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Dental caries in primary and permanent teeth in children's worldwide, 1995 to 2019: a systematic review and meta-analysis

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Abstract

Background: Early childhood caries (ECC) is a type of dental caries in the teeth of infants and children that is represented as one of the most prevalent dental problems in this period. Various studies have reported different types of prevalence of dental caries in primary and permanent teeth in children worldwide. However, there has been no comprehensive study to summarize the results of these studies in general, so this study aimed to determine the prevalence of dental caries in primary and permanent teeth in children in different continents of the world during a systematic review and meta-analysis.

Methods: In this review study, articles were extracted by searching in the national and international databases of SID, MagIran, IranMedex, IranDoc, Cochrane, Embase, ScienceDirect, Scopus, PubMed, and Web of Science (ISI) between 1995 and December 2019. Random effects model was used for analysis and heterogeneity of studies was evaluated by using the I^2 index. Data were analyzed by using the Comprehensive Meta-Analysis (Version 2) software.

Findings: In this study, a total of 164 articles (81 articles on the prevalence of dental caries in primary teeth and 83 articles on the prevalence of dental caries in permanent teeth) were entered the meta-analysis. The prevalence of dental caries in primary teeth in children in the world with a sample size of 80,405 was 46.2% (95% CI: 41.6–50.8%), and the prevalence of dental caries in permanent teeth in children in the world with a sample size of 1,454,871 was 53.8% (95% CI: 50–57.5%). Regarding the heterogeneity on the basis of meta-regression analysis, there was a significant difference in the prevalence of dental caries in primary and permanent teeth in children in different continents of the world. With increasing the sample size and the year of study, dental caries in primary teeth increased and in permanent teeth decreased.

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Conclusion: The results of this study showed that the prevalence of primary and permanent dental caries in children in the world was found to be high. Therefore, appropriate strategies should be implemented to improve the aforementioned situation and to troubleshoot and monitor at all levels by providing feedback to hospitals.

Keywords: Caries, Tooth, Primary and permanent, Prevalence, Meta-analysis

Background

Early childhood caries (ECC) is a type of dental caries in the teeth of infants and children that is represented as one of the most prevalent dental problems in this period [1] which can lead to pain, infection, interference with eating, increased risk of new dental caries in primary and permanent teeth, and, ultimately, worse effects on the eruption of permanent teeth [2]. These manifestations can range from demineralization to loss of tooth structure or complete destruction of the crown, a process of dynamic and active decay characterized by various periods of destruction and repair [3].

According to the American Academy of Dentistry, early childhood caries (ECC) is defined as "the presence of 1 or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth" in children [1]. Overall, 50% of children have one or more decayed primary teeth by the end of toddler age, but the importance of these teeth should not be overlooked, because, as has been said, healthy teeth in childhood have an important role in the eruption of healthy permanent teeth, healthy nutrition, and one's aesthetic appearance [2, 3]. Factors such as malnutrition, genetic predisposition, poor health performance, specific eating habits, the presence of organisms affecting tooth decay such as streptococci, and fluoride and vitamin D deficiency, excessive sugar consumption and prolonged bottle-feeding, and other factors such as age, gender and place of residence of children are effective in causing tooth decay [4].

The World Health Organization (WHO) has represented the early childhood caries as a worldwide problem with a prevalence of between 60 and 90% [5]. According to the statistics provided by the European countries, 61% of children aged 6 to 12 years have at least one decayed tooth, and due to widespread dental caries in all social classes, this disease can impose a great financial burden on the society [6]. In Iran the mean decay-missing-filled (DMF) index of primary teeth in children aged 3 to 6 years was 1.7 and DMF index of permanent teeth was reported to be 0.2 in 6- to 9-year-old children, 0.9 to 1.5 in 12-year-old children, and 3.3 to 4.8 in 9-year-old children [7]. The decay-missing-filled (DMF) index is used as an appropriate measure for the detection of dental caries in the society in which 12-year-old children are considered as a target group [8].

Primary teeth begin to erupt in infants' mouths at about 6 months of age, and are completed at age 3 to 5, including 10 teeth in the maxilla and 10 in the mandible to meet nutritional needs in infancy [6]. Since primary teeth are the basis of permanent teeth, on the one hand, and they have a high susceptibility to caries, on the other hand, these teeth are very important and maintaining their health is considered a serious health concern for children [3, 9].

Due to the influence of different factors on the prevalence of primary and permanent dental caries in children and lack of general statistics about this issue worldwide, we decided to review the studies in this area and to statistically analyze the results of these studies to compile a general statistics on the prevalence of dental caries in primary and permanent teeth in children in different continents of the world to open a window to more precise planning to reduce the complications of primary and permanent dental caries in children.

Methods

In this systematic review and meta-analysis, the prevalence of dental caries in primary and permanent teeth in children was evaluated based on studies conducted between 1995 and December 2019. To this end, articles published in the national databases of SID, MagIran, IranMedex, and IranDoc, and in the international databases of Google scholar, Cochrane, Embase, ScienceDirect, Scopus, PubMed, and Web of Science (ISI) were searched by using Persian and English keywords such as Prevalence, Caries, Rampant caries, Milky tooth, Permanent tooth and Children.

Selection of studies

Initially, all articles referring to the prevalence of dental caries in primary and permanent teeth in children in the world were collected by the researchers and accepted based on the inclusion and exclusion criteria. The inclusion criteria were observational (non-interventional) studies and their full text availability. For more information, the sources of the articles reviewed were also reviewed for access to other articles.

Exclusion criteria included irrelevant cases, case reports, interventional studies and other review, case-control, cohort, duplication of studies, unclear methodology, and full text unavailability. In order to reduce bias, the articles were searched independently by two researchers, and if they disagreed on a study, the article was reviewed by the group supervisor (blinded about the decision by the first two independent researchers' decision). A total of 180 studies entered the third stage, quality assessment.

Duplicate publication and multiple publications from the same population will be removed using citation management, software EndNote (version X7, for Windows, Thomson Reuters).

Quality assessment of studies

The quality of the articles was first evaluated on the basis of selected and related items of the 22- item STROBE checklist that could be evaluated in this study (study design, background and literature review, place and time of study, outcome, inclusion criteria, sample size, and statistical analysis) and also mentioned in the previous studies. Articles referring to 6 to 7 criteria were considered as high quality articles, articles that did not mention 2 items and more than 2 items from the seven items were considered as medium and low methodological quality articles, respectively [10]. In the present study, 164 articles with high quality and medium quality were entered the systematic review and meta-analysis, and 16 articles were of poor quality and were excluded.

Data extraction

All final articles entered into the meta-analysis process were prepared to be extracted by a pre-prepared checklist. The checklist included article title, first author's name, year of publication, place of study, sample size, mean age of sample, prevalence of dental caries in primary and permanent teeth.

Statistical analysis

Since prevalence has binomial distribution, prevalence variance was calculated using the binomial distribution variance formula, and weighted mean was used to combine the prevalence rate of different studies. In order to evaluate the heterogeneity of the selected studies, I^2 test was used (heterogeneity was divided into three classes of less than 25% (low heterogeneity), 25–75% (moderate heterogeneity) and more than 75% (high heterogeneity). Meta-regression analysis was used to investigate the relationship between the prevalence of dental caries with the sample size and the year of study. In order to evaluate the publication error with respect to the large sample size of studies entered the review, the Begg and Mazumdar test at the significant level of 0.1 and its corresponding Funnel plot were used. Sensitivity analysis was used to evaluate the effect of individual studies on the final result. Data were analyzed by using the Comprehensive Meta-Analysis (Version 2) software.

Results

In this study, all studies conducted on the prevalence of primary and permanent dental caries in children in the world were systematically investigated without time limitation based on the PRISMA guidelines. In the initial search, 2870 articles were identified, form which 164 studies published between 1995 and December 2019 were eventually entered the final analysis (Fig. 1).

The total sample size for the prevalence of primary dental caries was 80,405 and for the prevalence of permanent dental caries was 1,454,871, given with the mean age of the subjects in each study. The specifications of the selected articles are presented in Tables 1 and 2.

Heterogeneity and publication bias

Based on the results of the heterogeneity evaluation test (I^2), the prevalence of dental caries in primary and permanent teeth was reported to be I^2: 99.2 and I2: 99.8, respectively. Due to the heterogeneity of the selected studies, a random effects model was used to combine the studies and jointly estimate the prevalence of dental caries in primary and permanent teeth. The probability of publication bias was evaluated by the Funnel plot and the Begg and Mazumdar tests at a significant level of 0.1 (Figs. 2 and 3), indicating that the publication bias was not statistically significant in the investigation of the prevalence of primary dental caries ($P = 0.590$) and permanent dental caries ($P = 0.145$).

Meta-analysis (primary dental caries)

According to the results of the study in forest plot, the overall prevalence of dental caries in primary teeth in children in the world was 46.2% (95% CI: 41.6–50.8%) (Fig. 4). The middle point of each line shows the prevalence of primary dental caries in the world for each study, and the rhombic figure shows the prevalence of primary dental caries in the world for all studies.

Meta-analysis (permanent dental caries)

According to the results of the study in forest plot, the overall prevalence of dental caries in permanent teeth in children in the world was 53.8% (95% CI: 50–57.5%) (Fig. 5). The middle point of each line

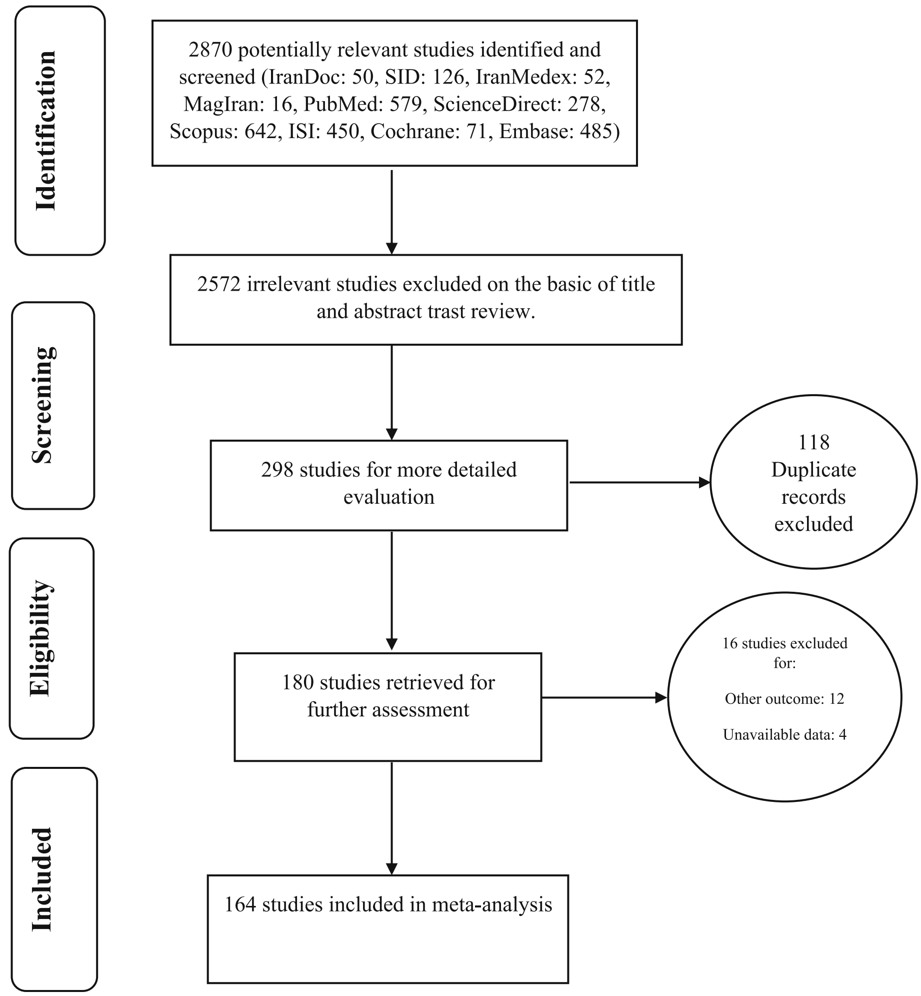


Fig. 1 Flow diagram of study selection

shows the prevalence of permanent dental caries in the world for each study, and the rhombic figure shows the prevalence of permanent dental caries in the world for all studies.

Meta-regression

The prevalence of primary dental caries was evaluated by meta-regression analysis based on the year of study and the sample size, which reported that with increasing the year of study and the sample size, the prevalence of dental caries in primary teeth increased in both cases and the difference was statistically significant ($P < 0.01$) (Figs. 6 and 7).

The prevalence of permanent dental caries was evaluated based on the year of study and the sample size, which reported that with increasing the year of study and the sample size, the prevalence of dental caries in permanent teeth decreased in both cases and the difference was statistically significant ($P < 0.01$) (Figs. 8 and 9).

Sub-group analysis

Also, Table 3 and Fig. 10 report the results of the prevalence of dental caries in primary and permanent teeth in children in different continents. These changes were reported in the continents of Asia, Europe, Africa, USA, and Australia, according to which 100 Asian studies (50 studies on the prevalence of dental caries in primary teeth and 50 studies on the prevalence of dental caries in permanent teeth), 32 European studies (10 studies on the prevalence of dental caries in primary teeth and 22 studies on the prevalence of dental caries in permanent teeth), 21 American studies (14 studies on the prevalence of dental caries in primary teeth and 7 studies on the prevalence of dental caries in permanent teeth), 10 African studies (5 studies on the prevalence of dental

Table 1 Characteristic of included studies prevalence of tooth decay

Author, year, Reference	Age (years)	Country	Sample size	Prevalence %	Quality
Kalantari, 2014, [11]	6–7	Iran	400	63.5	High
Abedini, 2013, [12]	2–6	Iran	310	48.7	High
Hematyar, 2009, [13]	3–7	Iran	200	63.5	High
Nabipour, 2013, [14]	3–6	Iran	838	71.8	High
Pahlavani, 2008, [15]	2–6	Iran	414	61.6	High
Amiri, 2017, [16]	4–6	Iran	359	87.7	High
Ajami, 2005, [17]	6–7	Iran	1938	76.5	High
Javadinezhad, 2008, [18]	40.5 Month	Iran	100	77.0	High
Karimi, 2012, [19]	2–5	Iran	211	82.9	High
Amanlou, 2011, [20]	3–6	Iran	205	49.3	High
Toutouni, 2015, [21]	2–3	Iran	239	61.1	High
Bagherian, 2013, [22]	2–5	Iran	400	51.3	Medium
Mohebbi, 2006, [23]	1–3	Iran	504	32.9	High
Ramos-Gomez, 1995, [24]	<6	USA	220	30.0	High
Rosenblatt, 2002, [25]	1–3	USA	468	28.4	High
Rajab, 2001, [26]	1–5	Jordan	384	47.9	High
Douglass, 1999, [27]	3–4	USA	517	37.9	High
Hallett, 1998, [28]	4–6	Australia	3375	37.6	High
Sayegh, 2002, [29]	4–5	Jordan	1140	67.0	Medium
Hallett, 2003, [30]	4–5	Australia	2474	37.6	High
Peressini, 2000, [31]	3–5	Canada	87	19.5	High
Chadwick, 2005, [32]	2–5	UK	449	24.1	High
Schroth, 2015, [33]	<6	Canada	408	53.7	High
Tsai, 1997, [34]	<6	Taiwan	951	55.9	Medium
Mahejabeen, 2006, [35]	3–5	India	1500	54.1	Medium
Du, 2002, [36]	3–5	China	2014	55.3	High
Ferro, 2005, [37]	3–5	Italy	4198	25.0	High
Schroth, 2004, [38]	1–5	USA	834	71.0	Medium
Wyne, 2008, [39]	3–5	Saludi Arabia	789	74.8	High
Lawrence, 2004, [40]	1–5	Canada	1275	72.7	High
Vazquez-Nava, 2005, [41]	4–5	Mexico	1160	17.9	High
Jigjid, 2005, [42]	1–5	Japan	670	71.9	High
Senesombath, 2010, [43]	36–47 Month	Thailand	400	82.0	Medium
Slabsinskiene, 2003, [44]	3	Lithuania	950	50.6	High
Zhou, 2010, [45]	32 Month	China	155	28.4	High
Rajshekar, 2005, [46]	1–6	India	500	43.4	Medium
Ozer, 2011, [47]	3–6	Turkey	226	49.6	High
Li, 2011, [48]	36–70 Month	China	1523	56.8	High
Kumarihamy, 2011, [49]	1–2	Sri Lanka	410	32.2	High
Prakash, 2012, [50]	8–48 Month	India	1500	27.5	Medium
Singh, 2012, [51]	36–60 Month	India	717	40.0	High
Perera, 2010, [52]	24–71 Month	Sri Lanka	410	32.2	Medium
Phipps, 2011, [53]	12–71 Month	India	8461	62.3	High
Parisotto, 2012, [54]	36–59 Month	Brazil	351	39.9	High

Table 1 Characteristic of included studies prevalence of tooth decay *(Continued)*

Author, year, Reference	Age (years)	Country	Sample size	Prevalence %	Quality
Zhang, 2012, [55]	5	China	723	84.9	High
Tanaka, 2007, [56]	3	Japan	2055	20.7	Medium
Colombo, 2019, [57]	48–71 Month	Italy	2522	38.0	Medium
Agouropoulos-1, 2019, [58]	<7	USA	175	92.6	High
Agouropoulos-2, 2019, [58]	<7	USA	175	53.7	High
Agouropoulos-3, 2019, [58]	<7	USA	175	36.0	High
Musinguzi, 2019, [59]	3–5	Kenya	432	48.1	High
Montes, 2019, [60]	5–7	Brazil	415	42.9	Medium
Boustedt, 2019, [61]	5	Sweden	336	13.1	High
Tonpe-1, 2019, [62]	3–5	India	358	2.8	High
Tonpe-2, 2019, [62]	3–5	India	358	4.2	High
Wang, 2019, [63]	6	China	4936	87.7	High
Nomura, 2019, [64]	5–6	Myanmar	187	81.3	Medium
Wu, 2019, [65]	5–6	China	1350	51.4	High
Abbass, 2019, [66]	5–6	Egypt	369	4.3	Medium
Goenka, 2018, [67]	5–7	India	312	65.1	High
Chugh, 2018, [68]	24–61 Month	India	425	47.3	High
Vandana, 2018, [69]	2–6	India	550	38.2	High
Igic, 2018, [70]	3–6	Serbia	250	38.4	High
Kato, 2017, [71]	3	Japan	6315	36.0	High
Li, 2017, [72]	3–5	China	1727	78.2	High
Mangla, 2017, [73]	1–3	India	510	21.0	High
Owen, 2017, [74]	3–5	Australia	623	14.1	High
Pal, 2017, [75]	5–6	India	408	46.6	High
Wagne, 2017, [76]	6.7	Germany	512	1.8	High
Shah, 2017, [77]	5–7	India	829	33.2	Medium
Yuan, 2017, [78]	3	China	959	28.1	High
Jiang, 2017, [79]	2–5	China	1509	71.4	High
Massignan, 2016, [80]	3.7	Brazil	565	39.1	High
Koya, 2016, [81]	24–71 Month	India	1897	42.0	High
Mothupi, 2016, [82]	4.8	Africa	495	48.9	High
Alkhtib, 2016, [83]	4–5	Qatari	250	89.2	High
Henry, 2016, [84]	<3	India	1486	40.6	High
Šačić, 2016, [85]	3–5	Bosnia and Herzegovina	165	17.0	Medium
Al-Meedani, 2016, [86]	3–5	Saludi Arabia	388	69.1	High
Elidrissi, 2016, [87]	3–5	Sudan	553	52.4	Medium
Gopal, 2016, [88]	3–6	India	477	27.3	High

caries in primary teeth and 5 studies on the prevalence of dental caries in permanent teeth), and 4 Australian studies (3 studies on the prevalence of dental caries in primary teeth and 1 studies on the prevalence of dental caries in permanent teeth) were included in the meta-analysis. There was a significant difference in the prevalence of dental caries in primary and permanent teeth in different continents (Table 3 and Fig. 10).

Cumulative meta-analysis

A cumulative meta-analysis of the included studies was performed based primary and permanent dental caries.

Table 2 Characteristic of included studies Prevalence of permanent dental caries

Author, year, Reference	Age (years)	Country	Sample size	Prevalence %	Quality
Aghighi, 2010, [89]	6–15	Iran	4666	66.3	High
Mortazavi, 1997, [90]	6–9	Iran	220	65.5	High
Asdagh, 2015, [91]	6–12	Iran	847	79.7	Medium
Memar, 1999, [92]	12	Iran	439	84.3	High
Javadi nejad, 2006, [93]	12	Iran	340	82.1	High
Sadeghi, 2007, [94]	12	Iran	563	68.6	High
Yousofi, 2015, [95]	7–12	Iran	460	89.8	High
Eskandarizadeh, 2015, [96]	6–12	Iran	15,369	79.5	High
Mossaheb, 2011, [97]	6–11	Iran	203	82.3	High
Qin, 2019, [98]	10–12	China	5057	39.2	High
Alshehhi, 2019, [99]	8.1	United Arab Emirates	62	58.1	High
Cheng, 2019, [100]	10.3	China	1,196,004	41.1	High
Villanueva-Gutiérrez, 2019, [101]	9	Spain	686	35.4	High
Lešić, 2019, [102]	6–15	Croatia	1589	50.0	High
Mohd Nor, 2019, [103]	12	Malaysia	595	74.3	High
Vanvitelli, 2019, [104]	8–10	Italy	530	29.1	Medium
Obregón-Rodríguez-1, 2019, [105]	12	Spain	1045	25.5	High
Obregón-Rodríguez-2, 2019, [105]	15	Spain	783	26.2	High
Mimoza, 2019, [106]	7–10	Italy	398	28.4	Medium
Abbass, 2019, [66]	6–12	Egypt	369	27.9	High
Aldossary, 2018, [107]	6–9	Saudi Arabia	1844	95.0	High
Goenka, 2018, [67]	8–10	India	353	56.7	High
Ballouk, 2019, [108]	8–12	Syria	1500	79.1	High
Alhabdan, 2018, [109]	6–8	Saudi Arabia	578	82.9	High
Konde, 2018, [110]	12	India	1000	13.6	High
Solis-Riggioni, 2018, [111]	8–15	Costa Rica	201	35.8	High
Musa, 2018, [112]	7–11	China	24,521	32.4	High
Dutra, 2018, [113]	8–12	Brazil	1211	32.4	High
Al-Akwa, 2018, [114]	6–12	Yemen	17,599	67.6	Medium
Cruz, 2018, [115]	11–12	Brazil	184	34.2	High
Andegiorgish, 2017, [116]	12	Eritrea	225	77.8	High
Alwayli, 2017, [117]	6–9	Saudi Arabia	17,891	64.6	High
Dobbiani-1, 2012, [118]	10	Italy	400	44.0	Medium
Dobbiani-2, 2013, [118]	10	Italy	400	18.5	Medium
Maran, 2017, [119]	6–12	India	1204	73.2	High
Shah, 2017, [77]	12–15	India	829	31.4	High
Kim, 2017, [120]	6–11	Korea	514	49.4	High
Sköld, 2016, [121]	13	Sweden	758	2.6	High
Plaka, 2017, [122]	12–15	India	193	36.3	High
Hiremath, 2016, [123]	6–11	India	13,200	78.9	High
Kottayi, 2016, [124]	12–15	India	2000	3.9	Medium
Ponnudurai, 2016, [125]	6–14	India	2796	68.8	High
Djossou, 2013, [126]	6–15	Benin	497	49.7	High
Weusmann, 2015, [127]	8	Germany	25,020	60.9	High

Table 2 Characteristic of included studies Prevalence of permanent dental caries *(Continued)*

Author, year, Reference	Age (years)	Country	Sample size	Prevalence %	Quality
Goel-1, 2015, [128]	12	India	992	34.3	Medium
Goel-2, 2015, [128]	15	India	992	46.5	High
Farooqi, 2014, [129]	6–9	Saudi Arabia	711	73.0	High
Arora, 2014, [130]	12	India	100	57.0	High
Sukhabogi-1, 2014, [131]	12	India	924	39.9	Medium
Sukhabogi-2, 2014, [131]	15-	India	951	46.7	Medium
Al-Darwish, 2014, [132]	12–14	Qatar	2113	85.0	High
Aidara, 2014, [133]	12–15	Senegal	677	96.0	High
Ingle, 2014, [134]	12–15	India	1400	53.0	Medium
Sofola, 2000, [135]	6–12	Nigeria	513	16.6	High
Das, 2013, [136]	6–14	West Bengal	1764	28.1	High
Mahfouz-1, 2013, [137]	12	Palestine	677	40.6	High
Mahfouz-2, 2013, [137]	13	Palestine	677	41.8	High
Mahfouz-3, 2013, [137]	14	Palestine	677	60.4	High
Riziwaguli, 2013, [138]	7–9	China	1600	26.5	Medium
Joshi, 2013, [139]	6–12	India	1600	69.1	Medium
Pieper, 2009, [140]	12	Germany	30,943	72.7	High
Yengopal, 2012, [141]	10.5	Africa	882	27.6	High
Murthy, 2014, [142]	12–15	India	1452	57.9	High
Koposova, 2013, [143]	12	Russia	590	68.0	High
Dixit, 2013, [144]	12–13	Nepal	361	41.0	Medium
Suprabha, 2013, [145]	11–13	India	857	59.4	High
Panagidis, 2012, [146]	12	Germany	951	32.6	High
Shailee-1, 2012, [147]	12	India	1011	32.6	Medium
Shailee-2, 2012, [147]	15	India	1011	42.2	High
Lagana, 2012, [148]	7–15	Albanian	2617	88.9	Medium
Subedi, 2011, [148]	12–13	Nepal	325	53.2	Medium
Shekar, 2011, [149]	12–15	India	474	56.3	High
Oulis-1, 2010, [150]	12	Greece	1224	80.0	High
Oulis-2, 2010, [150]	15	Greece	1257	83.0	High
Jamelli, 2010, [151]	12	Brazil	689	71.8	High
Kanagaratnam, 2009, [152]	9	New Zealand	612	54.9	High
Bissar, 2008, [153]	11–14	Germany	570	42.3	High
Ferro, 2007, [154]	12	Italy	260	56.9	High
Moreira, 2006, [155]	12–15	Brazil	1665	50.9	High
Schulte, 2004, [156]	12	Germany	43,950	39.3	High
Paredes, 2005, [157]	6–10	Spain	600	47.2	High
Mestriner, 2005, [158]	12	Brazil	256	53.9	High
Traebert, 2002, [159]	12	Brazil	803	62.1	High

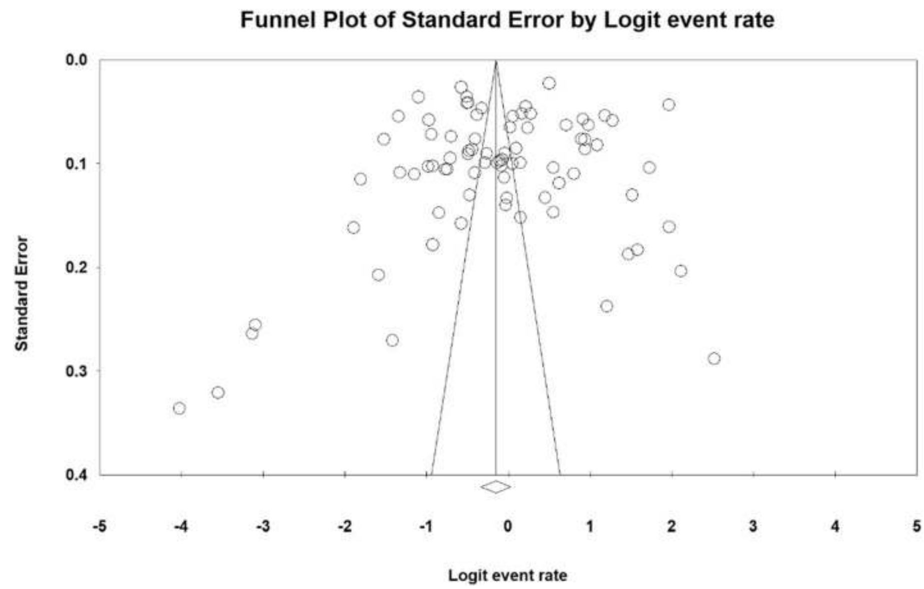


Fig. 2 Funnel plot of the results of the prevalence of dental caries in primary teeth in children

Cumulative risk of each study's addition to the meta-analysis are reported in Figs. 11 and 12.

Discussion

In this study, the prevalence of dental caries in studies conducted throughout the world was investigated, and it was reported that the overall prevalence of dental caries in primary teeth in children was 46.2%. Early childhood caries (ECC) in developing countries was reported to be more than in developed countries [1]. Also, in the present study, the overall prevalence of dental caries in permanent teeth in children was 53.8%.

Differences in the prevalence of dental caries in developed and underdeveloped countries may be due to differences in the age groups studied, but may also be due to ethnic, cultural, geographic, racial, and developmental differences as well as access to dental services, behavioral habits, health care behaviors,

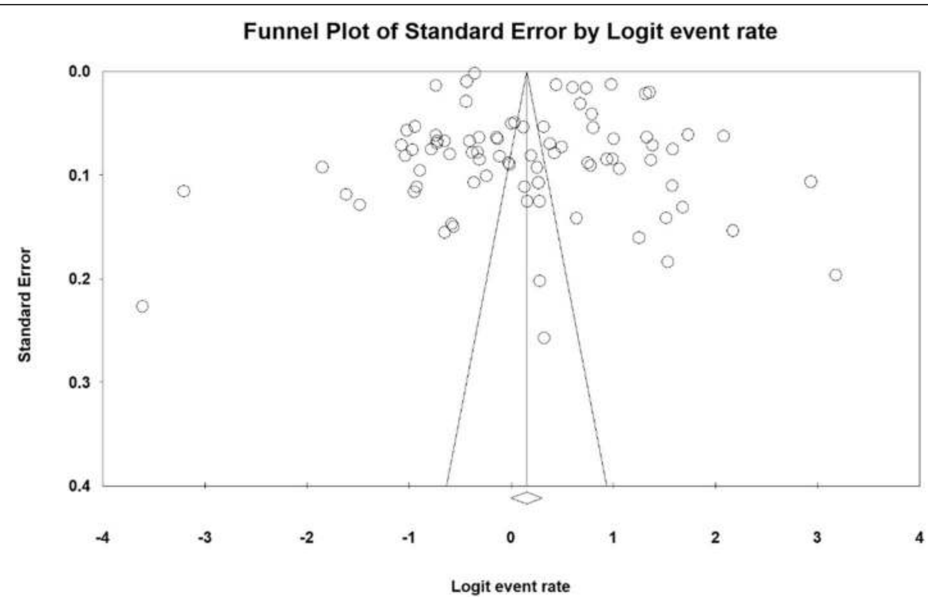


Fig. 3 Funnel plot of the results of the prevalence of dental caries in permanent teeth in children

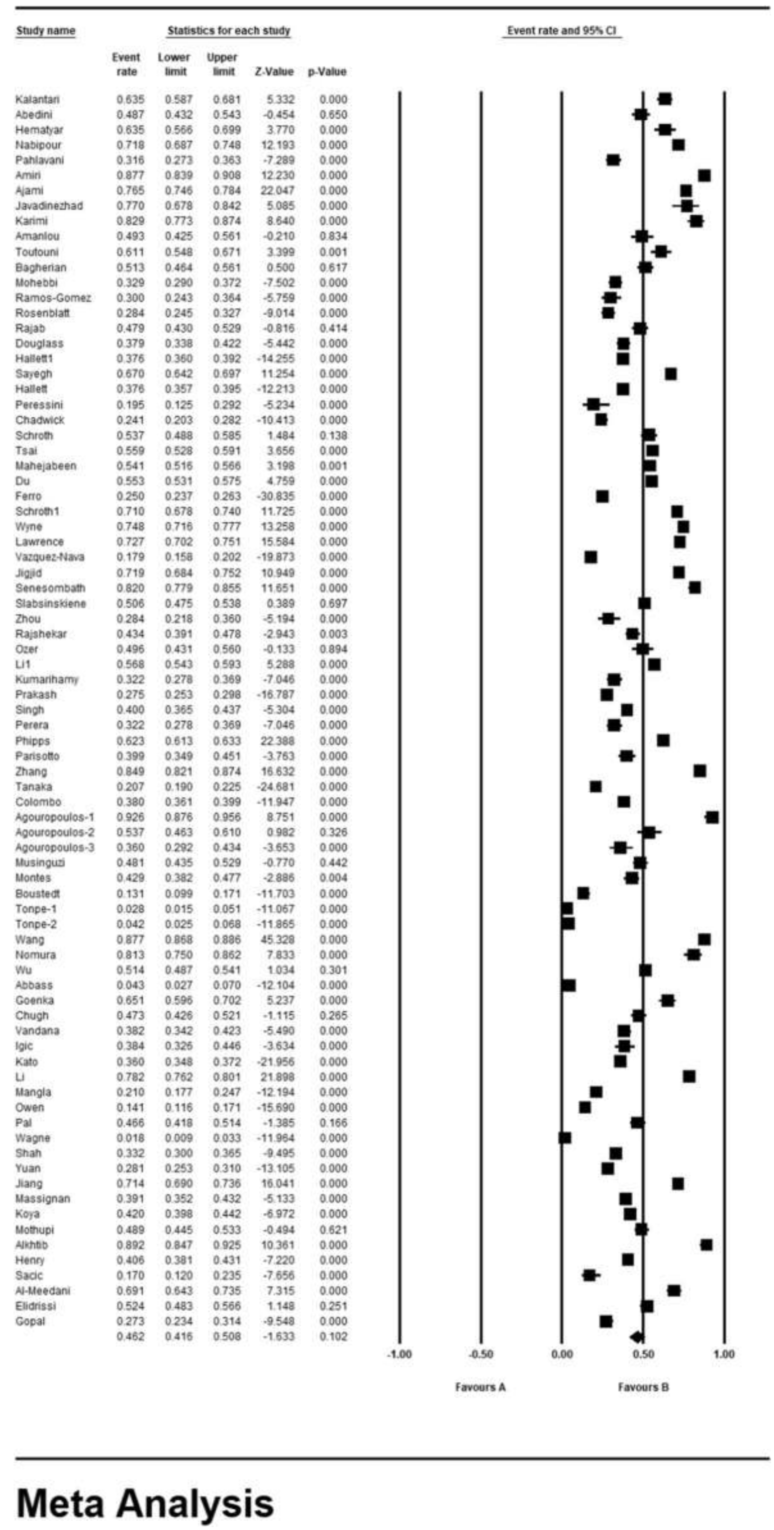
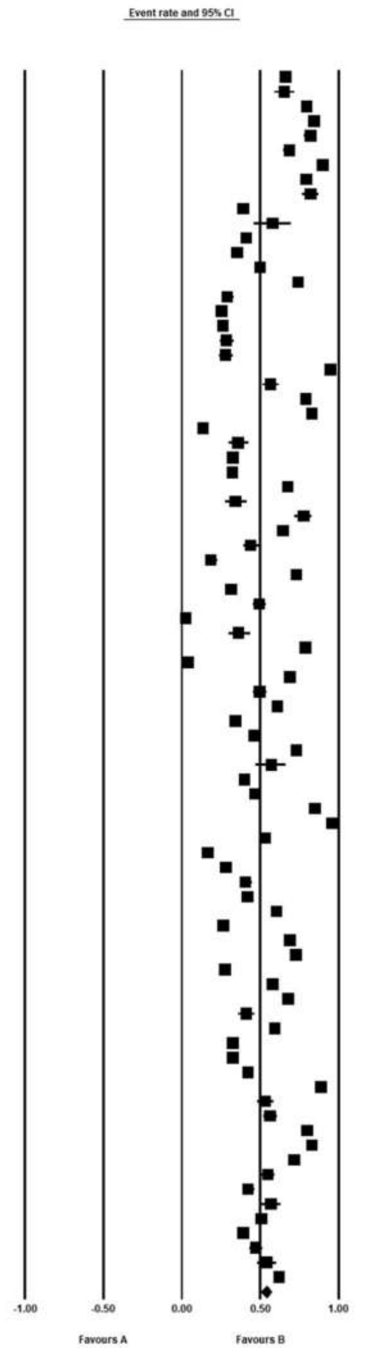


Fig. 4 Forest plot of the results of Prevalence of dental caries in primary teeth and 95% confidence intervals worldwide

Study name	Event rate	Lower limit	Upper limit	Z-Value	p-Value
Aghighi	0.663	0.649	0.677	21.861	0.000
Mortazavi	0.655	0.589	0.714	4.507	0.000
Asdagh	0.797	0.768	0.823	16.007	0.000
Memar	0.843	0.806	0.874	12.807	0.000
Javadi nejad	0.821	0.776	0.858	10.756	0.000
Sadeghi	0.686	0.646	0.723	8.589	0.000
Yousofi	0.898	0.867	0.922	14.118	0.000
Eskandarizadeh	0.795	0.789	0.801	67.827	0.000
Mossaheb	0.823	0.764	0.869	8.351	0.000
Qin	0.392	0.379	0.405	-15.247	0.000
Alshehhi	0.581	0.455	0.696	1.264	0.206
Cheng	0.411	0.411	0.412	-192.543	0.000
Villanueva-Gutiérrez	0.354	0.319	0.391	-7.522	0.000
Lesic	0.500	0.476	0.525	0.025	0.980
Mohd Nor	0.743	0.706	0.776	11.310	0.000
Vanvitelli	0.291	0.253	0.331	-9.330	0.000
Obregon	0.255	0.229	0.282	-15.131	0.000
Obregon1	0.262	0.232	0.294	-12.751	0.000
Mimoza	0.284	0.242	0.330	-8.322	0.000
Abbass	0.279	0.236	0.327	-8.175	0.000
Aldossary	0.950	0.939	0.959	27.584	0.000
Goenka	0.567	0.514	0.617	2.494	0.013
Ballouk	0.791	0.769	0.811	20.940	0.000
Alhabdan	0.829	0.796	0.857	14.280	0.000
Konde	0.136	0.116	0.159	-20.042	0.000
Solis-Riggioni	0.358	0.295	0.427	-3.964	0.000
Musa	0.324	0.318	0.330	-53.895	0.000
Dutra	0.324	0.298	0.351	-11.997	0.000
Al-Akwa	0.676	0.669	0.683	45.648	0.000
Cruz	0.342	0.277	0.414	-4.201	0.000
Andegiorgish	0.778	0.719	0.827	7.812	0.000
Alwayli	0.646	0.639	0.653	38.466	0.000
Dobbiani-1	0.440	0.392	0.489	-2.394	0.017
Dobbiani-2	0.185	0.150	0.226	-11.516	0.000
Maran	0.732	0.706	0.756	15.426	0.000
Shah	0.314	0.283	0.346	-10.463	0.000
Kim	0.494	0.451	0.537	-0.265	0.791
Skold	0.026	0.017	0.041	-15.922	0.000
Plaka	0.363	0.298	0.433	-3.765	0.000
Hiremath	0.789	0.782	0.796	61.830	0.000
Kottayi	0.039	0.031	0.048	-27.743	0.000
Ponnudurai	0.688	0.671	0.705	19.385	0.000
Djossou	0.497	0.453	0.541	-0.135	0.893
Weusmann	0.609	0.603	0.615	34.200	0.000
Goel-1	0.343	0.314	0.373	-9.733	0.000
Goel-2	0.465	0.434	0.496	-2.221	0.026
Farooqi	0.730	0.696	0.761	11.772	0.000
Arora	0.570	0.472	0.663	1.395	0.163
Sukhabogi-1	0.399	0.368	0.431	-6.077	0.000
Sukhabogi-2	0.467	0.435	0.499	-2.041	0.041
Al-Darwish	0.850	0.834	0.865	28.470	0.000
Aidara	0.960	0.942	0.973	16.197	0.000
Ingle	0.530	0.504	0.556	2.244	0.025
Sofola	0.166	0.136	0.200	-13.613	0.000
Das	0.281	0.260	0.302	-17.765	0.000
Mahfouz-1	0.406	0.370	0.444	-4.852	0.000
Mahfouz-2	0.418	0.381	0.456	-4.247	0.000
Mahfouz-3	0.604	0.567	0.640	5.379	0.000
Riziwaguli	0.265	0.244	0.287	-18.009	0.000
Joshi	0.691	0.668	0.713	14.848	0.000
Pieper	0.727	0.722	0.732	76.761	0.000
Yengopal	0.276	0.247	0.306	-12.828	0.000
Murthy	0.579	0.554	0.604	6.010	0.000
Koposova	0.680	0.641	0.716	8.525	0.000
Dixit	0.410	0.360	0.461	-3.402	0.001
Suprabha	0.594	0.561	0.626	5.467	0.000
Panagidis	0.326	0.297	0.356	-10.501	0.000
Shailee-1	0.326	0.298	0.356	-10.801	0.000
Shailee-2	0.422	0.392	0.453	-4.918	0.000
Lagana	0.889	0.877	0.901	33.440	0.000
Subedi	0.532	0.478	0.586	1.164	0.244
Shekar	0.563	0.518	0.607	2.748	0.006
Oulis-1	0.800	0.776	0.821	19.392	0.000
Oulis-2	0.830	0.808	0.850	21.106	0.000
Jamelli	0.718	0.684	0.751	11.058	0.000
Kanagaratnam	0.549	0.509	0.588	2.421	0.015
Bissar	0.423	0.383	0.464	-3.671	0.000
Ferro	0.569	0.508	0.628	2.225	0.026
Moreira	0.509	0.485	0.533	0.711	0.477
Schulte	0.393	0.388	0.398	-44.515	0.000
Paredes	0.472	0.432	0.512	-1.387	0.165
Mestriner	0.539	0.478	0.599	1.249	0.212
Traebert	0.621	0.587	0.654	6.811	0.000
	0.538	0.500	0.575	1.951	0.051



Meta Analysis

Fig. 5 Forest plot of the results of Prevalence of dental caries in permanent teeth and 95% confidence intervals worldwide

nutritional habits and behaviors, and lifestyle [144]. The effects of parents' lack of awareness of their children's tooth decay status as well as neglect and attention discrimination can also be well documented in the study of Nag et al. [160], suggesting that in the age group of 6 to 18 years, caries rates were higher in girls than in boys, as girls are more neglected by parents than boys. Although there has been no difference

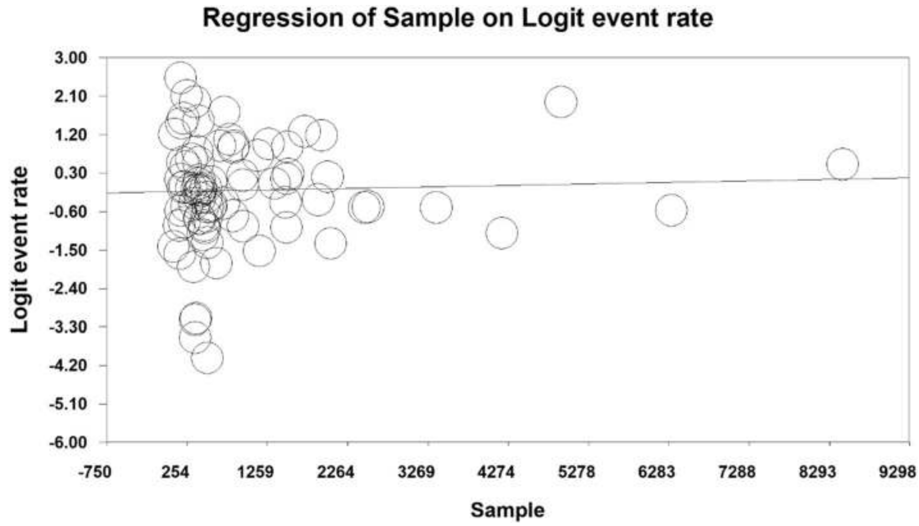


Fig. 6 Meta-regression analysis of the relationship between the sample size and the prevalence of dental caries in primary teeth in children in the world

in the prevalence rate of both sexes in the current systematic study, terms of access to health services and lack of parental awareness of and attention to children's dental caries are known as the most important factors in its development [2], so discrimination and inequality in the upbringing of children in the family can also multiply the impact of such a situation.

In the present meta-analysis study, the prevalence of dental caries in primary and permanent teeth in different continents is presented in Table 3 and Fig. 10, which was higher in the African continent and secondarily in the Asian continent.

According to the World Health Organization's Healthy People Plan, 90% of children between the ages of 5 and 6 should be free of tooth decay by 2010. However, according to the findings of this study which were based on the reviews performed in the studies searched, the prevalence of dental caries in children in most countries was found to be very high. Such a situation gives rise to worrying conditions in terms of tooth decay in adulthood and will also

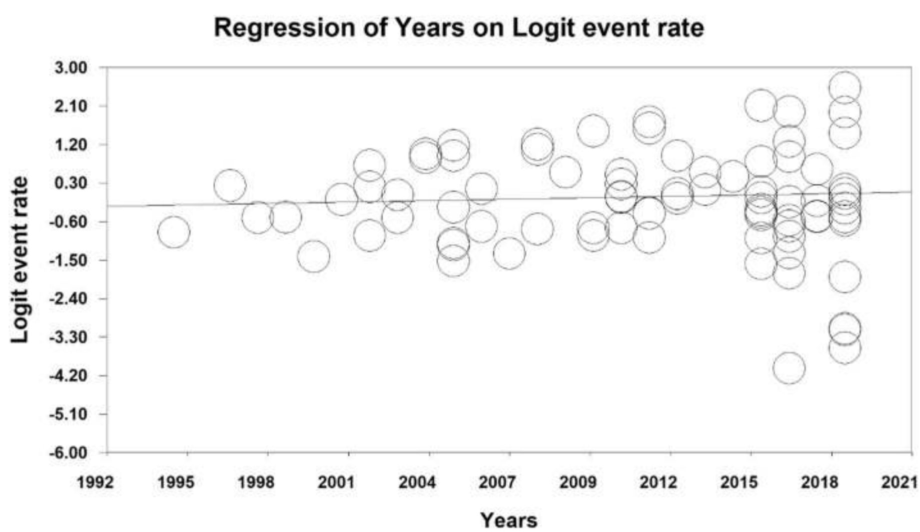


Fig. 7 Meta-regression analysis of the relationship between the year of study and the prevalence of dental caries in primary teeth in children in the world

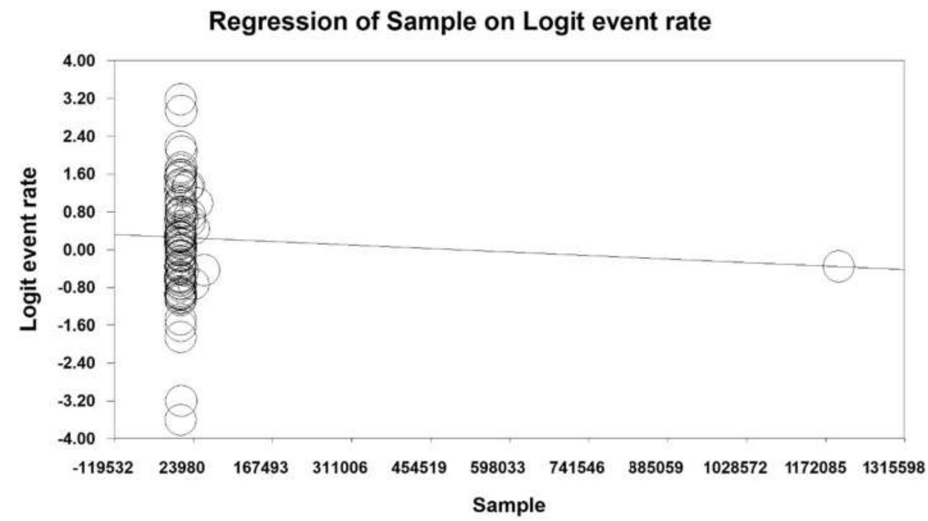


Fig. 8 Meta-regression analysis of the relationship between the sample size and the prevalence of dental caries in permanent teeth in children in the world

impose enormous tooth repair costs on the country's health sector. Such a situation in the country, in addition to what has been said, as well as conditions such as inequality in access to health care services, inequality in developmental and economic situation in different countries and different parts of countries may indicate that the lack of awareness of the health and preservation of primary teeth in all families with different socioeconomic status has been considered a serious problem [3] and a barrier to the provision of preventive and health services.

Families and parents should know that child dental care must start from the mother's pregnancy; children born to mothers with multiple dental caries are more likely to develop caries in the later stages of their lives. Cariogenic bacteria are usually transferred through the use of a spoon or a bottle of milk from the mother's moth to the child's mouth for the first time, so breast feeding should be avoided as much as possible during the baby's sleep. Regular dental appointments should be provided from the beginning of the baby's primary teeth eruption, especially with the eruption of the first

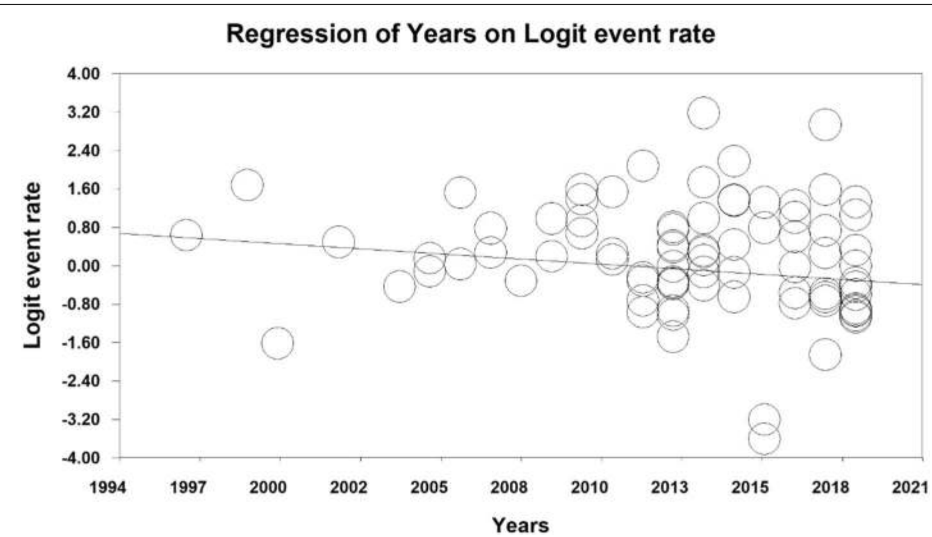


Fig. 9 Meta-regression analysis of the relationship between the year of study and the prevalence of dental caries in permanent teeth in children in the world

Table 3 Investigating the prevalence of dental caries in primary and permanent teeth in children in different continents

Tooth type	continents	Number of articles	Sample Size	I^2	Egger Test	Prevalence %
Caries in primary teeth	Asia	50	54,680	99.3	0.756	52.6 (95% CI: 46.7–58.5)
	Europe	10	9977	98.4	0.152	21.4 (95% CI: 15.3–29.1)
	America	14	6825	98.7	0.742	45.8 (95% CI: 34.2–58)
	Africa	5	3004	95.5	0.220	53.1 (95% CI: 44.3–61.7)
	Australia	3	6472	98.3	0.296	28.5 (95% CI: 20.3–38.5)
Permanent dental caries	Asia	50	1,334,133	99.8	0.284	58.8 (95% CI: 53.4–64)
	Europe	22	115,141	99.8	0.175	44.1 (95% CI: 36.1–52.5)
	America	7	5009	98.2	0.763	48.9 (95% CI: 37.6–60.3)
	Africa	5	2794	99.3	0.220	58.9 (95% CI: 29.4–83.1)
	Australia	1	612	–	–	54.9 (95% CI: 50.9–58.8)

permanent tooth, first molar tooth or the 6the tooth. The tooth develops immediately after the last primary tooth at the age of six and is most likely to be decayed. The American Academy of Pediatric Dentistry, the American Dental Association, and the American Academy of General Dentistry all recommend making sure to see a dentist 6 months after the eruption of teeth in children, before the age of one year's [161–166]. One of the most important and available measures to prevent caries, especially primary teeth in children, is performing dental procedures such as fissure sealant and fluoride therapy. In the fissure sealant method, deep grooves in the surface of the tooth are covered with a thin layer of tooth-colored material, thereby preventing the spread of cariogenic bacteria in tooth grooves. Other methods are caries prevention [167]and[168].

Given the high prevalence of primary and permanent dental caries in children worldwide, it is recommended that providing educational programs and interventions in primary and permanent dental health care especially for mothers, nurses, and child educators be of special interest to health services policy-makers and providers. Planning to provide educational programs and inexpensive dental and oral health services as well as ease of access to such services for children by the health system of countries is noted as well.

Strength and limitation

The most important strength of this study is that it has been studied for the first time in the world, includes all data sources and high-quality studies, and also analysis based on different continents for the use of the World Health Organization. The most important limitation of the present study is inaccessibility to the full text of the articles, incomplete search, and poor quality of some studies, as well as restricted search based on Persian and English languages.

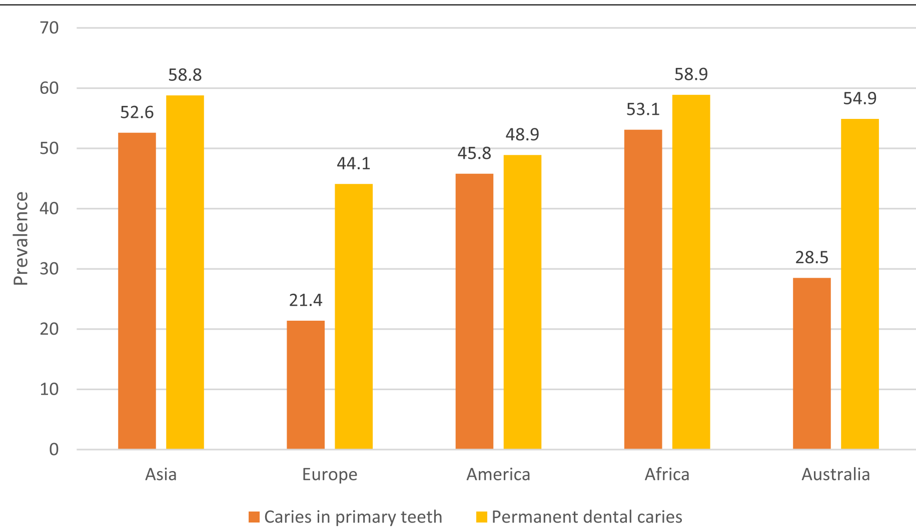


Fig. 10 Providing the results of the prevalence of dental caries in primary and permanent teeth in children in different continents

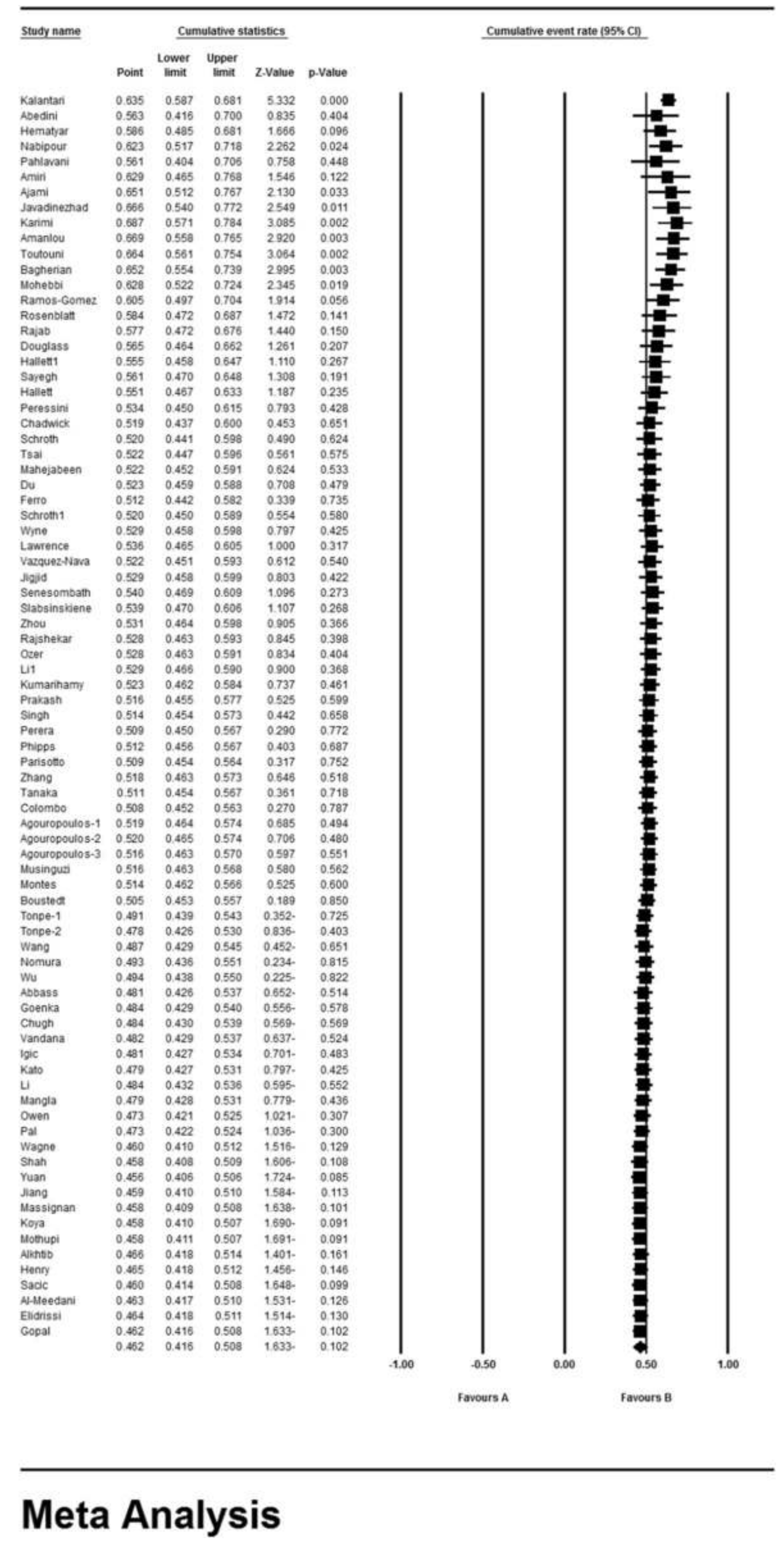


Fig. 11 Result of cumulative meta-analysis based on primary dental caries

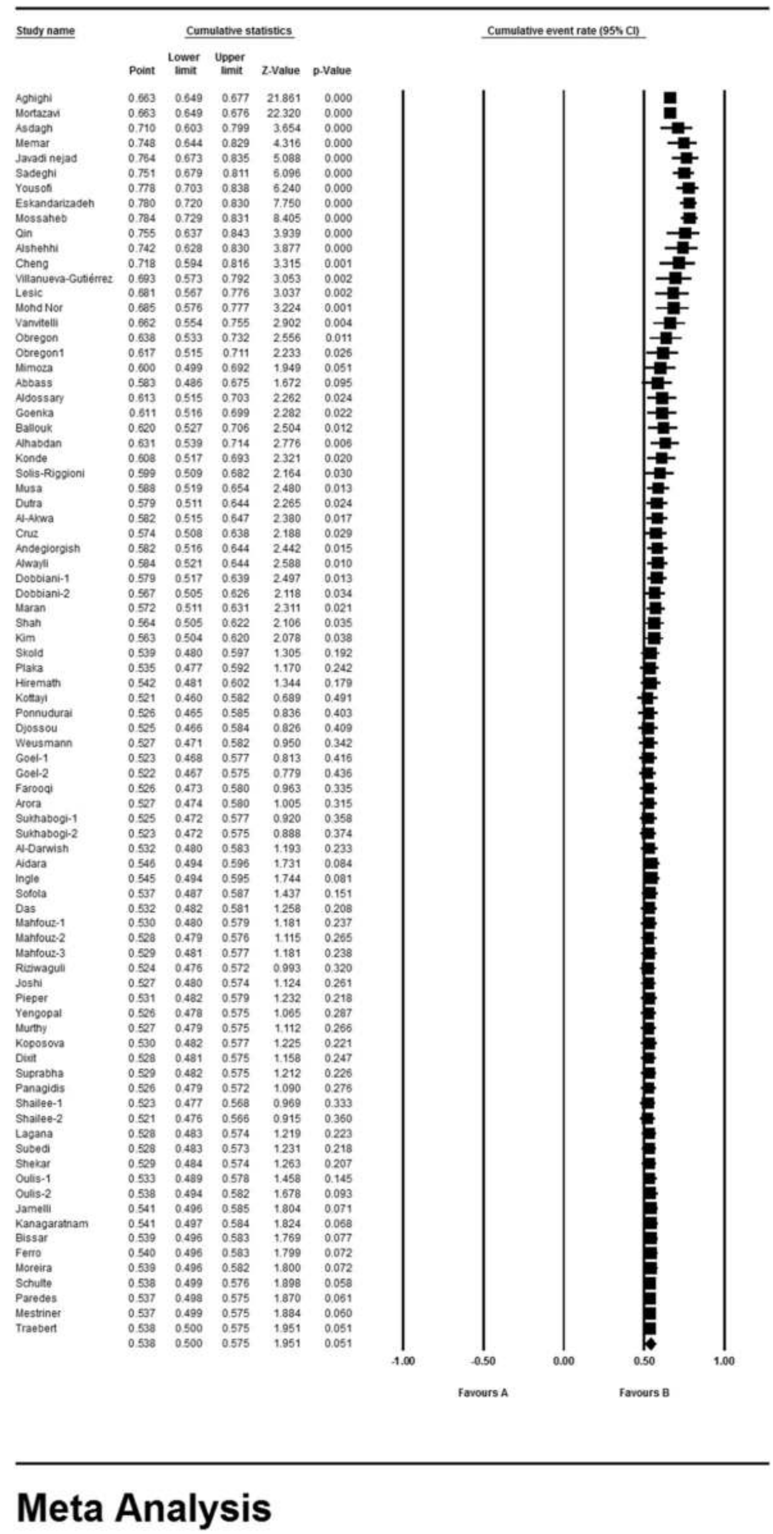


Fig. 12 Result of cumulative meta-analysis based on permanent dental caries

Conclusion

The results of this study showed that the prevalence of dental caries in primary and permanent teeth in children in the world was found to be high. Therefore, appropriate strategies should be implemented to improve the aforementioned situation and to troubleshoot and monitor at all levels by providing feedback to hospitals. Also, the prevalence of dental caries in primary and permanent teeth in children of Africa is higher than other continents and requires special attention of the World Health Organization to this continent in improving the oral health of children. These strategies can include providing educational programs to parents, periodic dental care for children, and fluoride therapy in childhood for the African continent.

Abbreviations

ECC: Early Childhood Caries; WHO: World Health Organization; DMF: Decay-Missing-Filled; SID: Scientific Information Database; MESH: Medical Subject Headings; ISI: Web of Science; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis; STROBE: Strengthening the Reporting of Observational Studies in Epidemiology for cross- sectional Study

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Authors' contributions

MK and AA contributed to the design, MM and RJ statistical analysis, participated in most of the study steps. AVR and SHSH prepared the manuscript. NS and MM assisted in designing the study, and helped in the, interpretation of the study. All authors have read and approved the content of the manuscript.

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Availability of data and materials

Datasets are available through the corresponding author upon reasonable request.

Ethics approval and consent to participate

Not declared.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no conflict of interest.

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