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# Predictors associated with malocclusion in children with and without sleep disorders: a cross-sectional study

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**Abstract:** The aim of the present study was to investigate predictors of malocclusion in Brazilian schoolchildren eight to ten years of age based on a causal directed acyclic graph model. A cross-sectional study was conducted with 739 schoolchildren eight to ten years of age. Parents/guardians provided information on sleep disorders of the child (Sleep Disturbance Scale for Children) and family characteristics (Family Adaptability and Cohesion Evaluation Scale). The diagnosis of malocclusion was performed by four trained examiners using the Dental Aesthetic Index. Control variables were selected using a directed acyclic graph. Descriptive analysis was performed, followed by robust logistic regression analysis for complex samples (α = 5%). The following variables were associated with malocclusion in the final model: sleep disorders (OR = 2.61; 95%CI: 2.43–2.86), mouth breathing (OR = 1.04; 95%CI: 1.02–1.99), non-nutritive sucking habits (OR = 2.45; 95%CI: 2.37–4.85), and obesity (OR = 1.54; 95%CI: 1.02–2.33). Sociodemographic characteristics, family functioning, and premature tooth loss did not remain associated with malocclusion. Sleep disorders, mouth breathing, sucking habits, and obesity are predictors of malocclusion in schoolchildren eight to ten years of age.

**Keywords:** Malocclusion; Sleep Wake Disorders; Obesity; Family Relations.

## Introduction

Malocclusion is caused by the incorrect positioning of the jaws and/or teeth[1] and is considered a public health problem due to its high prevalence throughout the world.[2] The prevalence in children ranges from 16.5% to 82.1%,[3,4] depending on the diagnostic method and characteristics of the study population.

Etiological factors of malocclusion include hereditary and environmental aspects, such as non-nutritive sucking habits, mouth breathing, respiratory disorders[5] and tooth loss.[6-8] Malocclusion can cause functional and esthetic problems as well as psychosocial effects on self-esteem and social interacitons.[3,9] Besides being a risk factor for low quality of life in children,[10] malocclusion can also have a negative effect on the quality of life of families, with an impact on emotional

aspects and family conflicts.[11,12] It is therefore important to investigate possible associations between biopsychosocial factors and malocclusion.

Biological factors, such as obesity and sleep disorders, have been associated with obstructive sleep apnea, adenoid hypertrophy, and atypical breathing in children.[3,14] Due to the impact on the stomatognathic system, these aspects can contribute to the development of malocclusion.[13,14] Sleep disorders in children may be associated with class II malocclusion with mandibular retrognathia.[15] However, a systematic review study concluded that it was not possible to confirm the association between sleep disorders and malocclusion in children due to the low quality of the evidence available in the literature,[16] underscoring the need for further studies that explore these aspects in childhood.

Regarding psychosocial factors, family relations have recently been the focus of scientific investigations due to the influence on the oral health of children and adolescents.[17,18] Moreover, family conflicts, school pressure, anxiety, and stress are involved in the etiology of harmful oral habits in children.[19,20] Thus, an extreme family context may contribute to the acquisition of harmful oral habits and, consequently, malocclusion. As no previous studies have explored the influence of family functioning on the occurrence of malocclusion, the conceptual hypothesis of this investigation is that family functioning is associated with malocclusion in children in the mixed dentition phase.

Therefore, the aim of the present study was to investigate predictors of malocclusion in Brazilian schoolchildren eight to ten years of age using a causal directed acyclic graph model.

## Methodology

### Ethical considerations

This study received approval from the local human research ethics committee (approval number: 3.255.174; process number: 10514619.2.0000.5187) and was conducted in accordance with the guidelines stipulated in the Declaration of Helsinki. Parents/guardians received clarifications regarding the objectives of the study and signed a statement of informed consent authorizing the participation of the children. The children also agreed to participate in the study by signing a term of assent.

### Study design and sample

A descriptive, analytical, cross-sectional study was conducted at public and private schools in the city of Campina Grande, which is located in northeastern Brazil. Data collection took place between August and November 2019. This study was reported following the guidelines of *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE statement).[21]

A representative sample was selected using a two-step (schools and children) probabilistic cluster sampling. Ten public schools and 13 private schools were randomly selected, followed by the selection of children aged eight to ten years at the selected schools using a simple random sampling procedure. The number of students was proportional to the number of children enrolled in the six different administrative districts of the city.

The sample size was calculated for analytical studies that compare two independent proportions using the G* Power software program, version 3.1 (Franz Faul, Universitat Kiel, Germany), considering a 95% significance level and 80% study power. The proportion of malocclusion in the pilot study in children with and without sleep disorders was respectively 54.1% and 40%. The use of this variable provided the largest sample for the evaluation of associations in the present study. The minimum sample was calculated to be 392 schoolchildren. A design effect of 1.6 was applied, leading to a sample of 628 schoolchildren, to which 20% was added to compensate for possible dropouts. Thus, the desired final sample was 785 schoolchildren.

A pilot study was conducted with 40 children from a public school and a private school. These children were selected by convenience and were not included in the main study. The results of the pilot study revealed no need to alter the proposed methods.

### Eligibility criteria

Children eight to ten years of age enrolled at public and private schools in the city of Campina Grande, Brazil, were included. Children with syndromes,

developmental disorders, cognitive impairment reported by teachers and guardians, a current or past orthodontic treatment, and whose guardians did not share the same residence as them were excluded from the study.

### Training and calibration exercises

Training of the examiners was conducted in two steps (theory and practice), as reported by Neves et al.[17] An experienced specialist trained four dentists in the diagnosis of malocclusion using the Dental Aesthetic Index. The first step was a discussion of the criteria for diagnosis involving photographs, plaster models, a clinical chart, and the sequence to follow during clinical examination. The second step consisted of the calibration exercise, in which 40 children from a public school and a private school were examined on two different occasions for the determination of inter-examiner and intra-examiner agreement using the Kappa statistic. The coefficients revealed good levels of agreement ($K > 0.80$).

### Non-clinical data collection

A sociodemographic questionnaire, oral habits questionnaire, the Sleep Disturbance Scale for Children, and the Family Adaptability and Cohesion Evaluation Scale were sent to the parents/guardians for the collection of non-clinical data.

The sociodemographic questionnaire addressed the child's sex, age and skin color, mother's age and schooling, family income, and number of residents in the home. Another questionnaire was used to collected the parents'/guardians' reports on the practice and frequency of oral habits of the child at the time of the data collection (digit [finger/thumb] sucking, pacifier sucking, and use of a feeding bottle).

Sleep disorders were investigated using the Sleep Disturbance Scale for Children (SDSC), which has been validated in Brazil[22]. The SDSC addresses the sleep habits of children in the previous six months and consists of 25 items that assess disorders of initiating and maintaining sleep, sleep breathing disorders, disorders of arousal, sleep-wake transition disorders, disorders of excessive sleepiness, and sleep hyperhydrosis. Each item has scored response options ranging from 1 to 5: "never", "occasionally" (once or twice per month), "sometimes" (once or twice per week), "often" (three to five times per week), and "always" (daily). The sum of the scores provides a total score ranging from 26 to 130 points.[23] In the present study, a cutoff of 39 points was used to characterize the presence of sleep disorder in a child.[22]

Family relations were evaluated using the Family Adaptability and Cohesion Evaluation Scale (FACES III), which has been validated in Brazil.[24] This instrument is composed of 20 items. Even-numbered items address family cohesion and odd-numbered items address family adaptability. Based on the results (sum of cohesion items and sum of adaptability items), family functioning is classified as extreme (1–2), medium level of balance (3-4), moderately balanced (5–6) or balanced (7–8). This determination was performed with the aid of a scoring table created by the authors.[24]

### Clinical data collection

The children performed supervised brushing prior to the clinical examinations to facilitate diagnosis and received counseling on appropriate oral hygiene. The participants were examined individually in a reserved room in the school, sitting in front of the examiner, who used personal protective equipment, a LED lamp on the head (Petzl Zoom; Petzl America; Clearfield, USA), sterilized mouth mirror (PRISMA, São Paulo, Brazil), sterilized Williams probe WHO-621; Trindade, Campo Mourão, Brazil), and gauze to dry the teeth.

The Dental Aesthetic Index (DAI) was used for the diagnosis of malocclusion. This is a quantitative index proposed by Cons et al.[25] and recommended by the World Health Organization[26] for the evaluation of the degree of esthetic impact of malocclusion based on occlusal characteristics: missing teeth, anterior crowding, anterior spacing, midline diastema, greater anterior misalignment in the maxilla, greater anterior misalignment in the mandible, horizontal overjet, negative horizontal overjet, anterior open bite, and anteroposterior molar relationship. The DAI results classify the severity of malocclusion and

the need for orthodontic treatment: ≤ 25 = normal occlusion, no need for treatment; 26 to 30 = definite malocclusion suggesting elective treatment; 31 to 35 = severe malocclusion with treatment highly recommended; ≥ 36 = very severe malocclusion, treatment necessary.[25,26]

Breathing pattern was evaluated using the breathing domain of the Nordic Orofacial Test-Screening (NOT-S), which has been adapted and validated for Brazilian Portuguese[27]. The NOT-S is administered as an interview with "yes" (1 point) and "no" (0 points) answers. Mouth breathing was recorded as present when at least one "yes" answer was given and absent when the score was 0.

For the evaluation of premature tooth loss due to caries, missing teeth were recorded during clinical examination for the determination of the DAI, except those lost due to physiological exfoliation. To obtain information on physiological exfoliation, the eruption chronology was considered, and the child was asked at the time of the examination whether the missing tooth "fell out on its own" or had been extracted due to caries. Anthropometric data (weight and height) were collected using a portable Tanita® digital scale (Model UM080W) and a stadiometer. Both devices were placed on the floor with no carpet or rug. Each measurement was taken three times, followed by the calculation of mean weight and height for each child. Nutritional status was calculated using the AnthroPlus program indicated by the World Health Organization[28] and the result was evaluated in percentiles: score of -3 (3$^{rd}$ percentile, severely underweight); -2 (15$^{th}$ percentile, underweight); -1 (50$^{th}$ percentile, adequate); +1 (85$^{th}$ percentile, overweight); +2 (97$^{th}$ percentile, obesity); +3 (> 97$^{th}$ percentile, severe obesity).

### Directed acyclic graph

A directed acyclic graph (DAG) was created using the DAGitty software program (version 3.0) to select covariables for the statistical adjustments and to assist in interpretating the effect of the exposure variables on malocclusion[29]. The DAG included the outcome, antecedents of the outcome, antecedents of the outcome and exposure, and latent variables (those not collected but that could have an influence on the outcome). Family income, mother's schooling, and number of residents in the home were used as control factors to adjust the model (Figure).

### Statistical analysis

Data organization and analysis were performed with the aid of SPSS Statistics (SPSS for Windows, version 25.0; IBM Inc., Armonk, USA). The dependent variable was malocclusion as determined by the DAI score and was treated as a dichotomous categorical variable (yes: DAI > 25; no: DAI ≤ 25).[4] The independent variables were sociodemographic characteristics, obesity, sleep disorders, sucking habits, mouth breathing, premature tooth loss, and type of family. Unadjusted and adjusted robust logistic regression analyses for complex samples were performed. Variables with a p-value < 0.20 were incorporated into the final model using the backward stepwise method and adjusted using the Hosmer-Lemeshow test. Variables with a p-value < 0.05 in the adjusted model were considered to be significantly associated with the outcome and remained in the final model.

## Results

The final sample was composed of 739 children eight to ten years of age (mean: 8.9 ± 0.82 years), for a 94% response rate. Dropouts occurred due to three consecutive student absences and refusals to participate.

Table 1 displays the characteristics of the sample. The prevalence of malocclusion was 49.1%. Most participants had sleep disorders (58.6%) and family functioning was classified as moderately balanced in 37.1% of the sample.

Table 2 displays associations between independent variables and malocclusion. In the unadjusted analysis, sociodemographic characteristics, obesity, premature tooth loss, and family functioning were not associated with malocclusion.

In the adjusted analysis, children with sleep disorders were 2.61-fold more likely to have malocclusion compared to those without sleep disorders (OR = 2.61; 95%CI: 2.43-2.86). Moreover,

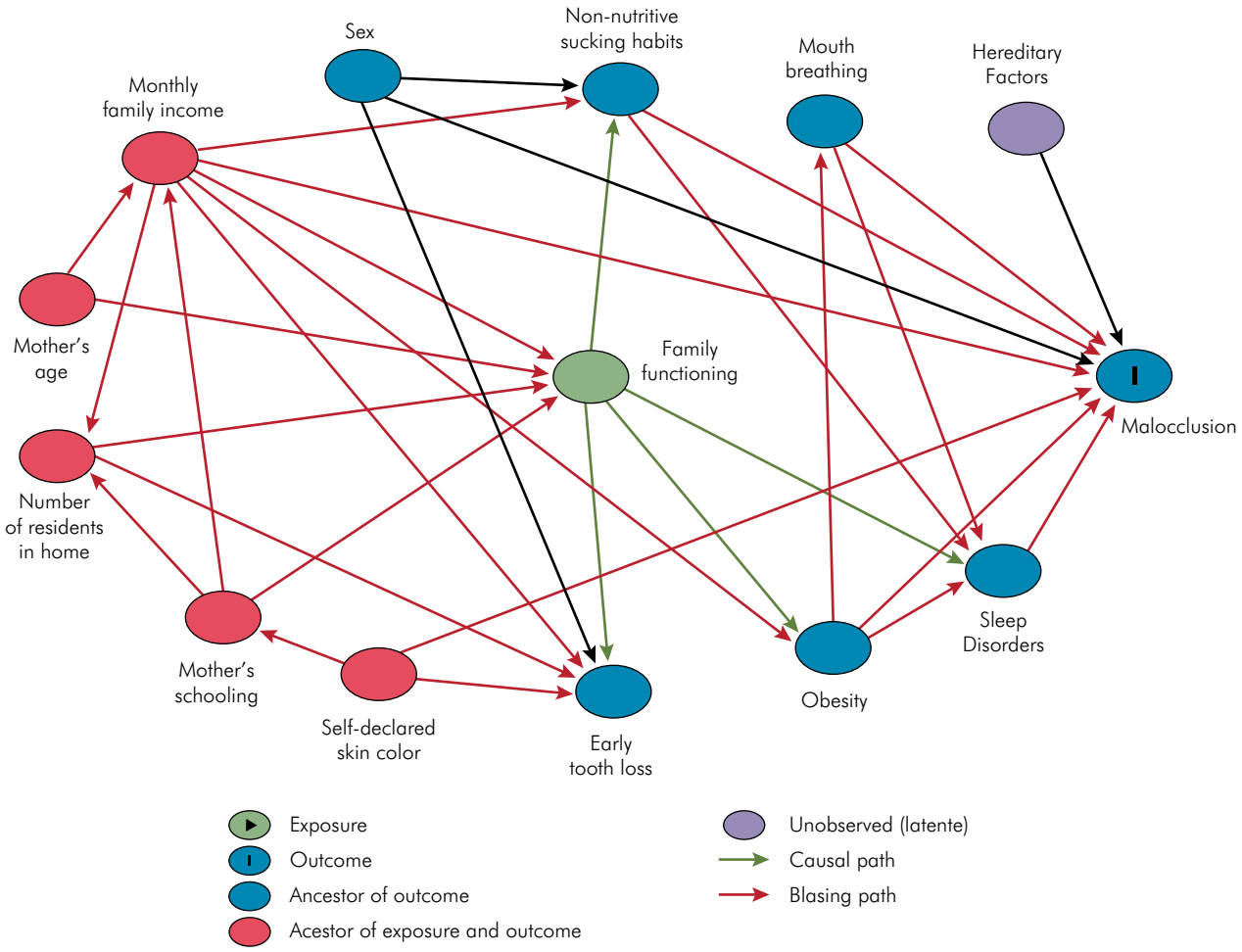


**Figure.** Directed acyclic graph (DAG) used for analysis of independent variables and malocclusion.

children with mouth breathing were 1.04-fold more likely to have malocclusion (OR = 1.04; 95%CI: 1.02–1.99). Children with non-nutritive sucking habits were 2.45-fold more likely to have malocclusion (OR = 2.45; 95%CI: 2.37–4.85) and those with obesity had a 54% greater likelihood of having malocclusion (OR = 1.54; 95%CI: 1.02–2.33).

## Discussion

In the present study, malocclusion was more prevalent in children with sleep disorders, sucking habits, mouth breathing, and obesity. This is the first study to evaluate the association between family functioning and malocclusion in children. However, this variable was not significantly associated with the outcome after model adjustments in the multivariate analysis. Thus, the hypothesis of this study was rejected.

The early analysis of predictors of malocclusion is important, as malocclusion in the mixed dentition phase tends to persist in the permanent dentition[30] and can have a negative impact on quality of life.[3,9,10] The prevalence of malocclusion in this study was high (49.1%). This high prevalence was probably influenced by genetic factors, which were not assessed in our study. However, children with sucking habits were more likely to have malocclusion, which is in agreement with findings described in the literature. Children care little about esthetic issues and may be reluctant to give up such habits. It is therefore important that parents/guardians recognize signs

**Table 1.** Characterization of the sample

| Variables | n (%) |
|---|---|
| Sex | |
| Male | 367 (49.7) |
| Female | 372 (50.3) |
| Self-declared skin color | |
| Non-White | 483 (65.4) |
| White | 255 (34.6) |
| Mother's schooling | |
| ≤ 8 years of study | 310 (42.2) |
| > 8 years of study | 425 (57.8) |
| Mother's age | |
| ≤ 35 years | 387 (53.1) |
| > 35 years | 342 (46.9) |
| Number of residents in home | |
| ≥ 6 | 96 (13.2) |
| ≤ 5 | 634 (86.8) |
| Sleep disorders | |
| Yes | 431 (58.3) |
| No | 305 (41.3) |
| Mouth breathing | |
| Yes | 362 (49.0) |
| No | 377 (51.0) |
| Non-nutritive sucking habits | |
| Yes | 57 (7.7) |
| No | 682 (92.3) |
| Monthly family income | |
| ≤ R$ 1000 | 327 (57.0) |
| > R$ 1000 | 247 (43.0) |
| Family functioning | |
| Extreme level | 83 (11.2) |
| Medium level of balance | 350 (47.4) |
| Moderately balanced | 274 (37.1) |
| Balanced | 32 (4.3) |
| Malocclusion | |
| Yes | 363 (49.1) |
| No | 376 (50.9) |
| Obesity | |
| Yes | 157 (21.2) |
| No | 582 (78.8) |
| Premature tooth loss | |
| Yes | 62 (8.4) |
| No | 677 (91.6) |

of harmful habits early[31] and seek multidisciplinary care when necessary.

Mouth breathing remained associated with higher frequency of malocclusion in the present sample. A systematic review study found that the mandible and maxilla undergo backward and downward rotation in children with mouth breathing.[32] Atypical breathing can lead to changes in the maxillofacial complex and have an impact on the facial profile. Children with sleep disorders were also more likely to have malocclusion in the present study. The possible causal factors of sleep disorders are rhinitis, tonsillar hypertrophy, and airway obstruction, which can lead to a change in the facial profile and, consequently, to malocclusion[6,7,15]. It is therefore important to investigate possible sleep disorders and causal factors in the population susceptible to the development of malocclusion.

Family functioning is a useful indicator for estimating the effect of family relations on the occurrence of dental caries.[17] This variable was not associated with malocclusion in the present sample, possibly because it has an indirect effect, as unbalanced families can generate anxiety and, consequently, children may develop harmful oral habits as a compensatory mechanism. However, there is no previous evidence on this aspect with regards to the occurrence of malocclusion. Thus, longitudinal studies or even cross-sectional studies that explore the indirect effect of this variable should be conducted, as family relations play an important role in child behavior.

Premature tooth loss did not have an influence on the prevalence of malocclusion in the present study. It is possible that the time elapsed since tooth loss was insufficient to cause the movement of adjacent teeth at the time of data collection and result in some type of malocclusion. A systematic review with meta-analysis on premature tooth loss found that the quality of evidence on this association is low and that further studies are needed.[8]

A limitation of the present study is the cross-sectional design, which does not allow a cause-and-effect relationship to be established between the variables analyzed. However, the study also has strengths, such as the representative school-

**Table 2.** Logistic regression for family functioning, sociodemographic characteristics, and clinical factors associated with malocclusion in children.

| Variable | Malocclusion | | Unadjusted OR | | Adjusted OR | |
|---|---|---|---|---|---|---|
| | Yes | No | | | | |
| | n (%) | n (%) | p-value | (95% CI) | p-value | (95% CI) |
| Sex | | | | | | |
| Male | 174 (47.4) | 193 (52.6) | 0.35 | - | - | - |
| Female | 189 (50.8) | 183 (49.2) | | - | | - |
| Self-declared skin color | | | | | | |
| White | 127 (49.8) | 128 (50.2) | 0.76 | - | - | - |
| Non-White | 235 (48.7) | 248 (51.3) | | - | | - |
| Monthly family income | | | | | | |
| ≤ R$ 1000 | 166 (50.8) | 161 (49.2) | 0.53 | - | - | - |
| > R$ 1000 | 119 (48.2) | 128 (51.8) | | - | | - |
| Mother's age | | | | | | |
| ≤ 35 years | 183 (47.3) | 204 (52.7) | 0.26 | - | - | - |
| > 35 years | 176 (51.5) | 166 (48.5) | | - | | - |
| Mother's schooling | | | | | | |
| ≤ 8 years of study | 161 (51.9) | 149 (48.1) | 0.17** | 1.10 (0.95–1.28) | - | - |
| > 8 years of study | 199 (46.8) | 226 (53.2) | | 1 | | - |
| Number of residents in home | | | | | | |
| > 5 | 51 (53.1) | 45 (46.9) | 0.40 | - | - | - |
| ≤ 5 | 308 (48.6) | 326 (51.4) | | - | | - |
| Sleep Disorders | | | | | | |
| Yes | 229 (53.1) | 202 (46.9) | 0.01** | 1.21 (1.04–1.42) | < 0.01* | 2.61 (2.43–2.86) |
| No | 133 (43.6) | 172 (56.4) | | 1 | | 1 |
| Mouth breathing | | | | | | |
| Yes | 196 (54.1) | 166 (45.9) | 0.007** | 1.22 (1.05–1.42) | 0.04* | 1.04 (1.02–1.99) |
| No | 167 (44.3) | 210 (55.7) | | 1 | | 1 |
| Non-nutritive sucking habits | | | | | | |
| Yes | 39 (68.4) | 18 (31.6) | 0.002** | 1.44 (1.19–1.75) | < 0.01* | 2.45 (2.37–4.85) |
| No | 324 (47.5) | 358 (52.5) | | 1 | | 1 |
| Family functioning | | | | | | |
| Extreme level | 43 (51.8) | 40 (48.2) | 0.18** | 1.65 (0.95–2.88) | | |
| Medium level of balance | 170 (48.6) | 180 (51.4) | | 1.55 (0.91–2.62) | | |
| Moderately balanced | 140 (51.1) | 134 (48.9) | | 1.63 (0.96–2.76) | | |
| Balanced | 10 (31.3) | 22 (68.7) | | 1 | | |
| Obesity | | | | | | |
| Yes | 88 (56.1) | 69 (43.9) | 0.14** | 1.15 (0.97–1.40) | 0.04* | 1.54 (1.02–2.33) |
| No | 294 (50.5) | 288 (49.5) | | - | | 1 |
| Premature tooth loss | | | | | | |
| Yes | 36 (58.1) | 26 (41.9) | 0.14** | 1.20 (0.96–1.50) | - | - |
| No | | 350 (51.7) | | 1 | | - |

OR: odds ratio; CI:confidence interval. *p ≤ 0.05; ** p ≤ 0.20.

based sample and the use of validated instruments. Moreover, the DAI was used for the diagnosis of malocclusion, which is recommended by the World Health Organization.[26] Another important aspect was the use of a DAG to select and control for confounding variables and to facilitate causal interpretation of the effect of the exposure on the outcome.

The present results are useful for the determination of health priorities and can assist in the planning of public policies directed at the family environment regarding oral health practices of children. Lectures that stress the influence of sleep disorders and obesity on oral abnormalities constitute important health promotion measures. Another point that merits attention concerns the clinical evaluation performed by a dentist, during which information on sleep characteristics, characteristics of the child, non-nutritive sucking habits, and mouth breathing should be investigated and could help prevent malocclusion.

Further studies are needed with a long-term evaluation of how sleep disorders influence the occurrence of malocclusion. Future studies should also evaluate different types of malocclusion in relation to these factors, which could contribute to a better understanding of this issue.

## Conclusion

According to the regression analyses based on a causal directed acyclic graph model, sleep disorders, mouth breathing, non-nutritive sucking habits, and obesity are predictors of malocclusion in schoolchildren aged eight to ten years. In contrast, family functioning does not seem to have a direct influence on the prevalence of malocclusion.

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