Prevalence of orthodontic treatment needs in permanent dentition in the population of Gulf Cooperation Council countries: A systematic review and meta-analysis of observational studies

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Abstract

The aim of this systematic review and meta-analysis was to comprehensively analyze the existing information on the prevalence of the need for orthodontic treatment in the permanent dentition stage among populations in Gulf Cooperation Council (GCC) countries. For observational studies in GCC countries, the key terms were electronically searched in Science Direct, PubMed, Embase, Cochrane Reviews, Google Scholar, and Sage databases (1990–2021). The bias risk for the selected studies was evaluated using the modified Strengthening the Reporting of Observational Studies in Epidemiology statement. Thirteen studies reported on the prevalence of orthodontic treatment needs among 33,134 children in GCC countries in permanent dentition with an age range of 11–19 years satisfied the inclusion criteria. Out of the 13 studies, 9 reported on the prevalence of malocclusion, 11 reported on the prevalence of occlusal traits, and 12 reported on the prevalence of orthodontic treatment needs as per the Dental Health Component (DHC) of Index of Orthodontic Treatment Need (IOTN), 4 reported as per both DHC and Aesthetic Component (AC) of IOTN, and 1 reported as per only AC of IOTN. Meta-analysis of the included studies indicated that the pooled malocclusion prevalence rate was 10.60% (confidence interval [CI] 95%: 0.093–0.076) with 8.58% Class I (CI 95%: 0.074–0.188), 2.09% Class II (CI 95%: 0.014–0.058), and 0.93% Class III (CI 95%: 0.005–0.018) malocclusions. The most prevalent type of occlusal trait was spacing (13.10%, CI 95%: 0.018–0.169), followed by crowding (4.96%, CI 95%: 0.017–0.091). The pooled prevalence of borderline and definite needs for orthodontic treatment based on DHC and AC of IOTN was 0.82% (CI 95%: 0.014–0.035), 1.13% (CI 95%: 0.011–0.091), 4.08% (CI 95%: 0.009–0.114), and 2.06% (CI 95%: 0.002–0.048), respectively. The findings were heterogeneous ($P < 0.05$). These findings indicated that the prevalence of malocclusion and orthodontic treatment needs was not high in the GCC population.

Keywords:

GCC countries, malocclusion, occlusal trait, orthodontic treatment need, prevalence

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Introduction

Malocclusion is one of the three most frequently occurring oral disorders, apart from caries and periodontal disease. Untreated malocclusion is associated with numerous harmful effects, including impairment in oral functions such as chewing, swallowing, speech, periodontal problems, dental pain, poor functional and aesthetic outcomes, and psychosocial distress.[1] Malocclusion is any deviation from normal occlusion in the teeth, dental bases, or arches.[2] Assessment of the need for orthodontic care in a community indicates

only the prevalence of different extents of malocclusion, some of which may not require treatment.[3] However, when normal occlusion undergoes changes that affect an individual's functional and aesthetic aspects, the need for orthodontic care becomes apparent.[4] Besides, the frequency and distribution of orthodontic treatment care vary depending on the age groups, regions of study subjects, and quality assessment criteria.[5] Recent years have garnered increasing research attention in evaluating the prevalence and the related requirements for orthodontic treatment,[6] as comprehensive observational data about the prevalence of the need for orthodontic care have been scant. Several indices have been developed for assessing the need for orthodontic treatment. The Index of Orthodontic Treatment Need (IOTN) by Shaw *et al*.[7] is one of the most cited indices as it is user-friendly and reliable.[8] The IOTN index comprises the Aesthetic Component (AC) and Dental Health Component (DHC). The former is based on perceived dental impairment due to changes in various occlusal traits for the dental health of an individual.[9] Alternatively, the Dental Aesthetic Index (DAI) combines biological and ACs of occlusion for assessing severity and the need for orthodontic measures.[10] Thus, evaluation of the prevalence of the need for orthodontic care as per the standard indices seems crucial to obtain information on the occurrence of treatment needs in populations, to establish the significance of treatment, and to target unmet oral needs and accessibility to dental services efficiently.[11]

The recent growth in Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) has generated an increasing population looking for orthodontic treatment, especially in the permanent dentition stage.[12] However, comprehensive reports have been limited, particularly systematic reviews and meta-analyses, which can offer valuable information regarding the orthodontic treatment needs in GCC countries.[12-14]

Although the high prevalence of orthodontic anomalies does not necessarily indicate the requirement for orthodontic treatment, a persistent increase in the orthodontic treatment cost in GCC countries seems evident. Thus, further evidence regarding the prevalence of orthodontic anomalies must be gathered to develop a suitable protocol to address various issues related to its treatment. Thus, this study aims to perform a systematic review and meta-analysis to comprehensively analyze and discuss the existing information on the prevalence of the need for orthodontic treatment in GCC countries. The research question to be addressed is: What is the prevalence of orthodontic treatment needs in subjects with permanent dentition in GCC countries?

Methods

Search strategy
A systematic method was followed in this study, which involved searching keyword terms in major databases like Science Direct, PubMed, Embase, Cochrane Reviews, Google Scholar, and Sage, focusing on observational studies related to the prevalence of orthodontic treatment needs in the permanent dentition stage in GCC countries. Studies published in English from 1990 to 2021, with the following search terms, were included: 'Orthodontic treatment needs', 'prevalence', 'permanent dentition', 'orthodontic treatment need index', and 'observational studies'. The Boolean word 'AND' was used. The following search was carried out: ('Orthodontic treatment need') AND ('prevalence') AND ('permanent dentition') AND ('orthodontic treatment need index') AND ('observational studies'). Besides, searching references of the selected studies and manual searching were conducted. The step-wise organization of the search terms yielded 342 articles, of which 336 studies were identified through keyword searches in the databases [Table 1], and six were identified through other sources.

Eligibility bases
The selection of the 342 studies was based on the relevance of titles, abstracts, keywords, full-text assessment, and cross-comparison against the following inclusion and exclusion criteria.

Inclusion criteria
1. Observational studies conducted in one of the six GCC countries that evaluated the prevalence of the need for orthodontic treatment in the permanent dentition stage based on IOTN.
2. Studies published from 1990–2021 in dental journals.
3. Studies conducted on subjects aged between 11 and 40 years.
4. Studies published in English.

Exclusion criteria
1. Book chapters, literature reviews, records, proceedings, editorials, and duplicate studies.
2. Studies conducted on individuals with developmental disorders of teeth and craniofacial complex.

Table 1: Number of hits in the search databases

Databases	Number of hits
Science Direct	74
Sage Publications	254
Google Scholar	4
Cochrane Reviews	1
PubMed	2
Embase	1
Total	336

3. Studies conducted on individuals undergoing orthodontic treatment.
4. Studies conducted on individuals with primary or mixed dentition stages.

The schematic representation for selecting the articles is illustrated in Figure 1. The following information was extracted from each selected study: the first author, year of publication, the country where the study was conducted, the total number of samples, age in years, the prevalence of malocclusion, prevalence of occlusal trait, prevalence of orthodontic treatment needs based on components of the IOTN, and conclusive findings. Both components of the IOTN index for orthodontic treatment needs are categorized into three groups (no or slight need, borderline need, and definite need).

Bias assessment

After selecting the articles, the methodological quality was assessed using the modified "Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)" statement. Bias risks were evaluated using 12 questions covering 10 domains: study objective, study design, sampling method, sample size, population, inspecting samples method, data collection tools, statistical analysis, way of reporting outcomes, and reporting outcomes

based on objectives.[11] The overall risk of bias for each parameter reported by the selected studies was scored from 0 to 10 points, and studies with a score of less than 8 were removed from the meta-analysis.[15]

Data analysis

For the meta-analysis, data from the studies that stated similar measurements using appropriate statistical tests were combined after examining sampling considerations, study design, study populations, or missing information in a random-effects model.[16] The possibility of publication bias across the studies was detected using Egger's test and Begg's rank correlation and visually examined using a funnel plot.[17,18] Variation due to statistical heterogeneity among the studies was detected using the Q and I^2 statistics. I^2 scores >70% were considered highly heterogenic.[19] The presence of heterogeneity was visually tested using forest plots. Here, statistical significance was considered at $P < 0.05$. All analyses were performed using the Jamovi statistical software.

Results

Identification and description of studies

Electronic searches from the databases (Science Direct, PubMed, Embase, Cochrane Reviews, Google Scholar, and
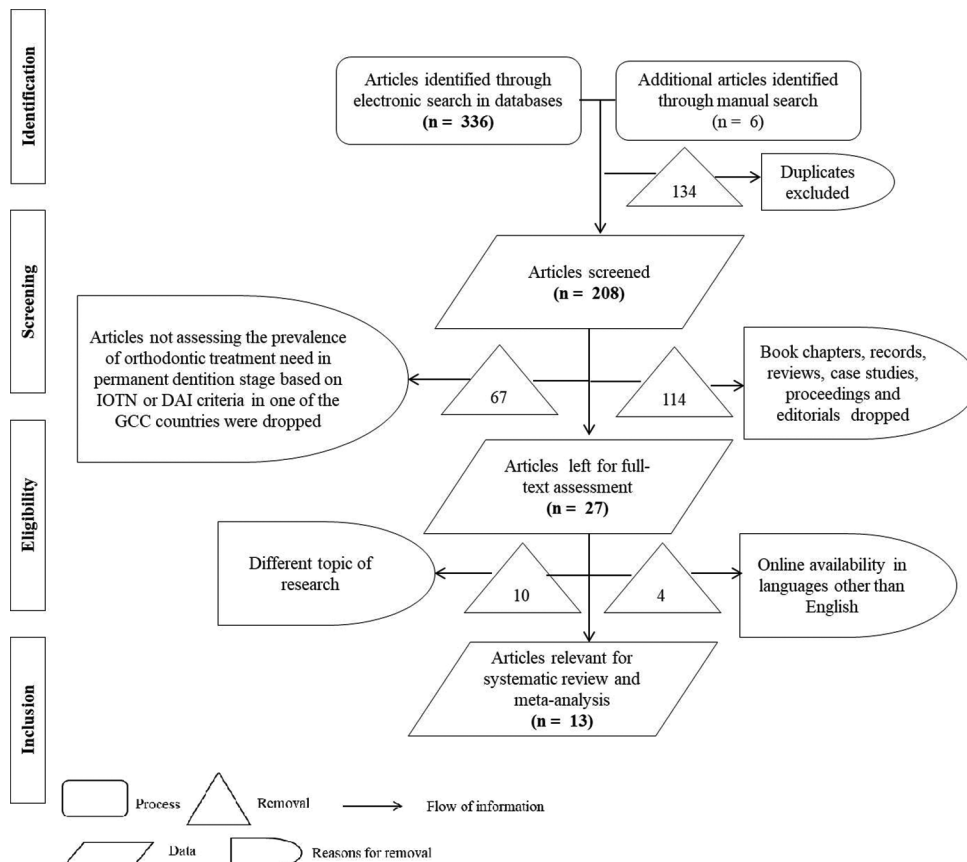

Figure 1: PRISMA representation for step-wise selection of articles

Sage) and other sources identified 342 articles [Figure 1]. Of the 342 articles screened, 27 were selected for full-text assessment. A final total of 13 studies (published between 1990 and 2021) were included in the systematic review and meta-analysis based on the inclusion criteria. The description of each study is compiled in Table 2. Of the 13 studies, four studies did not report the prevalence of malocclusion data,[20-23] while two studies did not report the data regarding the prevalence of malocclusion trait.[24,25] Besides, 12 studies[14,20-30] used the DHC component of IOTN, four studies[21,23-25] used both DHC and AC components of IOTN, and one study[31] used only AC component of IOTN for assessing the need for orthodontic treatment. The total number of participants in the permanent dentition in the included studies was 33,134 children aged 11–19 years. A large proportion of studies were carried out in Saudi Arabia (eight of the total studies included), while three were carried out in Kuwait, one study each in UAE and Oman. However, no studies in Bahrain and Qatar satisfied the inclusion criteria [Table 2].

Quality assessment of selected studies

Assessing the methodological quality of the observational studies is presented in Table 3. The modified STROBE criteria summarize an overall good level of evidence obtained from the findings of the selected studies. Based on the modified STROBE statement, four studies obtained a total score of 8,[23,25,26,31] three studies obtained a total score of 9,[20,22,28] and six studies had a total score of 10.[14,21,24,27,29,30] These scores indicate the acceptable quality of the studies included in this systematic review. Of the 13 studies, nine correctly reported outcome data and the way outcomes should be reported. These studies incorporated all expected outcomes. One study did not provide enough information on the inspecting samples method.[31] Moreover, five studies did not incorporate the appropriate statistical analysis for the research questions.[22,25,26,28,31]

Findings of Meta-Analysis

Prevalence by malocclusion

Around 8520 of the sampled population exhibited malocclusion, with a pooled prevalence of 10.60% (confidence interval [CI] 95%: 0.093–0.076). Seven studies reported the prevalence of Class I malocclusion, while six reported the prevalence of Class II and Class III malocclusions. Based on the pooled results, the highest prevalence of malocclusion in the GCC countries was Class I malocclusion at 8.58% (CI 95%: 0.074–0.188), followed by Class II malocclusion at 2.09% (CI 95%: 0.014–0.058) and Class III malocclusion at 0.93% (CI 95%: 0.005–0.018) [Table 4].

Prevalence by type of occlusal trait

The meta-analysis of the types of occlusal traits based on 13 studies revealed the following proportions:

spacing 13.10% (CI 95%: 0.018–0.169), crowding 4.96% (CI 95%: 0.017–0.091), transverse occlusal traits (lip incompetence, impeded eruption, contact point discrepancy, displacement, midline diastema) 1.56% (CI 95%: 0.023–0.091), and bite discrepancies (deep bite, open bite, overbite, crossbite, scissor bite) 0.79% (CI 95%: 0.011–0.05) and overjet 0.65% (CI 95%: 0.010–0.028) [Table 4].

Prevalence by orthodontic treatment needs

The meta-analysis showed that the prevalence of no or slight orthodontic treatment needs in samples according to DHC of IOTN was 1.74% (CI 95%: 0.039–0.113), and samples who had definite and borderline orthodontic treatment needs were 1.13% (CI 95%: 0.011–0.091) and 0.82% (CI 95%: 0.014–0.035), respectively [Table 5]. The findings of the present meta-analysis according to AC of IOTN criteria reported that 7.36% (CI 95%: 0.024–0.191) of samples had no or slight orthodontic treatment needs and only 4.08% (CI 95%: 0.009–0.114) and 2.06% (CI 95%: 0.002–0.048) had borderline and definite needs for orthodontic treatment [Table 5].

Heterogeneity and publication bias

The data, including the prevalence of malocclusion, types of occlusal traits, and prevalence of orthodontic treatment needs, were consolidated in a meta-regression random-effects model to identify heterogeneity and publication bias. The Begg's test and Egger's test for publication bias for the prevalence of malocclusion, the prevalence of occlusal traits, and the prevalence of orthodontic treatment needs ($I^2 > 70\%$; $P < 0.001$; Supplementary Table S1) reported significant heterogeneous findings and a possible suspicion of a publication bias [Supplementary Figures S1–S4], indicating large variability in the results of the pooled studies based on whether the individual studies differed noticeably in the samples included, methods used, age groups, publication year, geographical distribution, and outcomes measured.

Discussion

The present systematic review and meta-analysis combined the results of primary studies, presenting a clear status of the prevalence of malocclusion, types of occlusal traits, and the need for orthodontic treatment in GCC countries based on a random-effects model. The results indicated that a small proportion (10.6%) of the population in GCC countries exhibited at least one type of malocclusion. Compared to the Class II (2.09%) and Class III (0.93%) angle classifications of malocclusion, the Class I (8.58%) angle classification of malocclusion was reported to have the highest estimated prevalence. This result supports the study by Akbari et al.,[32] where Class I malocclusion was reported to have the highest

Table 2: Summary of studies included for the systematic review and meta-analysis

Author (publication year)	Country	Total samples	Age (in years)	Prevalence of malocclusion	Prevalence of malocclusion trait	Prevalence of orthodontic treatment needs	Conclusive findings
Al Emran et al.[26] (1990)	Saudi Arabia	500 children	14	Malocclusion parameters related to occlusion, dentition, or space were present in 62.4% of the study subjects	Crowding (19.4%), deep bite (17.4%), overjet (17.2%), cross-bite (7.2%), open bite (3.6%)	No need (37.6%), borderline need (7.5%), definite need (47.6%)	A high percentage of the samples needed orthodontic treatment
Artun et al.[27] (2005)	Kuwait	1583 school children	13–14	Prevalence of injuries to maxillary incisor (89.5%) and mandibular incisors (5.7%) due to malocclusion	Overjet (38.1%), lip incompetence (23.2%)	No or slight need (38.1%), moderate and definite need (76.2%)	Risk of maxillary incisor trauma was most prevalent and it increased by 13% for every 1 mm increase in overjet
Artun et al.[20] (2006)	Kuwait	1583 school children	13–14	NR	The most prevalent malocclusion trait was overjet >6.5 mm (6.7%) followed by anterior crossbite (4.2%) and posterior crossbite (3.0%)	13.9% exhibited treatment needs without any treatment experience	A small percentage of the participants needed early treatment
Al-Azemi and Artun[21] (2010)	Kuwait	1481	13–14	NR	The most prevalent malocclusion trait was associated with impeded eruption (77.4%), contact point discrepancy (49.4), and overjet (17.4%)	DHC: No need (49.4%), borderline need (21.3%), definite need (29.3%) AC: No need (57.8%), borderline need (29.3%), definite need (12.9%)	The requirement for definite treatment needs could be reduced from 30% to 25% provided loss of first molar could be prevented
Al Jeshi et al.[22] (2014)	UAE	20,880 school children	14.5	NR	The frequently occurring malocclusion traits included crossbite, displacement, overjet and overbite	DHC: No need (14.5%), slight need (40.3%), borderline need (38.8%), definite need (14.4%)	A moderate percentage of the samples exhibited a slight need for orthodontic treatment
Al-Hummayani and Taibah[23] (2018)	Saudi Arabia	670 school students	12–19	NR	The most prevalent malocclusion trait was crowding (48.8%) followed by overjet (21.8%) and spacing (16.1%)	DHC: No or slight need (54.3%), borderline need (21.3%), definite need (24.3%) AC: No or slight need (65.8%), borderline need (26.6%), definite need (7.6%)	Almost 25% of the subjects had a definite need for orthodontic treatment
Al Jadidi et al.[30] (2018)	Oman	854	11–16	The most prevalent malocclusion was the class I jaw relationship (86.2%) followed by the Class I molar relationship (81.6%) and the Class I incisor relationship (73.8%); Class II molar relationship (14.2%); Class III molar relationship (4.2%)	The most prevalent malocclusion trait was spacing (24.2%), followed by deep bite (16.3%), overjet >6 mm (8.6%), and crowding (2.3%)	DHC: No need (43.2%), borderline need (10.9%), and definite need (13.9%)	A moderate percentage of the subjects had no requirement of any treatment while a small percentage had a definite need for treatment
Gudipaneni et al.[14] (2018)	Saudi Arabia	500 adolescents	14–18	The most prevalent malocclusion was the angle's Class I relationship (52.8%), followed by Class II (31.8%) and Class III relationships (15.4%)	The most common malocclusion trait was crowding (47.2%)	DHC: No or slight need (49.4%), borderline need (29.6%), and definite need (21%)	Prevalence and need for orthodontic treatment are comparable with other regions of Saudi Arabia

Contd...

Table 2: Contd...

Author (publication year)	Country	Total samples	Age (in years)	Prevalence of malocclusion	Prevalence of malocclusion trait	Prevalence of orthodontic treatment needs	Conclusive findings
Taibah and Al-Hummayani[24] (2019)	Jeddah, Saudi Arabia	670 school students	12–15	Malocclusion was observed in 76.4% of the study samples	NR	DHC: No or slight need (58.9%), borderline need (30.2%), and definite need (38.5%) AC: No or slight need (74.6%), borderline need (20.3%) and definite need (3.3%)	Improvement of public understanding of the need for orthodontic treatment is suggested
Alajlan et al.[28] (2019)	Hail, Saudi Arabia	520		The most prevalent malocclusion was Class I molar relationship (70.4%) followed by Class II (21.3%) and Class III (8.3%) relationship	The most prevalent malocclusion trait was deep overbite (16.2%) followed by increased overjet (14.4%) and posterior crossbite (13.3%)	DHC: No need (58.5%), slight need (25.4%), borderline need (11.7%), and definite need (4.4%)	A moderate percentage of the samples exhibited a slight need for orthodontic treatment
Al-Harbi[31] (2020)	Al Kharj, Saudi Arabia	680 school children	11–14	The most prevalent malocclusion was Class I; molar relationship was (84.9%) followed by Class II (9%) and Class III (6.2%) molar relationships	Crowding (40.3%) was the most frequently occurring orthodontic issue followed by midline diastema (30.0%) and crossbites (15.5%)	AC: No or slight need (17.9%), borderline need, and definite need (39.1% and 42.9%	A moderate percentage of the samples exhibited subjective but definite need for treatment
Alogaibi et al.[29] (2020)	Saudi Arabia	3016 students	14–18	The most prevalent malocclusion was Class I occlusion (57%), followed by Class II (17%) and Class III (14%)	Displacement was the most prevalent malocclusion trait	DHC: Slight need (26%), borderline need (39%), and definite need (35%)	Overall high prevalence of malocclusion and high need for orthodontic treatment
Al-Khalifa et al.[25] (2021)	Saudi Arabia	197 school students	11–12	Class I molar relationship (78.2%) was the most prevalent malocclusion followed by Class II (17.5%) and Class III (4.2%)	NR	DHC: No treatment needs (44.6%) and treatment needs (55.4%) AC: No need (54.4%), borderline need (35.8%), and definite need (9.8%)	A high estimate (55.4%) of the samples required orthodontic treatment

*NR: Not reported

Table 3: STROBE criteria for quality assessment of the selected observational studies

Study	Study objective	Study design	Sampling method	Sample size	Population	Inspecting samples method	Data collection tools	Statistical analysis	Way of reporting outcomes	Reporting outcomes based on objectives	Total quality
Al Emran et al.[26] (1990)	+	+	+	+	+	+	+	−	+	−	8
Artun et al.[27] (2005)	+	+	+	+	+	+	+	+	+	+	10
Artun et al.[20] (2006)	+	+	+	+	+	+	+	+	−	+	9
Al-Azemi and Artun[22] (2010)	+	+	+	+	+	+	+	+	+	+	10
Al Jeshi et al.[22] (2014)	+	+	+	+	+	+	+	−	+	+	9
Al-Hummayani and Taibah[23] (2018)	+	+	−	+	+	+	+	+	+	−	8
Al Jadidi et al.[30] (2018)	+	+	+	+	+	+	+	+	+	+	10
Gudipaneni et al.[14] (2018)	+	+	+	+	+	+	+	+	+	+	10
Taibah and Al-Hummayani[24] (2019)	+	+	+	+	+	+	+	+	+	+	10
Alajlan et al.[28] (2019)	+	+	+	+	+	−	+	+	+	+	9
Alharbi[31] (2020)	+	+	+	+	+	+	+	−	−	+	8
Alogaibi et al.[29] (2020)	+	+	+	+	+	+	+	+	+	+	10
Al-Khalifa et al.[25] (2021)	+	+	+	+	+	+	+	−	−	+	8

prevalence among children of Iran, owing to loss of deciduous teeth due to caries at an early age. Besides, this study found a comparatively lower rate of prevalence of Class II and Class III malocclusion, which is consistent with the longitudinal study by Bugaighis,[33] where Class II (22.4%) and Class III (4.4%) malocclusion among Libyan pre-schoolers exhibited a lower prevalence compared to Class I malocclusion (69.6%). However, a different finding was reported by Shen et al.[34], which indicated that Class II malocclusion (7.97%) had a lower prevalence compared to Class III malocclusion (12.60%), but the prevalence of Class I malocclusion (26.50%) was highest. This difference in the finding could be due to genetic factors and the pattern of mandibular projection that could increase the prevalence of Class III malocclusion.[35] Bugaighis[33] suggested that early recognition of such malocclusions in the deciduous dentition stage may help to prevent a related high prevalence in the permanent dentition stage.

The most common occlusal trait was reported to be spacing, followed by crowding, which is consistent with a previous study by Bahadure et al.,[36] where spacing (64.7%) and crowding (27.1%) were observed among Indian children. Spacing, including the physiological, developmental, and primate spacing, indicates an accurate alignment of the permanent teeth[37,38]; thus, early detection and treatment are not indispensable in such cases. Developmental and primate spacing increase with the child's growth and expansion of the alveolar processes.[39] Crowding occurs mainly due to the modern diet in the deciduous dentition stage, which subsequently contributes to the discrepancy between the jaw and teeth in the permanent dentition[40]; thus, early detection and treatment are crucial to enhance the proportion between the jaw and teeth.[41] A similar finding was reported by Abu Alhaija and Qudeimat,[42] where spacing in the maxilla (61.8%) and mandible (61.1%) of primary dentition was the most prevalent among Jordanian pre-schoolers. Previous studies reported deep bite and spacing as common occlusal traits.[34,43] Shen et al.[34] reported spacing (28.34%) to be the second most prevalent occlusal trait after the deep bite (33.66%). These values were more than those reported in this study, possibly due to sampling error owing to the small sample size and differences in dentition stages. Besides, the lower prevalence of bite discrepancies (deep bite, open bite, overbite, crossbite, scissor bite) and overjet in this study could be due to the temporary occurrence of these traits during the transition from primary dentition to the permanent dentition stage and natural correction over time as a result of the vertical growth of the mandible, upward, and backward and the complete venting of permanent molars, as supported by a previous study by Baccetti et al.[44] Also, the lower prevalence of overbite

Table 4: Pooled prevalence of malocclusion and type of occlusal traits in permanent dentition among the studied population in GCC countries

Variables	Number of studies	Sample size	Pooled prevalence (%)	95% CI	Heterogeneity		
					Q	I^2 (%)	P
Malocclusion	9	8520	10.60	0.093–0.076	545.850	99.49	<0.001
Class I malocclusion	7	6267	8.58	0.074–0.188	462.311	98.89	<0.001
Class II malocclusion	6	5413	2.09	0.014–0.058	67.820	95.71	<0.001
Class III malocclusion	6	5413	0.93	0.005–0.018	15.719	75.79	0.008
Types of occlusal traits							
Spacing	2	2047	13.10	0.018–0.169	151.531	98.86	<0.001
Crowding	4	2704	4.96	0.017–0.091	121.051	95.97	<0.001
Transverse occlusal traits (lip incompetence, impeded eruption, contact point discrepancy, displacement, and midline diastema)	5	28310	1.56	0.023–0.091	458.939	99.22	<0.001
Bite discrepancies (deep bite, open bite, overbite, crossbite, and scissor bite)	8	28703	0.79	0.011–0.05	205.469	99.20	<0.001
Overjet	9	31087	0.65	0.01–0.028	195.069	97.07	<0.001

Table 5: Pooled prevalence of orthodontic treatment needs in permanent dentition in GCC countries

Variables	No. of study	Sample size	Pooled prevalence (%)	95% CI	Heterogeneity		
					Q	I^2 (%)	P
Dental health component							
No/Slight treatment needs	12	30871	1.744	0.039–0.113	563.306	99.72	<0.001
Borderline treatment needs	12	30973	0.827	0.014–0.035	182.2	97.39	<0.001
Definite treatment needs	12	30871	1.133	0.011–0.091	362.401	99.79	<0.001
Aesthetic component (AC)							
No/Slight treatment needs	5	3698	7.363	0.024–0.191	114.77	99.13	<0.001
Borderline treatment needs	5	3698	4.086	0.009–0.114	49.589	98.51	<0.001
Definite treatment needs	5	3698	2.069	0.002–0.048	42.912	97.50	<0.001

could be influenced by genetic and environmental factors,[45] while self-correction of anterior crossbite during the transition from the deciduous to permanent dentition stage was observed.[46] Similarly, early recognition and treatment decrease the long-term effects of crossbite in permanent dentition.[34] Compared to the relative prevalence of increased overjet reported in the previous studies[34,47], which ranges between 10.16% and 40.8%, the prevalence rate in this study was the lowest. This could be due to the alleviation of overjet from the deciduous to permanent dentition stage.[40]

This study found a rather low prevalence of definite and borderline needs for orthodontic treatment based on the DHC of IOTN, compared to those reported in Spanish, Italian, and Serbian school students (27.3%, 27.4%, and 21.8%).[48-50] According to the results of AC of IOTN, the prevalence of a definite need for orthodontic treatment in this study was similar to the previous studies that reported self-perceived orthodontic treatment needs among school children in London which was 2%,[51] 4.4% in Spain,[48] and 4.8% in Iran.[11] The epidemiological assessment of malocclusion requires precise information about orthodontic treatment needs, which can be helpful in policy-making and resource planning for oral healthcare systems. The IOTN is useful for gathering objective and subjective information for epidemiological purposes and establishing priorities for administrative purposes.

Limitations

Although this study offered some significant findings, these were not without some limitations and scope for further research.

1. The present review included cross-sectional studies, which unavoidably restricted the estimation of the prevalence of orthodontic treatment needs due to the use of different research methods, tools, and self-perceived judgments. Thus, longitudinal studies assessing the prevalence of orthodontic treatment needs in GCC countries are suggested.

2. The insufficient number of studies conducted in GCC countries that met the inclusion criteria restricted the accurate representation of the population. Also, a lack of enough studies was observed in Oman and the UAE, and no studies were observed in Bahrain and Qatar that satisfied the inclusion criteria. Thus, more epidemiologic studies on the prevalence of orthodontic treatment needs are suggested to be carried out in the GCC countries.

3. The significant heterogeneity observed among the included studies, which might be due to differences

in age groups, ethnic groups, analyzed traits, and genetic and environmental factors, limited the determination of the influence of variables on pooled prevalence.[52]

4. The methodological quality of the selected studies was a concern. Despite that, some of the studies mentioned the study question and sample size; these studies needed to wholly inspect the sampling method and the data collection, which might have led to biased evaluations of prevalence.

5. Only a few studies reported the prevalence of orthodontic treatment needs as per the AC criteria of IOTN. Thus, future studies descriptively assessing the prevalence of orthodontic treatment needs are suggested for epidemiological surveys.

Conclusion

This systematic review and meta-analysis identified 13 studies that estimated the prevalence of malocclusion, occlusal traits, and orthodontic treatment needs in the permanent dentition stage. This study observed that the prevalence of Class I malocclusion was highest, and Class III malocclusion was lowest in the studied populations. Moreover, the analysis of the occlusal traits revealed that spacing was most prevalent in the permanent dentition in the studied population, followed by crowding and other transverse traits (i.e., impeded eruption, contact point discrepancy, displacement, and midline diastema), vertical traits (deep bite, open bite, and overbite), and overjet. Furthermore, in this study, the majority of the population in GCC countries were categorized in no or slight need for orthodontic treatment as per DHC and AC criteria of IOTN. However, nearly 1.13% and 2.06% of the population have a definite need for orthodontic treatment. Thus, it calls for policymakers in GCC countries' attention to implement policies that recognize the importance of early preventive orthodontic treatment measures leading to improved oral health of subjects with permanent dentition.

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Conflicts of interest
There are no conflicts of interest.

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Table S1: Begg's and Egger's tests for publication bias

| Variables	Begg's test		Egger's Regression Test for Funnel Plot Asymmetry	
	Kendal tau	P	Z	P
Class I malocclusion	0.733	0.002	20.234	<0.001
Class II malocclusion	0.867	0.017	7.269	<0.001
Class III malocclusion	0.733	0.056	3.522	<0.001
Types of occlusal traits				
Crowding	0.667	0.333	10.991	<0.001
Deep bite, open bite, over bite, cross bite, scissor bite	0.5	0.109	7.149	<0.001
Overjet	0.278	0.358	6.515	<0.001
Malocclusion Lip incompetence, Impeded eruption, contact point discrepancy, displacement, spacing, midline diastema, missing teeth	927	<0.001	4.693	<0.001
Spacing	1	0.083	12.31	<0.001
Dental Health Component (DHC)				
No treatment need	0.491	0.041	16.554	<0.001
Borderline treatment need	0.467	0.073	10.541	<0.001
Definite treatment need	0.455	0.06	9.208	<0.001
Aesthetic component (AC)				
No/slight treatment need	0.8	0.083	7.785	<0.001
Borderline treatment need	1	0.017	6.892	<0.001
Definite treatment need	0.6	0.233	3.675	<0.001
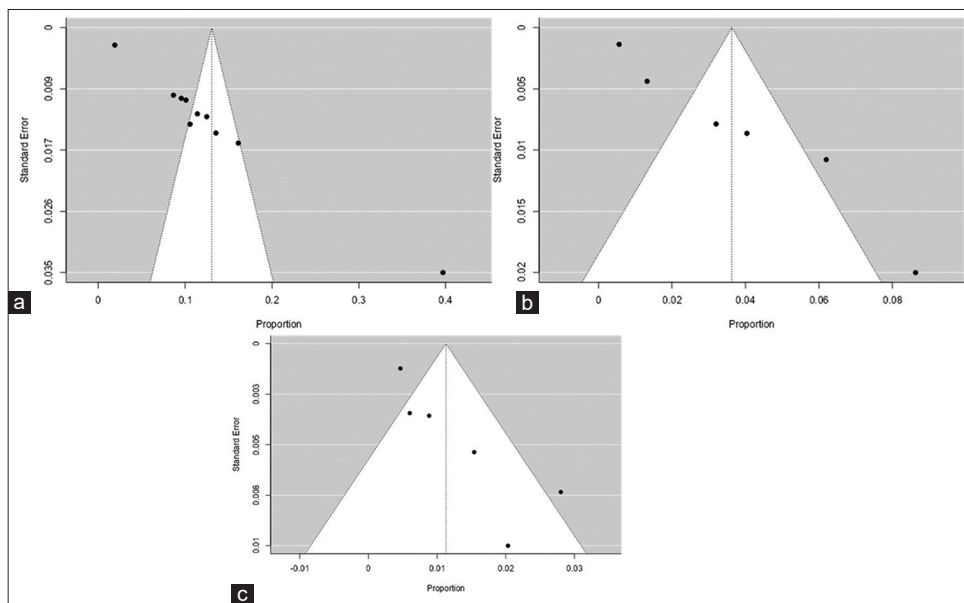
Figure S1: Funnel plot for the prevalence of malocclusion (a) class I malocclusion, (b) class II malocclusion, (c) class III malocclusion
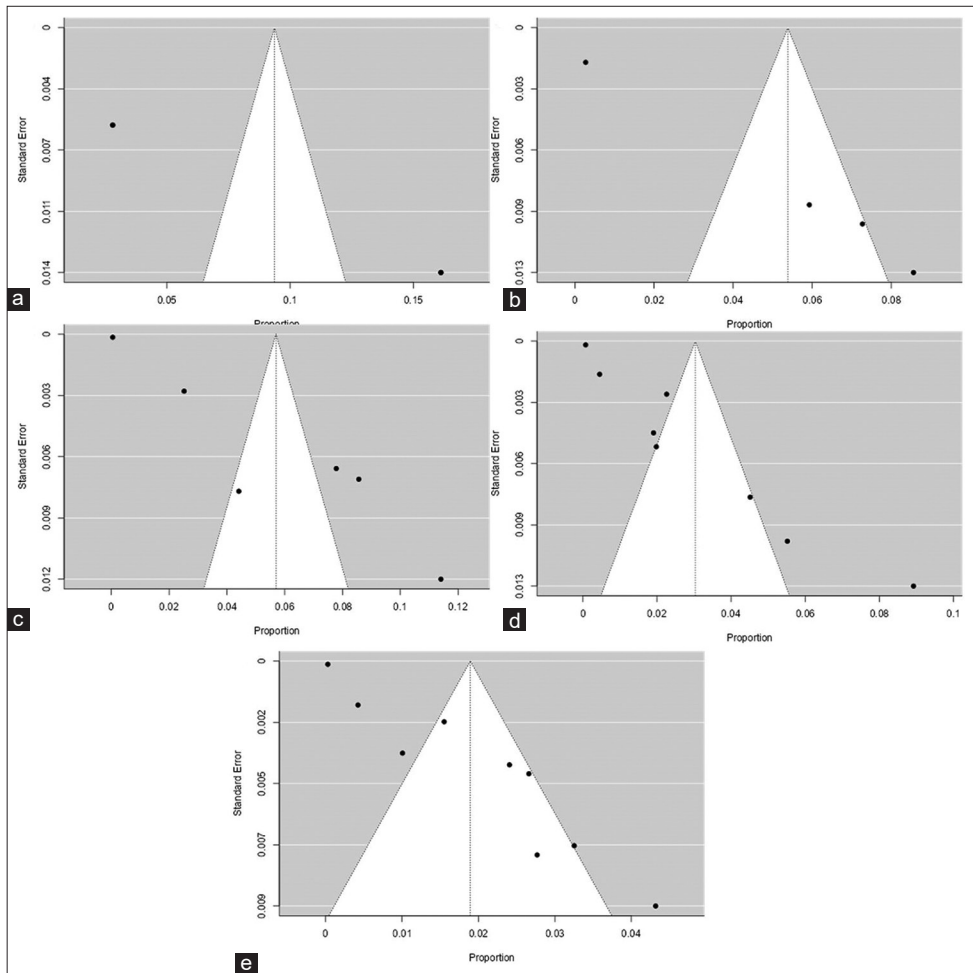
Figure S2: Funnel plot for the prevalence of occlusal traits (a) spacing, (b) crowding, (c) transverse occlusal traits, (d) bite types, (e) overjet
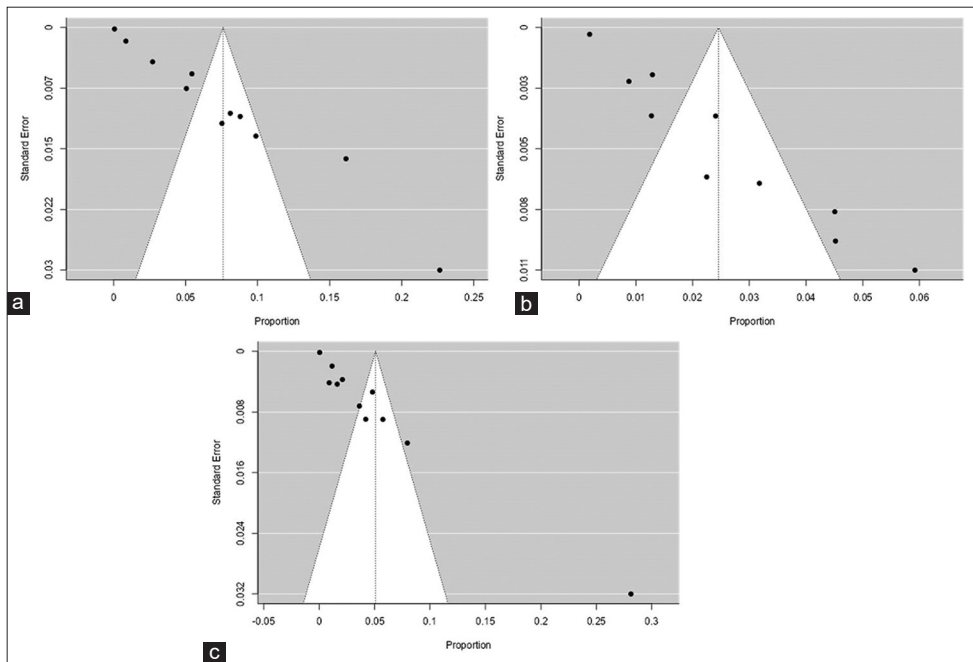

Figure S3: Funnel plot for the prevalence of orthodontic treatment needs as per the DHC of IOTN (a) no or slight treatment need, (b) borderline treatment need, (c) definite treatment need
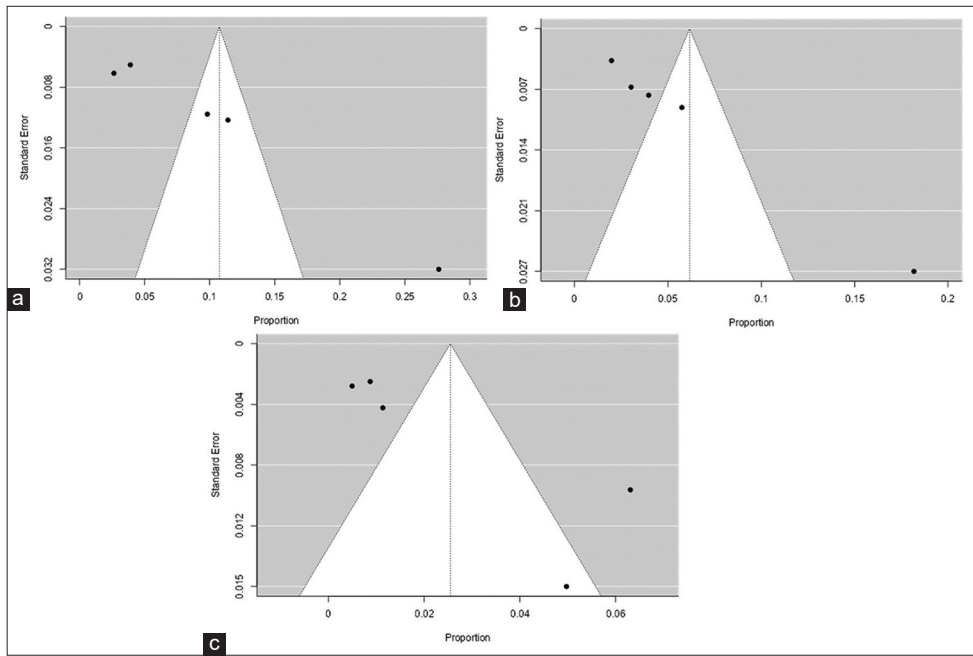
Figure S4: Funnel plot for the prevalence of orthodontic treatment needs as per the AC of IOTN (a) no or slight treatment need, (b) borderline treatment need, (c) definite treatment need