Review Article

A Systematic Review and Meta-analysis of School Children's Caries Studies in Gulf Cooperation Council States

Wafa Alayyan[1], Manal Al Halabi[1], Iyad Hussein[1], Amar Khamis[2], Mawlood Kowash[1]

[1]Department of Pediatric Dentistry and [2]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

ABSTRACT

Objectives: The aim of the present study was to evaluate the prevalence and severity of dental caries school children in the Gulf Cooperation Council (GCC) area, to help the development of systematic approaches for preventive oral care programs in the GCC states and to provide sound information for oral health promotion and public health care.

Materials and Methods: A comprehensive search to identify both published and unpublished articles concerning relevant studies of dental caries in children aged 6–16 years for their permanent teeth published from 1992 to 2016 with no language and time limit was performed. The search strategies employed electronic databases and incorporated both dental subject headings and free-text term.

Results: The overall mean decayed, missing and filled teeth in the permanent teeth was 2.57, and the prevalence was 64.7% in the GCC area.

Conclusions: Most of the studies were conducted in the Kingdom of Saudi Arabia. The results may not be a true reflection, and other countries in GCC are urged to study the prevalence and severity of caries in their children population.

KEYWORDS: *Caries decayed, caries prevalence, Gulf Cooperation Council states, missing and filled teeth, school children, systematic review*

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.[1] 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 socioeconomic groups.[2] 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.[3] 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.[4] In children, dental caries is particularly critical because even the following repair, the affected tooth structure exhibits increased vulnerability to damage.[1]

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.[5] 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

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World Health Organization (WHO) using the decayed, missing, and filled teeth (DMFT) index for permanent teeth.[6]

There are limited numbers of studies carried out 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). Farooqi *et al.* in 2015 examined 711 KSA children aged 6–9 and 10–12 years and reported prevalence rates of 78% and 68%, respectively.[7] In 2014, Bhayat and Ahmad. studied the prevalence of dental caries and mean DMFT in 360 12-year-old male children in Medina City, KSA. The mean DMFT score was 1.53, whereas the prevalence of dental caries was 57.2%.[8] Al-Agili and Alaki in Jeddah, KSA reported a prevalence of 83.13% in 1655 children aged 9 and 14 years.[9] Although in the UAE, the prevalence of dental caries was very high in children, the prevalence rate was 54% for 12 years and 75% for 15 years old, in a sample size of 2651.[10]

Therefore, the main objective of this systematic review is to identify the prevalence and severity of dental caries in school children in the GCC area, to assist in the development of systematic approaches for preventive oral care programs in the GGC states and provide sound information for oral health promotion and public health care.

MATERIALS AND METHODS

In June 2016, 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 search, and hand searching of journals and gathering of 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 1, 1992 to June 30, 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 protocol was approved by the Research and Ethics Committee of MBRU.

DATA COLLECTION

Search results showed 191 published, which had text terms "dental caries," "prevalence," and "DMFT" in the title or abstract. Then, inclusion 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 51 were excluded for various reasons (five studies duplicates, five studies due to the mixed dentition, two studies unfit children, one study investigated specific teeth and 38 studies due to the age investigated being above 16 or below 6 years of age [Figure 1]. Data extracted from the 22 studies included information for permanent teeth caries (prevalence and DMFT data) [Table 1].

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.[11] The random effects methods for meta-analysis was used combining data from studies that reported similar measurements in appropriate statistical forms,[12,13] 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 Jersy, USA). Significance was set at $P < 0.05$, except for 0.10 used for the heterogeneity (Ioannidis, 2008).[14] Visual inspection
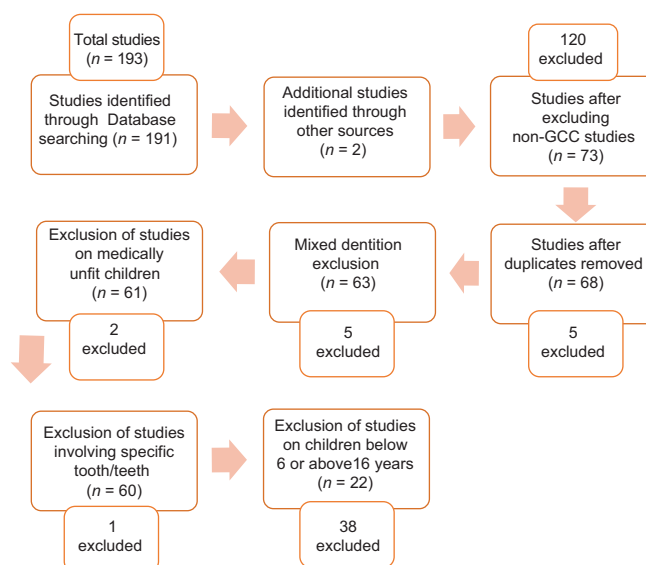

Figure 1: Flow diagram of literature search

Table 1: Studies and variables included after inclusion criteria on reported caries in permanent teeth as mean decayed, missing, filled, teeth and prevalence

Authors	Year	Country	Sample	Age	DMFT (SD)	Prevalence (%)
Al-Mutawa *et al.*[15]	2006	Kuwait	2290	12-14	3.25 (3.73)	18.825
Alsumait *et al.*[16]	2015	Kuwait	440	11-12	2.91 (2.75)	-
Ali *et al.*[17]	2016	Kuwait	486	12-16	-	52
Akpata *et al.*[18]	1992	KSA	363	12-13	2.02	76.5
Al-Shammery *et al.*[19]	1999	KSA	1873	12-13	-	>89
Wyne *et al.*[20]	2002	KSA	449	7-11	1.6 (1.5)	-
Dosari *et al.*[21]	2003	KSA	429	16	7.35 (4.99)	91.1
Dosari *et al.*[21]	2003	KSA	305	16	7.05 (4.58)	90.5
Al-Dosari *et al.*[22]	2004	KSA	392	12-13	5.06 (3.65)	92.3
Al-Dosari *et al.*[22]	2004	KSA	281	12-13	4.53 (3.57)	87.9
Al-Malik *et al.*[23]	2006	KSA	300	6-7	0.41 (0.86)	-
Al-Dosari *et al.*[24]	2010	KSA	3904	12-13	2.93 (3.2)	-
Al Agili *et al.*[9]	2014	KSA	1655	9 and 14	-	83.13
Bhayat *et al* [8]	2014	KSA	360	12	1.53 (1.88)	57.2
Farooqi *et al.*[7]	2015	KSA	314	10-12	1.94 (2)	68
Al-Ismaily *et al.*[25]	1996	Oman	3435	12	1.53	58.1
Al-Ismaily *et al.*[26]	2004	Oman	2860	15	3.23 (3.73)	-
Bener *et al.*[27]	2013	Qatar	1752	6-15	4.5 (4.2)	73
Al-Darwish *et al.*[28]	2014	Qatar	2113	12-14	-	85
Mustahsen *et al.*[29]	2008	UAE	242	11 and 14	3.27	-
El-Nadeef *et al.*[10]	2009	UAE	1323	12	1.6	54
El-Nadeef *et al.*[10]	2009	UAE	1328	15	2.5	65

KSA=Kingdom of Saudi Arabia, UAE=United Arab Emirates, SD=Standard deviation, DMFT=Decayed, missing and filled teeth

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.[30]

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, 22 studies were included in the systematic review. In four studies, the mean DMFT data were not recorded, whereas in six studies, the prevalence was not reported. The sample size of those studies in permanent teeth mean DMFT was 23,152 children, whereas sample size for the prevalence was 18,699 children. A large proportion of studies were carried out in KSA (12 of total studies included). Bahrain, however, did not have any publication [Table 1].

The analysis was again performed over the data set that had mean DMFT values [Figure 2]. Heterogeneity was checked first by forest plot and then by a Chi-square test. Visual inspection of

the forest plot and Chi-square ($P < 0.001$) gave adequate evidence of heterogeneity in the data set, and the index of heterogeneity was also very high Q-value of 4806.020 (df = 16) and I^2 value of 99.67%. The random effect model was used to estimate mean DMFT, and this was found to be 2.577 (0.022) with 95% CI (2.533–2.620).

A forest plot [Figure 3] shows that the overall estimation of the prevalence in permanent teeth was 64.7% and with 95% CI, the range was (63.9%–65.4%). It is very clear that the width of the CI is very small due a large number of participants in the analysis. A high heterogeneity was found as demonstrated by Q-value of 3,048.074 (df = 15), I^2 of 99.5% and $P < 0.001$.

The funnel plots for permanent dentition exhibited clear asymmetry among both DMFT and prevalence studies [Figures 4 and 5]. There was an asymmetrical profile, especially at the bottom of the plot, indicating the presence of publication bias. Egger's regression statistical test was used for confirmation of publication bias. A significant result (Egger's test $P = 0.001–0.003$) indicated the presence of publication bias.

DISCUSSION

The study focused on all the articles reporting caries in terms of DMFT and prevalence among school children in

Average of DMFT

Study name	Statistics for each study							Mean and 95% CI
	Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	*p*-Value	
Al-Mutawa *et al*,2006,Kuwait	3.250	0.078	0.006	3.097	3.403	41.696	0.000	
Alsumait *et al*,2015,Kuwait	2.910	0.131	0.017	2.653	3.167	22.197	0.000	
al-Banyan *et al*,2000,KSA	2.000	0.115	0.013	1.774	2.226	17.360	0.000	
wyne *et al*,2002,KSA	1.600	0.071	0.005	1.461	1.739	22.602	0.000	
DosariR *et al*,2003,KSA	7.350	0.241	0.058	6.878	7.822	30.508	0.000	
DosariQ *et al*,2003,KSA	7.050	0.262	0.069	6.536	7.564	26.883	0.000	
Al-Dosari R *et al*,2004,KSA	5.060	0.184	0.034	4.699	5.421	27.447	0.000	
Al-Dosari Q *et al*,2004,KSA	4.530	0.213	0.045	4.113	4.947	21.271	0.000	
Al-Malik *et al*,2006,KSA	0.410	0.050	0.002	0.313	0.507	8.257	0.000	
Al-Dosari *et al*,2010,KSA	2.930	0.051	0.003	2.830	3.030	57.210	0.000	
Bhayat A *et al*,2014,KSA	1.530	0.099	0.010	1.336	1.724	15.441	0.000	
Farooqi 1 *et al*,2015,KSA	1.940	0.113	0.013	1.719	2.161	17.188	0.000	
Al-Ismaily2 *et al*,2004,Oman	3.230	0.069	0.005	3.094	3.366	46.686	0.000	
Bener *et al*,2013,Qatar	4.500	0.100	0.010	4.303	4.697	44.847	0.000	
Al-Darwish1 *et al*,2014,Qatar	4.620	0.121	0.015	4.384	4.856	38.307	0.000	
Al-Darwish2 *et al*,2014,Qatar	4.790	0.132	0.017	4.531	5.049	36.312	0.000	
Al-Darwish3 *et al*,2014,Qatar	5.500	0.139	0.019	5.227	5.773	39.469	0.000	
	2.577	0.022	0.000	2.533	2.620	116.217	0.000	

-10.00   -5.00   0.00   5.00   10.00

Favours A   Favours B

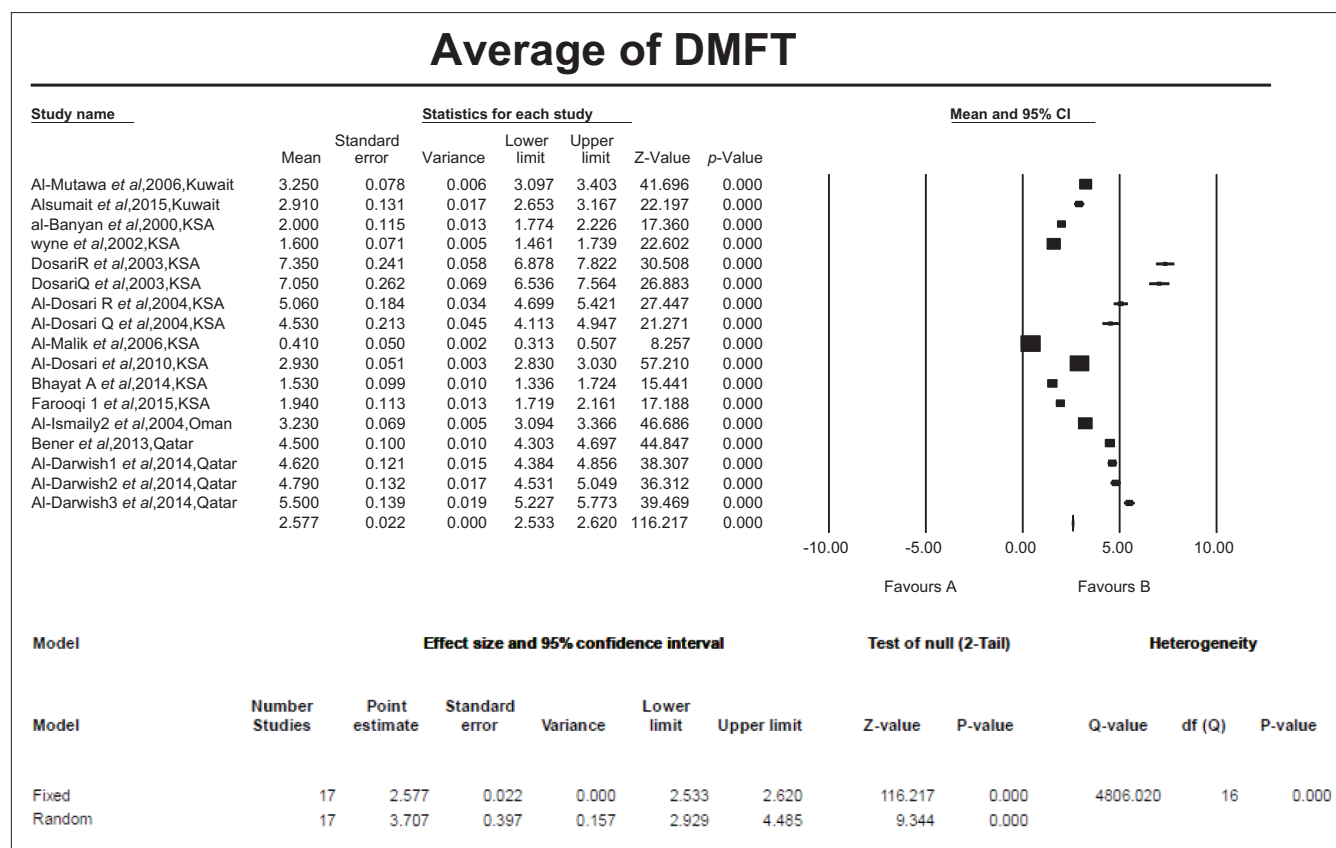| Model	Effect size and 95% confidence interval						Test of null (2-Tail)		Heterogeneity		
Model	Number Studies	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value
Fixed	17	2.577	0.022	0.000	2.533	2.620	116.217	0.000	4806.020	16	0.000
Random	17	3.707	0.397	0.157	2.929	4.485	9.344	0.000			

Figure 2: Study-specific and summary effect estimates (mean and 95% confidence interval [CI]) for mean decayed, missing, and filled teeth (DMFT) in studies, 1992–2016

GCC countries. Out of the 22 studies which were selected from an initial sample of 193 research papers published and unpublished from 1992 to 2016 met the inclusion criteria and included in the systematic review. Khan[31] in a meta-analysis study in 23 countries of Arab league from 1999 to 2012 reported that 35 research papers met the inclusion criteria and were included their study.

In the current study, the majority of studies were from KSA (12 out of 22). The mean DMFT for the permanent teeth in KSA range was (0.41–7.35) and the prevalence (57.2%–92.3%). The most reported cause was exposure to a cariogenic diet. There were only three UAE studies with DMFT range (1.6–3.27) and prevalence (54%–65%). The education of the parents and improving the dietary habits, good oral hygiene practices like brushing twice a day were the reported reasons for the decreased prevalence of caries over the past few years in the UAE. However, in Kuwait also there were three studies with DMFT range (2.91–3.25) and the prevalence (18.83%–52%). Increasing age with poor oral hygiene was a highly significant association with the risk of dental caries in the permanent teeth.

The number of included studies regarding permanent dentition in Oman and Qatar was two studies met the inclusion criteria. In the permanent dentition of Omani children, the mean DMFT range was (1.53–3.23), and the prevalence was 58.1%. The main causes of dental caries reported were poor oral hygiene, plaque and calculus accumulation. In the permanent dentition of children in the state of Qatar, the mean DMFT and the prevalence range were 4.5 and (73%–85%), respectively. One of the most commonly reported risk factor of caries in Qatar was the sociodemographic factor. However, no published studies in Bahrain.

The above results clearly showed high caries levels of both prevalence and severity in terms of mean DMFT scores. There was a wide range both in prevalence and severity in different studies. This is in line with Richardson *et al*. conclusion that the prevalence of caries in children varies greatly in different studies, which may be due to several factors such as: (1) Children studied; their age and the accessibility for examination; (2) socioeconomic status; (3) ethnic and cultural factors; and (4) criteria used for diagnosis.[32]

Most of the studies included in the systematic review used the WHO[33] method of caries diagnosis which is also widely used in international epidemiological studies. It is efficient in detecting dental cavities, but
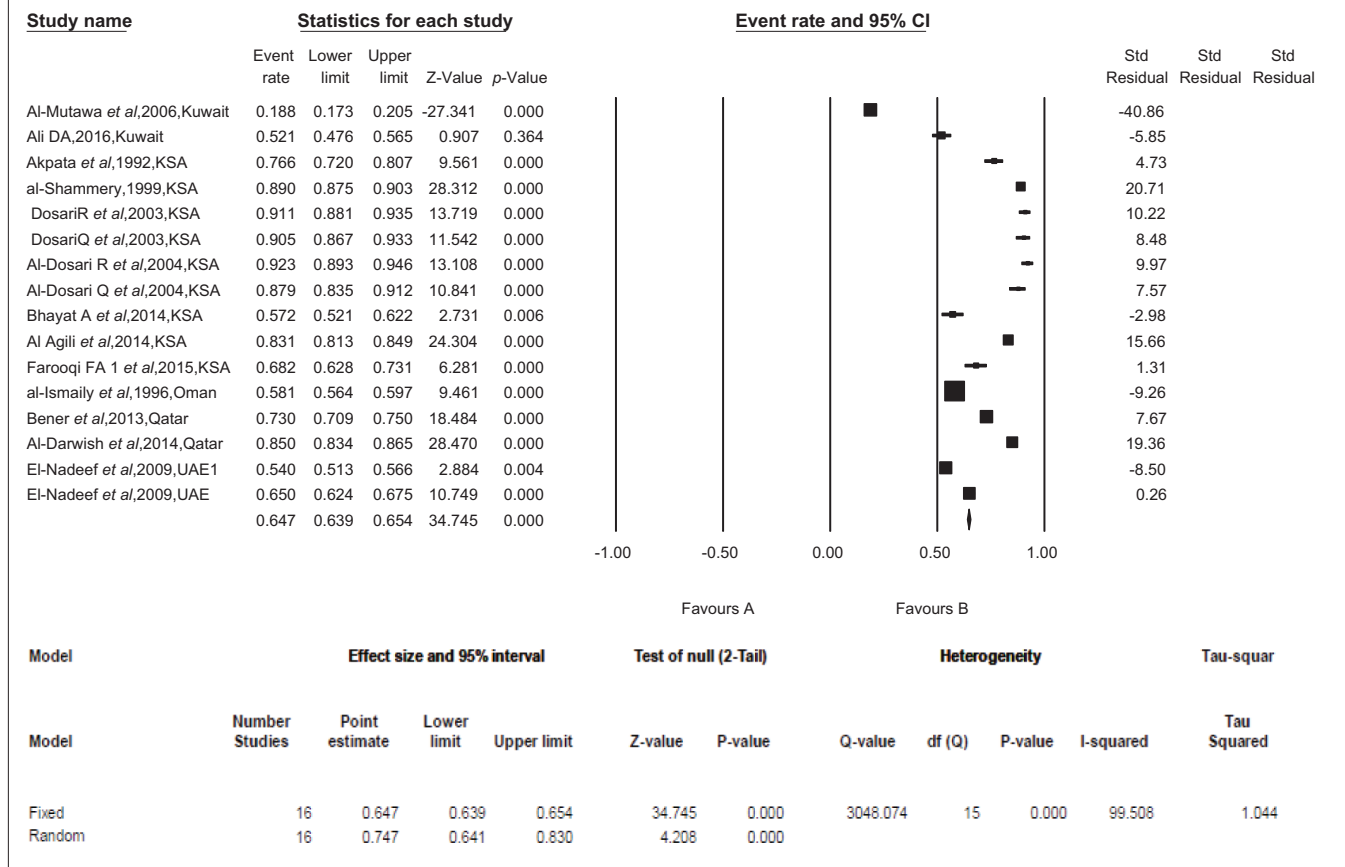
Prevalence of permenant teeth

Study name	Statistics for each study					Event rate and 95% CI			
	Event rate	Lower limit	Upper limit	Z-Value	*p*-Value		Std Residual	Std Residual	Std Residual
Al-Mutawa *et al*,2006,Kuwait	0.188	0.173	0.205	-27.341	0.000		-40.86		
Ali DA,2016,Kuwait	0.521	0.476	0.565	0.907	0.364		-5.85		
Akpata *et al*,1992,KSA	0.766	0.720	0.807	9.561	0.000		4.73		
al-Shammery,1999,KSA	0.890	0.875	0.903	28.312	0.000		20.71		
DosariR *et al*,2003,KSA	0.911	0.881	0.935	13.719	0.000		10.22		
DosariQ *et al*,2003,KSA	0.905	0.867	0.933	11.542	0.000		8.48		
Al-Dosari R *et al*,2004,KSA	0.923	0.893	0.946	13.108	0.000		9.97		
Al-Dosari Q *et al*,2004,KSA	0.879	0.835	0.912	10.841	0.000		7.57		
Bhayat A *et al*,2014,KSA	0.572	0.521	0.622	2.731	0.006		-2.98		
Al Agili *et al*,2014,KSA	0.831	0.813	0.849	24.304	0.000		15.66		
Farooqi FA 1 *et al*,2015,KSA	0.682	0.628	0.731	6.281	0.000		1.31		
al-Ismaily *et al*,1996,Oman	0.581	0.564	0.597	9.461	0.000		-9.26		
Bener *et al*,2013,Qatar	0.730	0.709	0.750	18.484	0.000		7.67		
Al-Darwish *et al*,2014,Qatar	0.850	0.834	0.865	28.470	0.000		19.36		
El-Nadeef *et al*,2009,UAE1	0.540	0.513	0.566	2.884	0.004		-8.50		
El-Nadeef *et al*,2009,UAE	0.650	0.624	0.675	10.749	0.000		0.26		
	0.647	0.639	0.654	34.745	0.000				

-1.00   -0.50   0.00   0.50   1.00

Favours A   Favours B

Model	Effect size and 95% interval				Test of null (2-Tail)		Heterogeneity				Tau-squar
Model	Number Studies	Point estimate	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared	Tau Squared
Fixed	16	0.647	0.639	0.654	34.745	0.000	3048.074	15	0.000	99.508	1.044
Random	16	0.747	0.641	0.830	4.208	0.000					

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

not the noncavitated lesions and this would probably underestimate caries prevalence. Certainly, the inclusion of noncavitated lesions would provide a better estimate of the disease prevalence and severity, which means a better understanding of treatment needs. The WHO criteria of caries diagnosis, however, are still a recognized and valid method in dental caries epidemiological studies, and its use allows comparison between studies. Furthermore, clinical diagnosis of the pre-cavitated lesion in epidemiological screenings would be challenging, especially in preschool children and using radiographs to detect noncavitated lesions for screening purposes would neither be ethical nor practical.[33]

The total number of sample sizes of those studies in permanent teeth caries mean DMFT [Figure 2] was 23,152. While sample size for prevalence it was 18,699 [Figure 3]. A large proportion of studies were carried out in the KSA (12 out of 22).

The prevalence and severity of caries in permanent teeth from a random effect model were high (64.7%) with (95% CI: 63.9-65.4%) and a mean DMFT of 2.577 with (95% CI: 2.53-2.62). A study by Khan *et al*. reported a slightly higher mean DMFT of 3.34 (95% CI: 1.97–4.75) in a KSA review of papers published from 1999 to 2008. A higher prevalence and mean DMFT were also reported in KSA children by Al-Ansari (2014) in his 30 years literature review study. The prevalence was 91%, and the mean DMFT was 7.35 in 12–19 years old. Al-Agili in a systematic review reported a slightly higher prevalence and a mean DMFT (70% and 3.5, respectively).[1] However, the mean DMFT of the current study was comparable with that reported by Khan's[31] Arab League meta-analysis study (2.469 with 95% CI: 2.019–2.919).

When comparing the results of the present study and the aforementioned studies on the prevalence of permanent dentitions caries in GCC countries and those from developed countries, it is clearly evident that the GCC population exhibits a higher prevalence. For example, the Child Dental Health Survey 2013 in England, Wales and Northern Ireland reported lower prevalence in 12 years old (34%) and in 15 years old (40%).[34] In
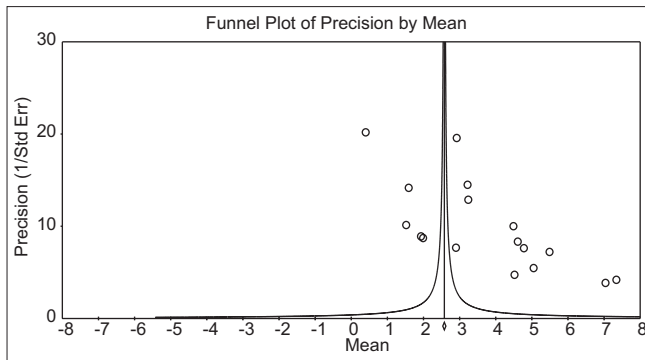
Figure 4: Bias in the mean decayed, missing and filled teeth of permanent dentition studies

Figure 5: Bias in the prevalence of permanent dentition studies

the USA National Health and Nutrition Examination Survey (2011–2012), the prevalence of dental caries in the permanent teeth of children aged 6–11 years old was 21%, whereas in the current meta-analysis, it was 64.7%.[35] In 2015, an Australian state study of dental caries of 3186 children (9- to 14-year-old) from 207 schools was carried out. The reported prevalence of dental caries for the permanent dentitions (38.8%), which was also lower than our study.[36]

The present study on the prevalence and severity of dental caries over the past 24 years in the GCC countries has shown that the prevalence and severity of caries, both in primary and permanent dentitions, were high and alarming. In 1981, the WHO and the World Dental Federation (Fédération Dentaire Internationale) jointly formulated goals for oral health to be achieved by the year 2000 as follows: 50% of children aged 5–6 years to be caries free; global average of DMFT not to be >3 for 12-year-old children and 85% of the population should retain all their teeth at the age of 18 years.[37] In addition, according to the WHO's basic global indicator of oral health 2000, DMFT >6.6 for the children aged 12 years is considered very high, between 4.5–6.5 is high, and 2.7–4.4 is moderate.[38] It is clear from the results of this study that GCC countries fell short of these goals and recommendations and that caries in permanent dentition moderate. This continuing problem is disturbing not only due to its high burden of caries management costs on the economy of GCC countries but also its negative effects on children's growth, development, and quality of life.

Heterogeneity can be determined by visual inspection of the forest plot. If CIs for the results of individual studies (generally depicted graphically using horizontal lines) have poor overlap, this generally indicates the presence of statistical heterogeneity. Higgins (2003)[39] argued that, since clinical and methodological diversity always occurs in a meta-analysis, statistical heterogeneity is inevitable.
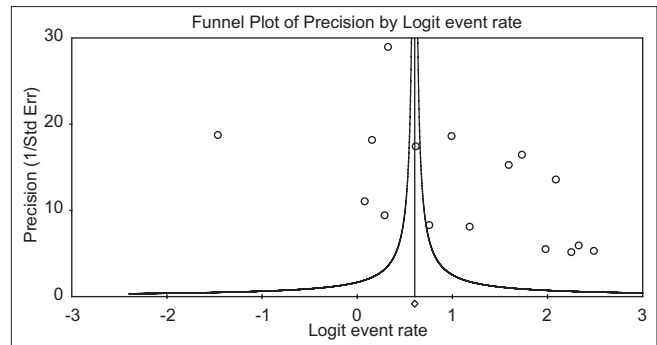
In this study, additional statistical tests (Q and I) were used to verify the presence of visual heterogeneity. In the permanent dentition also, visual inspection of the forest plot and Chi-square ($P < 0.001$) gave adequate evidence of heterogeneity in the data set, and the index of heterogeneity was also very high Q-value of 4,806.020 (df = 16) and I^2 value of 99.67%. Khan has reported the presence of heterogeneity in permanent 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.* 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%.

In this study, there was a publication bias seen visually by the asymmetrical distribution of studies [Figures 4 and 5] and also statistically (Egger's test $P = 0.001$–0.003). Similar results were reported by Khan in his Arab League meta-analysis study (Egger's test $P = 0.0.0016$). Khan *et al.* in a KSA study also reported the possibility of publication bias among permanent dentition studies (Egger's test $P = 0.018$).[40]

LIMITATIONS OF THE STUDY

Although this systematic review and meta-analysis study provided valuable information about the prevalence and severity of dental caries in children of GCC countries, it is clear that majority of the studies were carried out in KSA with a few studies in UAE, Kuwait, Oman, Qatar, and no published studies in Bahrain. Furthermore, even in the KSA, most of the studies were conducted in major cities such as Riyadh and Jeddah. Therefore, the current meta-analysis may not be representative of the overall 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 recording, randomization, and type of study. Other inevitable limitations in most meta-analysis studies are heterogeneity and publication bias; the latter was only evident in permanent dentition studies in this meta-analysis study.

Conclusions

The prevalence and severity of dental caries in terms of mean DMFT are high in children of the GCC countries. The main reported contributing factors were poor oral hygiene and the consumption of a high-sugar diet. There is 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 preventive strategies, especially community-based preventive programs. There should be more emphasis on prevention of ECC because by preventing caries in the very young population will result in lasting beneficial effects on oral health throughout the whole population life. This can be achieved by education of pregnant mothers and parents with young children through close cooperation between the dental and medical professions, especially antenatal clinic staff and pediatricians. This study did not provide a comprehensive picture of caries prevalence and severity in GCC because in many of these countries, only a few studies had been performed. Therefore, additional studies are needed to better evaluate the prevalence and severity of caries in children and adolescence in GCC countries.

Conflicts of interest
There are no conflicts of interest.

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