Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
https://doi.org/10.51168/sjhrafrica.v7i3.2466
Review article

Prevalence and pattern of orthodontic malocclusion in children aged 10–12 years: A systematic review of epidemiological studies.

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Abstract

Background

Malocclusion is a highly prevalent developmental condition in children and contributes to functional, esthetic, and psychosocial concerns. The age group of 10–12 years represents late mixed dentition, a critical phase for orthodontic evaluation and interceptive care. Considerable variation in reported prevalence necessitates focused synthesis within this specific age range.

Objective: To systematically evaluate the prevalence and pattern of orthodontic malocclusion in children aged 10–12 years based on epidemiological studies.

Materials and methods

This systematic review followed PRISMA 2020 guidelines. Electronic searches were conducted in PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar. School-based or population-based cross-sectional studies reporting malocclusion prevalence in children aged 10–12 years were included. Extracted data comprised study characteristics, diagnostic criteria, prevalence rates, sagittal molar relationships, and occlusal traits. Risk of bias was assessed using criteria appropriate for prevalence studies. Due to methodological heterogeneity, a narrative synthesis was performed.

Results

Four cross-sectional epidemiological studies from India, Turkey, and Iraq were included, representing 6,444 children. Reported malocclusion prevalence ranged from approximately three-quarters to more than four-fifths of the study populations. Angle's Class I malocclusion was consistently the most prevalent sagittal pattern, followed by Class II, while Class III was the least common. Increased overjet, increased overbite, crossbite, and midline deviations were frequently observed occlusal traits. No consistent gender differences were reported.

Conclusion

Malocclusion affects a substantial proportion of children aged 10–12 years, predominantly presenting as dental malalignment during late mixed dentition. Early screening programs and interceptive orthodontic strategies are warranted.

Future research

Standardized diagnostic criteria, multicentric longitudinal designs, and uniform reporting of occlusal traits are needed to improve comparability and strengthen epidemiological evidence.

Keywords: *Angle's classification, Epidemiology, Late mixed dentition, Malocclusion, Occlusal traits, Orthodontic malocclusion, Prevalence, School children*
Submitted: January 02, 2026 **Accepted:** February 17, 2026 **Published:** March 01, 2026

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Introduction

Malocclusion is defined as an irregularity of the teeth or an abnormal relationship between the dental arches that deviates from normal occlusion[1-3]. It represents one of the most prevalent developmental oral health conditions worldwide and is considered a major public health concern due to its high frequency and multifactorial impact on oral function, facial aesthetics, and overall quality of life[4,5]. Although malocclusion is not a life-threatening condition, its consequences extend beyond structural dental irregularities, influencing functional efficiency, psychological well-being, and social interactions, particularly during childhood and adolescence when self-image and social acceptance are actively developing[6-8].

The World Health Organization classifies malocclusion as a handicapping dentofacial anomaly when it interferes with normal oral function or adversely affects psychosocial well-being[8-11]. Untreated malocclusion in children has been associated with impaired mastication, speech articulation difficulties, compromised oral hygiene due to tooth irregularity, and an increased susceptibility to dental caries, periodontal disease, and traumatic dental injuries[12-14]. Beyond these functional implications, malocclusion can exert a significant psychosocial burden. Children with noticeable dental irregularities may experience reduced self-esteem, social withdrawal, and negative peer interactions, which can influence emotional development and academic performance during critical formative years[15-18].

The etiology of malocclusion is complex and multifactorial, involving an interplay of genetic, environmental, and behavioral factors[2,19,20]. Genetic influences determine craniofacial growth patterns and tooth size–arch length relationships, while environmental factors such as oral habits, premature tooth loss, nutritional status, and airway disturbances contribute to the development and progression of occlusal discrepancies. The relative contribution of these factors varies across populations, resulting in considerable diversity in the prevalence and pattern of malocclusion reported worldwide[21-25].

The age group of 10–12 years corresponds to the late mixed dentition or early permanent dentition stage, during which the permanent incisors and first molars are fully established and occlusal relationships become clearly defined. This period is widely regarded as a critical window for orthodontic assessment, as most malocclusions become clinically apparent while craniofacial growth potential remains significant. Importantly, many developing occlusal discrepancies at this stage are amenable to interceptive orthodontic measures, including habit correction, space management, and growth modification, which may reduce the severity of malocclusion and the need for complex orthodontic treatment in later adolescence[26,27].

From an epidemiological perspective, the assessment of malocclusion in the 10–12-year age group provides valuable insight into the burden of disease at a stage when preventive and interceptive strategies can be optimally implemented. Consequently, several population-based studies have evaluated malocclusion prevalence in children. However, reported prevalence rates vary widely across different regions and populations. These variations may be attributed to differences in diagnostic criteria, indices used for assessment, age ranges studied, racial and ethnic characteristics, examiner calibration, and methodological design. Additionally, some studies focus on the presence of malocclusion, while others assess orthodontic treatment need, further contributing to heterogeneity in reported outcomes.

Given these inconsistencies, there is a need for a systematic synthesis of available epidemiological evidence that specifically focuses on children aged 10–12 years. A targeted review of this age group allows for meaningful comparison of prevalence patterns and facilitates a clearer understanding of the magnitude and distribution of malocclusion during a critical developmental phase.

Therefore, the present systematic review was undertaken to evaluate the prevalence and pattern of orthodontic malocclusion in children aged 10–12 years based on epidemiological studies, to inform public health planning, early screening strategies, and timely orthodontic intervention.

Materials and methods

Study design and reporting guidelines

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines[28], ensuring transparency, reproducibility, and methodological rigor.

Review question

What is the prevalence and pattern of orthodontic malocclusion in children aged 10–12 years based on epidemiological studies?

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Search strategy

A comprehensive electronic literature search was performed to identify relevant studies reporting the prevalence of malocclusion in children aged 10–12 years. The following databases were searched:
PubMed/MEDLINE (last searched: 15 January 2026)
Scopus (last searched: 15 January 2026)
Web of Science (last searched: 15 January 2026)
Google Scholar (last searched: 18 January 2026)
The search strategy combined Medical Subject Headings (MeSH) terms and free-text keywords using Boolean operators (AND, OR). The primary search terms included:
"malocclusion" AND "prevalence" AND "children" AND "10–12 years"
"orthodontic malocclusion" AND "epidemiological study"
"Angle's classification" AND "schoolchildren"
Reference lists of all eligible full-text articles were manually screened to identify additional relevant studies.

Eligibility criteria

Inclusion criteria

- Epidemiological cross-sectional studies
- School-based or population-based samples
- Children aged 10–12 years
- Studies reporting the prevalence of malocclusion and/or occlusal traits
- Articles published in English

Exclusion criteria

- Clinic-based orthodontic treatment samples
- Studies involving age groups outside the 10–12-year range without separable data
- Case reports, case series, narrative reviews, editorials, and conference abstracts
- Studies lacking sufficient methodological detail

Study selection

Two reviewers independently screened the titles and abstracts of all retrieved records. Full-text articles of potentially eligible studies were subsequently assessed for inclusion. Disagreements between reviewers were resolved through discussion and consensus.

Data extraction

Data were extracted using a standardized data extraction form. The extracted variables included:
Author and year of publication
Country and study setting
Sample size
Age group
Diagnostic criteria used
Overall prevalence of malocclusion
Distribution of malocclusion according to Angle's classification
Prevalence of specific occlusal traits

Risk of bias assessment

The methodological quality of the included studies was assessed using criteria commonly applied to prevalence studies, including:
Representativeness of the sample
Adequacy of sample size
Validity and reliability of diagnostic criteria
Examiner calibration
Completeness of outcome reporting

Data synthesis

Due to heterogeneity in diagnostic methods and outcome reporting, a quantitative meta-analysis was not performed. Instead, a qualitative narrative synthesis of the findings was undertaken.

Certainty assessment

Given the inclusion of cross-sectional epidemiological prevalence studies and the absence of quantitative pooling, formal grading of evidence certainty using tools such as GRADE was not performed. Instead, confidence in the body of evidence was appraised qualitatively based on:
Risk of bias assessment using domain-based criteria adapted from the Joanna Briggs Institute checklist for prevalence studies
Consistency of prevalence estimates across geographically diverse populations
Adequacy of sample size and representativeness
Clarity and validity of diagnostic criteria used
The overall certainty of evidence was considered moderate, primarily limited by methodological heterogeneity in diagnostic approaches and outcome reporting across studies.

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Results

Study selection

The electronic database search initially identified 148 records relevant to the topic of malocclusion prevalence in children. After the removal of 42 duplicate records, 106 unique articles remained for title and abstract screening. During this stage, 82 articles were excluded due to irrelevance to the study objective, inappropriate age group, non-epidemiological design, or lack of prevalence data.

The full texts of the remaining 24 articles were assessed for eligibility. Following full-text evaluation, 20 studies were excluded for reasons including clinic-based samples, absence of age-specific data for children aged 10–12 years, use of orthodontic treatment records only, or insufficient methodological details. Ultimately, 4 epidemiological cross-sectional studies met all predefined inclusion criteria and were included in the qualitative synthesis.

The process of study identification, screening, eligibility assessment, and inclusion is summarized in the PRISMA flow diagram. (Figure 1)

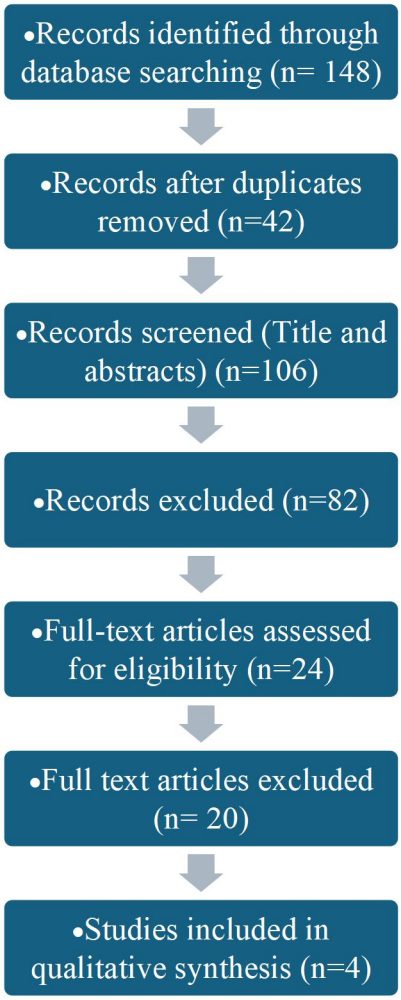

Figure 1: PRISMA flowchart

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Results of individual studies

Four cross-sectional epidemiological studies met the inclusion criteria, comprising a total sample of 6,444 children aged 10–12 years from India, Turkey, and Iraq. Because all included investigations were single-group prevalence studies without comparison groups, effect size measures such as risk ratios or odds ratios were not applicable. Each study reported point prevalence estimates for overall malocclusion and/or orthodontic treatment need. Confidence intervals were not consistently reported across the included publications.

Narayanan et al. (2016) evaluated 2,366 schoolchildren in Kerala, India, using Angle's classification and occlusal trait assessment. The study reported a high overall prevalence of malocclusion. Class I malocclusion constituted the largest proportion of cases, followed by Class II and Class III. Increased overjet, increased overbite, crossbite, open bite, and midline deviation were documented as occlusal traits. Precision estimates such as 95% confidence intervals were not reported.

Reddy et al. (2019) examined 2,550 schoolchildren in Telangana, India. Overall, malocclusion prevalence exceeded three-quarters of the study population. Class I malocclusion was most prevalent, followed by Class II and Class III. Increased overjet and overbite were frequently observed. This study did not provide confidence intervals for prevalence estimates.

Atasever İşler et al. (2025) assessed 1,144 Turkish schoolchildren. The majority of children demonstrated some form of malocclusion, with Class I predominating. Sagittal, vertical, and transverse discrepancies were reported. Precision estimates for prevalence were not uniformly presented.

Rashid et al. (2025) included 384 Iraqi children and evaluated orthodontic treatment need using the Index of Orthodontic Treatment Need (IOTN-DHC). A substantial proportion of participants fell into treatment-need categories. As with the other studies, confidence intervals were not consistently reported.

Given the absence of uniform reporting of precision measures and the heterogeneity in diagnostic criteria, quantitative synthesis was not performed.

Table 1: Characteristics of included epidemiological studies assessing malocclusion in children aged 10–12 Years

Author (Year)	Country	Study Design	Sample Size	Age Group (years)	Study Setting	Diagnostic Criteria / Index Used	Key Outcomes Reported
Narayanan et al. (2016)[29]	India (Kerala)	Cross-sectional epidemiological study	2366	10–12	School-based	Angle's classification and assessment of occlusal traits	Overall prevalence of malocclusion; sagittal molar relationships; overjet, overbite, crossbite, open bite, midline deviation
Reddy et al. (2019)[30]	India (Telangana)	Descriptive cross-sectional study	2550	10–12	School-based	Angle's classification with detailed occlusal trait evaluation	Overall malocclusion prevalence; distribution of Class I, II, III; overjet, overbite, crossbite, midline discrepancies
Atasever İşler et al.	Turkey	Cross-sectional epidemiological study	1144	10–12	School-based	Angle's classification	Prevalence of normal

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(2025)[31]						and occlusal characteristics	occlusion and malocclusion; sagittal, vertical, and transverse discrepancies
Rashid et al. (2025)[32]	Iraq	Cross-sectional study	384	10–12	School-based	Index of Orthodontic Treatment Need (IOTN-DHC)	Orthodontic treatment needs: severity grades of malocclusion

Risk of bias assessment

Reporting bias was assessed qualitatively. All included studies clearly described overall prevalence outcomes and key occlusal traits. However, variability existed in the depth of reporting for secondary outcomes such as severity grading, gender stratification, and precision estimates.

None of the studies indicated selective suppression of outcomes. Nevertheless, incomplete reporting of confidence intervals and lack of detailed subgroup analyses limited full transparency in some cases. The overall risk of reporting bias due to missing results was considered low to moderate, primarily related to incomplete statistical detail rather than evidence of selective reporting. (Table 2)

Table 2: Risk of bias assessment of included studies

Author (Year)	Sampling Representativeness	Sample Size Adequate	Diagnostic Criteria Clearly Defined	Examiner Calibration Reported	Outcome Reporting Complete	Overall Risk of Bias
Narayanan et al. (2016)[29]	Yes	Yes	Yes	Not clearly reported	Yes	Moderate
Reddy et al. (2019)[30]	Yes	Yes	Yes	Yes (single trained examiner)	Yes	Low
Atasever İşler et al. (2025)[31]	Yes	Yes	Yes	Yes	Yes	Low
Rashid et al. (2025)[32]	Yes	Moderate	Yes	Yes	Yes	Low to Moderate

Certainty of evidence

Certainty in the body of evidence for each assessed outcome was appraised qualitatively, considering:
Risk of bias within individual studies
Consistency of findings across geographically diverse populations
Adequacy of sample sizes
Clarity of diagnostic criteria
Overall prevalence of malocclusion:
Certainty was considered moderate, supported by large school-based samples and consistent findings across countries, though limited by methodological heterogeneity.
Distribution of Angle's classification:
Certainty was considered moderate, as Class I predominance was consistently observed across studies.
Occlusal traits (overjet, overbite, crossbite, midline deviation): Certainty was considered low to moderate, due to variation in trait definitions and reporting formats.
Orthodontic treatment need (IOTN-DHC):
Certainty was considered moderate, limited by reliance on a single included study for this specific outcome. The primary factor reducing certainty across outcomes was heterogeneity in diagnostic approaches and inconsistent reporting of statistical precision.

Discussion

The present systematic review demonstrated that orthodontic malocclusion is highly prevalent among children aged 10–12 years. All the included

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epidemiological studies consistently reported a substantial burden of malocclusion during the late mixed dentition stage. Narayanan et al. (2016)[29] reported that more than four-fifths of South Indian schoolchildren within this age group exhibited some form of malocclusion, while Reddy et al. (2019)[30] documented a prevalence exceeding three-quarters among schoolchildren from Telangana, India. Similar findings were observed in a Turkish population, where Atasever İşler et al. (2025)[31] reported that only a small proportion of children demonstrated normal occlusion. Furthermore, Rashid et al. (2025)[32], using the Index of Orthodontic Treatment Need, found that a considerable proportion of Iraqi children aged 10–12 years required orthodontic intervention. Collectively, these findings indicated that malocclusion was a common developmental condition across diverse populations in this age group.

With regard to sagittal molar relationships, the included studies uniformly identified Angle's Class I malocclusion as the most prevalent pattern. Narayanan et al. (2016)[29] and Reddy et al. (2019)[30] both reported a predominance of Class I malocclusion, followed by Class II, with Class III malocclusion being relatively uncommon. Atasever İşler et al. (2025)[31] similarly observed that Class I malocclusion constituted the largest proportion of sagittal discrepancies among Turkish schoolchildren. This consistent distribution suggested that the majority of malocclusions identified in the included studies were primarily dental in nature rather than severe skeletal discrepancies. Such a pattern was clinically significant, as dental malalignments at this stage were considered more responsive to interceptive orthodontic measures during late mixed dentition.

Evaluation of occlusal traits across the included studies revealed that increased overbite and increased overjet were among the most frequently reported findings. Reddy et al. (2019)[30] documented a high prevalence of these sagittal and vertical discrepancies, and similar observations were made by Narayanan et al. (2016)[29]. Crossbite and midline deviations were also commonly reported, whereas open bite and reverse overjet were observed less frequently. Rashid et al. (2025)[32] further demonstrated that sagittal and vertical discrepancies constituted the principal contributors to orthodontic treatment need in Iraqi schoolchildren. These findings reflected the transitional nature of dentofacial development during late mixed dentition, a phase characterized by active growth and evolving occlusal relationships.

In terms of gender distribution, the included studies generally reported no statistically significant difference in overall malocclusion prevalence between males and females. Narayanan et al. (2016)[29] and Reddy et al. (2019)[30] observed comparable prevalence rates among boys and girls, while Atasever İşler et al. (2025)[31] similarly reported minimal gender-based variation. Although Rashid et al. (2025)[32] noted minor differences in the distribution of treatment need grades, these variations did not indicate a consistent or clinically meaningful sex predilection.

When the findings of the included studies were compared with earlier epidemiological literature, a high degree of agreement was evident. Helm (1968)[34] reported a high prevalence of malocclusion among Danish children with adolescent dentition, with Class I malocclusion being the most common sagittal pattern. Foster and Day (1974)[35] similarly documented a substantial frequency of malocclusion among 11–12-year-old schoolchildren in the United Kingdom, predominantly involving dental malalignments. Hill (1992)[36], in a study of Glasgow schoolchildren aged 9, 12, and 15 years, also reported a predominance of Class I malocclusion, supporting the sagittal distribution observed in the present review.

Comparable prevalence patterns were further documented in epidemiological studies conducted across diverse geographic regions. Thilander et al. (2001)[37] reported a high prevalence of malocclusion among children and adolescents in Bogotá, Colombia, with Class I malocclusion predominating across different stages of dental development. Garner and Butt (1985)[47] reported similar findings among Black American and Nyeri Kenyan populations, while Ng'ang'a et al. (1996)[48] documented a substantial prevalence of malocclusion among Kenyan schoolchildren. Bourzgui et al. (2012)[38] observed similar findings among Moroccan schoolchildren aged 8–12 years, while Brito et al. (2009)[39] reported a high burden of malocclusion among Brazilian children aged 9–12 years. Studies conducted in Saudi Arabia and Nigeria also demonstrated substantial malocclusion prevalence among school-aged children, reinforcing the global consistency of these findings[40,41].

The predominance of increased overjet and overbite observed in the included studies was consistent with earlier reports from British and European populations. Foster and Day (1974)[35] and Hill (1992)[36] identified sagittal and vertical discrepancies as common occlusal traits in schoolchildren, while similar trait distributions were reported in Brazilian and Moroccan populations[38,39]. A global systematic review by Alhammadi et al. (2018)[42] further confirmed that increased overjet and overbite were among the most prevalent malocclusion traits worldwide, findings that were corroborated by the more recent systematic review by De Ridder et al. (2022)[43].

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The prevalence of crossbite reported in the included studies was also consistent with previous epidemiological evidence. Thilander et al. (2001)[37] emphasized the clinical importance of posterior crossbite due to its association with functional mandibular shifts and asymmetric craniofacial growth, while Harrison and Davis (1996)[44] reported similar concerns among indigenous Canadian children. The identification of crossbite during late mixed dentition in the included studies, therefore, underscored the need for early orthodontic assessment and intervention.

The absence of consistent gender differences in malocclusion prevalence observed in the included studies was in accordance with earlier epidemiological findings. Helm (1968)[34], Hill (1992)[36], Thilander et al. (2001)[37], Bourzgui et al. (2012)[38], and Abu Alhaija et al. (2004)[45] all reported minimal or no significant sex-related differences in overall malocclusion prevalence, suggesting that gender was not a major determinant of malocclusion during this developmental stage.

Variations in malocclusion prevalence across studies were likely influenced by methodological differences, including diagnostic criteria, examiner calibration, and assessment indices. While some studies evaluated the presence of malocclusion using Angle's classification and occlusal trait analysis, others emphasized orthodontic treatment need using indices such as the IOTN[36,38,46]. Such methodological heterogeneity has been widely acknowledged in epidemiological literature and was identified as a key factor limiting direct comparison of prevalence estimates across populations.

Longitudinal evidence further supported the importance of early assessment. Peres et al. (2015)[49] demonstrated that malocclusion present during the deciduous dentition significantly predicted orthodontic treatment need later in life, underscoring the value of early screening. Methodological considerations also influenced reported prevalence. Peres et al. (2001)[50] highlighted the importance of examiner calibration in epidemiological studies to enhance diagnostic reliability, a factor not uniformly reported across all included studies.

Limitations of the Evidence and Review Process

Several limitations must be acknowledged. First, the evidence base was restricted to four cross-sectional epidemiological studies from three countries. Although the total pooled sample size was substantial, geographic representation was limited. The findings, therefore, cannot be generalized to all global populations, particularly regions with different ethnic, socioeconomic, and environmental determinants of craniofacial growth. Second, heterogeneity in diagnostic approaches limited comparability. Three studies used Angle's classification with occlusal trait assessment, whereas one relied on the Index of Orthodontic Treatment Need (IOTN-DHC). Variations in examiner calibration, trait definitions, and reporting formats reduced methodological uniformity. Confidence intervals and precision measures were not consistently reported, restricting statistical interpretation. Third, all included studies were cross-sectional. Such designs permit estimation of prevalence but do not allow inference regarding causal pathways, developmental progression, or long-term orthodontic outcomes. Fourth, although the risk of bias was assessed using domain-based criteria adapted from the Joanna Briggs Institute checklist for prevalence studies, no formal GRADE assessment was undertaken due to the descriptive nature of the included evidence. Certainty appraisal was therefore qualitative.

With respect to the review process, inclusion was limited to English-language publications, which may have introduced language bias. Grey literature was not systematically searched beyond Google Scholar screening. Additionally, meta-analysis was not feasible due to heterogeneity in outcome definitions and reporting, limiting quantitative synthesis.

Implications for practice

The consistently high prevalence of malocclusion in children aged 10–12 years supports routine orthodontic screening during late mixed dentition. School-based dental health programs provide an effective platform for early identification of sagittal, vertical, and transverse discrepancies. Since Angle's Class I malocclusion with dental malalignment predominated, many cases may be amenable to interceptive orthodontic measures such as space management, habit correction, and growth modification during this developmental stage.

Early detection may reduce severity progression and decrease the complexity of comprehensive orthodontic treatment during adolescence.

Implications for policy

The substantial burden of malocclusion demonstrated across geographically distinct populations supports the incorporation of orthodontic screening into public oral health surveillance systems. Policymakers may consider structured school-based orthodontic assessment programs, particularly in regions with limited access to specialist care.

Standardized national epidemiological protocols using uniform diagnostic criteria would improve comparability and resource allocation planning. Integration of

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orthodontic need assessment into community dental indices could strengthen public health prioritization.

Implications for future research

Future investigations should prioritize:
Multicentric studies across diverse geographic and ethnic populations
Standardized diagnostic criteria and uniform reporting of occlusal traits
Mandatory reporting of precision measures, such as 95% confidence intervals
Longitudinal cohort designs to evaluate progression from late mixed dentition to adolescence
Comparative assessment of prevalence versus orthodontic treatment need
Methodological consistency, examiner calibration reporting, and transparent statistical presentation will enhance reliability and allow meaningful meta-analytic synthesis.

Conclusion

The present systematic review demonstrated that orthodontic malocclusion was highly prevalent among children aged 10–12 years across diverse populations, with the majority of cases characterized by Angle's Class I malocclusion and commonly associated with increased overjet, increased overbite, crossbite, and midline deviations. These findings indicated that most malocclusions identified during late mixed dentition were primarily dental in nature rather than severe skeletal discrepancies, highlighting the potential effectiveness of early orthodontic assessment and interceptive intervention at this stage of development. The absence of consistent gender differences further suggested that both male and female children were equally affected. Overall, the results underscored the importance of early screening and timely orthodontic referral, particularly through school-based programs, to reduce the severity of malocclusion and the need for complex orthodontic treatment in later adolescence.

Acknowledgement

The authors acknowledge PSP Medical College Hospital and Research Institute, Tamil Nadu, India, for providing academic support and institutional facilities necessary for completion of this review.

List of abbreviations

IOTN-DHC – Index of Orthodontic Treatment Need, Dental Health Component
JBI – Joanna Briggs Institute
MeSH – Medical Subject Headings
PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Registration and protocol

This systematic review was not registered in a prospective review registry.
A formal review protocol was not prepared before the commencement of the study.

Support

No financial support was received for this review.
The study was conducted as part of independent academic work.
No external funding bodies or sponsors had any role in study design, literature search, data extraction, analysis, interpretation, or manuscript preparation.

Author contributions

Hemalatha D.: Conceptualization, supervision, critical review of manuscript.
Karthik Shunmugavelu: Study design, literature search, data extraction, risk of bias assessment, data synthesis, manuscript drafting, and corresponding author responsibilities.
Santosh Kumar S.: Literature screening, data extraction assistance, manuscript formatting, and reference verification.
All authors reviewed and approved the final manuscript.

Author biography

Hemalatha D. is an Associate Professor in the Department of Biochemistry at PSP Medical College Hospital and Research Institute, Tamil Nadu, India. Her academic interests include biochemical research and interdisciplinary applications in medical sciences.
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https://doi.org/10.51168/sjhrafrica.v7i3.2466
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interests include oral pathology, epidemiology, and clinical dentistry.

Santosh Kumar S. is an undergraduate medical student (MBBS) at PSP Medical College Hospital and Research Institute, Tamil Nadu, India, with academic interests in clinical research and public health.

Competing interests

The authors declare no competing interests.

Availability of data, code, and other materials

The data extraction form used in this review was developed by the authors and is available from the corresponding author upon reasonable request. All data extracted from included studies are presented within the manuscript tables. No analytic code was generated, as no meta-analysis was performed. No additional materials are publicly archived.

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e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.7 No. 3 (2026): March 2026 Issue
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Publisher details

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256 775 434 261
Location: Scholar's Summit Nakigalala, P. O. Box 701432, Entebbe Uganda, East Africa