



Contents lists available at ScienceDirect

The Saudi Dental Journal

journal homepage: www.ksu.edu.sa
www.sciencedirect.com

Review Article

SEQUEL: Prevalence of dental caries in Saudi Arabia: A systematic review and *Meta*-analysisSoban Qadir Khan^a, Haneen A. Alzayer^b, Shahad T. Alameer^b, Muhammad Ajmal Khan^c, Nazeer Khan^d, Haitham AlQuorain^e, Mohammed M. Gad^{f,*}^a Department of Dental Education, College of Dentistry, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam, 31441, Saudi Arabia^b Dental Intern, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia^c Directorate of Library Affairs, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia^d Professor of Biostatistics, Director of Office of Research, Innovation and Commercialization, Baqai Medical University, Karachi, Pakistan^e Department of Restorative Dental Science, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia^f Department of Substitutive Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

ARTICLE INFO

Keywords:

Dental caries

Prevalence

Decayed-missing-filled teeth index

Saudi population

ABSTRACT

This *meta*-analysis investigated the prevalence of dental caries throughout the Kingdom of Saudi Arabia (KSA) between 2011 and 2023 as a follow-up to a previously published review in 2013 by Khan et al. and aimed to provide an update on the current status of caries prevalence in the KSA. A literature search was conducted, and thirty-three articles were included in the final analysis. To determine the prevalence of caries in primary teeth, the 2- to 12-year-old Saudi population was included in the search, and an age range of 6–18 years was used for permanent teeth. The prevalence of caries in the primary and permanent dentition was analyzed separately. As the included studies for the primary and permanent teeth had insignificant heterogeneity, fixed-effect models and forest plots were used to evaluate caries prevalence in both dentitions. In the primary dentition, the mean decayed-missing-filled teeth (dmft) index was 4.14 (95 % confidence interval (CI): 3.11–5.18), with an average prevalence of 75.43 %. For the permanent teeth, the mean DMFT (uppercase used for permanent dentition) was 1.28 (95 % CI: 0.93–1.64), with an average prevalence of 67.7 %. The average dmft/DMFT scores decreased in both primary and permanent teeth compared to the previous *meta*-analysis by Khan et al., suggesting a beneficial effect of preventative measures on caries prevalence. Continuing these measures is necessary to maintain the downward trend of caries prevalence in the KSA.

1. Introduction

According to the World Health Organization (WHO), dental caries is among the most common oral diseases. Globally, an estimated 2.5 billion people suffer from dental caries in either the permanent or primary dentition, underscoring the importance of understanding its prevalence in specific regions, including Saudi Arabia. The prevalence of dental caries in the Middle East concerns both children and adults (Kale et al., 2020; Elamin et al., 2021). Recently, dental caries have become a problem due to lifestyle changes in the population. Furthermore, inadequately fluoridated water, high sugar diets, and poor oral hygiene contribute to the development of early childhood caries, which increases an individual's susceptibility to developing tooth decay in their permanent dentition (Powell, 1998). Recent studies in Saudi Arabia have

shown that, on average, the prevalence of dental caries is 86 % in primary teeth and 65 % in permanent teeth (Al-Rafee et al., 2019). Similarly, a study by Al Agili in 2013 reported that, among Saudi children aged 6–7 years, the prevalence of dental caries ranged from 66.9 % to 94.6 %, with a mean decayed-missing-filled teeth (DMFT) score of 3.5 for children with permanent dentition, and a mean dmft score of 5.0 for the primary dentition. The nationwide prevalence is projected to be 70 % and 80 % for the permanent and primary dentitions, respectively. Alshammari et al. (2021) found that the range of dental caries proportions for primary and permanent teeth was 0.21 to 1.00 and from 0.05 to 0.99, respectively. In a study published by Al-Ansari et al. (2014), the highest DMFT value (7.35) was recorded in children and adolescents aged 12–19. These studies highlight the high prevalence of dental caries in Saudi Arabia across various age groups and the need to

* Corresponding author: College of Dentistry, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam, 31441, Saudi Arabia.

E-mail address: mmjad@iau.edu.sa (M.M. Gad).<https://doi.org/10.1016/j.sdentj.2024.04.011>

Received 18 December 2023; Received in revised form 4 April 2024; Accepted 28 April 2024

Available online 29 April 2024

1013-9052/© 2024 THE AUTHORS. Published by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

implement preventive measures, oral health education, and improved access to dental care (Aqeeli et al., 2021).

The DMFT index for permanent teeth and the dmft index for primary teeth are used as a base measure for caries in individuals (Bödecker et al., 1931). In 2003, a WHO report stated that dental caries are strongly present in developing countries despite efforts stressing the importance of maintaining oral health (Petersen, 2003). The KSA must improve the health of the population for better production efficiency. According to the General Authority of Statistics, children and adolescents represent nearly 37.28 % of the Saudi population, highlighting the need to improve their quality of life.

This study aimed to include all published articles on the prevalence of caries throughout the KSA from 2011 to 2023 as a follow-up to a previously published review by Khan et al. (2013). We calculated the overall prevalence of dental caries using a meta-analysis to calculate mean dmft/DMFT scores, compared the current caries prevalence to previous meta-analyses, and determined the current course of dental caries in the population.

2. Materials and methods

2.1. Search strategy

A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. A literature search was carried out in January 2023 on the prevalence of dental caries in the primary and permanent dentition among the 2- to 18-year-old Saudi population. The search included all published studies from 2011 until January 2023. The age range for primary teeth was 2 to 12 years, and for the permanent teeth, the range was 6 to 18 years.

The databases were “Web of Science”, “PubMed”, and “Scopus”. The keywords used were “dental caries”, “dmft” and “DMFT”. The initial search uncovered 139 articles, which were further filtered by two independent reviewers. In the first filter, the titles and abstracts of the studies were reviewed, and only original studies reporting caries prevalence in primary and permanent teeth were selected for further screening (Fig. 1).

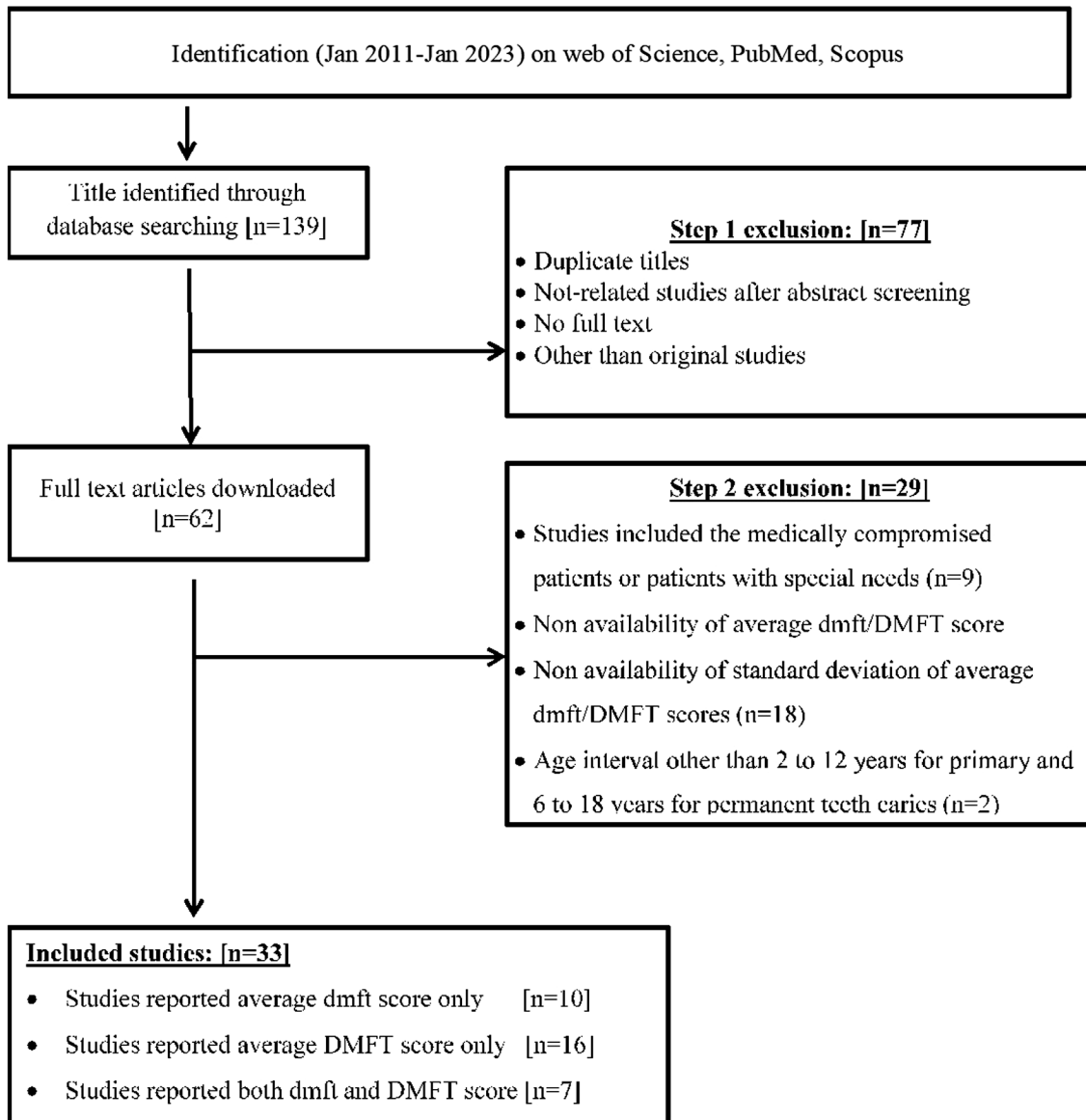


Fig. 1. Study Design.

2.2. Eligibility criteria

A total of 62 studies were identified and passed through the first filter. The full-text articles of these studies were then downloaded, and the following inclusion criteria were applied: the availability of the mean and standard deviation (SD) of dmft/DMFT and the sample size of the study, a participant age interval of 2–18 years, and otherwise healthy patients. Studies that did not report the average dmft/DMFT scores, did not include the SD or sample size, or included patients with comorbidities were excluded. However, articles that included cases and control groups where the control group was healthy were included for analysis.

2.3. Data extraction

Thirty-three articles were included in the final analysis. Data for primary and permanent dentitions was extracted and tabulated in Tables 1 and 2, respectively. Seven articles included both primary and

permanent teeth (Madhan et al., 2021; Aqeeli et al., 2021; Gudipani et al., 2021; Al-Badr et al., 2021; Al-Samadani et al., 2017; Farooqi et al., 2015; Bhayat et al., 2013), while ten studies only reported caries in primary teeth (Alamri et al., 2017; Vanka et al., 2022; AlMarshad et al., 2021a; AlMarshad et al., 2021b; Gudipani et al., 2020; Al-Malik et al., 2019; Alhabdan et al., 2018; Abdallah et al., 2016; Al-Meedani et al., 2016; Alkarimi et al., 2014). Sixteen articles reported caries in permanent teeth (Alsaif et al., 2022; Al-Zahrani et al., 2022; Alghamdi et al., 2022; Gudipani et al., 2022; Alotaibi et al., 2021; Al-Ansari et al., 2020; Abdellatif et al., 2020; Abolfotouh et al., 2020; Basheer et al., 2020; Alshahrani et al., 2018; Aljanakh, 2017; Alkhadra, 2017; Mustafa et al., 2016; Al-Shahrani N et al., 2015; Bhayat et al., 2014; Togoo et al., 2011).

2.4. Statistical analysis

The statistical program Jeffrey's Amazing Statistics Program (JASP 0.17) was used for the analysis. The meta-analysis was performed using

Table 1

Studies and data related to caries in the primary teeth.

Author name, Year	Age	Sample Size	Prevalence Percentage	Mean dmft	SD
Vanka S et al, 2022	3–5	244	57 %	2.51	2.9
Madhan G et al, 2021	7–9	250	80.13 %	4.6	3.67
AlMarshad LK et al, 2021a	3–6	360	36.4 %	4.2	4.1
AlMarshad LK et al, 2021b	3–6	383	72.6 %	4.13	3.9
Aqeeli A et al, 2021	9–12	1000	70.4 %	2.66	2.6
Gudipani R et al, 2021	3–5	83	76.7 %	5.42	3
Al-Badr AH et al, 2021	6–12	209		3.29	0.75
Gudipani R et al, 2020	6–7	248	99.3 %	5.74	3.08
Al-Malik M et al, 2019	6–7	312	88.8 %	5.63	3.8
Alhabdan Y et al, 2018	6–8	578	83 %	4.2	2.96
Alamri AA et al, 2017	6–9	1,844	80.15 %	4.3	3.8
Al-Samadani KH et al, 2017	9–12	276		3.82	3
Abdallah MA et al, 2016	3–6	160		10.33	1.81
Al-Meedani LA, 2016	3–5	269	69 %	3.4	3.6
Farooqi F et al, 2015	6–9	397	78 %	3.66	3.17
Alkarimi HA et al, 2014	6–8	417	89.5 %	5.7	4.2
Bhayat A et al, 2013	6	170	75 %	4.86	4.17
	12	146		1.41	2.56

Table 2

Studies and data related to caries in the permanent teeth.

Author name, Year	Age	Sample Size	Prevalence Percentage	Mean DMFT	SD
Alsaif AA et al, 2022	11–14	99		2.37	2.3
Alghamdi SA et al, 2022	5–14	95	60–85 %	2.9	2.45
Al-Zahrani A et al, 2022	12–15	2262	75 %	4	3.3
Gudipani R et al, 2022	7–9	390	64.4 %	2.75	1.26
Madhan G et al, 2021	10–12	208	52.62 %	1.48	1.93
Alotaibi A et al, 2021	8–12	562		1.87	1.92
Aqeeli A et al, 2021	9–12	1000	56.6 %	1.43	1.7
Gudipani R et al, 2021	6–7	112	36.7 %	0.47	0.78
Al-Badr AH et al, 2021	6–12	209		1.85	0.65
Al-Ansari A et al, 2020	12–15	258	79.8 %	3.55	3.15
Abdellatif H et al, 2020	12–15	2247	83.7 %	5.31	3.8
Abolfotouh MA, 2020	6–12	180		1.8	2.3
Basheer B et al, 2020	6–9	355	82.5 %	1.19	1.43
Alshahrani I et al, 2018	15–17	3411	72.9 %	4.3	5.6
Aljanakh M, 2017	16–18	379	78.9 %	3.49	2.8
Alkhadra T, 2017	12–17	105		8.92	4.02
Al-Samadani KH et al, 2017	9–12	276		1.59	1.7
Mustafa M et al, 2016	15–17	111		3.07	0.87
Al-Shahrani N et al, 2015	9–11	128	66.4 %	5.61	3.01
Farooqi F et al, 2015	10–12	314	68 %	1.94	2
Bhayat A, 2014	12	360	57.2 %	1.53	1.88
Bhayat A et al, 2013	6	171	75 %	0.07	0.34
	12	145		1.31	1.2
Togoo R et al, 2011	7	156	66.4 %	1.88	0.98
	8	254		2.48	1.29
	9	215		2.88	1.05
	10	211		3.04	1.12

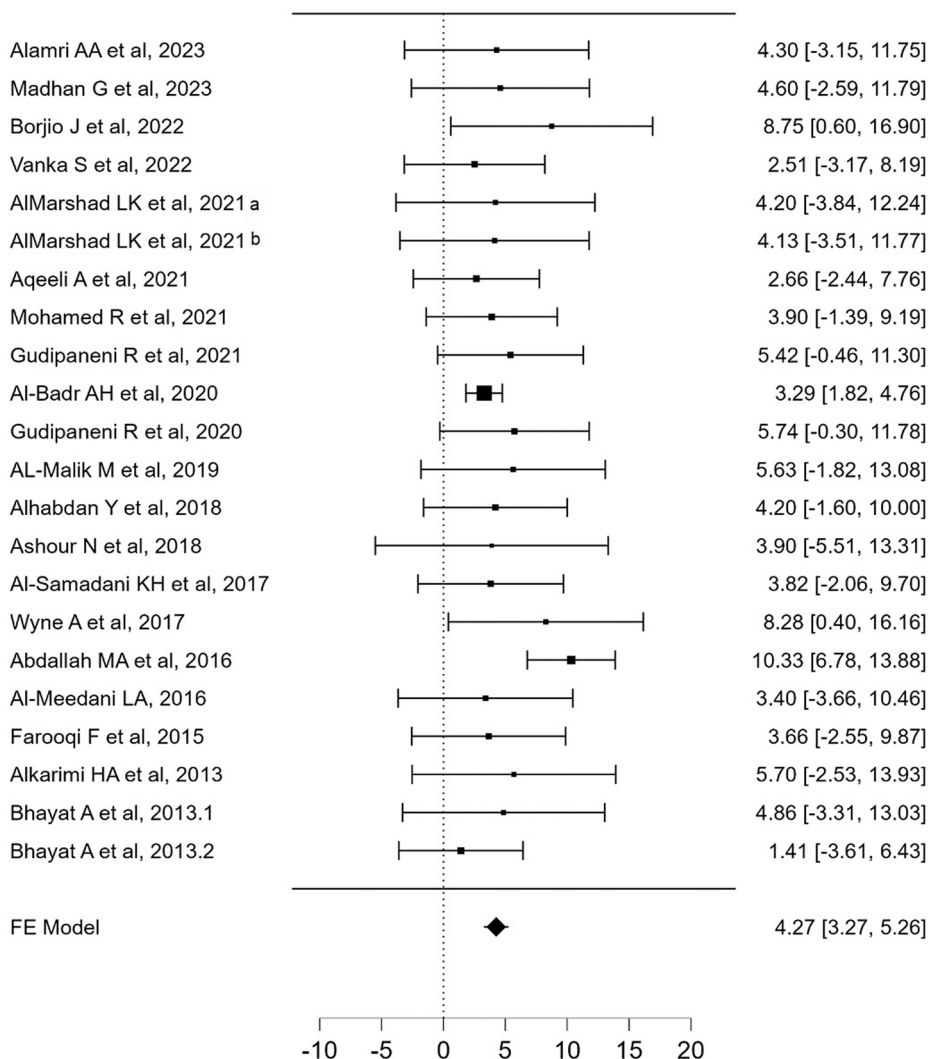


Fig. 2. Effect estimates for caries prevalence in primary dentition.

either a random- or fixed-effect model. The random-effect model was used if heterogeneity was present in the data. In the absence of heterogeneity, a fixed-effect model was used.

3. Results

3.1. Primary teeth

Seventeen studies reported caries in the primary teeth and were included in the meta-analysis. The sum of the sample sizes was 7,775. Of these studies, 14 reported the prevalence of caries in the primary teeth, which was 75.43 % (range 36.4 % to 99.3 %).

A heterogeneity test was run before constructing a forest plot. The test ($P = 0.551$) and the index of heterogeneity (20.94 %) were not significant, suggesting an absence of heterogeneity in the data. Therefore, the fixed-effect model was used when constructing a forest plot (Fig. 2). The estimated caries prevalence (dmft) in the primary dentition of 2 to 12-year-olds was 4.14 (95 % confidence interval (CI): 3.11–5.18). A funnel plot was also constructed to study publication bias. Visual inspection of the funnel plot revealed a symmetrical arrangement of data points, suggesting an absence of publication bias (Fig. 3). Egger’s test was then applied to test the symmetry of the funnel plot, which was not.

3.2. Permanent teeth

Twenty-three studies reported caries in the permanent dentition and were included in the meta-analysis. The total sample size of these studies was 14,213. Sixteen studies reported the percentage of the sampled population with carious teeth, with an average caries prevalence of 67.7 % (range 36.7 % to 83.7 %).

A heterogeneity test was run before constructing a forest plot. The test of heterogeneity ($P = 0.134$) and index of heterogeneity (32.2 %) were not significant. Therefore, a fixed-effect model was used when constructing the forest plot (Fig. 4). The estimated caries prevalence (DMFT) among 6 to 18-year-olds was 1.28 (95 % CI: 0.93–1.64). A funnel plot was constructed to estimate the publication bias. Visual inspection of the plot showed an asymmetrical arrangement of data points suggestive of publication bias (Fig. 5). To further test the symmetry of the funnel plot, Egger’s test was used. The results were significant ($p < 0.001$), supporting the presence of publication bias.

4. Discussion

Assessing the prevalence of dental caries over time is critical, as this can clarify the causes of dental caries and methods for its prevention. Various measures have been undertaken to reduce the occurrence of dental caries in the KSA. In early 2007, the Saudi Arabian Standard Organization implemented the recommendations of the Ministry of

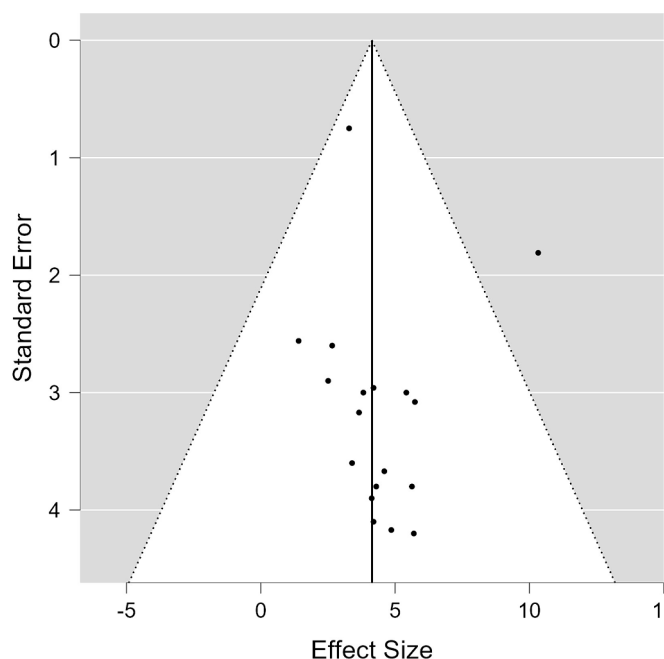


Fig. 3. Visual inspection of publication bias in the primary dentition studies.

Health concerning fluoride ion concentrations in water networks that aimed to decrease the caries prevalence from 90 % to 50 %–60 % (Adam et al., 2022; Khan, 2014). Therefore, this meta-analysis was designed to assess the effectiveness of measures taken to reduce the incidence of caries between 2011 and 2023 in the KSA and to function as a continuation/extension of previous studies (Al Agili, 2013; Khan et al., 2013; Khan, 2014). Compared to the previously published meta-analysis by

Khan et al. (2013), the results of this meta-analysis revealed a decrease in mean dmft/DMFT scores.

The articles included in this meta-analysis exhibited no heterogeneity, with indices of 20.94 % and 32.2 % for both the primary and permanent dentitions, respectively. Hence, there was no significant variation in the outcome of the studies in terms of dmft/DMFT scores. These findings are in contrast to previous reviews (Alshammari et al.,

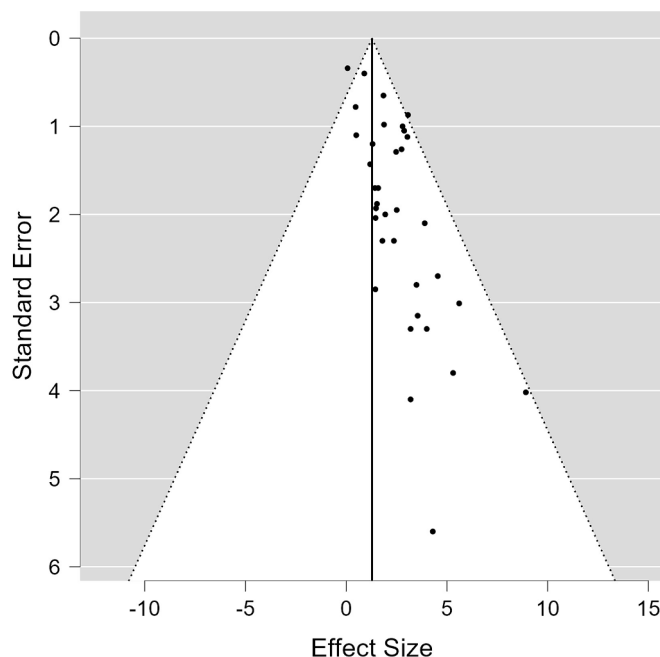


Fig. 5. Visual inspection of publication bias in the permanent dentition studies.

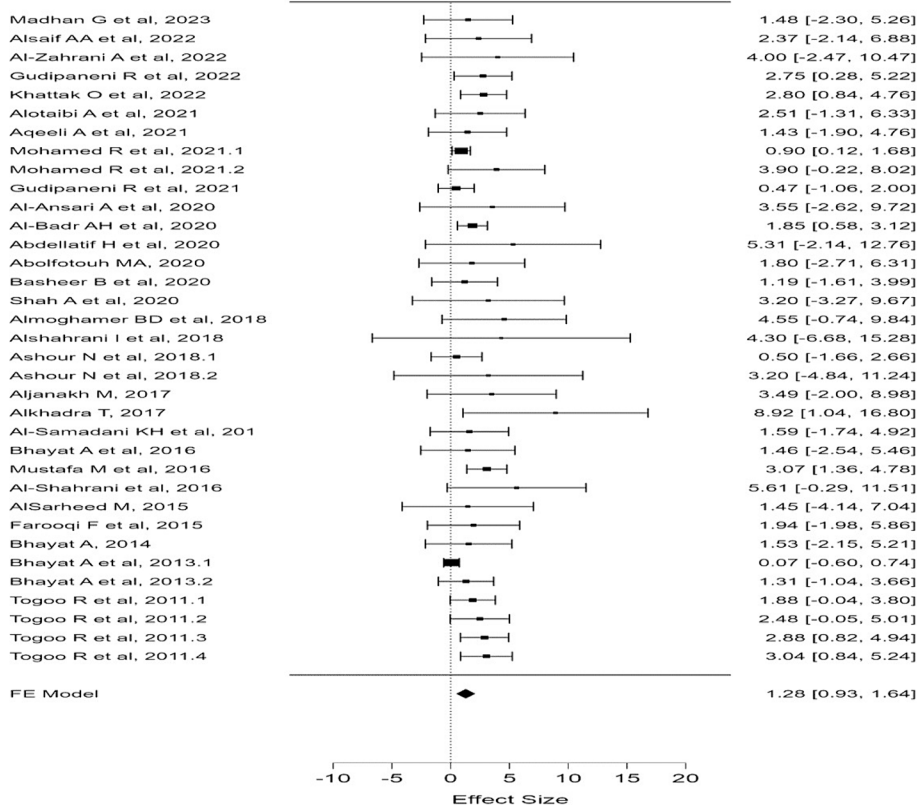


Fig. 4. Effect estimates for caries prevalence in permanent dentition.

2021; Khan, 2014) that reported high study heterogeneity, which was attributed to varying methodologies with different sample sizes and participants.

Alhabdan et al. (2018) found that the prevalence of caries was high among children. This was also reported by Al-Ansari et al. (2014). This high prevalence was in contrast to efforts to decrease caries prevalence between 1985 and 2010. More recently, Al-Rafee et al. (2019) found a caries prevalence of 86 % in primary teeth, which is higher than the results in the present study. In a 2009 study conducted in Jeddah, an 83.5 % caries prevalence was reported by Qutob (2009), while a systematic review conducted by Adam et al. (2022) estimated the prevalence of dental caries among 5–7 year-old and 12–15 year-old children to be 84 % and 74 %, respectively. In contrast, a study by Al-Shahrani et al. (2015) reported a low caries prevalence of 66 % in the 9–11 age group.

According to the findings of the present review, the average prevalence of primary teeth caries was 75.43 % based on 14 studies. This is in agreement with Farooqi et al. (2015), who found the caries prevalence to be approximately 78 % in children between the ages of 6 and 12 years. While the studies mentioned previously reported different levels of caries prevalence in primary teeth (ranging from 66 % to 86 %), the overall prevalence was high, suggesting a need to focus on factors associated with the causes of tooth decay.

For permanent teeth, the average prevalence of dental caries was 67.7 %. This is similar to previous studies by Al-Rafee et al. (2019) and Alayyan (2017), who found the prevalence of dental caries in permanent teeth to be 65 % and 64 %, respectively. Similarly, in 2019, a study conducted in Riyadh by Al-Rafee et al. showed that caries prevalence in permanent teeth was 65 %. These results are in contrast to a previous review that reported a high prevalence of dental caries at 72 % (Adam et al., 2022). Although, this difference is likely related to the participants' age in the Adam et al. study, which investigated the permanent teeth of 12–15 children. In 2021, Alshammari et al. reported that the prevalence of caries in permanent teeth for the entire Saudi Arabian population was 72 %. Al-Ansari et al. (2014) also reported an increase in caries prevalence, which was consistent with previous findings. These variations in prevalence may be attributed to methodological differences and time periods. In the present study, the period from 2013 to 2023 may be associated with a positive effect of different awareness in adults. However, the current percentage (67.81 %) is still below the value needed to meet the global goal for dental caries prevalence.

In the present review, the estimated dmft in primary teeth was 4.14 (95 % CI: 3.11–5.18) and in the permanent teeth it was 1.28 (95 % CI: 0.93–1.64). Alaki et al. (2013) reported a dmft of 8.96 with asthma and 8.03 without asthma. For DMFT, the values were 2.16 with asthma and 1.96 without asthma. In Khan et al. (2013), their review was conducted from 1999 to 2008 and reported a dmft of 5.38 (95 % CI: 4.314–6.436) and a DMFT of 3.34 (95 % CI: 1.97–4.75). In Saudi Arabia, multiple studies have been conducted that measure the prevalence of dental caries, and the primary dentition frequently has a higher prevalence of dental caries than the permanent dentition. Al Agili et al. (2013) measured the prevalence of dental caries in Saudi Arabia between 1988 and 2010 and found that 70 % of children in primary schools had caries in their permanent dentition, while 80 % had them in their primary dentition. Similarly, Al-Ansari et al. (2014) found that the mean dmft in primary dentition was 7.34, while the mean DMFT in the permanent dentition of adults was 7.35.

According to national data from 2010, the frequency of caries among children was 74 % in primary teeth and 59.80 % in permanent teeth (AlDosari et al., 2010). The percentage of caries found in the different reviews indicates that, while there appears to be a decline in the general prevalence compared to earlier national surveys, the changes are not as pronounced as in other developed nations (Togoo et al., 2012). This is most likely due to the nature of dental caries. Several factors contribute to the rise in dental caries, including a lack of awareness, poor oral hygiene, a lack of preventative dental care, and under-utilization of

dental services (Al-Rafee et al., 2019; Togoo et al., 2012). However, the high heterogeneity between studies requires caution and limits the generalizability of the findings (Adam et al., 2021).

One strength of the current review is the low heterogeneity between the studies included for analysis. However, there were some limitations. The included studies had limitations affecting the overall findings regardless of other correlated factors such as sugar consumption, parents' awareness, systemic conditions, urban participants, different ages, and different caries experiences between school children. In addition, certain demographics were targeted in the studies, such as individuals with specific medical issues such as a cleft lip and palate, blindness, deafness, mental disorders, children with cerebral palsy, orphans, and participants with asthma. Moreover, techniques used for the detection of caries prevalence (tactile or visual) were not included in the present study. Inclusion of the type of technique could have effect on the reported caries prevalence. Therefore, future analyses should focus on participants' ages and factors, including location and medical condition, and how they are correlated with prevention measurements such as school programs, continuous education, and water networks to decrease the prevalence of dental caries.

5. Conclusion

The average dmft/DMFT scores decreased in primary and permanent dentitions compared to a previously published meta-analysis in 2013. This suggests that preventative measures have positively affected caries prevalence within the last ten years in the KSA. However, preventive measures should be either enhanced or maintained to reduce caries prevalence to a minimal level.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sector.

Ethical statement

Ethical approval was not required for this study.

CRediT authorship contribution statement

Soban Qadir Khan: Conceptualization, Methodology, Formal analysis, Project administration, Writing – review & editing. **Haneen A. Alzayer:** Conceptualization, Methodology. **Shahad T. Alameer:** Methodology, Data curation. **Muhammad Ajmal Khan:** Methodology, Writing – original draft. **Nazeer Khan:** Investigation, Writing – original draft. **Haitham AlQuorain:** Investigation, Writing – review & editing. **Mohammed M. Gad:** Methodology, Formal analysis, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Abdallah, M.A., Abed, H.H., Hamza, G., Alshahafi, E.N., 2016. The association between dmft index and haemoglobin levels in 3–6 year-old Saudi children with anaemia: A cross sectional study. *J. Taibah Univ. Med. Sci.* 11 (1), 72–76.
- Abdellatif, H., Hebbal, M.I., 2020. Dental caries and its association with body mass index among school children of Riyadh, Saudi Arabia. *J. Pharm. Bioallied Sci.* 12 (Suppl 1), S176.
- Abolfotouh, M., Alhumaidan, G., Almalki, B., Alhasson, A., Bushnak, I., Adlan, A., 2020. Predictors of dental general anesthesia receipt among children attending a tertiary hospital in Saudi Arabia. *Ibnosina J. Med. Biomed. Sci.* 12 (04), 288–294.

- Adam, T.R., Al-Sharif, A.I., Tonouhewa, A., AlKheraif, A.A., 2022. Prevalence of Caries among School Children in Saudi Arabia: A Meta-Analysis. *Adv. Prev. Med.* 2022, 7132681.
- Al Agili, D.E., 2013. A systematic review of population-based dental caries studies among children in Saudi Arabia. *Saudi Dent. J.* 25 (1), 3–11.
- Alaki SM, Ashiry EA, Bakry NS, Baghlaf KK, Bagher SM. The effects of asthma and asthma medication on dental caries and salivary characteristics in children. *Oral health Prev. Dentist.* 2013 Jun 1;11(2).
- Alamri, A.A., Aldossary, M.S., Alshiha, S.A., Alwayli, H.M., Alfraih, Y.K., Hattan, M.A., 2017. Dental caries prevalence among primary male schoolchildren in Riyadh, Saudi Arabia: A cross-sectional survey. *Journal of International Oral Health.* 9 (4), 146.
- Al-Ansari, A.A., 2014. Prevalence, severity, and secular trends of dental caries among various Saudi populations: a literature review. *Saudi J. Med. Med. Sci.* 2 (3), 142–150.
- Al-Ansari, A., Nazir, M., 2020. Relationship between obesity and dental caries in Saudi male adolescents. *Int J Dent.* 2020, 8811974.
- Alayyan, W., Al Halabi, M., Hussein, I., Khamis, A., Kowash, M., 2017. A systematic review and meta-analysis of school children's caries studies in gulf cooperation council states. *J. Int. Soc. Prev. Commun. Dentist.* 7 (5), 234.
- Al-Badr, A.H., AlJameel, A.H., Halawany, H.S., Al-Jazairy, Y.H., Alhadlaq, M.K., Al-Maflehi, N.S., Al-Sharif, J.A., Jacob, V., Abraham, N., 2021. Dental caries prevalence among Type 1 diabetes mellitus (T1DM) 6- to 12-year-old children in Riyadh, Kingdom of Saudi Arabia compared to non-diabetic children. *Saudi Dent J.* 33 (5), 276–282.
- AlDosari, A.M., Akpata, E.S., Khan, N., 2010. Associations among dental caries experience, fluorosis, and fluoride exposure from drinking water sources in Saudi Arabia. *J. Public Health Dent.* 70 (3), 220–226.
- Alghamdi, S.A., Aljohar, A., Almulhim, B., Allassaf, A., Bhardwaj, S.S., Thomas, J.T., Almalki, A., Aljuaid, A.O., Mallineni, S.K., 2022 Jul 8. Correlation between BMI and oral health status (DMFT, PI, mSBI, and Salivary 1,5-AG) among the Pediatric population in Saudi Arabia: a clinico-biochemical study. *Children (basel).* 9 (7), 1017.
- Alhabdan, Y.A., Albeshr, A.G., Yenugadhari, N., Jradi, H., 2018. Prevalence of dental caries and associated factors among primary school children: a population-based cross-sectional study in Riyadh, Saudi Arabia. *Environ. Health Prev. Med.* 23 (1), 60.
- Aljanakh, M., 2017. Prevalence and severity of dental caries among public school students aged 16–18 in Hai'l, Kingdom of Saudi Arabia. *Int. J. Health Sci.* 11 (3), 50.
- Alkarimi, H.A., Watt, R.G., Pikhart, H., Sheiham, A., Tsakos, G., 2014. Dental caries and growth in school-age children. *Pediatrics* 133 (3), e616–e623.
- Alkhadra, T., 2017. Prevalence of dental caries and oral hygiene status among juvenile prisoners in the kingdom of Saudi Arabia. *J. Contemp. Dent. Pract.* 18 (11), 991–995.
- Al-Malik, M., AlKattan, H., AlBukhari, L., El Meligy, O., 2019. Assessment of Dental Decay in a Group of Children in Jeddah, Kingdom of Saudi Arabia. *Int. J. Clin. Pediatr. Dent.* 12 (5), 423–428.
- AlMarshad, L.K., AlJobair, A.M., Al-Anazi, M.R., Bohol, M.F.F., Wyne, A.H., Al-Qahtani, A.A., 2021a. Association of polymorphisms in genes involved in enamel formation, taste preference and immune response with early childhood caries in Saudi pre-school children. *Saudi J. Biol. Sci.* 28 (4), 2388–2395.
- AlMarshad, L.K., Wyne, A.H., AlJobair, A.M., 2021b. Early childhood caries prevalence and associated risk factors among Saudi preschool children in Riyadh. *Saudi Dent J.* 33 (8), 1084–1090.
- Al-Meedani, L.A., Al-Dlaigan, Y.H., 2016. Prevalence of dental caries and associated social risk factors among preschool children in Riyadh, Saudi Arabia. *Pakistan J. Medi. Sci.* 32 (2), 452.
- Alotaibi, A., Alzaid, A., Alenezi, K., Anil, S., 2021. Association between dental caries and body mass index in 8–12-year-old school children. *Int. J. Dentistry Oral Sci.* 8 (1), 1030–1034.
- Al-Rafee, M.A., AlShammery, A.R., AlRumikan, A.S., Pani, S.C., 2019. A comparison of dental caries in urban and rural children of the Riyadh region of Saudi Arabia. *Front. Public Health* 7, 195.
- Alsaiif, A.A., Alkhadra, T.A., AlJameel, A.H., 2022. Impact of DMFT, PUFA, DAI, and TDIs on oral health-related quality of life (OHRQoL) among founding, delinquent, and mainstream school children: a preliminary study. *Front. Public Health* 10, 894638.
- Al-Samadani, K.H., Ahmad, M.S., Bakeer, H.A., Elanbya, M.O., 2017. Oral health knowledge and practice among 9–12-year-old schoolchildren in the region of Madinah, Saudi Arabia, and its impact on the prevalence of dental caries. *Europ. J. General Dentistry.* 6 (01), 54–58.
- Al-Shahrani, N., Al-Amri, A., Hegazi, F., Al-Rowis, K., Al-Madani, A., Hassan, K.S., 2015. The prevalence of premature loss of primary teeth and its impact on malocclusion in the Eastern Province of Saudi Arabia. *Acta Odontol. Scand.* 73 (7), 544–549.
- Alshahrani, I., Tikare, S., Meer, Z., Mustafa, A., Abdulwahab, M., Sadatullah, S., 2018. Prevalence of dental caries among male students aged 15–17 years in southern Asir Saudi Arabia. *Saudi Dental J.* 30 (3), 214–218.
- Alshammari, F.R., Alamri, H., Aljohani, M., Sabbah, W., O'Malley, L., Glenny, A.M., 2021. Dental caries in Saudi Arabia: A systematic review. *J. Taibah Univ. Med. Sci.* 16 (5), 643–656.
- Al-Zahrani, A., Al-Qahtani, M., Al-Barti, M., Bakhurji, E.A., 2022. Dietary determinants of dental caries prevalence and experience in Saudi schoolchildren: Frequency versus quantity. *Sci. World J.* 5447723.
- Aqeeli, A., Alsharif, A.T., Kruger, E., Tennant, M., Bakeer, H., 2021. Caries prevalence and severity in association with sociodemographic characteristics of 9-to-12-year-old school children in Al-Madinah Saudi Arabia. *Saudi Dent. J.* 33 (8), 897–903.
- Basheer, B., Aloufi, S., Almeshrafi, A., Alkubedan, N., Aldalaan, K., Alobathani, A., Alhamed, A., Alsaf, F., Alshahrani, N., Alshehri, R., 2020. Oral hygiene practices, dietary habits and dental caries experience among primary children in Riyadh, Saudi Arabia: a cross-sectional study. *Med. Sci.* 24 (102), 960–967.
- Bhayat, A., Ahmad, M.S., Hifnawy, T., Mahrous, M.S., Al-Shorman, H., Abu-Naba'a, L., Bakeer, H., 2013. Correlating dental caries with oral bacteria and the buffering capacity of saliva in children in Madinah, Saudi Arabia. *J. Int. Soc. Prev. Community Dent.* 3 (1), 38–43.
- Bhayat, A., Ahmad, M.S., 2014. Oral health status of 12-year-old male schoolchildren in Medina Saudi Arabia. *East Mediterr. Health J.* 20 (11), 732–737.
- Bödecker, C.F., Bödecker, H.W.C., 1931. A practical index of the varying susceptibility to dental caries in man. *Dent. Cosmos* 77, 707–716.
- Elamin, A., Garemo, M., Mulder, A., 2021. Determinants of dental caries in children in the Middle East and North Africa region: a systematic review based on literature published from 2000 to 2019. *BMC Oral Health* 21 (1), 1–30.
- Farooqi, F.A., Khabeer, A., Moheet, I.A., Khan, S.Q., Farooq, I., ArRejaie, A.S., 2015. Prevalence of dental caries in primary and permanent teeth and its relation with tooth brushing habits among schoolchildren in Eastern Saudi Arabia. *Saudi Med. J.* 36 (6), 737–742.
- Gudipani, R.K., Patil, S.R., Ganji, K., Yadiki, J.V., Assiry, A., Alam, M.K., 2020. Clinical Consequences of Untreated Dental Caries among Primary School Children: A Cross-Sectional Study. *Pesqui Bras. Odontopediatria Clin. Integr.* 20, e4791.
- Gudipani, R.K., Albilasi, R.M., Alrewili, O.H., Alam, M.K., Patil, S.R., Saeed, F., 2021. Association of body mass index and waist circumference with dental caries and consequences of untreated dental caries among 12- to 14-year-old boys: a cross-sectional study. *Int. Dent. J.* 71 (6), 522–529.
- Gudipani, R.K., Alkuwaykibi, A.S., Ganji, K.K., Bandela, V., Karobari, M.I., Hsiao, C.Y., Kulkarni, S., Thambar, S., 2022. Assessment of caries diagnostic thresholds of DMFT, ICDAS II and CAST in the estimation of caries prevalence rate in first permanent molars in early permanent dentition—a cross-sectional study. *BMC Oral Health* 22 (1), 133.
- Kale, S., Kakodkar, P., Shetiya, S., 2020. Prevalence of dental caries among children aged 5–15 years from 9 countries in the Eastern Mediterranean Region: a meta-analysis. *East Mediterr. Health J.* 26 (6), 726–735.
- Khan, S.Q., 2014. Dental caries in Arab League countries: a systematic review and meta-analysis. *Int. Dent. J.* 64 (4), 173–180.
- Khan, S.Q., Khan, N.B., ArRejaie, A.S., 2013. Dental caries: A meta-analysis on Saudi population. *Saudi Med. J.* 34 (7), 744–749.
- Madhan, G., Togoo, R., Abumelha, M., AlJahdal, M., Alkahtani, Z., Ain, T., 2021. Intelligence quotient and dental caries: an analytical cross-sectional study among Saudi Arabian children. *Nigerian J. Basic Clin. Sci.* 18 (2), 134–139.
- Mustafa, M., AlJeaifi, Z., AlAjajam, W.H., Dafaalla Mohammed, K.A., 2016. Study of caries prevalence among miswak and non-miswak users: a prospective study. *J. Contemp. Dent. Pract.* 17 (11), 926–929.
- Togoo, R.A., Yaseen, S.M., Khoraj, A.L., Meer, A., 2011. Prevalence of first permanent molar caries among 7–10 years old school going boys in Abha city. *Saudi Arabia.* 3 (5), 29.
- Togoo, R.A., Al-Rafee, M.A., Kandyala, R., Luqam, M., Al-Bulowey, M.A., 2012. Dentists' opinion and knowledge about preventive dental care in Saudi Arabia: a nationwide cross-sectional study. *J. Contemp. Dent. Pract.* 13 (3), 261–265.
- Vanka, S., Vanka, A., Wali, O., Chauhan, N.S., Alhazmi, L.S., Alqazlan, A.A., 2022. Prevalence of early childhood caries among the 3-5-year-old children in Jeddah, Saudi Arabia. *Int. J. Clin. Pediatr. Dentistry.* 15 (Suppl 2), S197.