







Perception of malocclusion and school performance in adolescents: a systematic review

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Abstract: This study aimed to assess the potential association between perception malocclusion and school performance in children and adolescents. An electronic search was performed in ten databases. Based on the PECO acronym (Population, Exposition, Comparator, and Outcome), the eligibility criteria included observational studies that compared the school performance of children and adolescents with and without the perception of malocclusion. There were no restrictions on the language or year of publication. Two reviewers selected the studies, extracted the data, and assessed the risk of bias by using the Joanna Briggs Institute tool for cross-sectional studies. School performance was measured by analyzing student grades; levels of absenteeism; and child or adolescent self-perception and/or the perception of parents, guardians, close friends, and teachers regarding the impact of malocclusion on school performance. The data were described narratively/descriptively. The search resulted in 3,581 registers, of which eight were included in the qualitative synthesis. These studies were published between 2007 and 2021. Two studies concluded that there was no significant association between school performance and perception of malocclusion, five studies found that only some of the children with malocclusion had their school performance affected, and one study concluded that there was a significant association between perception of malocclusion and low school performance. Considering all variables and the very low certainty of evidence, the perception of malocclusion seems to negatively impact school performance when associated with external and subjective factors. Further studies using additional measurement standards are required.

Keywords: Academic Performance; Adolescent; Child; Dental Occlusion.

Introduction

Individuals undergo several physical and emotional changes from birth to adulthood.¹ Children and adolescents show a high worldwide prevalence of malocclusion.² This is associated with multiple factors such as dental caries, pulpal and periapical lesions, dental trauma, abnormality of development, and oral habits.³ Moreover, on its own, facial growth from childhood to adolescence is unable to correct most of the malocclusions of primary dentition.²



Malocclusions constitute oral changes with a global prevalence of 39% among adolescents.⁴ In some phases of their development, children and adolescents spend a considerable number of years in schools and other education and training institutions.¹ The presence of oral disorders may affect the school life of these individuals.^{5,6} Some explicit and extreme malocclusions may also be related to bullying in childhood and adolescence.⁷

There is evidence that certain oral conditions, such as caries, periodontal disease, tooth loss, and orofacial pain, may negatively affect oral health-related quality of life^{8,9} and school performance.¹⁰ However, the primary evidence in the literature on the role of malocclusion in the school performance of children and adolescents has not yet been gathered into secondary studies. Thus, the present systematic review aimed to investigate and expose the existing scientific evidence about the impact of the perception of malocclusion on children and adolescents' school performance.

Methodology

Protocol registration

The protocol of this systematic review was described according to the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols guidelines¹¹ and registered in the International Prospective Register of Systematic Reviews database under number CRD42020172295 (<https://www.crd.york.ac.uk/prospero/>). Moreover, this systematic review was reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines¹² and conducted according to the norms of the Joanna Briggs Institute manual for Evidence Synthesis¹³ and according to the Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology guidelines.¹⁴

Research question and eligibility criteria

This systematic review aimed to answer the following guiding question based on the PECO acronym (Population, Exposition, Comparator, and Outcome): "Do children and adolescents with malocclusion present lower school performance than individuals without malocclusion?"

Inclusion criteria

Population: Children and adolescents up to 19 years old, according to the World Health Organization¹⁵

Exposition: Malocclusion perceived by the individuals and/or their parents/guardians and assessed using reliable methods, such as self-perception or dental indices

Comparator: Children and adolescents who did not report perceived malocclusion and without any diagnosed malocclusion

Outcome: School performance (grade analyses, level of absenteeism, and child or adolescent self-perception or the perception of parents, guardians, and/or teachers regarding the impact of malocclusion on school performance)

Type of study: observational studies (cross-sectional, case-control, or cohort studies)

There were no restrictions on language or year of publication.

Exclusion criteria

Studies with a sample of individuals with current or previous orthodontic treatment

Studies with a sample of syndromic individuals

Studies assessing school performance using the perception of malocclusion images by third parties

Review articles, letters to the editor or editorials, personal opinions, book chapters or books, textbooks, case reports or case series, reports, and congress abstracts

Studies with overlapping samples; when two or more studies were conducted in the same place, by the same authors, and in similar years, but published in different journals or years. In this case, the most recent study that best described the methodology and results was considered.

Sources of information and search

Electronic searches were performed in November 2020 and updated until June 2022 in the following databases: Embase, LILACS and BBO, MedLine (via PubMed), SciELO, Scopus, and Web of Science. The BDTD, EASY, and WorldCat databases were used to partially capture the "gray literature". A manual search was also performed using a systematized analysis of the list of references of eligible studies. Medical

Subject Headings, Health Sciences Descriptors, and Embase Subject Headings were used to select keywords used in the search strategies. Synonyms and free terms were also used. Boolean operators “AND”

and “OR” were used to refine the research strategy using several combinations. The search strategies for each database were based on their respective syntax rules (Table 1).

Table 1. Strategies for database search

Database	Search Strategy
Main Databases	
Embase http://www.embase.com/	("malocclusion"/exp OR "malocclusion" OR "tooth crowding"/exp OR "tooth crowding" OR "crossbite"/exp OR "crossbite" OR "cross bite"/exp OR "cross bite" OR "angle classification" OR "esthetics"/exp OR "esthetics" OR "aesthetics"/exp OR "aesthetics" OR "esthetics, dental"/exp OR "esthetics, dental" OR "tooth"/exp OR "tooth" OR "teeth"/exp OR "teeth") AND ("academic performance" OR "school performance" OR "educational measurement" OR "educational test score" OR "absenteeism" OR "student dropouts" OR "student dropout" OR "school dropout")
LILACS and BBO http://lilacs.bvsalud.org/	((("Malocclusion" OR "Tooth Crowding" OR "Crossbite" OR "Cross Bite" OR "Angle Classification" OR "Esthetics" OR "Aesthetics" OR "Esthetics, Dental" OR "Tooth" OR "Teeth") AND ("Academic Performance" OR "School Performance" OR "Educational Measurement" OR "Educational Test Score" OR "Absenteeism" OR "Student Dropouts" OR "Student Dropout" OR "School Dropout")) AND (db:("LILACS" OR "BBO")))
MEDLINE (via PubMed) http://www.ncbi.nlm.nih.gov/pubmed	#1 "Malocclusion"[Mesh] OR "Tooth Crowding"[tw] OR "Crossbite"[tw] OR "Cross Bite"[tw] OR "Angle Classification"[tw] OR "Esthetics"[Mesh] OR "Aesthetics"[tw] OR "Esthetics, Dental"[Mesh] OR "Tooth"[Mesh] OR "Teeth"[tw] #2 "Academic Performance"[Mesh] OR "School Performance"[tw] OR "Educational Measurement"[Mesh] OR "Educational Test Score"[tw] OR "Absenteeism"[Mesh] OR "Student Dropouts"[Mesh] OR "Student Dropout"[tw] OR "School Dropout"[tw] #1 AND #2
SciELO http://www.scielo.org/	#1 ("Malocclusion" OR "Tooth Crowding" OR "Crossbite" OR "Cross Bite" OR "Angle Classification" OR "Esthetics" OR "Aesthetics" OR "Esthetics, Dental" OR "Tooth" OR "Teeth") #2 ("Academic Performance" OR "School Performance" OR "Educational Measurement" OR "Educational Test Score" OR "Absenteeism") #1 AND #2
Scopus https://www.scopus.com/	(TITLE-ABS-KEY (("Malocclusion" OR "Tooth Crowding" OR "Crossbite" OR "Cross Bite" OR "Angle Classification" OR "Esthetics" OR "Aesthetics" OR "Esthetics, Dental" OR "Tooth" OR "Teeth")) AND TITLE-ABS-KEY (("Academic Performance" OR "School Performance" OR "Educational Measurement" OR "Educational Test Score" OR "Absenteeism" OR "Student Dropouts" OR "Student Dropout" OR "School Dropout")))
Web Of Science http://apps.webofknowledge.com/	#1 TS= (("Malocclusion" OR "Tooth Crowding" OR "Crossbite" OR "Cross Bite" OR "Angle Classification" OR "Esthetics" OR "Aesthetics" OR "Esthetics, Dental" OR "Tooth" OR "Teeth")) #2 TS= (("Academic Performance" OR "School Performance" OR "Educational Measurement" OR "Educational Test Score" OR "Absenteeism" OR "Student Dropouts" OR "Student Dropout" OR "School Dropout")) #1 AND #2
Gray Literature	
BDTD http://btdtd.ibict.br/	(Todos os campos:(("Malocclusion" OR "Tooth Crowding" OR "Crossbite" OR "Cross Bite" OR "Angle Classification" OR "Esthetics" OR "Aesthetics" OR "Esthetics, Dental" OR "Tooth" OR "Teeth") E Todos os campos:(("Academic Performance" OR "School Performance" OR "Educational Measurement" OR "Educational Test Score" OR "Absenteeism" OR "Student Dropouts" OR "Student Dropout" OR "School Dropout")))
Easy https://easy.dans.knaw.nl/	((("Malocclusion" OR "Tooth Crowding" OR "Crossbite" OR "Cross Bite" OR "Angle Classification" OR "Esthetics" OR "Aesthetics" OR "Esthetics, Dental" OR "Tooth" OR "Teeth") AND ("Academic Performance" OR "School Performance" OR "Educational Measurement" OR "Educational Test Score" OR "Absenteeism" OR "Student Dropouts" OR "Student Dropout" OR "School Dropout")))
WorldCat https://www.worldcat.org/	((("Malocclusion" OR "Tooth Crowding" OR "Crossbite" OR "Cross Bite" OR "Angle Classification" OR "Esthetics" OR "Aesthetics" OR "Esthetics, Dental" OR "Tooth" OR "Teeth") AND ("Academic Performance" OR "School Performance" OR "Educational Measurement" OR "Educational Test Score" OR "Absenteeism" OR "Student Dropouts" OR "Student Dropout" OR "School Dropout")))

Study selection

The search results were exported to the EndNote Web™ software (Thomson Reuters, Toronto, Canada) for cataloging and removing duplicates. The results obtained in the partial search of the “gray literature” were exported to Microsoft Word (Microsoft, Washington, USA) to manually remove duplicates. Before the selection of studies, a calibration exercise was performed when the examiners discussed the eligibility criteria and applied them to a sample of 20% of the eligible studies to determine the inter-examiner agreement.

After reaching an adequate level of agreement ($\kappa \geq 0.81$), the reviewers (ACC and DMP) performed a detailed analysis of the titles and abstracts of the studies, applying the inclusion and exclusion criteria mentioned above. Studies that did not meet these criteria were excluded. Next, the full texts of the eligible preliminary studies were obtained and evaluated. In this phase, the excluded studies were listed separately, specifying the reasons for their exclusion. Two eligible reviewers independently performed the entire selection process. Disagreements were resolved by consulting with a third reviewer (LRP).

Data extraction

Two reviewers (ACC and DMP) independently extracted data from eligible studies. A calibration exercise was performed to ensure consistency between the two reviewers, in which information was jointly extracted from one eligible study. A third reviewer (LRP) performed calibration. The following data were extracted: identification and characteristics of the study (author, year, country, research location, and application of ethical criteria), sample characteristics (number of participants, age group, sex distribution, and method of malocclusion analysis), and main outcome characteristics (school grades, absenteeism, relationship with bullying, and assessment of school performance by parents or teachers). In case of incomplete or insufficient data, the corresponding author was contacted via e-mail up to three times at weekly intervals.

Risk of bias assessment

Evaluation of methodological quality

The studies were assessed for the risk of individual bias using the JBI Critical Appraisal Tools for use in the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies.¹⁶ Two authors (ACC and DMP) independently assessed each domain for the risk of bias as recommended by the PRISMA statement.¹²

Each question could be answered as follows: “Yes,” if the study did not present biases for the domain assessed in the question; “No,” if the study presented biases for the domain assessed in the question; “Uncertain,” if the study did not provide sufficient information to assess the question bias; and “Not Applicable,” if the question did not fit in the study.

Evaluation of control statements for possible confounders and bias consideration

The control statements for possible confounders and risk of bias were evaluated based on the methodology described by Hemkens et al.¹⁷ First, eligible studies that mentioned only bivariate analysis or did not report multivariate analysis were excluded from this evaluation. Second, two independent reviewers (ACC and DMP) critically appraised the remaining studies. The reviewers were blinded, and a third reviewer (LRP) was consulted in case of disagreements. Each article had the Abstract and Discussion sections analyzed in consideration of confounders using six questions which were previously established. Only the sixth question considered the Conclusion section. If the conclusion section was absent, the last paragraph of the Discussion section was considered.

Assessment of confounding factors

The confounding factors were assessed based on the methodology described by Wallach et al.¹⁸ It was conducted by two reviewers (ACC and DMP), independent and blinded. A third reviewer (LRP) was consulted during disagreements. All studies included in the evaluation of control statements for possible confounders and bias consideration had their Methods and Result sections analyzed. The aim was to list the variables included in each

study and identify which variables were used to perform adjustment, stratification, or matching between groups.

Adjustment variables were analyzed using multivariate logistic regression analysis or Poisson's regression. Stratification variables were those used in the sample selection to make strata. Matching variables ensured compatibility of characteristics between groups. In addition, variables considered possible confounding factors were set together in their respective confounding domains.

Summary of measurements and synthesis of results

The data collected were organized and described descriptively or narratively (qualitative synthesis) according to the findings presented in each study. School performance was measured by analyzing student grades; levels of absenteeism; and child or adolescent self-perception and/or the perception of parents, guardians, close friends, and teachers regarding the impact of malocclusion on school performance.

Certainty of evidence

Two reviewers (WAV and MTCV) independently ranked the overall strength of evidence using the Grading of Recommendations, Assessment, Development and Evaluation tool.¹⁹ To assess the criteria in systematic reviews without meta-analyses, the authors followed the adaptations proposed by Murad et al.²⁰

Results

Study selection

The electronic search identified 3,581 results distributed into nine electronic databases, including the "gray literature". After removing duplicates, 3,098 results remained for the analysis. Careful reading of the titles and abstracts excluded 3,071 results. Twenty-seven registers were sought for retrieval and three were not retrieved. Twenty-four studies remained for full-text reading. At this stage, 16 studies were excluded because they did not meet the inclusion criteria. Thus, eight studies were included in the

qualitative synthesis.^{10,21-27} Figure shows the details of the study selection process.

Characteristics of the eligible studies

The studies were published between 2007 and 2021 and performed in five different countries: Brazil,^{10,22,24,25} Chile,²⁶ India,²³ Mongolia,²⁷ and Peru.²¹ All studies reported the following ethical criteria with the approval of an ethics committee and/or application of a consent form to the research participants. The sample included 9,369 children and adolescents allocated to public and private schools. The reported ages varied between 3 and 19 years.

Malocclusion was assessed using the Dental Aesthetic Index (DAI),^{10,22,23,26} self-perceived malocclusion,²¹ malocclusion exam for the presence of dentofacial features,²⁴ the use of a Community Periodontal Index (CPI) probe,²⁵ and the Index of Orthodontic Treatment Need (IOTN).²⁷ The tools used to measure the school performance of participants varied among grades,^{10,22,23,26,27} self-reports by adolescents,^{21,25} and absenteeism.²⁴

Table 2 details the information of each eligible study.

Summary of measurements and synthesis of results

Eight studies^{10,21-27} were included in the qualitative synthesis, and their outcomes are summarized below.

The study by Paula et al.²² did not show a significant association between the need for orthodontic treatment (assessed using the DAI) and school performance, with an odds ratio (OR) of 1.33 (0.87-2.03). Similarly, Julca-Ching and Carruitero²⁶ did not find a significant difference in school performance scores between young individuals with normal occlusion and those with malocclusion, regardless of severity. Furthermore, both studies highlighted the potential association between the influence of external and subjective factors, especially related to family members and socioeconomic conditions, and the impact of malocclusion on school performance.

Ortiz et al.¹⁰ reported that some adverse oral conditions, such as malocclusion, as well as subjective and socioeconomic factors, might have impacted

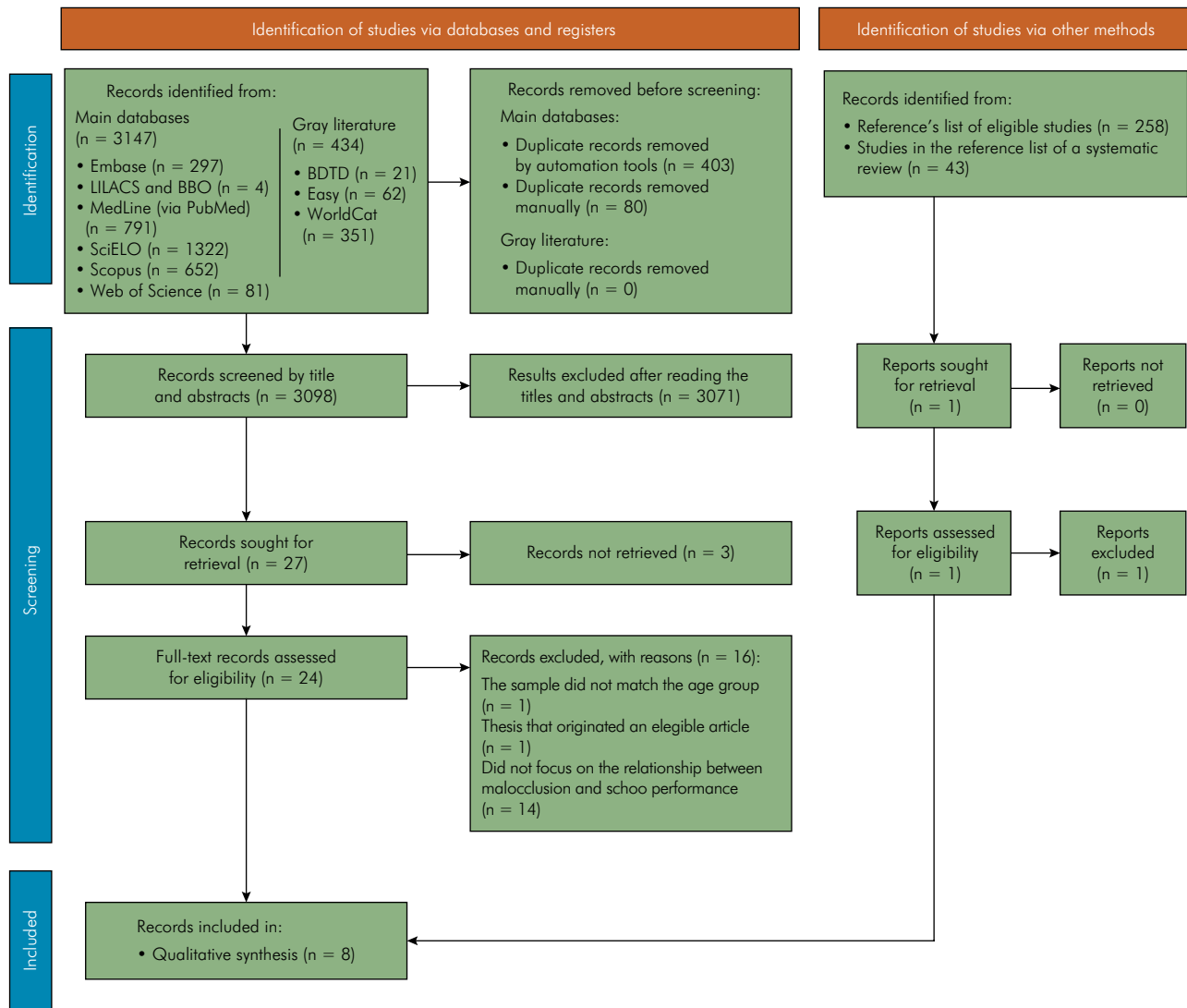


Figure. Flowchart depicting the study selection process (Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram).

adolescents' academic performance. Bernabé et al.²¹ observed that only 0.6% of the children analyzed reported some impact of malocclusion on their education, with the impact intensity ranging from mild to moderate.

In turn, Basha et al.²³ found that 42% of students with malocclusion presented impact on school performance, with grades below average over the last three years. Regarding the self-perceived impact, 20% of the students reported that school performance was affected by their dental appearance. As for the perception of parents, 77% felt that the school

performance of their children was affected by dental appearance, 79% of teachers reported such perception, and 32.7% of the close friends of the students analyzed mentioned such a relationship. Badrakhkhuu et al.²⁷ also observed that schoolchildren in Mongolia with dental crowding, a type of malocclusion, might be prone to poor academic performance, particularly in arts and physical education.

Neves et al.²⁴ showed a prevalence of 8.5% in school absences due to oral problems. Lastly, Cunha et al.²⁵ observed a significant association between malocclusion (such as accentuated overjet and

Table 2. Main characteristics of the eligible studies

Author, year ^{ref} (country)	Sample (♂/♀)	Mean age ± SD (Age range)	Number and type of school	Assessment of malocclusion	Type or grade of malocclusion assessed (%)	Assessment of school performance
Bernabé <i>et al.</i> , 2007 (Peru) ²¹	805 (393/412)	11.96 ± 0.63 (11-12)	Four public schools	Self-perceived	Perceived malocclusion (36.3%): · Position of teeth (28.4%) · Spacing of teeth (16.3%) · Deformity of the mouth or face (1.6%)	Self-assessment Condition-specific impacts were reported during interview with adolescents using the Child-OIDP questionnaire.
de Paula <i>et al.</i> , 2015 (Brazil) ²²	515 (225/290)	12 ± 0 (12)	Private and public schools	Dental Aesthetic Index (DAI)	DAI grade 3 and 4 (24.3%)	School records were assessed to obtain students' grades.
Basha <i>et al.</i> , 2016 (India) ²³	366 (185/181)	nr (14-15)	nr	Dental Aesthetic Index (DAI)	DAI grade 3 and 4 (nr)	Self-assessment and assessment of parents, teachers, friends, and School records to obtain students' grades
Neves <i>et al.</i> , 2016 (Brazil) ²⁴	836 (431/405)	3.96 ± 0.78 (3-5)	Eighteen public and fifteen private schools	Malocclusion exam	Dentofacial features (34.8%): · Increased overbite greater than 2 mm · Increased overjet greater than 2 mm · Anterior open bite · Posterior crossbite · Anterior crossbite	School absenteeism assessed within B-ECOHS questionnaire self-reported by the parents.
da Cunha <i>et al.</i> , 2019 (Brazil) ²⁵	5162 (2255/2907)	14.79 ± 1.53 (15-19)	nr	Community Periodontal Index (CPI) probe*	Dentofacial features (52.8%): · Maxillary overjet lesser than 1 mm · Maxillary overjet greater than 3 mm · Mandibular overjet · Anterior open bite	School failure questionnaire self- reported by the adolescents.
Julca-Ching and Carruitero, 2019 (Chile) ²⁶	147 (132/15)	14.54 ± 1.76 (12-18)	One private school	Dental Aesthetic Index (DAI)	DAI grade 1 (12.2%) DAI grade 2 (42.9%) DAI grade 3 (28.6%) DAI grade 4 (16.3%)	School records were assessed to obtain students' grades.
Badrakhkhoo <i>et al.</i> , 2021 (Mongolia) ²⁷	767 (336/431)	11.3 ± 1.9 (nr)	Two public schools	Index of Orthodontic Treatment Need (IOTN) and dental casts	Dentofacial features (32.6%): · Increased overjet (3.8%) · Reverse overjet (1.6%) · Deep bite (1.7%) · Anterior crossbite (9.4%) · Posterior crossbite (6.8%) · Scissor bite (4.2%) · Crowding (21.1%) · Hypodontia (4.6%)	School records were assessed to obtain students' grades.
Ortiz <i>et al.</i> , 2021 (Brazil) ²⁸	771 (361/410)	12 ± 0 (12)	Twenty public schools	Dental Aesthetic Index (DAI)	DAI grade 2, 3, and 4 (49.5%)	School records were assessed to obtain students' grades.

nr: not related to the study; SD, standard deviation; * CPI probe was used to perform measurements.

open bite) and school performance, directing the measurement to school failure (OR, 1.40 (1.31–1.50)) after adjusting for confounding factors.

Table 3 shows the main outcomes and quantitative results regarding the presence of malocclusion and its impact on school performance in each eligible study.

Risk of individual bias of the studies

Methodological quality of the eligible studies

Only two studies^{24,26} met all criteria from the checklist. Three studies^{21,23,26} did not meet the fifth, sixth, and eighth question criteria because they lacked proper confounding acknowledgement and did not perform multivariate analysis to adjust for their variables, showing high potential biases in their

methodology. Table 4 shows more details about the methodological evaluation of the eligible studies.

Evaluation of control statements for possible confounders and bias consideration

All eight eligible studies were analyzed, and three studies were excluded for mentioning only bivariate analysis or not reporting multivariate analysis. After this, five studies^{10,22,24,25,27} were included in the evaluation of control statements for possible confounders and bias consideration. Only one study²⁷ did not mention the term “confounding” and only two studies^{27,28} mentioned the term “bias”. Only two studies^{10,25,28} mentioned non-adjusted variables that were not measured. The results of four studies^{10,22,24,27} were possibly affected by confounding factors.

Table 3. Main outcomes of the eligible studies

Author ^{ref}	Presence of malocclusion (%)	Impact of malocclusion on school performance	Main outcomes
Bernabé <i>et al.</i> ²¹	36.3	0.6	Self-perceived malocclusion primarily affected psychological and social everyday activities. These findings provide further evidence to support the importance of psychological and social components of oral health on children’s lives.
de Paula <i>et al.</i> ²²	24.3	38.4	The results of this study showed that socioenvironmental factors, subjective perceptions, and oral health status of children - particularly carious lesions, have an important impact on school performance, demonstrating the need for planning public health dentistry based on intersectoral public policies.
Basha <i>et al.</i> ²³	100	20.2	Untreated gross dental malocclusion significantly affects the psychosocial well-being of adolescents, who may avoid participating in social activities and tend to underperform in school.
Neves <i>et al.</i> ²⁴	34.8	8.5	The prevalence of preschool absenteeism due to oral problems was 8.5 % and associated with the occurrence of cavitated dental caries. Further studies, especially investigations with a longitudinal design, are needed to garner a better understanding of this problem.
da Cunha <i>et al.</i> ²⁵	87.76	nr	Oral disorders and social factors were associated with school failure in adolescents. A successful school trajectory was a strong determinant of health; therefore, actions between the educational and health sectors must be developed for adolescents, especially those who fit this profile.
Julca-Ching and Carruitero ²⁶	52.8	26.8	The need for orthodontic treatment in school-going children did not show an impact on academic performance, self-esteem, and bullying scores. The need for orthodontic treatment, as measured by the Dental Aesthetic Index, did not prove to be a determining factor in the presence of such variables in school-going children.
Badrakhkhoo <i>et al.</i> ²⁷	32.6	nr	School-going children in Mongolia with dental crowding may be prone to poor academic performance, particularly in arts and physical education. Further randomized controlled trials are needed to determine whether the treatment of crowding boosts academic performance.
Ortiz <i>et al.</i> ²⁸	42.5	nr	Adverse oral conditions as well as subjective and socioeconomic factors impacted adolescents’ academic performance.

nr, not related to the study.

Four studies^{22,24,25,27} reported the need for caution when interpreting their results. Only one study²⁷ included limitations in the Conclusion section. The results of the evaluation of the control statements for confounders and bias consideration are presented in Table 5.

Assessment of confounding factors

Eighty-six variables were identified in the studies included in this analysis. They were classified into five domains: dentofacial features, school environment, sociodemographic and socioeconomic factors, residential environment, and dental services. The domain with the most variables was the dentofacial feature domain with 20 different variables. The most frequent variables were age, sex, and family income, which were present in all studies. There was high heterogeneity among all studies, as well as their variables within the school environment, residential environment, and dental services domains. Some variables had similar meanings; thus, they were set together in standardized terms for better analysis. The confounding domains identified in the eligible studies are presented in Table 6.

In addition, 59 continuous and categorical variables were used as adjustment variables. Age and sex were used for adjustment in three studies and were the most commonly used variables within the adjusted variables. Only one study²⁴ used stratification variables: school district and school type. Only age was used

to match groups; this matching variable was present in two studies.^{10,22}

Certainty of evidence

The certainty of evidence was classified as “very low” and downgraded due to the risk of bias, inconsistency, and indirectness (Table 7).

Discussion

The present systematic review aimed to assess whether adolescents with malocclusion tend to have lower school performance than those without malocclusion. The evidence from the studies included in the qualitative synthesis suggests that this dental condition affects student performance when associated with external factors, especially those related to family members and socioeconomic conditions.

School performance can be assessed by using several indicators. The quantitative indicators relate to the grades obtained by students in evaluations, tests, and homework, the approval rate,²² and levels of absenteeism.²⁵ Indicators obtained from self-perception or the perception of parents, guardians, teachers, or close friends are considered qualitative indicators because they depend on a subjective interpretation and the individual judgment of a situation.²⁸ Therefore, the analysis of school performance is associated with objective factors and organic, cognitive, psychological, socioeconomic, and educational factors.²⁹ The eligible

Table 4. Risk of bias assessed with the Joanna Briggs Institute Critical Appraisal Tools for use in the JBI Critical Appraisal Checklist for Analytic Cross-Sectional Studies

Authors ^{ref}	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Bernabé <i>et al.</i> ²¹	U	√	--	--	--	--	U	--
de Paula <i>et al.</i> ²²	U	√	√	√	√	√	√	√
Basha <i>et al.</i> ²³	√	U	√	√	--	--	√	--
Neves <i>et al.</i> ²⁴	√	√	√	√	√	√	√	√
da Cunha <i>et al.</i> ²⁵	U	U	√	√	√	√	√	√
Julca-Ching and Carruitero ²⁶	√	√	√	√	--	--	√	--
Badrakhkhoo <i>et al.</i> ²⁷	√	√	√	√	√	√	√	√
Ortiz <i>et al.</i> ²⁸	U	√	√	√	√	√	√	√

Q1) Were the sample inclusion criteria clearly defined? Q2) Were the study participants and environment described in detail? Q3) Was the exposure measured both valid and reliable? Q4) Were the criteria used for measuring the condition objective? Q5) Were confounding factors identified? Q6) Were there any strategies to handle confounding factors? Q7) Were the results valid and reliable? Q8) Was there proper statistical analysis? √, Yes; --, No; U, Unclear.

Table 5. Evaluation of control statements for possible confounders and bias consideration

Section	Question	Possible answers with explanation	N (%)
Abstract and Discussion	Is the term “confounding” mentioned in the Abstract or Discussion?	Specific: if the authors used the exact term “confounding”	2 (40%)
		Alluded: if the authors used a similar term or phrase	2 (40%)
		No: if the authors used neither the exact nor similar term	1 (20%)
	Is the term “bias” used in the Abstract or Discussion?	Yes: if the authors used the term “bias”	2 (40%)
		No: if the authors did not use this term	3 (60%)
		Yes: if there was a specific mention of non-adjusted variables with no reasons presented	0
	Is there any specific mention of non-adjusted variables in the Abstract or Discussion?	Not measured: if there was a specific mention of non-adjusted variable not being measured	2 (40%)
		Other reasons: if there was a specific mention about non-adjust variables, with plausible reasons for not adjusting them	0
		No reasons: if there was a specific mention about non-adjusted variables, with implausible reasons for not adjusting them	0
		No: if there was no mention about any non-adjusted variable	3 (60%)
		Likely: if the authors used terms such as “likely” or convincing statements implying that the confounders were not controlled	1 (20%)
		Possibly: if the authors used terms such as “possibly” or unsure statements suggesting that the confounders were or were not controlled	4 (80%)
Is there any mention about confounders affecting results in the Abstract or Discussion?	Unlikely: if the authors used terms such as “unlikely” or convincing statements suggesting that the confounders were controlled	0	
	No mention: if there was no mention of this possibility	0	
	Yes: if there was explicit mention about the need for caution in interpreting the results obtained in the study	4 (80%)	
Is there any statement on the need for caution in interpreting the results?	No mention: if there was no mention about this need for caution	1 (20%)	
	Yes: if there was a mention of this limitation	1 (20%)	
Conclusion	Does the Conclusion include any limitation about confounders?	No: if there was no mention of this limitation	4 (80%)

studies of this review showed high heterogeneity for the tools for measuring school performance among the young people assessed.

In this context, the presence of abnormal dentofacial characteristics, such as malocclusion, may negatively interfere with the school performance of individuals, as suggested by some of the eligible studies.^{10,21,24,25,27} In general, poor health conditions of students might harm their cognitive development and participation in school activities, increasing the levels of absenteeism,³⁰ which corroborates the negative impact of malocclusion on school performance.^{10,21,24,25,27} In studies that used qualitative indicators,^{21,23} there was a focus on the self-perception of students with malocclusion and the perception of parents, teachers, and close friends. Divergent results from the perceptions of parents

and teachers to that of students and close friends showed that, in most cases, adults did not understand the situations and difficulties that children and adolescents faced in school.²³

However, the neutral results of those impacts on school performance from other eligible studies^{22,26} highlighted the strong influence of external and subjective factors when dealing with different adverse situations on behavioral changes and decreased school performance, such as poor family socioeconomic conditions,³¹ low level of education of parents or guardians,³¹ household overcrowding,^{32,33} and the type of school attended by the child or adolescent.²²

Eligible studies were conducted in different countries, with major socioeconomic and cultural factors that might have influenced the results. For

Table 6. Confounding domains identified in selected studies

Confounding domain		Description	Examples
1	Dentofacial features	Dentofacial features in general, occlusal traits, dental caries, traumatic dental injuries, periodontal changes, and oral impacts	Increased overjet; Reverse overjet; Deep bite; Anterior crossbite; Posterior crossbite; Scissors bite; Crowding; Decayed teeth; Missing tooth; Dental caries; Severity of dental caries; Avulsion and/or luxation; Discoloration; Enamel-dentin fracture; Enamel fracture without trauma; Toothache; Bleeding on probing; DAI; DMFT index; OIDP.
2	School environment	School administrative and infrastructural characteristics, school absenteeism, school failure, and school performance parameters	School type; School location; School district; School absenteeism; School failure; Overall score; Arts score; Language score; Mathematics score; Physical education score; Science score; Social science score; Distraction in class; Difficulty in doing homework; Difficulty in speaking or reading aloud in class; Verbal bullying; IDEB.
3	Sociodemographic and socioeconomic	Sociodemographic and socioeconomic characteristics	Age; Sex; Family income; Father's education; Mother's education; Ethnicity.
4	Residence environment	Residence environment characteristics, and psychosocial perceptions of parents and children	Number of people in house; House ownership; House overcrowding; Children living with both biological parents; Parents' perception on general health; Parents' perception on oral health; Children's perception on general health; Children's perception on oral health; Children's perception on happiness; Children's perception on community cooperation; Children's perception on community safety.
5	Dental services	Accessibility and frequency of dental services	Accessibility; Reason for access; Access within the last 6 months.

DAI, Dental Aesthetics Index; DMFT, Decayed, Missing, and Filled Teeth; OIDP, Oral Impacts on Daily Performance; IDEB, Basic Education Development Index.

Table 7. Summary of findings by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) for the outcomes of the systematic review

Number of studies	Study design	Risk of bias	Certainty assessment Summary of results				Impact	Certainty
			Inconsistency	Indirectness	Imprecision	Other considerations		
<i>CHANGES IN PULPAL BLOOD FLOW (ORME)</i>								
8	Cross-sectional studies	Serious ^a	Serious ^b	Serious ^c	Not serious	none	Two studies concluded that there was no significant association between school performance and perception of malocclusion, five studies found that only part of the children with malocclusion had their school performances affected, and one study concluded that there was a significant association between perception of malocclusion and low school performance.	⊕ Very Low

a – The majority of the studies presented import bias due to confounding factors.

b – The studies presented divergent results.

c – The main outcome was assessed using different tools that indirectly evaluated school performance.

GRADE Working Group grades of evidence

High certainty: Very confident that the true effect is close to the estimated effect.

Moderate certainty: Moderately confident in the estimated effect; the true effect is likely close to the estimated effect, but it may be substantially different.

Low certainty: Limited confidence in the estimated effect; the true effect may be substantially different from the estimated effect.

Very low certainty: Very little confidence in the estimated effect; the true effect may be substantially different from the estimated effect.

example, low- and middle-income countries, such as Brazil and India, still present concerns about child labor, which can affect the physical and mental health of this population.³⁴ In poor families, it may be common to observe children and adolescents working to help their parents or relatives with monthly bills. These less privileged conditions may also be related to typical public health and social questions, which are already associated with impaired school performance: dental caries and worse oral health,³⁵ altered sleep time,³⁶ and less access to proper schooling resources and equipment,³⁷ especially in the recent online study methods.³⁶

All eligible studies were cross-sectional. This type of study can lead to limitations when analyzing outcomes, as they analyze exposure and outcome at the same time, which impairs the inference of causality.³⁸ Furthermore, observational studies do not present permutability between their study groups, because of the lack of randomized variables.³⁹ On the other hand, as the focus is on malocclusions, it may favor a cause-and-effect interpretation, as they can be considered as inborn characteristics of the individuals.³⁸ However, it is still not a longitudinal design to better estimate the exact correlation of the variables studied. This could also underestimate the role of confounding factors.

Some potential biases in the eligible studies should be acknowledged. First, the performance of only bivariate analysis or the lack of multivariate analysis in observational studies are common and dangerous pitfalls. Observational studies have a high risk of presenting several uncontrolled confounders, which limits their results.¹⁴ Multivariate analysis is a reliable statistical test to provide proper adjustment of variables, reducing the potential confounding influence.³⁸ Secondly, this reduction is unfortunately not absolute, and the interpretation of results should be performed with caution. Although there was acceptable prudence in selected studies regarding this caution, they lacked proper acknowledgement of non-adjusted variables and inclusion of limitations in the Conclusion section.

The confounding domains identified in the selected studies brought up some confounders to be considered in the association between malocclusion

and school performance. It is important to highlight them because of their potential roles as causes, effects, or coincidences without any relationship. However, inferences about the roles of each variable are limited to be made based on observational studies.¹⁴ Therefore, further studies with longitudinal and controlled designs are necessary to better understand this association.

This review had a few limitations. First, different observational designs might have affected the presence of divergences among the individual results of the studies, especially regarding the absence of standardization of the tools for assessing malocclusions. Most studies^{10,22-27} were based on dental professionals' perception measurements to assess malocclusions, such as the DAI, malocclusion exam, IOTN, and the use of a CPI probe. Only one study²¹ subjectively measured malocclusion using Child Oral Impacts on Daily Performances, with the self-perception of individuals. Subjective measurements may be subject to the influence of individual experiences, considering that the same condition may be understood differently by each individual. Moreover, the assessment of several school performance indicators was verified among the studies and some of them^{21,23,26} did not perform analyses to deal with confounding factors associated with the outcomes. Thus, owing to the lack of measurement standards, the results may not reflect the true impact of malocclusion on school performance. Further studies with the application of more standardized and better-designed methodologies are encouraged to address such limitations. Another significant limitation worth noting is that malocclusion may relate to other factors that can also affect school performance, such as bullying.⁴⁰ The lack of analysis of confounding factors was a bias identified in part of the eligible studies and deserves attention when interpreting the results.

Some strengths of this systematic review must be highlighted, such as its preparation according to specific instructions¹² and caution to minimize biases. Moreover, this is the first systematic review to specifically assess the impact of malocclusion on the school performance of children and adolescents. The evidence summarized may be useful for the decision-making of governments and school administrators,

especially regarding the need to establish a partnership between schools and dental professionals in an attempt to provide better oral health and higher access to dental treatments, such as orthodontic treatment to correct malocclusions.

Conclusion

The very low certainty evidence suggests that the perception of malocclusion negatively affects the school performance of students when associated with external factors, especially those related to family members and socioeconomic conditions. Considering

the limitations of this systematic review, the results may not accurately reflect the impact of malocclusion on school performance. Nevertheless, the findings provide important data to encourage health actions toward the development of oral health care programs for students, aiming to improve their quality of life physically and psychologically, and consequently, their school performance.

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