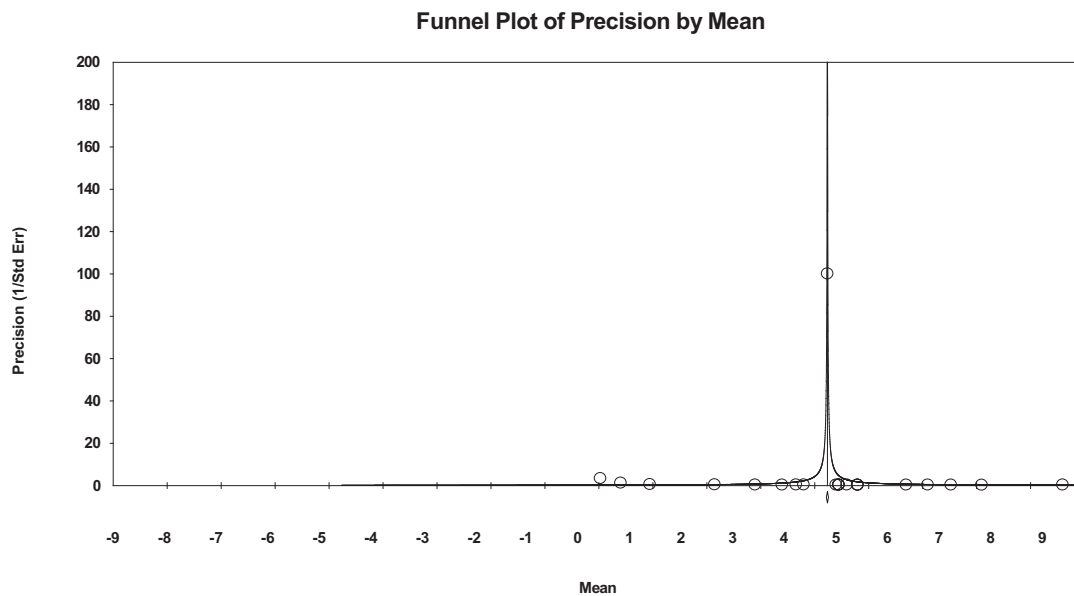


Fig. 4 Bias in Mean decayed, missing and filled teeth (*dmft*) according to precision of the mean *dmft* in primary dentition studies.

papers published during the period from 1999 to 2008 but the mean *dmft* in the current study was higher than the Arab League meta-analysis study (Khan, 2014), which was 4.341 (95% CI 3.714–4.969). Al Agili (2013) in a KSA systematic review reported similar high prevalence (80%) and a similar mean *dmft* (5.0) (Al Agili, 2013). Al-Ansari (2014) in a 30 years liter-

ature review (1982–2012) in KSA reported a higher prevalence (95%) in 3–7 year-old children and a higher mean *dmft* of 7.34 (Al-Ansari, 2014).

Developed countries have less caries prevalence and a decline in caries levels in older children as a result of several research studies and preventive programs focusing in caries

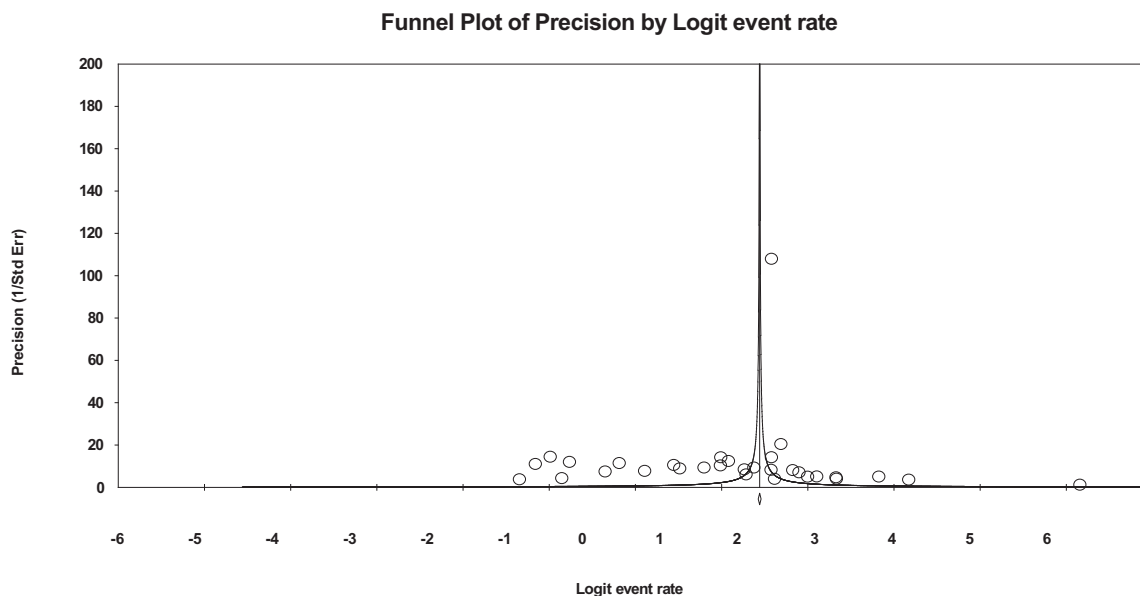


Fig. 5 Bias in the prevalence of primary dentition studies.

prevention. However, ECC is still a continuing oral health problem even in countries with a very effective oral health system like the Scandinavian countries (Haugejorden and Birkeland, 2002). The results of the Child Dental Health Survey 2013 in England, Wales and Northern Ireland showed that the prevalence of caries in five-year-old children was 31% (Holmes et al., 2015). In the USA a 2011–2012 National Health and Nutrition Examination Survey showed a lower prevalence than the current study (23% vs 80.9%) in preschool children (Dye et al., 2015). In a recent Australian state study conducted in 2015 in 2214 children aged 5 to 8 years. The prevalence of dental caries in the primary teeth was also lower than the current study (47.1%) (Do et al., 2015).

Heterogeneity can be determined by visual inspection of the forest plot. If confidence intervals for the results of individual studies (generally depicted graphically using horizontal lines) have poor overlap, this generally indicates the presence of statistical heterogeneity. Higgins et al. (2003) argued that, since clinical and methodological diversity always occur in a meta-analysis, statistical heterogeneity is inevitable.

In this study additional statistical tests (Q and I) were used to verify the presence of visual heterogeneity. Q statistic (chi-square test) of 2538.501 (df = 21) provided a significant P-value (<0.001) and I^2 value of 99.17% confirmed the presence of heterogeneity between studies. Khan (2014) has reported the presence of heterogeneity both in primary dentition studies visually and statistically by obtaining a significant Q test value with $p < 0.001$ and I^2 value of >90%. Khan et al. (2013) also reported the presence of heterogeneity between studies as indicated by a significant Q test value with $p = 0.00$ and I^2 value of >75%.

Although this systematic review and meta-analysis study provided valuable information about the prevalence and severity of dental caries in primary teeth of children in GCC countries, it is clear that the majority of the studies were carried out in KSA and the UAE and hence the results may not be a true reflection of caries levels in all GCC. There is an important and urgent need to conduct high-quality research studies in all GCC countries, including small cities and rural areas in each country, to accurately evaluate the levels and the extent of

the dental caries burden. This significantly assists oral health policy makers in GCC countries to plan cost-effective caries preventive strategies.

5. Conclusions

Caries levels in primary dentition of GCC children were high both in terms of mean *dmft* (5.14) and prevalence (80.95%).

Conflict of interest

The authors declared that there is no conflict of interest.

Acknowledgment

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